Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

10442

COAL PREPARATION PLANT EMISSION TESTS

EPA TEST NO. 72-CI-22

FINAL

TEST NO. 1281-35

WESTMORELAND COAL COMPANY

WENTZ PLANT

Stonega, Virginia

PREPARED FOR

ENVIRONMENTAL PROTECTION AGENCY

Research Triangle Park

North Carolina 27711

Contract No 68-02-0233

SCOTT RESEARCH LABORATORIES, INC.

PLUMSTEADVILLE, PENNSYLVANIA 18949

SRL 1281 35 0472

Test No. 1281-35

Westmoreland Coal Company
Wentz Plant
Stonega, Virginia, Norman R. Troxel

SCOTT RESEARCH LABORATORIES, INC.
Plumsteadville, Pennsylvania 18949

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1.0 INTRODUCTION

Scott Research Laboratories, Inc. performed source sampling tests at the Wentz Plant of Westmoreland Coal Company during the week of March 20, 1972. This plant is located in Stonega, Virginia. The plant uses a Research Cottrell venturi scrubber to control the exhaust gas emissions from a coal cleaning and preparation operation.

The exhaust gases, as they were being emitted to the atmosphere, were sampled and analyzed for the determination of total particulate loading, oxides of nitrogen, total hydrocarbons, carbon monoxide, carbon dioxide, and oxygen concentrations.

There are two types of coal processed at the plant, Osaka coal and Wentz coal. The Osaka coal is a low sulfur, medium ash, high volatile steam coal of 55 grindability index, while the Wentz coal is a low sulfur, low ash, high volatile metallurgical coal of 55 grindability index. One sample run with Osaka coal being processed was performed on March 20, 1972, and two other runs were conducted on March 22, 1972. Two sample runs were performed with the Wentz coal being processed on March 23, 1972. Figure 1 shows the location of the sampling point at the plant.

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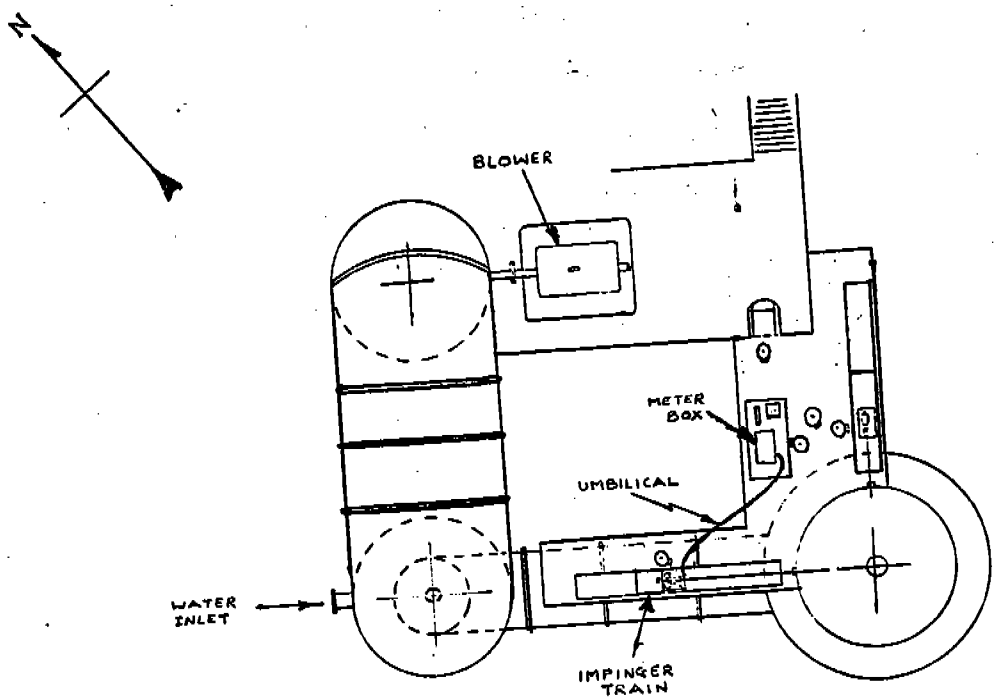
WESTMORELAND COAL CO.

STONEGA, VIRGINIA



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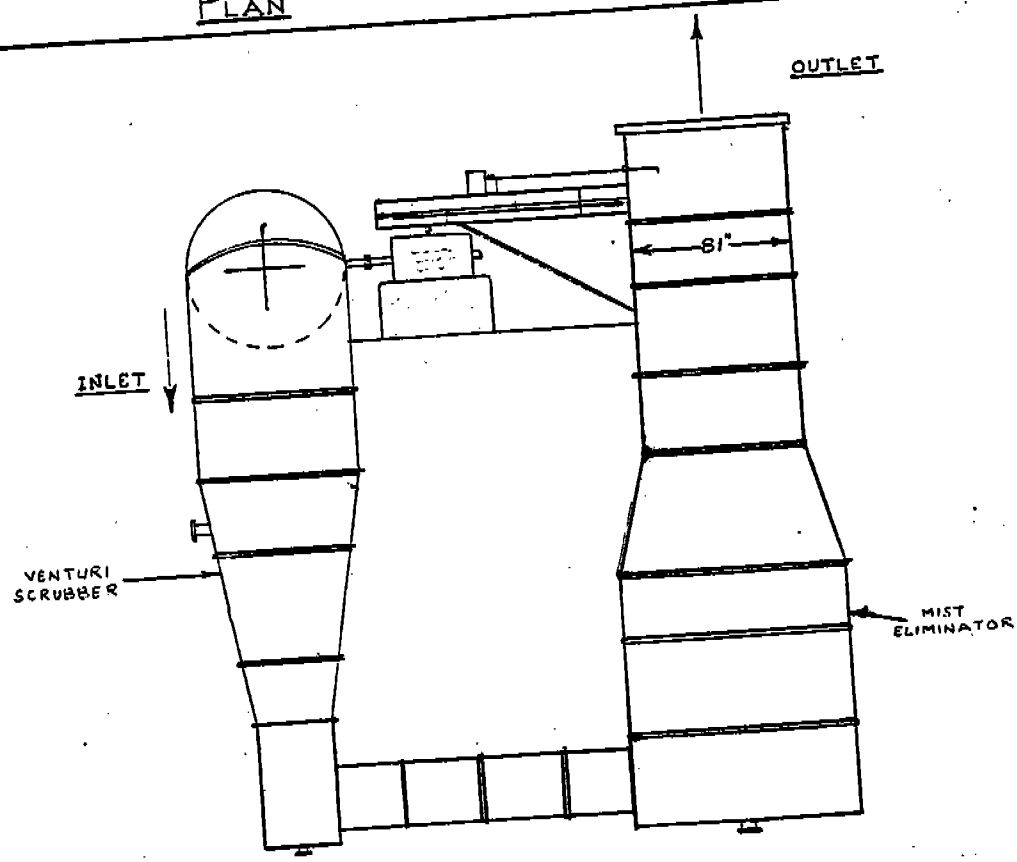

ELEVATION

FIGURE 1 - SAMPLE POINT LOCATION

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APR 7, 1972

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2.0 SUMMARY OF RESULTS

A summary of test results is presented in Table 1. The particulate weights are summarized and shown in Table 2, with all of the particulate results included as Appendix A. Appendix B presents all of the gaseous results, and the raw data sheets are included as Appendix C.

From Table 2 it is observed that the particulate matter collected during the three runs while Osaka coal was being processed averaged approximately 40 percent more than what was collected during the two runs performed while Wentz coal was being processed. This is also shown in Table 1 where the particulate emission rate to the atmosphere was approximately 50% higher for Osaka coal compared to Wentz coal.

A visible trail of brownish smoke was observed from the stack during the processing of Osaka coal. It was difficult to compare this occurrence with the visible emissions during processing of Wentz coal, since it was snowing the day of the tests. However, there did appear to also be somewhat of a brownish trail.

The NO_x concentrations were fairly consistent for all of the tests. The total hydrocarbon concentrations, however, varied considerably. They ranged from 18 ppm to 208 ppm.

TABLE 1 - SUMMARY OF TEST RESULTS

Run Number	1	2	3	4	5
Type of Coal	Osaka	Osaka	Osaka	Wentz	Wentz
Sample Date	3/20/72	3/22/72	3/22/72	3/23/72	3/23/72
Sample Gas Vol., scf.	88.56	86.95	86.09	95.90	94.51
Moisture, %	12.61	13.61	12.56	11.93	9.37
Stack Gas Temp., ^{o}F	120	120	120	120	120
Stack Gas Vel., fpm.	5165	4961	4847	5120	4998
Stack Gas Vol., SCFM	137,310	128,520	127,100	135,450	136,070
Particulate Collected					
Probe, cyclone, filter, mg.	261.5	206.5	242.0	169.5	173.0
Total, mg.	337.0	280.5	314.0	220.5	225.0
Particulate Concentration					
Probe, cyclone, filter, gr/scf.	0.046	0.037	0.043	0.027	0.028
Total, gr/scf.	0.059	0.050	0.056	0.035	0.037
Particulate Emissions					
Probe, cyclone, filter, lb/hr.	53.54	40.31	47.16	31.57	32.88
Total, lb/hr.	68.96	54.74	61.22	41.09	42.80
Percent Isokinetic	87.89	92.19	92.30	96.48	94.65
Carbon Monoxide, %	0.0	0.0	0.0	0.0	0.0
Carbon Dioxide, %	0.2	0.3	0.2	0.3	0.4
Oxygen, %	18.2	19.6	19.4	19.8	19.8
Total Hydrocarbon (ppm-C)	208.2	102.0	48.0	31.5	18.0
NO_x, ppm	52.8	54.4	37.6	59.6	44.6

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TABLE 2 - PARTICULATE WEIGHTS SUMMARY

Run Number	1	2	3	4	5
Container 1, mg.	92.0	101.5	94.0	64.0	78.0
Container 2, mg.	169.5	105.0	148.0	105.5	95.0
Container 3a, mg.	5.0	9.0	8.0	9.0	8.0
Container 3b, mg.	61.0	54.0	5.5	32.5	30.5
Container 5, mg.	9.5	11.0	13.5	9.5	13.5
Probe, cyclone filter, mg.	261.5	206.5	242.0	169.5	173.0
Total, mg.	337.0	280.5	314.0	220.5	225.0

3.0 PROCESS DESCRIPTION

At the Wentz plant the coal from the mines is screened, washed and then dried. The exhaust from the drier passes through a Research Cottrell venturi scrubber before it is emitted to the atmosphere. Figure 2 shows a flow diagram of the Wentz plant.

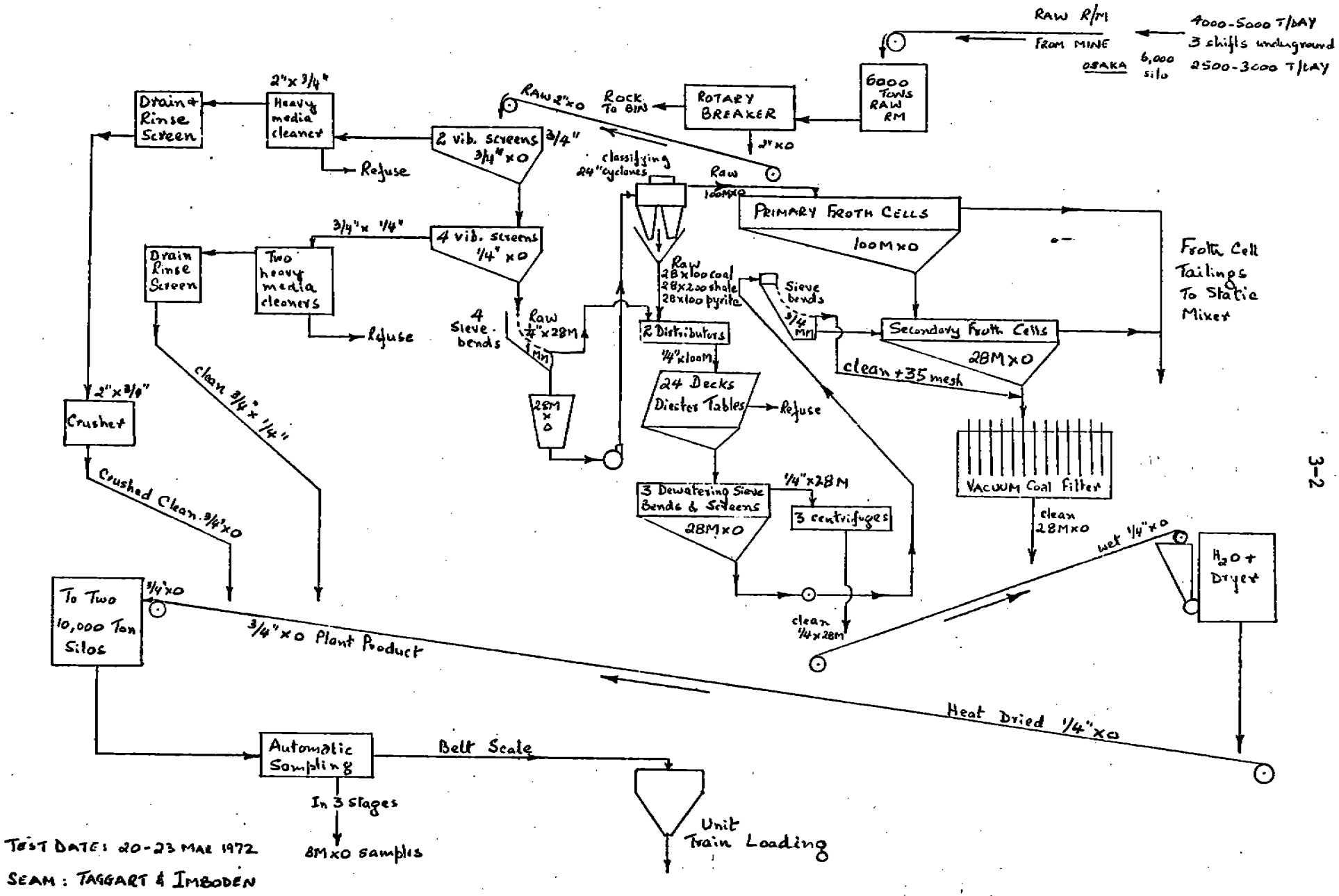

FIGURE 2 COAL FLOW IN WENTZ CLEANING PLANT

4.0 LOCATION OF SAMPLE POINTS

The exhaust gases from the coal cleaning operation pass through a Research Cottrell venturi scrubber to a mist eliminator and then are emitted to the atmosphere through an 81 inch diameter stack. Two sampling ports located at 90° apart were in the stack at a point approximately 10 feet upstream from the top of the stack and approximately 25 feet downstream from the outlet of the mist eliminator.

There had been a platform installed at the sample point location for some previous test work. An angle iron support rail extending ten feet out from each port was used to hold the sample box. The sample control unit was located in the same area. Figure 1 shows the physical layout of the system and the location of the sample ports.

Figure 3 shows the traverse points used. A total of 48 traverse points were sampled two and one half minutes each. In order to stay at least two inches away from the wall, the first two and last two points on the traverse were combined. Thus, the first and last points (each containing two traverse points) were samples for five minutes each. The traverse points were chosen in accordance with Method 1 published in the Federal Register, Volume 36, No. 24.

The two ports were designated as A and B, with A being the port on the left and B the port 90° to the right of A.

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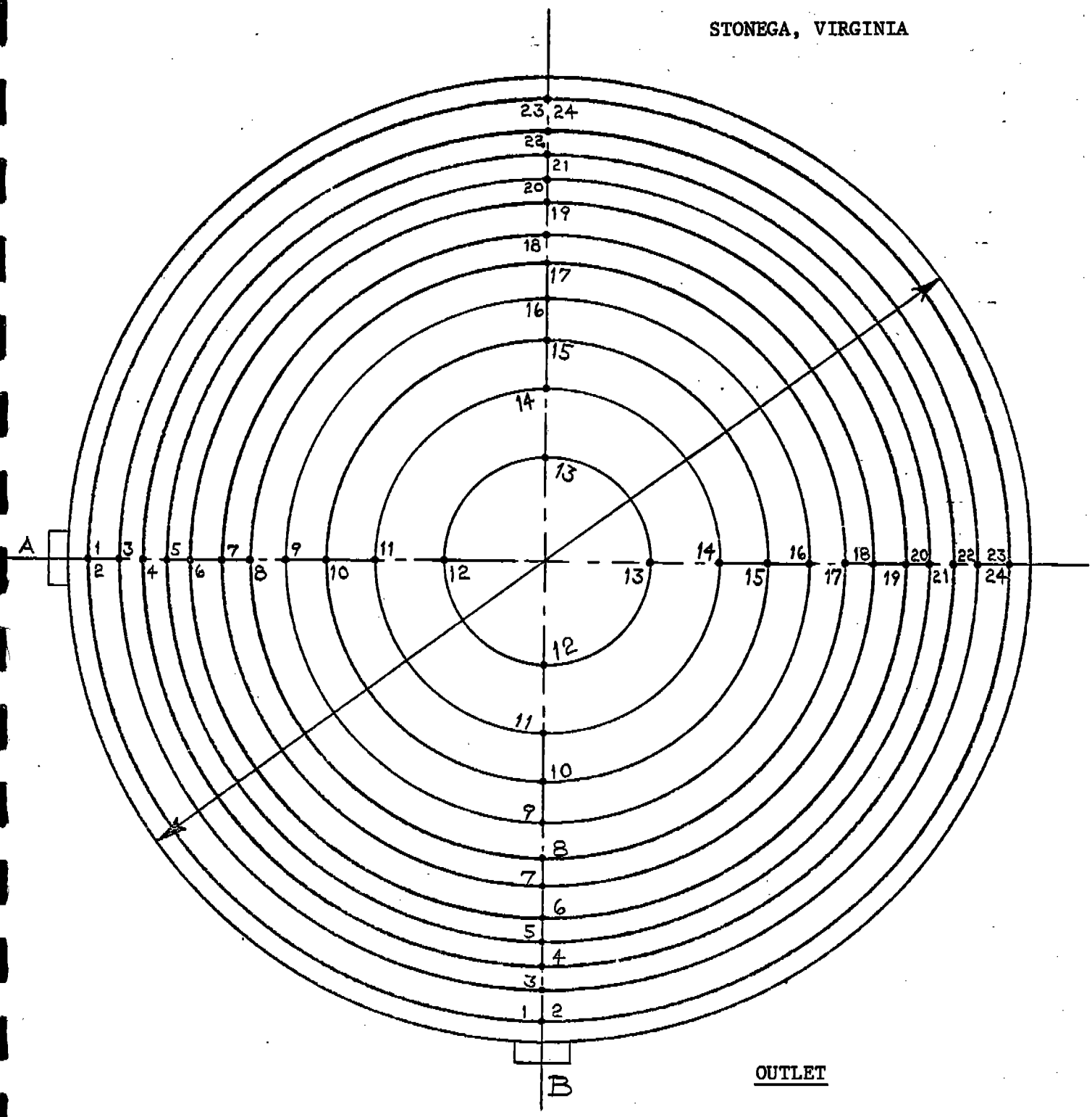

FIGURE 3 TRAVERSE POINT LOCATIONS

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5.0 PROCESS OPERATION

During the test all filter cake from flotation cells was fed to the dryer. Measured loadout of rail cars indicated that the plant production during our tests was 300 TPH, of which 200 TPH had been thermally dried.

Process variables monitored during the test were the furnace combustion zone temperature. These were recorded as follows:

		Dryer Temperature Combustion Zone			Exhaust Temperature		
Date	Test No.	Hi	Lo	Avg.	Hi	Lo	Avg.
3/22	2	1300	1100	1150	180	155	170
3/22	3	1250	1100	1150	180	170	175
3/23	4	1200	900	1100	150	140	145
3/23	5	1200	700	1050	155	140	145

Process operating data was not obtained during the first test on March 20, 1972.

6.0 SAMPLING AND ANALYTICAL PROCEDURES

6.1 PARTICULATE SAMPLING AND ANALYTICAL PROCEDURES

Samples were collected for the determination of particulate matter from the outlet of the venturi scrubber. The sampling and analytical procedures used were the same as those specified by Method 5, "Determination of Particulate Emissions from Stationary Sources", and published in the Federal Register, Volume 36, No. 247, Thursday, December 23, 1971. In addition, the impinger catch was analyzed. This method is attached as Appendix D.

Briefly, the method consists of withdrawing a sample isokinetically from the stack through a heated glass probe into a cyclone, filter, and impinger train. The cyclone and filter are contained in a heated box. The sample volume is measured with a dry gas meter, and isokinetic conditions are maintained by monitoring the stack gas velocity with an "S" type pitot tube. After testing is completed, the train is thoroughly washed including the probe. The washings are evaporated, dried, and weighed along with the filter in order to obtain a total weight of particulate matter collected.

The stack gas velocity and flow rate was measured using Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)", and published in the Federal Register. Using both the weight of sample collected and the flow rate determined, a total particulate emission rate was calculated.

6.2 GASEOUS SAMPLING PROCEDURES

Stack gas samples were taken at regular intervals during each particulate sampling traverse to determine the concentrations of O_2,

CO, CO_2, NO_x and total hydrocarbons present in the stack effluent. The sampling location was the same with respect to the venturi scrubber as that used for the particulate samples. The sampling and analytical procedures used were in accordance with Federal Register, Volume 36, No. 247, December 23, 1972, "Standards of Performance for New Stationary Sources".

6.3 NO_x SAMPLING AND ANALYTICAL PROCEDURES

All NO_x samples were taken through a ½ inch O.D. glass probe heated to approximately 250°F. Each sample was drawn through this probe into a previously evacuated 2 liter flask containing 25 ml. of NO_x absorbing solution. The flasks were shaken for 5 minutes following each sampling period and then allowed to stand for at least 16 hours. Following this, the samples were shaken again for 2 minutes just prior to measuring the final flask pressure. The samples were then transferred to glass shipping bottles with distilled water washes and neutralized with 1.0 N sodium hydroxide. At the end of the test period, all samples were returned to the laboratory for analysis.

The samples were analyzed via the phenoldisulfonic acid procedure described in the aforementioned Federal Register. The absorbances were measured with a Bausch and Lomb Spectronic 20 Colorimeter and the results were reported as parts per million NO_2.

6.4 ORSAT SAMPLING AND ANALYTICAL PROCEDURES

Integrated bag samples were taken for Orsat analysis (CO, CO_2 and O_2) during each particulate sampling period. The sampling apparatus consisted of a ¼ inch O.D. stainless steel probe, a stainless steel coiled tube condenser, a glass water trap, a carbon vane pump, a flowmeter and needle valve assembly, a 3 inch #21 stainless steel hypodermic needle, and a 5 liter Tedlar sample bag fitted with a syringe cap.

The sampling procedure was initiated by purging the probe and condenser system with stack air, adjusting the sample flow rate to approximately 80 cc per mintue, and inserting the hypodermic needle into the syringe cap on the sample bag. The integrated sample was taken over a 1 hour period yielding approximately 4.8 liters of sample for analysis.

At the end of each test day, the sample bags were analyzed by Orsat for CO, CO_2, and O_2. Repetitive analyses were performed on each bag to insure satisfactory duplication. The results were reported in percentages.

6.5 TOTAL HYDROCARBON SAMPLING AND ANALYSIS PROCEDURES

The same integrated bag sample that was taken for Orsat analysis was analyzed for total hydrocarbons via a Beckman Model 108-A Total Hydrocarbon Analyzer. Following each Orsat analysis the Tedlar sample bag was connected to the hydrocarbon analyzer via a Teflon sample tube. The sample was drawn into the instrument until a stable reading was recorded on the meter. Before and after each analysis the instrument was zeroed with hydrocarbon free air (<0.1 ppm-C) and spanned with a Scott close

tolerance blend of 99.9 ppm propane in nitrogen (analysis: ±2.0%). The meter readings for each sample were converted to ppm-C as shown in Section E-5 of Appendix E.

APPENDIX A

COMPLETE PARTICULATE RESULTS WITH EXAMPLE CALCULATIONS

REPORT NO. 1281-35 PAGE OF PAGES

SOURCE TESTING CALCULATION FORMS

Test. No. 3 No. Runs 5

Name of Firm Westmoreland Coal Co.

Location of Plant Stonega, Virginia

Type of Plant Coal cleaning operation

Control Equipment Venturi Scrubber

Sampling Point Locations Outlet stack; dia 84"; 2 ports; 24 points each;*

Pollutants Sampled Particulate, NOx, Orsat, Total Hydrocarbon

Time of Particulate Test:

Run No.	1	Date	3/20/72	Begin	1523	End	1825
Run No.	2 & 3	Date	3/22/72	Begin	0940 & 1305	End	1142 & 1515
Run No.	4 & 5	Date	3/23/72	Begin	0931 & 1144	End	1130 & 1430

PARTICULATE EMISSION DATA

	OSAKA COAL			WENTZ COAL		
Run No.	1	2	3	4	5	
P_b barometric pressure, "Hg Absolute	27.94	27.53	27.53	27.59	27.59	
P_m orifice pressure drop, "H_2O	2.366	2.162	2.072	2.519	2.410	
V_m volume of dry gas sampled @ meter conditions, ft.^{3}	97.53	94.21	92.95	101.05	99.80	
T_m Average Gas Meter Temperature, ^oF	88	71	69	58	59	
$V_{m_{std.}}$ Volume of Dry Gas Sampled @ Standard Conditions, ft.^{3}	88.56	86.95	86.09	95.70	94.51	
V_w Total H_2O collected, ml., Impingers & Silical Gel.	269.7	289.0	260.9	274.1	206.1	
$V_{w_{gas}}$ Volume of Water Vapor Collected ft.^{3} @ Standard Conditions*	12.78	13.70	12.37	12.99	9.77	

* 70°F, 29.92" Hg.

2½ minutes each point.

PARTICULATE EMISSION DATA (cont'd)

	OSAKA			WENTZ	
Run No.	1	2	3	4	5
%M - % Moisture in the stack gas by volume	12.61	13.61	12.56	11.93	9.37
M_d - Mole fraction of dry gas	0.8739	0.8639	0.8744	0.8807	0.9063
% CO_2 (dry)	0.2	0.3	0.2	0.3	0.4
% O_2 (dry)	18.2	19.6	19.4	19.3	19.8
% N_2 (dry)	81.57	80.08	80.39	79.89	79.79
MW_d - Molecular weight of dry stack gas	28.760	28.826	28.805	28.837	28.853
MW - Molecular weight of stack gas	27.403	27.353	27.448	27.544	27.836
ΔP_s - Velocity Head of stack gas, In.H_2O	1.8541	1.6833	1.6125	1.8083	1.7416
T_s - Stack Temperature, °F	120	120	120	120	120
$\sqrt{\Delta P_s X (T_s+460)}$	32.793	31.246	30.582	32.385	31.783
P_s - Stack Pressure, "Hg. Absolute	27.84	27.44	27.44	27.49	27.49
V_s - Stack Velocity @ stack conditions, fpm	5164.60	4961.23	4847.39	5119.56	4997.97
A_s - Stack Area, in.^{2}	5153	5153	5153	5153	5153
Q_s - Stack Gas Volume @ Standard Conditions. *SCFM	137,310	123,520	127,100	135,450	136,070
T_t - Net Time of Test, min.	120	120	120	120	120
D_n - Sampling Nozzle Diameter, in.	0.2	0.2	0.2	0.2	0.2
%I - Percent isokinetic	87.89	92.19	92.30	96.48	94.65
m_f - Particulate - probe, cyclone and filter, mg.	261.5	206.5	242.0	169.5	173.0
m_t - Particulate - total, mg.	337.0	280.5	314.0	220.5	225.0
C_{an} - Particulate - probe, cyclone, and filter, gr/SCF	0.0455	0.0366	0.0433	0.0272	0.0282
C_{ao} - Particulate - total, gr/SCF	0.0586	0.0497	0.0562	0.0354	0.0367
C_{at} - Particulate - probe, cyclone, & filter gr/cf @ stack conditions	0.0338	0.0265	0.0317	0.0201	0.0214

PARTICULATE EMISSION DATA (cont'd)

A-4

	OSAKA			WENTZ		
Run No.	1	2	3	4	5	
C_{au} - Particulate, total, gr/cf @ stack cond.	0.0435	0.0360	0.0412	0.0262	0.0279	
C_{aw} - Particulate, probe, cyclone, and filter, lb/hr.	53.54	40.31	47.16	31.57	32.88	
C_{ax} - Particulate - total, lb/hr.	68.96	54.74	61.22	41.09	42.80	
% EA - % Excess air @ sampling point	520.35	1152.1	977.95	1364.8	1390.3	

*70°F. 29.92" Hg.

PARTICULATE CALCULATIONS

1. Volume of dry gas sampled at standard conditions - 70°F, 29.92" Hg, ft.^{3}

$$V_{m_{std}} = \frac{17.7 \times V_m \left(P_B + \frac{P_m}{13.6}\right)}{(T_m + 460)} = \text{Ft.}^3 = \frac{17.7 \times 97.53 \left(29.94 + \frac{2.366}{13.6}\right)}{(89+460)} = \underline{88.56}$$

2. Volume of water vapor at 70°F & 29.92" Hg, Ft.^{3}

$$V_{w_{gas}} = 0.0474 \times V_w = \text{Ft.}^3 = 0.0474 \times 269.7 = \underline{12.78}$$

3. % moisture in stack gas

$$\%M = \frac{100 \times V_{w_{gas}}}{V_{m_{std}} + V_{w_{gas}}} = \% = \frac{100 \times 12.78}{88.56 + 12.78} = \underline{12.61}$$

4. Mole fraction of dry gas

$$M_d = \frac{100 - \%M}{100} = \frac{100 - 12.61}{100} = \underline{0.8739}$$

5. Average molecular weight of dry stack gas

$$MW_d = (\%CO_2 \times \frac{44}{100}) + (\%O_2 \times \frac{32}{100}) + (\%N_2 \times \frac{28}{100})$$

$$= (0.2 \times 0.44) + (18.2 \times 0.32) + (81.57 \times 0.28)$$

$$= \underline{28.76}$$

6. Molecular weight of stack gas

$$MW = MW_d \times M_d + 18\,(1 - M_d) = 28.760 \times 0.8739 + 18\,(1 - 0.8739)$$

$$= \underline{27.403}$$

7. Stack velocity @ stack conditions, fpm

$$V_s = 4350 \times \sqrt{\Delta P_s \times (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2} = \text{fpm} = 4350 \times 32.793 \left[\frac{1}{27.84 \times 27.403}\right]^{1/2}$$

$$= \underline{5164.60}$$

8. Stack gas volume @ standard conditions, SCFM

$$Q_s = \frac{0.123 \times V_s \times A_s \times M_d \times P_s}{(T_s + 460)} = \text{SCFM} = \frac{0.123 \times 5164.60 \times 5153 \times .8739 \times 27.84}{(120 + 460)}$$

$$= \underline{13731.0}$$

9. Per cent isokinetic

$$\%I = \frac{1032 \times (T_s + 460) \times V_{m_{std}}}{V_s \times T_t \times P_s \times M_d \times (D_n)^2} = \% = \frac{1032 \times 580 \times 88.56}{5164.6 \times 120 \times 27.84 \times .8739 \times 0.04}$$

$$= \underline{87.89}$$

10. Particulate - probe, cyclone, & filter, gr/SCF

$$C_{an} = 0.0154 \times \frac{M_f}{V_{m\,std}} = \text{gr/SCF} = 0.0154 \times \frac{261.5}{88.56}$$

$$= \underline{0.0455}$$

11. Particulate total, gr/SCF

$$C_{ao} = 0.0154 \times \frac{M_t}{V_{m_{std}}} = gr/SCF = 0.0454 \times \frac{337}{88.56}$$

$$= \underline{0.0586}$$

12. Particulate - probe, cyclone & filter, gr/CF at stack conditions

$$C_{at} = \frac{17.7 \times C_{an} \times P_s \times M_d}{(T_s + 460)} = gr/CF = \frac{17.7 \times 0.0455 \times 27.84 \times 0.8739}{580}$$

$$= \underline{0.0338}$$

13. Particulate - total, gr/CF @ stack conditions

$$C_{au} = \frac{17.7 \times C_{ao} \times P_s \times M_d}{(T_s + 460)} = gr/CF = \frac{17.7 \times 0.0586 \times 27.84 \times 0.873}{580}$$

$$= \underline{0.0435}$$

14. Particulate - probe, cyclone, & filter, lb/hr.

$$C_{aw} = 0.00857 \times C_{an} \times Q_s = lb/hr. = 0.00857 \times 0.0455 \times 137310$$

$$= \underline{53.54}$$

15. Particulate - total, lb/hr.

$$C_{ax} = 0.00857 \times C_{ao} \times Q_s = lb/hr. = 0.00857 \times 0.0586 \times 137310$$

$$= \underline{68.96}$$

16. % excess air at sampling point

$$\% \text{ EA} = \frac{100 \times \% O_2}{0.266 \times \% N_2 - \% O_2} = \% = \frac{100 \times 18.2}{0.266 \times 81.57 - 18.2}$$

$$= \underline{520.35}$$

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APPENDIX B

COMPLETE GASEOUS RESULTS WITH EXAMPLE CALCULATIONS

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ORSAT ANALYSIS DATA SHEET

Run No.	Date	Analysis Number	% CO	% CO_2	% O_2
1	3/20/72	1	0.0	0.2	18.2
		2	0.0	0.2	18.1
		3	0.0	0.2	18.2
		Avg.	0.0	0.2	18.2
2	3/22/72	1	0.0	0.3	19.6
		2	0.0	0.2	19.7
		3	0.0	0.3	19.6
		Avg.	0.0	0.3	19.6
3	3/22/72	1	0.0	0.2	19.4
		2	0.0	0.2	19.4
		3	0.0	0.3	19.5
		Avg.	0.0	0.2	19.4
4	3/23/72	1	0.0	0.3	19.8
		2	0.0	0.4	19.7
		3	0.0	0.3	19.8
		Avg.	0.0	0.3	19.8
5	3/23/72	1	0.0	0.4	19.8
		2	0.0	0.4	19.8
		3	0.0	0.5	19.8
		Avg.	0.0	0.4	19.8

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TOTAL HYDROCARBON DATA

Run No.	Date	Sample No.	Range	Meter Units	THC* (ppm-C_3H_8)	THC (ppm-C)
1	3/20/72	1	100	69.5	69.4	208.2
		2	100	69.5	69.4	208.2
2	3/22/72	1	100	35.0	35.0	105.0
		2	100	33.0	33.0	99.0
3	3/22/72	1	100	16.0	16.0	48.0
		2	100	16.0	16.0	48.0
4	3/24/72	1	100	10.5	10.5	31.5
		2	100	10.5	10.5	31.5
5	3/23/72	1	100	5.0	5.0	15.0
		2	100	7.0	7.0	21.0

* All spans were set at full scale on Range 100 using a 99.9 ppm C_3H_8 standard.

Sample calculation:

Run #1, Sample #1:

$$\text{ppm-}C_2H_8 = \frac{\text{meter units x 99.9 ppm-}C_3H_8}{\text{100 units span}}$$

$$\text{ppm-}C_3H_8 = \frac{(69.5)(99.9)}{100}$$

$$\text{ppm-}C_3H_8 = 69.4$$

$$\text{ppm-C} = \text{ppm-}C_3H_8 \times 3$$

$$\text{ppm-C} = 208.2$$

NO_x EMISSION DATA

Osaka Coal

Run No.	1-1	1-2	1-3			
Date	20Mar72	20Mar72	20Mar72			
mg NO_2	0.120	0.170	0.153			
T_f - Flask Temperature, °F	65	68	63			
V_f - Flask Volume, liters	2.040	2.039	2.053			
P_i - Initial Flask Vacuum, "Hg.	25	25	25			
P_f - Final Flask Vacuum, "Hg.	8	1.2	1.4			
ppm NO_2	53.8	54.9	49.7			

$$\text{ppm } NO_2 = \frac{29.63 \times \text{mg } NO_2 \times (T_f + 460)}{V_f \times (P_i - P_f)}$$

Example Calculation:

Run # 1-1 :

$$\text{ppm } NO_2 = \frac{29.63 \times 0.120 \text{ mg } NO_2 \times (65 + 460)}{2.040 \text{ l} \times (25 - 8)}$$

$$\text{ppm } NO_2 = 53.8$$

NO_x EMISSION DATA
Osaka Coal

Run No.	2-1	2-2	2-3	3-1	3-2	3-3
Date	22 Mar	22 Mar	22 Mar	22 Mar	22 Mar	22 Mar
mg NO_2	0.181	0.180	(lost)	0.127	0.156	0.037
T_f - Flask Temperature, °F	43	47		50	55	50
V_f - Flask Volume, liters	2.033	2.043		2.050	2.040	2.039
P_i - Initial Flask Vacuum, "Hg.	25	25		25	25	25
P_f - Final Flask Vacuum, "Hg.	-0.4	-0.4		0	0.3	14.0
ppm NO_2	54.8	53.9		38.7	48.0	26.0

$$\text{ppm } NO_2 = \frac{29.63 \times \text{mg } NO_2 \times (T_f + 460)}{V_f \times (P_i - P_f)}$$

NO_x EMISSION DATA

Wentz Coal

Run No.	4-1	4-2	4-3	5-1	5-2	5-3
Date	23 Mar	23 Mar	23 Mar	23 Mar	23 Mar	23 Mar
mg NO_2	0.192	0.028	0.172	0.070	0.194	0.149
T_f - Flask Temperature, °F	32	32	32	32	32	32
V_f - Flask Volume, liters	2.040	2.039	2.017	2.033	2.052	2.050
P_i - Initial Flask Vacuum, "Hg.	25	25	25	25	25	25
P_f - Final Flask Vacuum, "Hg.	1.5	0.5	1.3	2.2	1.2	1.1
ppm NO_2	62.7	8.7*	56.5	23.6	62.4	47.8

$$\text{ppm } NO_2 = \frac{29.63 \times \text{mg } NO_2 \times (T_f + 460)}{V_f \times (P_i - P_f)}$$

* Not included in average for Run #4

APPENDIX C

FIELD DATA

1536 ... 1553

Plant
Location
Operator
Date
Run No. 1 A
Sample Box No.
Meter Box No.
Meter ΔH_g 1.82
C Factor .85

Schematic of Stack Cross Section

Ambient Temperature 65
Barometric Pressure ~~770.5~~ 27.94
Assumed Moisture, % 12
Box Setting 25
...gth, m.
...eter, In. .200
Setting
4680

Traverse Point Number	Sampling Time (θ) min.	1 Static Pressure (P_s) In. ~~Hg.~~ H2O	2 Stack Temperature (T_s) °F	3 Velocity Head (ΔP_s)	4 Pressure Differential Across Orifice Meter (ΔH) In. H_2O	610,348 Gas Sample Volume (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
1+2	5	.45	12.0	1.4	1.8	613.5	67	66	250	56
3	7.5	.70		1.3	1.7	[illegible]	[illegible]	66	[illegible]	[illegible]
4	10	.80		1.4	2.1	Should	[illegible]	[illegible]	2.1	
5	12.5	.90		1.21	1.8	619.18	82	67		58
6	15	.91		1.3	1.7	[illegible]	86	68	250	60
7	17.5	.92		1.3	1.7	622.15	88	68	250	61
8	20	.96		1.1	1.4	624.39	91	69	250	65
9	22.5	1.10		1.4	1.8	626.20	93	70	240	66
10	25	.20		1.4	1.8	628.04	96	71	250	66
11	27.5	1.1		1.5	1.9	629.92	97	72	[illegible]	66
12	30	1.4		1.6	2.1	631.91	Avg. 98	Avg. 73		66
Average							Avg.			

5 Clear

Plant _____
Location _____
Operator _____
Date _____
Run No. 1A
Sample Box No. _____
Meter Box No. _____
Meter ΔH_g _____
C Factor _____

Schematic of Stack Cross Section

Ambient Temperature _____
Barometric Pressure _____
Assumed Moisture, % _____
Heater Box Setting _____
Probe Length, m. _____
Nozzle Diameter, In. _____
Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg. 1	Stack Temperature (T_s) °F 2	Velocity Head (ΔP_s) 3	Pressure Differential Across Orifice Meter (ΔH) In. H_2O 4	Gas Sample Volume (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
13	32.5	1.7	120	2.2	2.7	634.04	104	75	250	70
14	35	1.7		2.3	2.8	[illegible]	108	75		70
15	37.5	1.6		2.4	3.1	638.64	110	76		72
16	40	1.6		2.5	3.2	641.05	114	78		72
17	42.5	1.5		2.5	3.2	643.14	118	80		73
18	45	1.4		2.5	3.3	645.64	118	81		73
19	47.5	1.4		2.6	3.3	648.37	112	82		76
20	50	1.5		2.7	3.4	650.9	115	82		76
21	52.5	1.5		2.7	3.4	653.19	121	83		80
22	55	1.5		2.8	3.5	655.64	120	85		83
Total 23+24	60	1.5		2.2	2.7	660.211	Avg 77	Avg 72		50
Average							Avg.			

C-3

Plant _____
Location _____
Operator _____
Date _____
Run No. 1 B
Sample Box No. _____
Meter Box No. _____
Meter ΔH_g _____
C Factor _____

Schematic of Stack Cross Section

Ambient Temperature _____
Barometric Pressure _____
Assumed Moisture, % _____
Heater Box Setting _____
Probe Length, m. _____
Nozzle Diameter, In. _____
Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	1 Static Pressure (P_s) In. Hg.	2 Stack Temperature (T_s) °F	3 Velocity Head (ΔP_s)	4 Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume, (V_m) ft^3	Gas Sample Temperature at Dry Gas Meter: Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter: Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
1+2	5	.90		1.5	[illegible]	[illegible]	7[illegible]	[illegible]	250	60
3	[illegible]	.91		1.6	[illegible]	[illegible]	68	[illegible]		[illegible]
4	[illegible]	[illegible]		1.6	[illegible]	[illegible]	73	73		[illegible]
5		.92		1.5	1.9	[illegible]	[illegible]	73		62
6		.95		1.5	1.9	671.06	100	73		64
7		1.0		1.5	1.9	[illegible]	102	74		67
8		1.15		1.6	2.1	675.49	102	75		67
9		1.30		1.6	1	677.44	104	76		69
10		1.20		1.4	1	679.42	[illegible]	[illegible]		73
11	[illegible]	1.25		1.8	3	681.10	109	7[illegible]		72
Total 12		1.70		[illegible]	2.5	682.78	Avg. 112	Avg. 79		72
Average							Avg.			

m at 1.26

Plant _____
Location _____
Operator _____
Date _____
Run No. 113
Sample Box No. _____
Meter Box No. _____
Meter ΔH_g _____
C Factor _____

Schematic of Stack Cross Section

Ambient Temperature _____
Barometric Pressure _____
Assumed Moisture, % _____
Heater Box Setting _____
Probe Length, m. _____
Nozzle Diameter, In. _____
Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential across Orifice Meter (ΔH) In. H_2O	682.72 Gas Sample Volume, (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
13	32.5	1.7		1.7	2.2	684.48	112	80		72
14	35	1.6		1.7	2.1	686.175				72
15	37.5	1.7		1.7	2.1	688.16	114	82		70
16	40	1.7		1.7	2.1	690.144	111	83		70
17	42.5	1.6		1.8	2.3	692.165	109	82		70
18	45	1.5		1.9	2.4	694.27	106	82		73
19	47.5	1.5		2.0	2.6	696.45	103	81		71
20	50	1.4		2.1	2.7	698.667	102	80		72
21	52.5	1.2		2.2	2.8	700.92	101	79		74
22	55			2.3	3.0	703.27	101	78		74
Total 23+24	60	1.1		2.2	2.8	707.879	Avg. 99	Avg. 78		74
Average							Avg.			

P5

BIG STONE GAP C-6

~~550.0~~ ~~515.3~~ ~~34.7~~

WATER VOLUME

Run No. 1 (ONE) Date 3/20/72

Bubbler #1 265 ml Silica Gel No. 2 Wgt. g. 515.3 g

#2 160 ml

#3 10 ml Bubbler #4 ~~[illegible]~~ 550.0 g

Gross 435

Water Added(-) 200 Gross Wgt.(-) 515.3 g ~~[illegible]~~

Net (A) 235 cc Net (B) 34.7 g

Net (A) 235

Net (B) (+) 34.7

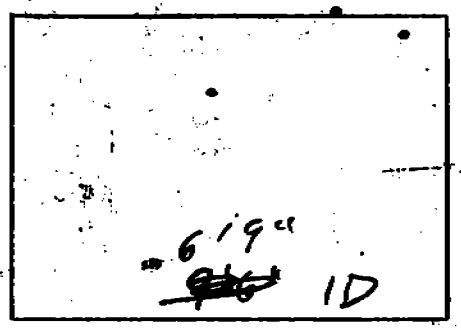
Total Water 269.7 cc

Form R&D 109

#1

0940 Start

Plant [illegible]
Location Stongga Va
Operator [illegible]
Date 3/22/72
Run No. 2 [illegible]
Sample Box No.
Meter Box No.
Meter ΔH_g 1.84
C Factor .82
Pitot Cor. .855



Schematic of Stack Cross Section

Ambient Temperature 45
Barometric Pressure 27.54
Assumed Moisture, % 12
Heater Box Setting 250
Probe Length, m.
Nozzle Diameter, In. .250
Probe Heater Setting 225
Filter II .4542
Plant elev. 2152

Traverse Point Number	Sampling Time (θ) min.	Stack Pressure (P_s) In. Hg	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume (Vm) ft^3 714.666	Gas Sample Temperature at Dry Gas Meter: Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter: Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
1	.5	.90	120	1.3	1.7	718.32	47	46	250	52
2	7.5	1.80		1.4	1.8	720.25	60	48		52
3	10			1.3	1.7	721.83	63	48		50
4	12.5	1.0		1.4	1.8	723.61	65	48		53
5	15	1.2		1.2	1.5	722.48	68	49		56
6	17.5	1.3		1.3	1.7	727.3	69	50		57
7	20	1.4		1.4	1.8	728.76	71	51		60
8	22.5	1.4		1.4	1.8	730.65	71	51		61
9	25	1.5		1.5	1.9	732.34	73	52		66
10	27.5	1.6		1.5	1.9	734.17	74	54		68 4" bac
Total	70	1.5		1.5	1.9	736.02	Avg. 76	Avg. 53		65
Average							Avg.			

[redacted] Pl[redacted]

Location _____

Operator _____

Date _____

Run No. 2A

Sample Box No. _____

Meter Box No. _____

Meter ΔH_g _____

C Factor _____

Schematic of Stack Cross Section

[redacted]ble[redacted]per[redacted]

Barometric Pressure _____

Assumed Moisture, % _____

Heater Box Setting _____

Probe Length, m. _____

Nozzle Diameter, In. _____

Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume, (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter: Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter: Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
13	32.5	1.5	120	2.0	2.6	738.065	82	55		65
14	35	1.8		2.1	2.7	740.19	82	55		65
15	37.5	1.7		2.1	2.7	742.355	83	58		63
16	40	1.6		2.1	2.7	744.57	81	56		61
17	42.5	1.4		2.1	2.7	746.79	84	57		63
18	45	1.3		2.0	2.6	748.965	86	57		65
19	47.5	1.3		2.1	2.7	751.155	88	59		65
20	50	1.0		2.1	2.7	753.36	87	60		65
21	52.5	1.0		2.1	2.7	755.57	88	60		65
22	55	1.1		2.2	2.8	757.78	91	62		65
Total 22	60	1.1		2.1	2.7	762.199	Avg. 94	Avg. 63		65
Average							Avg.			

C-8

Plant [redacted]
Location
Operator
Date
Run No. 2 B
Sample Box No.
Meter Box No.
Meter ΔH_g
C Factor

Schematic of Stack Cross Section

Ambient Temperature [redacted]
Barometric Pressure 27.54"
Assumed Moisture, %
Heater Box Setting
Probe Length, m.
Nozzle Diameter, In.
Probe Heater Setting

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume, (V_m) ft^3	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
13	32.5	1.7	120	1.7	2.1	787.7	85	64		60
14	35	1.7		1.7	2.1	789.065	81	63		61
15	32.5	1.7		1.7	2.1	791.61	85	64		61
16	[illegible]	1.7		1.5	1.9	793.6	[illegible]	[illegible]		61
17	[illegible]	1.4		1.5	1.9	795.375	81	[illegible]		62
[illegible]	[illegible]	1.3		1.5	1.9	797.195	[illegible]	[illegible]		62
19	[illegible]	1.0		1.6	2.1	[illegible]	89	[illegible]		60
20	[illegible]	.9		1.7	2.2	801.13	93	65		62
[illegible]	52.5	.75		1.6	2.1	803.1	92	66		62
	[illegible]	.75		1.7	2.2	805.11	94	66		60
Total [illegible]	[illegible]	.65		1.6	2.1	809.076	Avg. 93	Avg. 67		62
Average							Avg.			

BIG STONE GAP

C-11

WATER VOLUME

Run No. 2 Date 3/22/72

Bubbler #1 288 Silica Gel No. 1 Wgt. g. 513.0

#2 152

#3 15 Bubbler #4 547.0

Gross 455

Water Added(-) 200 Gross Wgt.(-) 513.0

Net (A) 255 cc Net (B) 34.0 g

Net (A) 255

Net (B) (+) 34

Total Water 289 cc

Silica Gel
G. 547.0
T. 513.0 g
Net 34.0 g

Form R&D 109

I B

Plant _____
Location _____
Operator _____
Date _____
Run No. 3 B
Sample Box No. _____
Meter Box No. _____
Meter ΔH_g _____
C Factor _____

Schematic of Stack Cross Section

Ambient Temperature _____
Barometric Pressure _____
Assumed Moisture, % _____
Heater Box Setting _____
Probe Length, m. _____
Nozzle Diameter, In. _____
Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume, (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter: Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter: Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
13	32.5	1.6	120	1.7	2.2	834.31	75	62		61
14	35	1.7		1.9	2.4	836.39	79	62		61
15	37.5	1.7		1.7	2.2	838.455	82	63		61
16	40	1.5		1.7	2.2	840.47	84	63		63
17	42.5	1.4		1.6	2.1	842.445	87	64		68
18	45	1.4		1.6	2.1	844.41	85	65		70
19	47.5	1.5		2.0	2.6	846.58	85	65		74 7" vac
20	50	1.6		2.3	2.9	848.85	85	65		80
21	52.5	1.5		2.1	2.7	851.15	89	66		85
22	55	1.6		2.2	2.9	853.44	90	66		95
Total 23+24	60	1.7		2.3	2.95	858.174	Avg. 89	Avg. 66		91 7" vac
Average							Avg.			

C-13

Pl[redacted]

Location

Operator

Date

Run No. 3 B

Sample Box No.

Meter Box No.

Meter ΔH_g

C Factor

Schematic of Stack Cross Section

Ambient Temperature

Barometric Pressure

Assumed Moisture, %

Heater Box Setting

Probe Length, m.

Nozzle Diameter, In.

Probe Heater Setting

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume (Vm) ft^3 858.124	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
1+2	5	.85	120	1.6	2.1	862.24	75	63		70
3	7.5	.86		1.5	1.9	864.24	78	64		65
4	10	.9		1.4	1.8	866.19	78	63		65
5	12.5	1.1		1.6	2.1	868.17	80	63		64.5
6	15	1.2		1.5	1.98	870.05	81	63		63
7	17.5	1.4		1.5	1.9	871.90	80	63		62
8	20	1.3		1.7	2.2	873.82	79	63		62
9	22.5			1.7	2.2	875.82	75	62		
10	25			1.6	2.1	877.85	75	61		65
11	27.5			2.2	2.6	879.89	79	61		64
Total 12	30			20	2.5	882.4	Avg. 77	Avg. 61		62
Average							Avg.			

C-14

#8

Plant _____
Location _____
Operator _____
Date _____
Run No. 3B
Sample Box No. _____
Meter Box No. _____
Meter ΔH_g _____
C Factor _____

Schematic of Stack Cross Section

Ambient Temperature _____
Barometric Pressure _____
Assumed Moisture, % _____
Heater Box Setting _____
Probe Length, m. _____
Nozzle Diameter, In. _____
Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter: Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter: Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
13	32.5		120	2.2	2.7	884.21	78	60		62
14	35			1.5	1.9	886.16	79	60		61
15	37.5			1.5	1.9	888.05	80	60		60
16	40			1.4	1.8	889.90	80	60		59 5" Oc
17	42.5			1.3	1.7	891.71	79	61		57
18	45			1.3	1.7	893.485	77	61		55
19	47.5			1.5	1.9	895.345	76	60		55
20	50			1.5	1.9	897.47	77	61		55
21	52.5			1.3	1.7	899.00	77	60		55
22	55			1.7	2.2	900.9	79	60		55
Total 23+24	60			1.3	1.7	904.599	Avg. 83	Avg. 61		57
Average							Avg.			

BIG STONE GAP

WATER VOLUME

Run No. 3 Date 3/22/72

Bubbler #1 320 ml Silica Gel No. 4 Wgt. g. 515.8

#2 90 ml

#3 15 ml Bubbler #4 551.7

Gross

Water Added(-) 425 200 Gross Wgt.(-) 515.8

Net (A) 225 cc Net (B) 35.9 g

Net (A) 225

Net (B) (+) 35.9

Total Water 260.9 cc

Form R&D 109

0931 Flat

Plant Westmoreland
Location Stonega Va
Operator
Date 3/23/72
Run No. 4 A
Sample Box No.
Meter Box No.
Meter ΔH_g 1.84
C Factor
Pitot

6'9" ID

Schematic of Stack Cross Section

Ambient Temperature 32°
Barometric Pressure 27.64"
Assumed Moisture, % 12
Heater Box Setting
Probe Length, m. .200
Nozzle Diameter, In. .200
Probe Heater Setting
filter 145.87
gel #5 515.49

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	906.0 Gas Sample Volume, (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
1	5		120	1.3	1.8	909.475	36	32		50
3	7.5			1.3	1.8	911.24	48	36		50
4	10			1.4	1.95	913.095				50
5	12.5				1.95	914.95	52	36		50
6	15			1.4	1.95	916.575	55	36		50
7	17.5			1.4	1.95	918.43				
8	20			1.4	1.95	920.285	59	49		50
9	22.5	5.0		1.5	2.1	922.21	58	38		50
10	25	8		1.5	2.1	924.35	58	38		50
11	27.5	10.5		1.6	2.2	926.095	58	38		50
Total 12	30	13.0		1.6	2.2	928.075	Avg 60	Avg. 39		
Average		15.5					Avg.			

Pl[redacted]

Location _____

Operator _____

Date _____

Run No. 4 A

Sample Box No. _____

Meter Box No. _____

Meter $\Delta H_@$ _____

C Factor _____

Schematic of Stack Cross Section

[redacted]bien[redacted]pera[redacted]

Barometric Pressure _____

Assumed Moisture, % _____

Heater Box Setting _____

Probe Length, m. _____

Nozzle Diameter, In. _____

Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume, (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
13	32.5		124	2.2	3.0	930.28	64	45		
14	35			2.2	3.0	932.580	68	46		50
15	37.5			2.3	3.2	934.92	72	45		52
16	40			2.3	3.2	937.285	69	43		54
17	42.5			2.4	3.4	939.70	66	45		55
18	45			2.3	3.2	942.095	67	45		55
19	47.5			2.3	3.2	944.5	70	45		55
20	50			2.4	3.4	946.9	69	45		54
21	52.5			2.5	3.5	949.4	71	45		53
22	55			2.6	3.7	952.0	72	46		54
Total	60			2.6	3.7	957.07	Avg 74	Avg 47		54
Average							Avg.		—	

C-18

1030 -4th

Plant _____
Location _____
Operator _____
Date _____
Run No. 4B3
Sample Box No. _____
Meter Box No. _____
Meter ΔH_g _____
C Factor _____

Schematic of Stack Cross Section

Ambient Temperature _____
Barometric Pressure _____
Assumed Moisture, % _____
Heater Box Setting _____
Probe Length, m. _____
Nozzle Diameter, In. _____
Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume, (V_m) ft^3	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
1&2	5		120	1.5	2.1	960.91	60	45		50
3	7.5			1.4	1.9	962.82	64	45		50
4	10			1.4	1.9	964.7	63	[illegible]		50
5	12.5			1.4	1.9	966.55	63	[illegible]		
6	15			1.6	2.2	968.55	66	45		4" Dec
7	17.5			1.6	2.2	972.56	67	40		50
8	20			1.6	2.2	972.56				
9	22.5			1.7	2.4	[illegible]	74	47		
10	25			1.9	2.6	976.77	77	48		50
11	27.5			2.0	2.8	979.08	79	49		5" Dec
Total 12	30			2.2	3.1	981.32	Avg. 80	Avg. 50		
Average							Avg.			

Plant [redacted]
Location _____
Operator _____
Date _____
Run No. 4B
Sample Box No. _____
Meter Box No. _____
Meter $\Delta H_@$ _____
C Factor _____

Schematic of Stack Cross Section

Ambient Temperature _____
Barometric Pressure _____
Assumed Moisture, % _____
Heater Box Setting _____
Probe Length, m. _____
Nozzle Diameter, In. _____
Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_g) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume, (V_m) ft^3	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
	32.5		120	1.9	2.6	953.57	81	54		
	35			1.8	2.5	955.72	79	52		50
	37.5			1.8	2.5	[illegible]	75	52		[illegible]
	40			1.7	2.4	961.59	80	53		
	42.5			1.7	2.4	963.50				
15	45			1.7	2.4	965.20	[illegible]	55		
16	47.5			1.7	2.4	966.325	[illegible]	[illegible]		
[illegible]	50			1.7	2.4	[illegible]	[illegible]	[illegible]		
[illegible]	52.5			1.8	2.5	[illegible]	[illegible]	57		
22	55			1.8	2.5	2.70	[illegible]	57		
Total [illegible]	60			1.8	2.5	[illegible]	Avg. 53	Avg. 57		
Average							Avg.			

C-29

WATER VOLUME

Run No. 4 Date 3/23/72

Bubbler #1 284 ml Silica Gel No. 5 Wgt. g. 515.4

#2 155 ml

#3 8 Bubbler #4 542.5

Gross 447

Water Added(-) 200 Gross Wgt.(-) 515.4

Net (A) 247 cc Net (B) 27.1 g

Net (A) 247

Net (B) (+) 27.1

Total Water 274.1 cc

Silica Gel

Gross 542.5
Tare 515.4
Net 27.1

Form R&D 109

Plant Weyerhaeuser
Location Sonoma Va.
Operator
Date 3/23/72
Run No. 5A
Sample Box No.
Meter Box No.
Meter ΔH_g 1.84
C Factor .82
pitot .855

6' 9" ID

Schematic of Stack Cross Section

Ambient Temperature 52
Barometric Pressure 27.6"
Assumed Moisture, % 12
Heater Box Setting 2[illegible]
Probe Length, m.
Nozzle Diameter, In. .200
Probe Heater Setting 220
gal 577.5
filter .4[illegible]

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	07.384 Gas Sample Volume (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
1	5		120	1.4	2.0	[illegible]	52	50	–	50
2	7.5			1.4	2.0	13.[illegible]	63	50		
3	10			1.5	2.1	15.[illegible]	[illegible]	[illegible]		
4	[illegible]			1.6	2.2	[illegible]	[illegible]	[illegible]		
5	[illegible]			1.6	2.2	[illegible]	[illegible]	[illegible]		
6	[illegible]			1.6	2.2	20.[illegible]	67	49		
7	[illegible]			1.5	2.1	23.[illegible]	70	[illegible]		50
8	[illegible]			1.2	1.7	[illegible]	73	50		[illegible]
9	[illegible]			1.6	2.2	26.[illegible]	70	[illegible]	–	
10	[illegible]			1.7	2.4	28.65	71	50		
11	27.5			1.7	2.4	30.73	Avg. 72	Avg. 50	–	
Total 12	30									
Average							Avg.			

Plant _____
Location _____
Operator _____
Date _____
Run No. 5A
Sample Box No. _____
Meter Box No. _____
Meter $\Delta H_@$ _____
C Factor _____

Schematic of Stack Cross Section

Ambient Temperature _____
Barometric Pressure _____
Assumed Moisture, % _____
Heater Box Setting _____
Probe Length, m. _____
Nozzle Diameter, In. _____
Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
1	[illegible]		120	2.1	2.9	[illegible]	72	[illegible]		
2	[illegible]			2.3	3.2	35.30	73	50		
3	[illegible]			2.3	3.2	3[illegible]	[illegible]	[illegible]		
4	[illegible]			2.4	3.3	4[illegible]	87	[illegible]		6" Vac
5	[illegible]			2.3	3.2	42.50	80	50		60
6	45			2.2	3.0	47.85	82	52		
7	45			2.2	3.0	047.2.10	82	52		65
8	50			2.3	3.2	048.6	80	53		62
9	55			2.2	3.0	051.9	76	52		62
10	54			2.3	3.2	054.3	78	52		63
Total	60			2.3	3.2	055.182	80	52		62
Average							Avg.			

Plant _____
Location _____
Operator _____
Date _____
Run No. 5B
Sample Box No. _____
Meter Box No. _____
Meter ΔH_g _____
C Factor _____

Schematic of Stack Cross Section

Ambient Temperature _____
Barometric Pressure _____
Assumed Moisture, % _____
Heater Box Setting _____
Probe Length, m. _____
Nozzle Diameter, In. _____
Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s)	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter: Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter: Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F	
1 42	5.0		120	1.3	1.8	63.15	66	51			4.0" vac
3	7.5	1254 start		1.4	1.9	64.89	65	51		53	
4	10.0	1336 stop		1.7	2.4	66.93	40	43		50	
5	12.5			1.6	2.2	68.95	47	44			
6	15.0			1.6	2.2	70.94	54	44		50	
7	17.5			1.6	2.2	72.92	59	44		51	vac
8	20.0			1.7	2.4	74.97	63	45			
9	22.5			1.8	2.5	77.075	[illegible]	46			
10	25.0			1.9	2.7	79.234	68	46		71	vac
11	27.5			1.9	2.7	81.48	72	47			
Total 12	30.0			1.7	2.4	83.52	Avg. 74	Avg. 48			
Average							Avg.				

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Plant _____
Location _____
Operator _____
Date _____
Run No. 5 E PAGE 2
Sample Box No. _____
Meter Box No. _____
Meter ΔH_g _____
C Factor _____

Schematic of Stack Cross Section

Ambient Temperature _____
Barometric Pressure 27.65 ft 14 [illegible]
Assumed Moisture, % _____
Heater Box Setting _____
Probe Length, m. _____
Nozzle Diameter, In. _____
Probe Heater Setting _____

Traverse Point Number	Sampling Time (θ) min.	Static Pressure (P_s) In. Hg.	Stack Temperature (T_s) °F	Velocity Head (ΔP_s)	Pressure Differential Across Orifice Meter (ΔH) In. H_2O	Gas Sample Volume (Vm) ft^3	Gas Sample Temperature at Dry Gas Meter: Inlet (Tm_{in}) °F	Gas Sample Temperature at Dry Gas Meter: Outlet (Tm_{out}) °F	Sample Box Temperature °F	Temperature Leaving Condenser or Last Impinger °F
13	32.5		120	1.6	2.2	85.60	71	48		
14	35.0			1.6	2.2	87.565	71	48		
15	37.5			1.6	2.2	89.57	73	48		
16	40.0			1.5	2.0	91.52	74	48		
17	42.5			1.5	2.0	93.46	74	49		54
18	45.0			1.6	2.2	95.43	72	49		
19	47.5			1.5	2.0	097.[illegible]	73	49		
20	50.0			1.6	2.5	099.41	72	49		55
21	52.5			1.4	1.9	101.[illegible]	73	50		55
22	55.0			1.6	2.2	10[illegible]2	76	50		55
Total 3424	60.0			1.5	2.0	107.181	Avg 80	Avg 57		55
Average							Avg.			

6.81 [illegible]

6.0 [illegible]

BIG STONE GAP

WATER VOLUME

Run No. 5 Date 3/28/72

Bubbler #1 202 ml Silica Gel No. 3 Wgt. g. 511.5

#2 156 ml

#3 18 ml Bubbler #4 541.6

Gross 376

Water Added(-) 200 Gross Wgt.(-) 511.5

Net (A) 176 cc Net (B) 30.1 g

Net (A) 176

Net (B) (+) 30.1

Total Water 206.1 cc

Silica Gel
Gross 541.6
Tare 511.5
Net 30.1

Form R&D 109

46 385

LABORATORY TEST SHEET

4ND-GEN-112B

LABORATORY

TEST OF: Westmoreland Coal Cleaner

TEST ENGINEER:

OBSERVERS:

DATE: 20 March 72

TEST EQUIPMENT: NOx [redacted]PA

Sample #	Sample Time	Flask	Bars Press	and Temp.	Port Location	Sheet Time 21 Mar 72	Press Flask IN Hg	Bars Press 21 Mar 72	Flask Volume cc	P. Abs Initial (in Hg)	P. Abs Final (in Hg)	
1	1540	A	27.94 ~~[illegible]~~	65	B	1030	-8.0	27.74 ~~[illegible]~~	2040.4	2.94	19.74	65
2	1628	C	27.94 ~~[illegible]~~	68	B	1030	-1.2	27.74 ~~[illegible]~~	2039.2	2.94	26.54	65
3	1807	B	27.94 ~~[illegible]~~	63	A	1030	-1.4	27.74 ~~[illegible]~~	2052.8	2.94	26.34	65
						23 March			22 March 72			
1	0950	E	27.54 ~~29.94~~	43	B	0600	0.4	27.60	2033.0	2.54	28.00	
2	1025	F	27.54 ~~29.93~~	47	B	0600	0.4	27.60	2043.0	2.54	28.00	
3	1115	G	27.54 ~~29.90~~	48	A	0600	0.2 NO	Good		2.54	27.80	65
1	1325	D	27.54 ~~29.85~~	50	B	0600	0	27.60	2049.8	2.54	27.60	6
2	1430	A	27.54 ~~29.86~~	55	A	0600	-0.3	27.60	2040.4	2.54	27.30	6
3	1505	B	27.54 ~~29.86~~	51	A	NO	GOOD		(Smashed)			
4	1520	C	27.54 ~~29.86~~	50	A	0600	-14.0	27.60	2039.2	2.54	13.60	6
						24 Mar			23 March 72			
1	0950	A	27.6	32	B	0830	-1.5	27.6	2040.4	2.60	26.10	65
2	1020	C	27.6	32	B	0830	-0.5	27.6	2039.2	2.60	27.10	65
3	1115	H	27.6	32	A	0830	-1.3	27.6	2016.8	2.60	26.30	65
4	1205	E	27.6	32	B	0830	-2.2	27.6	[illegible]	2.60	25.40	6
5	1340	G	27.6	32	A	0830	-1.2	27.6	2051.9	2.60	26.40	6
6	1476	D	27.6	32	A	0830	-1.1	27.6	2049.8	2.60	26.60	6
						28317 cc/in Sf						

LABORATORY TEST SHEET

LABORATORY

4ND-GEN-1128

TEST OF: Westmoreland Coal Cleaner

TEST ENGINEER:

OBSERVERS:

DATE: 20 Mar 72

TEST EQUIPMENT: Orsat's Fid

Sample #	Start Time	Stop Time	Baro Press	amb °F Temp	Point Location	CO_2 %	O_2 %	CO %	HC PPM-C	HC PPM C_3H_8
1	1512	1607	27.94	65	B	0.2	18.2	0%	208.5	69.5
									22 March 72	
1	0935	1030	27.54	43	B	0.3	19.6	0%	102.0	34.0
2	1304	1404	27.54	50	B	0.2	19.4	0%	48.0	16.0
									23 March 72	
1	0925	1026	27.60	32	B	0.3	19.8	0	31.5	10.5
2	1138	1238	27.60	32	B	0.4	19.8	0	18.0	6.0

SRL 1281 35 0472

APPENDIX D

STANDARD SAMPLING PROCEDURES

The sampling procedures used during the test are the same as those published in the Federal Register, Volume 36, Number 247, Thursday, December 23, 1971. These methods are as follows: Methods 1, 2, 3, 4, 5, and 7. In addition, the impinger catch was analyzed.

method(s) prescribed by the manufacturer(s) of such instrument, the instrument shall be subject to manufacturers recommended zero adjustment calibration procedures at least once per 24-hour operating period unless the manufacturer(s) specified or recommends calibration at shorter intervals, in which case such specifications or recommendations shall be followed. The applicable method specified in the appendix of this part shall be the reference method.

(c) Production rate and hours of operation shall be recorded daily.

(d) The owner or operator of any sulfuric acid production unit subject to the provisions of this subpart shall maintain a file of all measurements required by this subpart. Appropriate measurements shall be reduced to the units of the applicable standard daily and summarized monthly. The record of any such measurement and summary shall be retained for at least 2 years following the date of such measurements and summaries.

§ 60.85 Test methods and procedures.

(a) The provisions of this section are applicable to performance tests for determining emissions of acid mist and sulfur dioxide from sulfuric acid production units.

(b) All performance tests shall be conducted while the affected facility is operating at or above the maximum acid production rate at which such facility will be operated and under such other relevant conditions as the Administrator shall specify based on representative performance of the affected facility.

(c) Test methods set forth in the appendix to this part or equivalent methods as approved by the Administrator shall be used as follows:

(1) For each repetition the acid mist and SO_3 concentrations shall be determined by using Method 8 and traversing according to Method 1. The minimum sampling time shall be 2 hours, and minimum sampling volume shall be 40 ft.^{3} corrected to standard conditions.

(2) The volumetric flow rate of the total effluent shall be determined by using Method 2 and traversing according to Method 1. Gas analysis shall be performed by using the integrated sample technique of Method 3. Moisture content can be considered to be zero.

(d) Acid produced, expressed in tons per hour of 100 percent sulfuric acid shall be determined during each 2-hour testing period by suitable flow meters and shall be confirmed by a material balance over the production system.

(e) For each repetition acid mist and sulfur dioxide emissions, expressed in lb./ton of 100 percent sulfuric acid shall be determined by dividing the emission rate in lb./hr. by the acid produced. The emission rate shall be determined by the equation, lb./hr.$=Q_s \times c$, where Q_s=volumetric flow rate of the effluent in ft.^{3}/hr. at standard conditions, dry basis as determined in accordance with paragraph (c)(2) of this section, and c=acid mist and SO_3 concentrations in lb./ft.^{3} as determined in accordance with paragraph (c)(1) of this section, corrected to standard conditions, dry basis.

APPENDIX—TEST METHODS

METHOD 1—SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

1. *Principle and Applicability.*

1.1 Principle. A sampling site and the number of traverse points are selected to aid in the extraction of a representative sample.

1.2 Applicability. This method should be applied only when specified by the test procedures for determining compliance with the New Source Performance Standards. Unless otherwise specified, this method is not intended to apply to gas streams other than those emitted directly to the atmosphere without further processing.

2. *Procedure.*

2.1 Selection of a sampling site and minimum number of traverse points.

2.1.1 Select a sampling site that is at least eight stack or duct diameters downstream and two diameters upstream from any flow disturbance such as a bend, expansion, contraction, or visible flame. For rectangular cross section, determine an equivalent diameter from the following equation:

$$\text{equivalent diameter}=2\left(\frac{(\text{length})(\text{width})}{\text{length}+\text{width}}\right) \quad \text{equation 1-1}$$

2.1.2 When the above sampling site criteria can be met, the minimum number of traverse points is twelve (12).

2.1.3 Some sampling situations render the above sampling site criteria impractical. When this is the case, choose a convenient sampling location and use Figure 1-1 to determine the minimum number of traverse points. Under no conditions should a sampling point be selected within 1 inch of the stack wall. To obtain the number of traverse points for stacks or ducts with a diameter less than 2 feet, multiply the number of points obtained from Figure 1-1 by 0.67.

2.1.4 To use Figure 1-1 first measure the distance from the chosen sampling location to the nearest upstream and downstream disturbances. Determine the corresponding number of traverse points for each distance from Figure 1-1. Select the higher of the two numbers of traverse points, or a greater value, such that for circular stacks the number is a multiple of 4, and for rectangular stacks the number follows the criteria of section 2.2.2.

2.2 Cross-sectional layout and location of traverse points.

2.2.1 For circular stacks locate the traverse points on at least two diameters according to Figure 1-2 and Table 1-1. The traverse axes shall divide the stack cross section into equal parts.

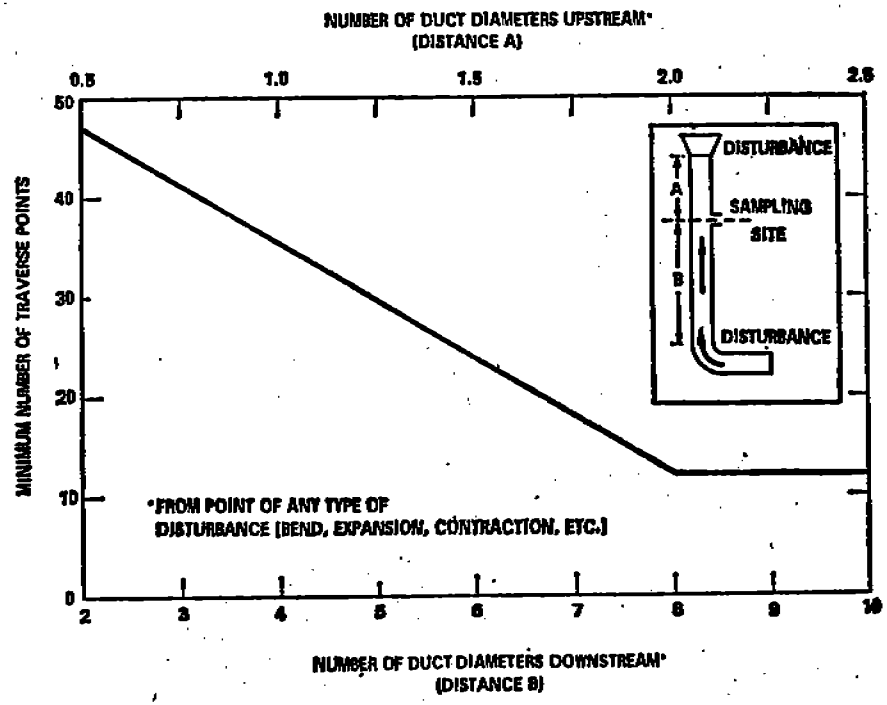

Figure 1-1. Minimum number of traverse points.

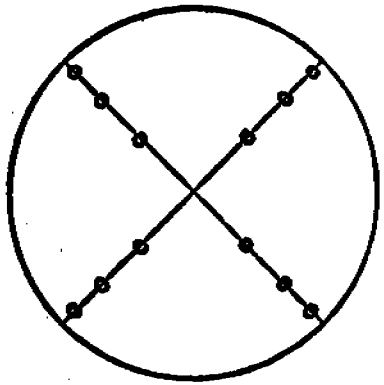

Figure 1-2. Cross section of circular stack divided into 12 equal areas, showing location of traverse points at centroid of each area.

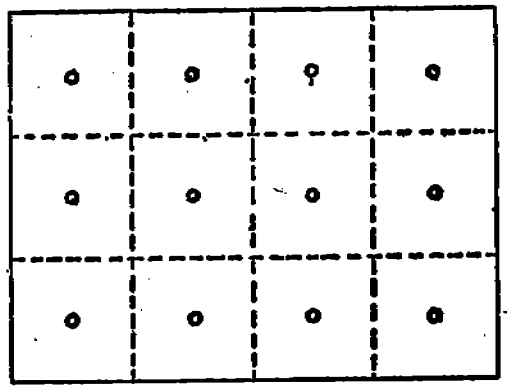

Figure 1-3. Cross section of rectangular stack divided into 12 equal areas, with traverse points at centroid of each area.

Table 1-1. Location of traverse points in circular stacks
(Percent of stack diameter from inside wall to traverse point)

Traverse point number on a diameter	Number of traverse points on a diameter											
	2	4	6	8	10	12	14	16	18	20	22	24
1	14.6	6.7	4.4	3.3	2.5	2.1	1.8	1.6	1.4	1.3	1.1	1.1
2	85.4	25.0	14.7	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2
3		75.0	29.5	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5
4		93.3	70.5	32.3	22.6	17.7	14.6	12.5	10.9	9.7	8.7	7.9
5			85.3	67.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5
6			95.6	80.6	65.8	35.5	26.9	22.0	18.8	16.5	14.6	13.2
7				89.5	77.4	64.5	36.6	28.3	23.6	20.4	18.0	16.1
8				96.7	85.4	65.0	63.4	37.5	29.6	25.0	21.8	19.4
9					91.8	82.3	73.1	62.5	38.2	30.6	26.1	23.0
10					97.5	88.2	79.9	71.7	61.8	38.8	31.5	27.2
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8
13							94.3	87.5	81.2	75.0	68.5	60.2
14							98.2	91.5	85.4	79.6	73.9	67.7
15								95.1	89.1	83.5	78.2	72.8
16								98.4	92.5	87.1	82.0	77.0
17									95.6	90.3	85.4	80.6
18									98.6	93.3	88.4	83.9
19										96.1	91.3	86.8
20										98.7	94.0	89.5
21											96.5	92.1
22											98.9	94.5
23												96.8
24												98.9

2.2.2 For rectangular stacks divide the cross section into as many equal rectangular areas as traverse points, such that the ratio of the length to the width of the elemental areas is between one and two. Locate the traverse points at the centroid of each equal area according to Figure 1-3.

3. *References.*

Determining Dust Concentration in a Gas Stream, ASME Performance Test Code #27, New York, N.Y., 1957.

Devorkin, Howard, et al., Air Pollution Source Testing Manual, Air Pollution Control District, Los Angeles, Calif. November 1963.

Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases, Western Precipitation Division of Joy Manufacturing Co., Los Angeles, Calif. Bulletin WP-50, 1968.

Standard Method for Sampling Stacks for Particulate Matter, In: 1971 Book of ASTM Standards, Part 23, Philadelphia, Pa. 1971, ASTM Designation D-2928-71.

METHOD 2—DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE (TYPE S PITOT TUBE)

1. *Principle and applicability.*

1.1 Principle. Stack gas velocity is determined from the gas density and from measurement of the velocity head using a Type S (Stauscheibe or reverse type) pitot tube.

1.2 Applicability. This method should be applied only when specified by the test procedures for determining compliance with the New Source Performance Standards.

2. *Apparatus.*

2.1 Pitot tube—Type S (Figure 2-1), or equivalent, with a coefficient within ±5% over the working range.

2.2 Differential pressure gauge—Inclined manometer, or equivalent, to measure velocity head to within 10% of the minimum value.

2.3 Temperature gauge—Thermocouple or equivalent attached to the pitot tube to measure stack temperature to within 1.5% of the minimum absolute stack temperature.

2.4 Pressure gauge—Mercury-filled U-tube manometer, or equivalent, to measure stack pressure to within 0.1 in. Hg.

2.5 Barometer—To measure atmospheric pressure to within 0.1 in. Hg.

2.6 Gas analyzer—To analyze gas composition for determining molecular weight.

2.7 Pitot tube—Standard type, to calibrate Type S pitot tube.

3. *Procedure.*

3.1 Set up the apparatus as shown in Figure 2-1. Make sure all connections are tight and leak free. Measure the velocity head and temperature at the traverse points specified by Method 1.

3.2 Measure the static pressure in the stack.

3.3 Determine the stack gas molecular weight by gas analysis and appropriate calculations as indicated in Method 3.

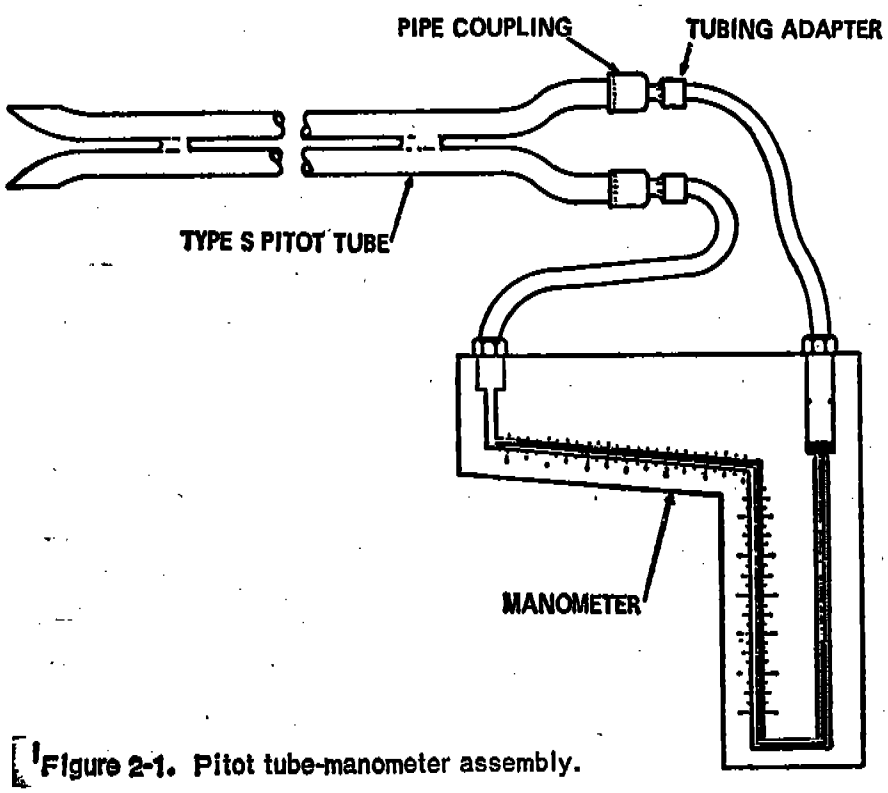

Figure 2-1. Pitot tube-manometer assembly.

4. *Calibration.*

4.1 To calibrate the pitot tube, measure the velocity head at some point in a flowing gas stream with both a Type S pitot tube and a standard type pitot tube with known coefficient. Calibration should be done in the laboratory and the velocity of the flowing gas stream should be varied over the normal working range. It is recommended that the calibration be repeated after use at each field site.

4.2 Calculate the pitot tube coefficient using equation 2-1.

$$C_{p_{test}} = C_{p_{std}} \sqrt{\frac{\Delta p_{std}}{\Delta p_{test}}} \quad \text{equation 2-1}$$

where:

$C_{p_{test}}$ = Pitot tube coefficient of Type S pitot tube.

$C_{p_{std}}$ = Pitot tube coefficient of standard type pitot tube (if unknown, use 0.99).

Δp_{std} = Velocity head measured by standard type pitot tube.

Δp_{test} = Velocity head measured by Type S pitot tube.

4.3 Compare the coefficients of the Type S pitot tube determined first with one leg and then the other pointed downstream. Use the pitot tube only if the two coefficients differ by no more than 0.01.

5. *Calculations.*

Use equation 2-2 to calculate the stack gas velocity.

$$(V_s)_{avg.} = K_p C_p (\sqrt{\Delta p})_{avg.} \sqrt{\frac{(T_s)_{avg.}}{P_s M_s}}$$

Equation 2-2

where:

$(V_s)_{avg.}$ = Stack gas velocity, feet per second (f.p.s.).

$K_p = 85.48 \frac{\text{ft.}}{\text{sec.}} \left(\frac{\text{lb.}}{\text{lb. mole-°R}}\right)^{1/2}$ when these units are used.

C_p = Pitot tube coefficient, dimensionless.

$(T_s)_{avg.}$ = Average absolute stack gas temperature, °R.

$(\sqrt{\Delta p})_{avg.}$ = Average velocity head of stack gas, inches H_2O (see Fig. 2-2).

P_s = Absolute stack gas pressure, inches Hg.

M_s = Molecular weight of stack gas (wet basis), lb./lb.-mole.

$M_s = M_d(1-B_{wo}) + 18B_{wo}$

M_d = Dry molecular weight of stack gas (from Method 3).

B_{wo} = Proportion by volume of water vapor in the gas stream (from Method 4).

Figure 2-2 shows a sample recording sheet for velocity traverse data. Use the averages in the last two columns of Figure 2-2 to determine the average stack gas velocity from Equation 2-2.

Use Equation 2-3 to calculate the stack gas volumetric flow rate.

$$Q_s = 3600\ (1-B_{wo})\ V_s A \left(\frac{T_{std}}{(T_s)_{avg.}}\right)\left(\frac{P_s}{P_{std}}\right)$$

Equation 2-3

where:

Q_s = Volumetric flow rate, dry basis, standard conditions, ft.³/hr.

A = Cross-sectional area of stack, ft.²

T_{std} = Absolute temperature at standard conditions, 530° R.

P_{std} = Absolute pressure at standard conditions, 29.92 inches Hg.

6. *References.*

Mark, L. S., Mechanical Engineers' Handbook, McGraw-Hill Book Co., Inc., New York, N.Y., 1951.

Perry, J. H., Chemical Engineers' Handbook, McGraw-Hill Book Co., Inc., New York, N.Y., 1960.

Shigehara, R. T., W. F. Todd, and W. S. Smith, Significance of Errors in Stack Sampling Measurements. Paper presented at the Annual Meeting of the Air Pollution Control Association, St. Louis, Mo., June 14–19, 1970.

—— Standard Method for Sampling Stacks for Particulate Matter, In: 1971 Book of ASTM Standards, Part 23, Philadelphia, Pa., 1971, ASTM Designation D-2928-71.

Vennard, J. K., Elementary Fluid Mechanics, John Wiley & Sons, Inc., New York, N.Y., 1947.

PLANT____________________

DATE____________________

RUN NO.____________________

STACK DIAMETER, in.____________________

BAROMETRIC PRESSURE, in. Hg.____________________

STATIC PRESSURE IN STACK (P_g), in. Hg.__________

OPERATORS____________________

SCHEMATIC OF STACK CROSS SECTION

Traverse point number	Velocity head, in. H_2O	$\sqrt{\Delta_p}$	Stack Temperature (T_S), °F
	AVERAGE:		

Figure 2-2. Velocity traverse data.

METHOD 3—GAS ANALYSIS FOR CARBON DIOXIDE, EXCESS AIR, AND DRY MOLECULAR WEIGHT

1. *Principle and applicability.*

1.1 Principle. An integrated or grab gas sample is extracted from a sampling point and analyzed for its components using an Orsat analyzer.

1.2 Applicability. This method should be applied only when specified by the test procedures for determining compliance with the New Source Performance Standards. The test procedure will indicate whether a grab sample or an integrated sample is to be used.

2. *Apparatus.*

2.1 Grab sample (Figure 3-1).

2.1.1 Probe—Stainless steel or Pyrex[1] glass, equipped with a filter to remove particulate matter.

2.1.2 Pump—One-way squeeze bulb, or equivalent, to transport gas sample to analyzer.

[1] Trade name.

2.2 *Integrated sample (Figure 3-2).*

2.2.1 Probe—Stainless steel or Pyrex[1] glass, equipped with a filter to remove particulate matter.

2.2.2 Air-cooled condenser or equivalent—To remove any excess moisture.

2.2.3 Needle valve—To adjust flow rate.

2.2.4 Pump—Leak-free, diaphragm type, or equivalent, to pull gas.

2.2.5 Rate meter—To measure a flow range from 0 to 0.035 cfm.

2.2.6 Flexible bag—Tedlar,[1] or equivalent, with a capacity of 2 to 3 cu. ft. Leak test the bag in the laboratory before using.

2.2.7 Pitot tube—Type S, or equivalent, attached to the probe so that the sampling flow rate can be regulated proportional to the stack gas velocity when velocity is varying with time or a sample traverse is conducted.

2.3 *Analysis.*

2.3.1 Orsat analyzer, or equivalent.

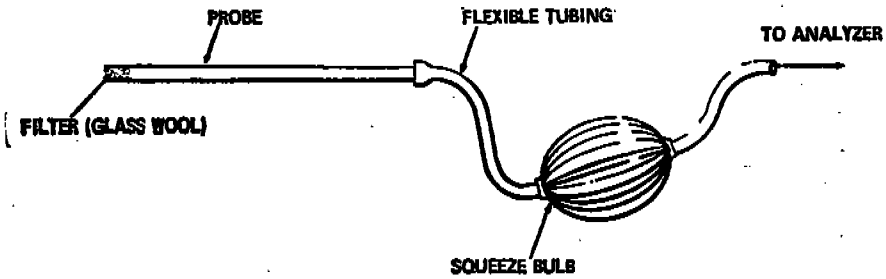

Figure 3-1. Grab-sampling train.

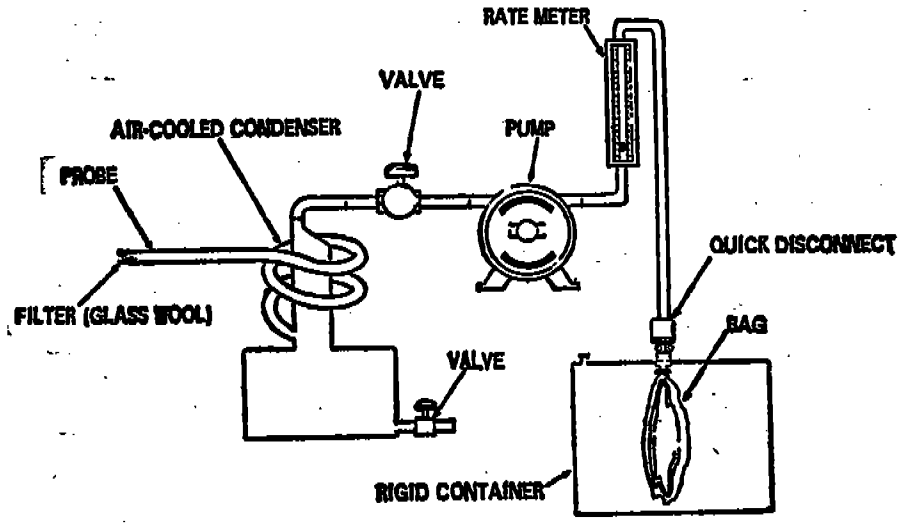

Figure 3-2. Integrated gas - sampling train.

3. *Procedure.*

3.1 Grab sampling.

3.1.1 Set up the equipment as shown in Figure 3-1, making sure all connections are leak-free. Place the probe in the stack at a sampling point and purge the sampling line.

3.1.2 Draw sample into the analyzer.

3.2 Integrated sampling.

3.2.1 Evacuate the flexible bag. Set up the equipment as shown in Figure 3-2 with the bag disconnected. Place the probe in the stack and purge the sampling line. Connect the bag, making sure that all connections are tight and that there are no leaks.

3.2.2 Sample at a rate proportional to the stack velocity.

3.3 Analysis.

3.3.1 Determine the CO_2, O_2, and CO concentrations as soon as possible. Make as many passes as are necessary to give constant readings. If more than ten passes are necessary, replace the absorbing solution.

3.3.2 For grab sampling, repeat the sampling and analysis until three consecutive samples vary no more than 0.5 percent by volume for each component being analyzed.

3.3.3 For integrated sampling, repeat the analysis of the sample until three consecutive analyses vary no more than 0.2 percent by volume for each component being analyzed.

4. *Calculations.*

4.1 Carbon dioxide. Average the three consecutive runs and report the result to the nearest 0.1% CO_2.

4.2 Excess air. Use Equation 3-1 to calculate excess air, and average the runs. Report the result to the nearest 0.1% excess air.

$$\%\,EA = \frac{(\%\,O_2) - 0.5(\%\,CO)}{0.264(\%\,N_2) - (\%\,O_2) + 0.5(\%\,CO)} \times 100 \qquad \text{equation 3-1}$$

where:

%EA = Percent excess air.

$\%O_2$ = Percent oxygen by volume, dry basis.

$\%N_2$ = Percent nitrogen by volume, dry basis.

%CO = Percent carbon monoxide by volume, dry basis.

0.264 = Ratio of oxygen to nitrogen in air by volume.

4.3 Dry molecular weight. Use Equation 3-2 to calculate dry molecular weight and average the runs. Report the result to the nearest tenth.

$$M_d = 0.44(\%CO_2) + 0.32(\%O_2) + 0.28(\%N_2 + \%CO) \qquad \text{equation 3-2}$$

where:

M_d = Dry molecular weight, lb./lb-mole.

$\%CO_2$ = Percent carbon dioxide by volume, dry basis.

$\%O_2$ = Percent oxygen by volume, dry basis.

$\%N_2$ = Percent nitrogen by volume, dry basis.

0.44 = Molecular weight of carbon dioxide divided by 100.

0.32 = Molecular weight of oxygen divided by 100.

0.28 = Molecular weight of nitrogen and CO divided by 100.

5. *References.*

Altshuller, A. P., et al., Storage of Gases and Vapors in Plastic Bags, Int. J. Air & Water Pollution, 6:75–81, 1963.

Conner, William D., and J. S. Nader, Air Sampling with Plastic Bags, Journal of the American Industrial Hygiene Association, 25:291–297, May–June 1964.

Devorkin, Howard, et al., Air Pollution Source Testing Manual, Air Pollution Control District, Los Angeles, Calif., November 1963.

METHOD 4—DETERMINATION OF MOISTURE IN STACK GASES

1. *Principle and applicability.*

1.1 Principle. Moisture is removed from the gas stream, condensed, and determined volumetrically.

1.2 Applicability. This method is applicable for the determination of moisture in stack gas only when specified by test procedures for determining compliance with New Source Performance Standards. This method does not apply when liquid droplets are present in the gas stream[1] and the moisture is subsequently used in the determination of stack gas molecular weight.

Other methods such as drying tubes, wet bulb-dry bulb techniques, and volumetric condensation techniques may be used.

2. *Apparatus.*

2.1 Probe—Stainless steel or Pyrex[2] glass sufficiently heated to prevent condensation and equipped with a filter to remove particulate matter.

2.2 Impingers—Two midget impingers, each with 30 ml. capacity, or equivalent.

2.3 Ice bath container—To condense moisture in impingers.

2.4 Silica gel tube (optional)—To protect pump and dry gas meter.

2.5 Needle valve—To regulate gas flow rate.

2.6 Pump—Leak-free, diaphragm type, or equivalent, to pull gas through train.

2.7 Dry gas meter—To measure to within 1% of the total sample volume.

2.8 Rotameter—To measure a flow range from 0 to 0.1 c.f.m.

2.9 Graduated cylinder—25 ml.

2.10 Barometer—Sufficient to read to within 0.1 inch Hg.

2.11 Pitot tube—Type S, or equivalent, attached to probe so that the sampling flow rate can be regulated proportional to the stack gas velocity when velocity is varying with time or a sample traverse is conducted.

3. *Procedure.*

3.1 Place exactly 5 ml. distilled water in each impinger. Assemble the apparatus without the probe as shown in Figure 4–1. Leak check by plugging the inlet to the first impinger and drawing a vacuum. Insure that flow through the dry gas meter is less than 1% of the sampling rate.

3.2 Connect the probe and sample at a constant rate of 0.075 c.f.m. or at a rate proportional to the stack gas velocity. Continue sampling until the dry gas meter registers 1 cubic foot or until visible liquid droplets are carried over from the first impinger to the second. Record temperature, pressure, and dry gas meter readings as required by Figure 4–2.

3.3 After collecting the sample, measure the volume increase to the nearest 0.5 ml.

4. *Calculations.*

4.1 Volume of water vapor collected.

$$V_{wc}=\frac{(V_f-V_i)\rho_{H_2O}RT_{std}}{P_{std}M_{H_2O}}=0.0474\frac{\text{ft.}^3}{\text{ml.}}(V_f-V_i) \qquad \text{equation 4–1}$$

where:

V_{wc} = Volume of water vapor collected (standard conditions), cu. ft.

V_f = Final volume of impinger contents, ml.

V_i = Initial volume of impinger contents, ml.

R = Ideal gas constant, 21.83 inches Hg—cu. ft./lb. mole-°R.

ρ_{H_2O} = Density of water, 1 g./ml.

T_{std} = Absolute temperature at standard conditions, 530° R.

P_{std} = Absolute pressure at standard conditions, 29.92 inches Hg.

M_{H_2O} = Molecular weight of water, 18 lb./lb.-mole.

[1] If liquid droplets are present in the gas stream, assume the stream to be saturated, determine the average stack gas temperature by traversing according to Method 1, and use a psychrometric chart to obtain an approximation of the moisture percentage.

[2] Trade name.

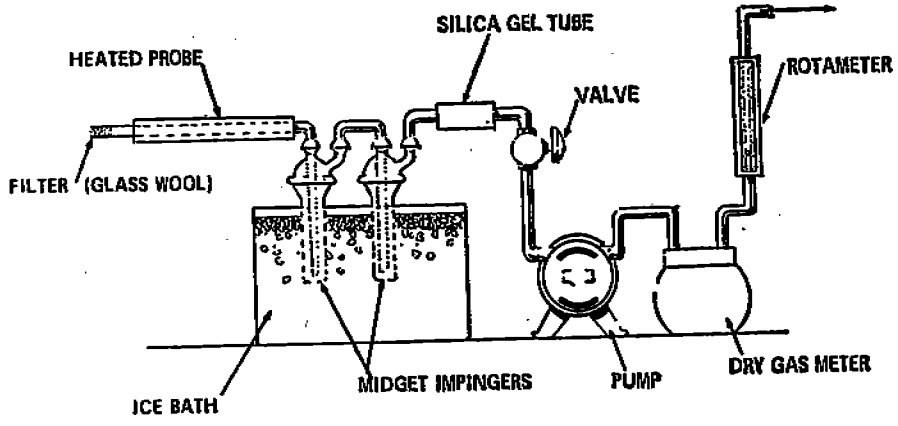

Figure 4-1. Moisture-sampling train.

LOCATION _____ COMMENTS

TEST _____

DATE _____

OPERATOR _____

BAROMETRIC PRESSURE _____

CLOCK TIME	GAS VOLUME THROUGH METER, (Vm), ft^3	ROTAMETER SETTING ft^3/min	METER TEMPERATURE, °F

Figure 4-2. Field moisture determination.

4.2 Gas volume.

$$V_{mc}=V_m\left(\frac{P_m}{P_{std}}\right)\left(\frac{T_{std}}{T_m}\right)=17.71\,\frac{°R}{in.\ Hg}\left(\frac{V_mP_m}{T_m}\right)\quad \text{equation 4-2}$$

where:

V_{mc} = Dry gas volume through meter at standard conditions, cu. ft.

V_m = Dry gas volume measured by meter, cu. ft.

P_m = Barometric pressure at the dry gas meter, inches Hg.

P_{std} = Pressure at standard conditions, 29.92 inches Hg.

T_{std} = Absolute temperature at standard conditions, 530° R.

T_m = Absolute temperature at meter (°F+460), °R.

4.3 Moisture content.

$$B_{wo}=\frac{V_{wc}}{V_{wc}+V_{mc}}+B_{wm}=\frac{V_{wc}}{V_{wc}+V_{mc}}+(0.025)\quad \text{equation 4-3}$$

where:

B_{wo} = Proportion by volume of water vapor in the gas stream, dimensionless.

V_{wc} = Volume of water vapor collected (standard conditions), cu. ft.

V_{mc} = Dry gas volume through meter (standard conditions), cu. ft.

B_{wm} = Approximate volumetric proportion of water vapor in the gas stream leaving the impingers, 0.025.

5. *References.*

Air Pollution Engineering Manual, Danielson, J. A. (ed.), U.S. DHEW, PHS, National Center for Air Pollution Control, Cincinnati, Ohio, PHS Publication No. 999-AP-40, 1967.

Devorkin, Howard, et al., Air Pollution Source Testing Manual, Air Pollution Control District, Los Angeles, Calif., November 1963.

Methods for Determination of Velocity, Volume, Dust and Mist Content of Gases, Western Precipitation Division of Joy Manufacturing Co., Los Angeles, Calif., Bulletin WP-50, 1968.

METHOD 5—DETERMINATION OF PARTICULATE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and applicability.*

1.1 Principle. Particulate matter is withdrawn isokinetically from the source and its weight is determined gravimetrically after removal of uncombined water.

1.2 Applicability. This method is applicable for the determination of particulate emissions from stationary sources only when specified by the test procedures for determining compliance with New Source Performance Standards.

2. *Apparatus.*

2.1 Sampling train. The design specifications of the particulate sampling train used by EPA (Figure 5-1) are described in APTD-0581. Commercial models of this train are available.

2.1.1 Nozzle—Stainless steel (316) with sharp, tapered leading edge.

2.1.2 Probe—Pyrex[1] glass with a heating system capable of maintaining a minimum gas temperature of 250° F. at the exit end during sampling to prevent condensation from occurring. When length limitations (greater than about 8 ft.) are encountered at temperatures less than 600° F., Incoloy 825[1], or equivalent, may be used. Probes for sampling gas streams at temperatures in excess of 600° F. must have been approved by the Administrator.

2.1.3 Pitot tube—Type S, or equivalent, attached to probe to monitor stack gas velocity.

2.1.4 Filter Holder—Pyrex[1] glass with heating system capable of maintaining minimum temperature of 225° F.

2.1.5 Impingers / Condenser—Four impingers connected in series with glass ball joint fittings. The first, third, and fourth impingers are of the Greenburg-Smith design, modified by replacing the tip with a ½-inch ID glass tube extending to one-half inch from the bottom of the flask. The second impinger is of the Greenburg-Smith design with the standard tip. A condenser may be used in place of the impingers provided that the moisture content of the stack gas can still be determined.

2.1.6 Metering system—Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 5° F., dry gas meter with 2% accuracy, and related equipment, or equivalent, as required to maintain an isokinetic sampling rate and to determine sample volume.

2.1.7 Barometer—To measure atmospheric pressure to ±0.1 inches Hg.

2.2 Sample recovery.

2.2.1 Probe brush—At least as long as probe.

2.2.2 Glass wash bottles—Two.

2.2.3 Glass sample storage containers.

2.2.4 Graduated cylinder—250 ml.

2.3 Analysis.

2.3.1 Glass weighing dishes.

2.3.2 Desiccator.

2.3.3 Analytical balance—To measure to ±0.1 mg.

2.3.4 Trip balance—300 g. capacity, to measure to ±0.05 g.

3. *Reagents.*

3.1 Sampling.

3.1.1 Filters—Glass fiber, MSA 1106 BH[1], or equivalent, numbered for identification and preweighed.

3.1.2 Silica gel—Indicating type, 6-16 mesh, dried at 175° C. (350° F.) for 2 hours.

3.1.3 Water.

3.1.4 Crushed ice.

3.2 Sample recovery.

3.2.1 Acetone—Reagent grade.

3.3 Analysis.

3.3.1 Water.

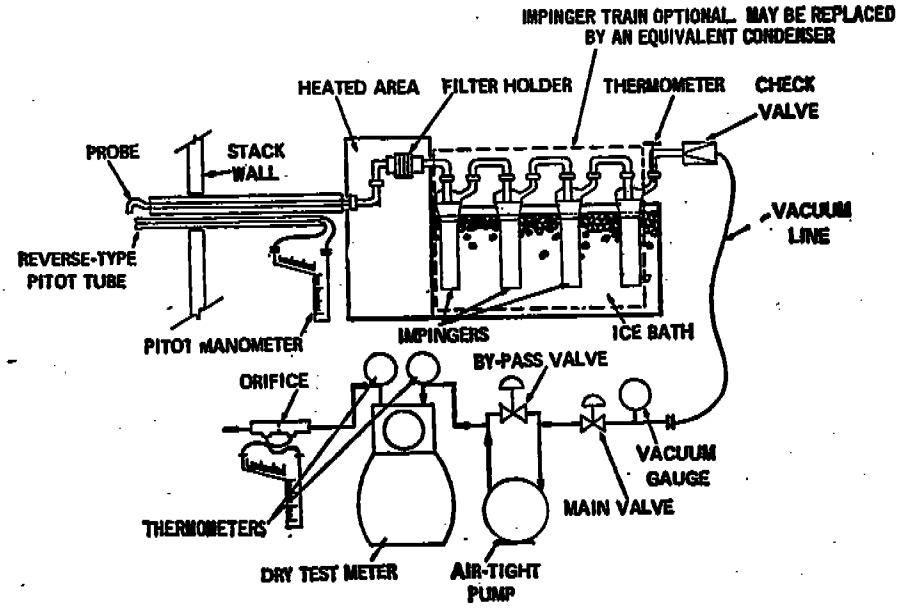

Figure 5-1. Particulate-sampling train.

3.3.2 Desiccant—Drierite,[2] indicating.

4. *Procedure.*

4.1 Sampling

4.1.1 After selecting the sampling site and the minimum number of sampling points, determine the stack pressure, temperature, moisture, and range of velocity head.

4.1.2 Preparation of collection train. Weigh to the nearest gram approximately 200 g. of silica gel. Label a filter of proper diameter, desiccate[2] for at least 24 hours and weigh to the nearest 0.5 mg. in a room where the relative humidity is less than 50%. Place 100 ml. of water in each of the first two impingers, leave the third impinger empty, and place approximately 200 g. of preweighed silica gel in the fourth impinger. Set up the train without the probe as in Figure 5-1. Leak check the sampling train at the sampling site by plugging up the inlet to the filter holder and pulling a 15 in. Hg vacuum. A leakage rate not in excess of 0.02 c.f.m. at a vacuum of 15 in. Hg is acceptable. Attach the probe and adjust the heater to provide a gas temperature of about 250° F. at the probe outlet. Turn on the filter heating system. Place crushed ice around the impingers. Add more ice during the run to keep the temperature of the gases leaving the last impinger as low as possible and preferably at 70° F., or less. Temperatures above 70° F. may result in damage to the dry gas meter from either moisture condensation or excessive heat.

4.1.3 Particulate train operation. For each run, record the data required on the example sheet shown in Figure 5-2. Take readings at each sampling point, at least every 5 minutes, and when significant changes in stack conditions necessitate additional adjustments in flow rate. To begin sampling, position the nozzle at the first traverse point with the tip pointing directly into the gas stream. Immediately start the pump and adjust the flow to isokinetic conditions. Sample for at least 5 minutes at each traverse point; sampling time must be the same for each point. Maintain isokinetic sampling throughout the sampling period. Nomographs are available which aid in the rapid adjustment of the sampling rate without other computations. APTD-0576 details the procedure for using these nomographs. Turn off the pump at the conclusion of each run and record the final readings. Remove the probe and nozzle from the stack and handle in accordance with the sample recovery process described in section 4.2.

[1] Trade name.

[2] Dry using Drierite[1] at 70° F. ± 10° F.

PLANT _____
LOCATION _____
OPERATOR _____
DATE _____
RUN NO. _____
SAMPLE BOX NO. _____
METER BOX NO. _____
METER $\Delta H_@$ _____
C FACTOR _____

SCHEMATIC OF STACK CROSS SECTION

AMBIENT TEMPERATURE _____
BAROMETRIC PRESSURE _____
ASSUMED MOISTURE, % _____
HEATER BOX SETTING _____
PROBE LENGTH, in. _____
NOZZLE DIAMETER, in. _____
PROBE HEATER SETTING _____

TRAVERSE POINT NUMBER	SAMPLING TIME (θ), min.	STATIC PRESSURE (P_g), in. Hg.	STACK TEMPERATURE (T_s), °F	VELOCITY HEAD (ΔP_s),	PRESSURE DIFFERENTIAL ACROSS ORIFICE METER (ΔH), in. H_2O	GAS SAMPLE VOLUME (V_m), ft^3	GAS SAMPLE TEMPERATURE AT DRY GAS METER		SAMPLE BOX TEMPERATURE, °F	TEMPERATURE OF GAS LEAVING CONDENSER OR LAST IMPINGER, °F
							INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F		
TOTAL							Avg.	Avg.		
AVERAGE							Avg.			

Figure 5-2. Particulate field data.

4.2 Sample recovery. Exercise care in moving the collection train from the test site to the sample recovery area to minimize the loss of collected sample or the gain of extraneous particulate matter. Set aside a portion of the acetone used in the sample recovery as a blank for analysis. Measure the volume of water from the first three impingers, then discard. Place the samples in containers as follows:

Container No. 1. Remove the filter from its holder, place in this container, and seal.

Container No. 2. Place loose particulate matter and acetone washings from all sample-exposed surfaces prior to the filter in this container and seal. Use a razor blade, brush, or rubber policeman to lose adhering particles.

Container No. 3. Transfer the silica gel from the fourth impinger to the original container and seal. Use a rubber policeman as an aid in removing silica gel from the impinger.

4.3 Analysis. Record the data required on the example sheet shown in Figure 5-3. Handle each sample container as follows:

Container No. 1. Transfer the filter and any loose particulate matter from the sample container to a tared glass weighing dish, desiccate, and dry to a constant weight. Report results to the nearest 0.5 mg.

Container No. 2. Transfer the acetone washings to a tared beaker and evaporate to dryness at ambient temperature and pressure. Desiccate and dry to a constant weight. Report results to the nearest 0.5 mg.

Container No. 3. Weigh the spent silica gel and report to the nearest gram.

5. *Calibration.*

Use methods and equipment which have been approved by the Administrator to calibrate the orifice meter, pitot tube, dry gas meter, and probe heater. Recalibrate after each test series.

6. *Calculations.*

6.1 Average dry gas meter temperature and average orifice pressure drop. See data sheet (Figure 5-2).

6.2 Dry gas volume. Correct the sample volume measured by the dry gas meter to standard conditions (70° F., 29.92 inches Hg) by using Equation 5-1.

$$V_{m_{std}} = V_m\left(\frac{T_{std}}{T_m}\right)\left(\frac{P_{bar}+\frac{\Delta H}{13.6}}{P_{std}}\right) = \left(17.71\ \frac{°R}{in.\ Hg}\right)V_m\left(\frac{P_{bar}+\frac{\Delta H}{13.6}}{T_m}\right)$$

equation 5-1

where:

$V_{m_{std}}$ = Volume of gas sample through the dry gas meter (standard conditions), cu. ft.

V_m = Volume of gas sample through the dry gas meter (meter conditions), cu. ft.

T_{std} = Absolute temperature at standard conditions, 530° R.

T_m = Average dry gas meter temperature, °R.

P_{bar} = Barometric pressure at the orifice meter, inches Hg.

ΔH = Average pressure drop across the orifice meter, inches H_2O.

13.6 = Specific gravity of mercury.

P_{std} = Absolute pressure at standard conditions, 29.92 inches Hg.

6.3 Volume of water vapor.

$$V_{w_{std}} = V_{l_c}\left(\frac{\rho_{H_2O}}{M_{H_2O}}\right)\left(\frac{RT_{std}}{P_{std}}\right) = \left(0.0474\ \frac{cu.\ ft.}{ml.}\right)V_{l_c}$$

equation 5-2

where:

$V_{w_{std}}$ = Volume of water vapor in the gas sample (standard conditions), cu. ft.

V_{l_c} = Total volume of liquid collected in impingers and silica gel (see Figure 5-3), ml.

ρ_{H_2O} = Density of water, 1 g./ml.

M_{H_2O} = Molecular weight of water, 18 lb./lb.-mole.

R = Ideal gas constant, 21.83 inches Hg—cu. ft./lb.-mole-°R.

T_{std} = Absolute temperature at standard conditions, 530° R.

P_{std} = Absolute pressure at standard conditions, 29.92 inches Hg.

6.4 Moisture content.

$$B_{wo} = \frac{V_{w_{std}}}{V_{m_{std}} + V_{w_{std}}}$$

equation 5-3

where:

B_{wo} = Proportion by volume of water vapor in the gas stream, dimensionless.

$V_{w_{std}}$ = Volume of water in the gas sample (standard conditions), cu. ft.

$V_{m_{std}}$ = Volume of gas sample through the dry gas meter (standard conditions), cu. ft.

6.5 Total particulate weight. Determine the total particulate catch from the sum of the weights on the analysis data sheet (Figure 5-3).

6.6 Concentration.

6.6.1 Concentration in gr./s.c.f.

$$c'_s = \left(0.0154\ \frac{gr.}{mg.}\right)\left(\frac{M_n}{V_{m_{std}}}\right)$$

equation 5-4

where:

c'_s = Concentration of particulate matter in stack gas, gr./s.c.f., dry basis.

M_n = Total amount of particulate matter collected, mg.

$V_{m_{std}}$ = Volume of gas sample through dry gas meter (standard conditions), cu. ft.

PLANT _____

DATE _____

RUN NO. _____

CONTAINER NUMBER	WEIGHT OF PARTICULATE COLLECTED, mg		
	FINAL WEIGHT	TARE WEIGHT	WEIGHT GAIN
1			
2			
TOTAL			

	VOLUME OF LIQUID WATER COLLECTED		
	IMPINGER VOLUME, ml	SILICA GEL WEIGHT, g	
FINAL			
INITIAL			
LIQUID COLLECTED			
TOTAL VOLUME COLLECTED		g*	ml

CONVERT WEIGHT OF WATER TO VOLUME BY DIVIDING TOTAL WEIGHT INCREASE BY DENSITY OF WATER. (1 g. ml):

$$\frac{\text{INCREASE, g}}{(1\ \text{g/ml})} = \text{VOLUME WATER, ml}$$

Figure 5-3. Analytical data.

6.6.2 Concentration in lb./cu. ft.

$$c_s = \frac{\left(\frac{1}{453{,}600}\frac{\text{lb.}}{\text{mg.}}\right)M_n}{V_{m_{std}}} = 2.205\times10^{-6}\frac{M_n}{V_{m_{std}}} \qquad \text{equation 5-5}$$

where:

c_s = Concentration of particulate matter in stack gas, lb./s.c.f., dry basis.

453,600 = Mg/lb.

M_n = Total amount of particulate matter collected, mg.

$V_{m_{std}}$ = Volume of gas sample through dry gas meter (standard conditions), cu. ft.

6.7 Isokinetic variation.

$$I = \frac{T_s\left[\frac{V_{1_c}(\rho_{H_2O})R}{M_{H_2O}} + \frac{V_m}{T_m}\left(P_{bar} + \frac{\Delta H}{13.6}\right)\right]}{\theta V_s P_s A_n}\times 100$$

$$= \frac{\left(1.667\frac{\text{min.}}{\text{sec.}}\right)\left[\left(0.00267\frac{\text{in. Hg-cu. ft.}}{\text{ml.-°R}}\right)V_{1_c} + \frac{V_m}{T_m}\left(P_{bar} + \frac{\Delta H}{13.6}\right)\right]}{\theta V_s P_s A_n} \qquad \text{Equation 5-6}$$

where:

I = Percent of isokinetic sampling.

V_{1_c} = Total volume of liquid collected in impingers and silica gel (See Fig. 5-3), ml.

ρ_{H_2O} = Density of water, 1 g./ml.

R = Ideal gas constant, 21.83 inches Hg-cu. ft./lb. mole-°R.

M_{H_2O} = Molecular weight of water, 18 lb./lb.-mole.

V_m = Volume of gas sample through the dry gas meter (meter conditions), cu. ft.

T_m = Absolute average dry gas meter temperature (see Figure 5-2), °R.

P_{bar} = Barometric pressure at sampling site, inches Hg.

ΔH = Average pressure drop across the orifice (see Fig. 5-2), inches H_2O.

T_s = Absolute average stack gas temperature (see Fig. 5-2), °R.

θ = Total sampling time, min.

V_s = Stack gas velocity calculated by Method 2, Equation 2-2, ft./sec.

P_s = Absolute stack gas pressure, inches Hg.

A_n = Cross-sectional area of nozzle, sq. ft.

6.8 Acceptable results. The following range sets the limit on acceptable isokinetic sampling results:

If $90\% \le I \le 110\%$, the results are acceptable; otherwise, reject the results and repeat the test.

7. *Reference.*

Addendum to Specifications for Incinerator Testing at Federal Facilities, PHS, NCAPC, Dec. 6, 1967.

Martin, Robert M., Construction Details of Isokinetic Source Sampling Equipment, Environmental Protection Agency, APTD-0581.

Rom, Jerome J., Maintenance, Calibration, and Operation of Isokinetic Source Sampling Equipment, Environmental Protection Agency, APTD-0576.

Smith, W. S., R. T. Shigehara, and W. F. Todd, A Method of Interpreting Stack Sampling Data, Paper presented at the 63d Annual Meeting of the Air Pollution Control Association, St. Louis, Mo., June 14-19, 1970.

Smith, W. S., et al., Stack Gas Sampling Improved and Simplified with New Equipment, APCA paper No. 67-119, 1967.

Specifications for Incinerator Testing at Federal Facilities, PHS, NCAPC, 1967.

METHOD 6—DETERMINATION OF SULFUR DIOXIDE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and applicability.*

1.1 Principle. A gas sample is extracted from the sampling point in the stack. The acid mist, including sulfur trioxide, is separated from the sulfur dioxide. The sulfur dioxide fraction is measured by the barium-thorin titration method.

1.2 Applicability. This method is applicable for the determination of sulfur dioxide emissions from stationary sources only when specified by the test procedures for determining compliance with New Source Performance Standards.

2. *Apparatus.*

2.1 Sampling. See Figure 6-1.

2.1.1 Probe—Pyrex[1] glass, approximately 5 to 6 mm. ID, with a heating system to prevent condensation and a filtering medium to remove particulate matter including sulfuric acid mist.

2.1.2 Midget bubbler—One, with glass wool packed in top to prevent sulfuric acid mist carryover.

2.1.3 Glass wool.

2.1.4 Midget impingers—Three.

2.1.5 Drying tube—Packed with 6 to 16 mesh indicating-type silica gel, or equivalent, to dry the sample.

2.1.6 Valve—Needle valve, or equivalent, to adjust flow rate.

2.1.7 Pump—Leak-free, vacuum type.

2.1.8 Rate meter—Rotameter or equivalent, to measure a 0-10 s.c.f.h. flow range.

2.1.9 Dry gas meter—Sufficiently accurate to measure the sample volume within 1%.

2.1.10 Pitot tube—Type S, or equivalent,

[1] Trade names.

necessary only if a sample traverse is required, or if stack gas velocity varies with time.

2.2 Sample recovery.

2.2.1 Glass wash bottles—Two.

2.2.2 Polyethylene storage bottles—To store impinger samples.

2.3 Analysis.

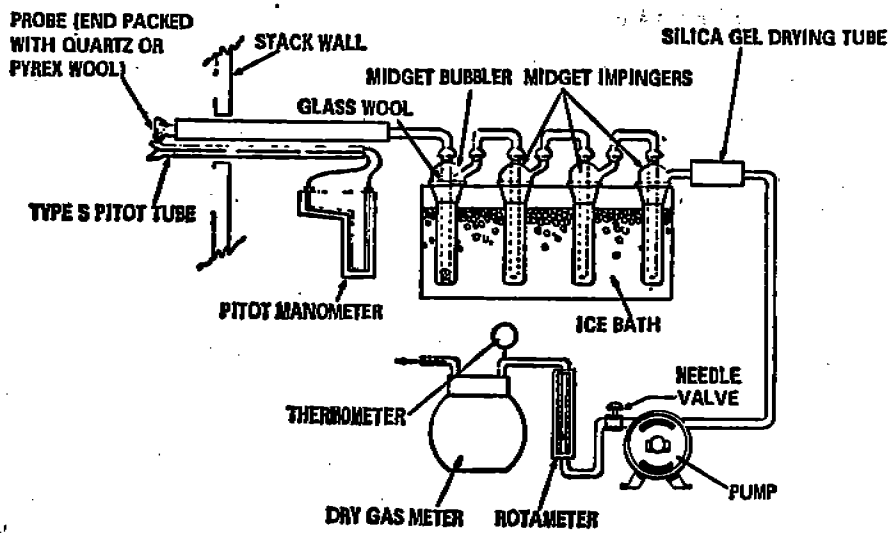

Figure 6-1. SO_2 sampling train.

2.3.1 Pipettes—Transfer type, 5 ml. and 10 ml. sizes (0.1 ml. divisions) and 25 ml. size (0.2 ml. divisions).

2.3.2 Volumetric flasks—50 ml., 100 ml., and 1,000 ml.

2.3.3 Burettes—5 ml. and 50 ml.

2.3.4 Erlenmeyer flask—125 ml.

3. *Reagents.*

3.1 Sampling.

3.1.1 Water—Deionized, distilled.

3.1.2 Isopropanol, 80%—Mix 80 ml. of isopropanol with 20 ml. of distilled water.

3.1.3 Hydrogen peroxide, 3%—dilute 100 ml. of 30% hydrogen peroxide to 1 liter with distilled water. Prepare fresh daily.

3.2 Sample recovery.

3.2.1 Water—Deionized, distilled.

3.2.2 Isopropanol, 80%.

3.3 Analysis.

3.3.1 Water—Deionized, distilled.

3.3.2 Isopropanol.

3.3.3 Thorin indicator—1-(o-arsonophenylazo)-2-naphthol-3,6-disulfonic acid, disodium salt (or equivalent). Dissolve 0.20 g. in 100 ml. distilled water.

3.3.4 Barium perchlorate (0.01 *N*)—Dissolve 1.95 g. of barium perchlorate [$Ba(ClO_4)_2 \cdot 3H_2O$] in 200 ml. distilled water and dilute to 1 liter with isopropanol. Standardize with sulfuric acid. Barium chloride may be used.

3.3.5 Sulfuric acid standard (0.01 *N*)—Purchase or standardize to ±0.0002 *N* against 0.01N NaOH which has previously been standardized against potassium acid phthalate (primary standard grade).

4. *Procedure.*

4.1 Sampling.

4.1.1 Preparation of collection train. Pour 15 ml. of 80% isopropanol into the midget bubbler and 15 ml. of 3% hydrogen peroxide into each of the first two midget impingers. Leave the final midget impinger dry. Assemble the train as shown in Figure 6-1. Leak check the sampling train at the sampling site by plugging the probe inlet and pulling a 10 inches Hg vacuum. A leakage rate not in excess of 1% of the sampling rate is acceptable. Carefully release the probe inlet plug and turn off the pump. Place crushed ice around the impingers. Add more ice during the run to keep the temperature of the gases leaving the last impinger at 70° F. or less.

4.1.2 Sample collection. Adjust the sample flow rate proportional to the stack gas velocity. Take readings at least every five minutes and when significant changes in stack conditions necessitate additional adjustments in flow rate. To begin sampling, position the tip of the probe at the first sampling point and start the pump. Sample proportionally throughout the run. At the conclusion of each run, turn off the pump and record the final readings. Remove the probe from the stack and disconnect it from the train. Drain the ice bath and purge the remaining part of the train by drawing clean ambient air through the system for 15 minutes.

4.2 Sample recovery. Disconnect the impingers after purging. Discard the contents of the midget bubbler. Pour the contents of the midget impingers into a polyethylene shipment bottle. Rinse the three midget impingers and the connecting tubes with distilled water and add these washings to the same storage container.

4.3 Sample analysis. Transfer the contents of the storage container to a 50 ml. volumetric flask. Dilute to the mark with deionized, distilled water. Pipette a 10 ml. aliquot of this solution into a 125 ml. Erlenmeyer flask. Add 40 ml. of isopropanol and two to four drops of thorin indicator. Titrate to a pink endpoint using 0.01 *N* barium perchlorate. Run a blank with each series of samples.

5. *Calibration.*

5.1 Use standard methods and equipment which have been approved by the Administrator to calibrate the rotameter, pitot tube, dry gas meter, and probe heater.

5.2 Standardize the barium perchlorate against 25 ml. of standard sulfuric acid containing 100 ml. of isopropanol.

6. *Calculations.*

6.1 Dry gas volume. Correct the sample volume measured by the dry gas meter to standard conditions (70° F. and 29.92 inches Hg) by using equation 6-1.

$$V_{m_{std}} = V_m \left(\frac{T_{std}}{T_m}\right)\left(\frac{P_{bar}}{P_{std}}\right) = 17.71 \frac{°R}{\text{in. Hg}}\left(\frac{V_m P_{bar}}{T_m}\right) \quad \text{equation 6-1}$$

where:

$V_{m_{std}}$ = Volume of gas sample through the dry gas meter (standard conditions), cu. ft.

V_m = Volume of gas sample through the dry gas meter (meter conditions), cu. ft.

T_{std} = Absolute temperature at standard conditions, 530° R.

T_m = Average dry gas meter temperature, °R.

P_{bar} = Barometric pressure at the orifice meter, inches Hg.

P_{std} = Absolute pressure at standard conditions, 29.92 inches Hg.

6.2 Sulfur dioxide concentration.

$$C_{SO_2} = \left(7.05 \times 10^{-5} \frac{\text{lb.-l.}}{\text{g.-ml.}}\right) \frac{(V_t - V_{tb}) N \left(\frac{V_{soln}}{V_a}\right)}{V_{m_{std}}} \quad \text{equation 6-2}$$

where:

C_{SO_2} = Concentration of sulfur dioxide at standard conditions, dry basis, lb./cu. ft.

7.05×10^{-5} = Conversion factor, including the number of grams per gram equivalent of sulfur dioxide (32 g./g.-eq.), 453.6 g./lb., and 1,000 ml./l., lb.-l./g.-ml.

V_t = Volume of barium perchlorate titrant used for the sample, ml.

V_{tb} = Volume of barium perchlorate titrant used for the blank, ml.

N = Normality of barium perchlorate titrant, g.-eq./l.

V_{soln} = Total solution volume of sulfur dioxide, 50 ml.

V_a = Volume of sample aliquot titrated, ml.

$V_{m_{std}}$ = Volume of gas sample through the dry gas meter (standard conditions), cu. ft., see Equation 6-1.

7. *References.*

Atmospheric Emissions from Sulfuric Acid Manufacturing Processes, U.S. DHEW, PHS, Division of Air Pollution, Public Health Service Publication No. 999-AP-13, Cincinnati, Ohio, 1965.

Corbett, P. F., The Determination of SO_2 and SO_3 in Flue Gases, Journal of the Institute of Fuel, 24:237-243, 1961.

Matty, R. E. and E. K. Diehl, Measuring Flue-Gas SO_2 and SO_3, Power *101*:94-97, November, 1957.

Patton, W. F. and J. A. Brink, Jr., New Equipment and Techniques for Sampling Chemical Process Gases, J. Air Pollution Control Association, *13*, 162 (1963).

METHOD 7—DETERMINATION OF NITROGEN OXIDE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and applicability.*

1.1 Principle. A grab sample is collected in an evacuated flask containing a dilute sulfuric acid-hydrogen peroxide absorbing solution, and the nitrogen oxides, except

nitrous oxide, are measure colorimetrically using the phenoldisulfonic acid (PDS) procedure.

1.2 Applicability. This method is applicable for the measurement of nitrogen oxides from stationary sources only when specified by the test procedures for determining compliance with New Source Performance Standards.

2. *Apparatus.*

2.1 Sampling. See Figure 7-1.

2.1.1 Probe—Pyrex[1] glass, heated, with filter to remove particulate matter. Heating is unnecessary if the probe remains dry during the purging period.

2.1.2 Collection flask—Two-liter, Pyrex,[1] round bottom with short neck and 24/40 standard taper opening, protected against implosion or breakage.

[1] Trade name.

2.1.3 Flask valve—T-bore stopcock connected to a 24/40 standard taper joint.

2.1.4 Temperature gauge—Dial-type thermometer, or equivalent, capable of measuring 2° F. intervals from 25° to 125° F.

2.1.5 Vacuum line—Tubing capable of withstanding a vacuum of 3 inches Hg absolute pressure, with "T" connection and T-bore stopcock, or equivalent.

2.1.6 Pressure gauge—U-tube manometer, 36 inches, with 0.1-inch divisions, or equivalent.

2.1.7 Pump—Capable of producing a vacuum of 3 inches Hg absolute pressure.

2.1.8 Squeeze bulb—One way.

2.2 Sample recovery.

2.2.1 Pipette or dropper.

2.2.2 Glass storage containers—Cushioned for shipping.

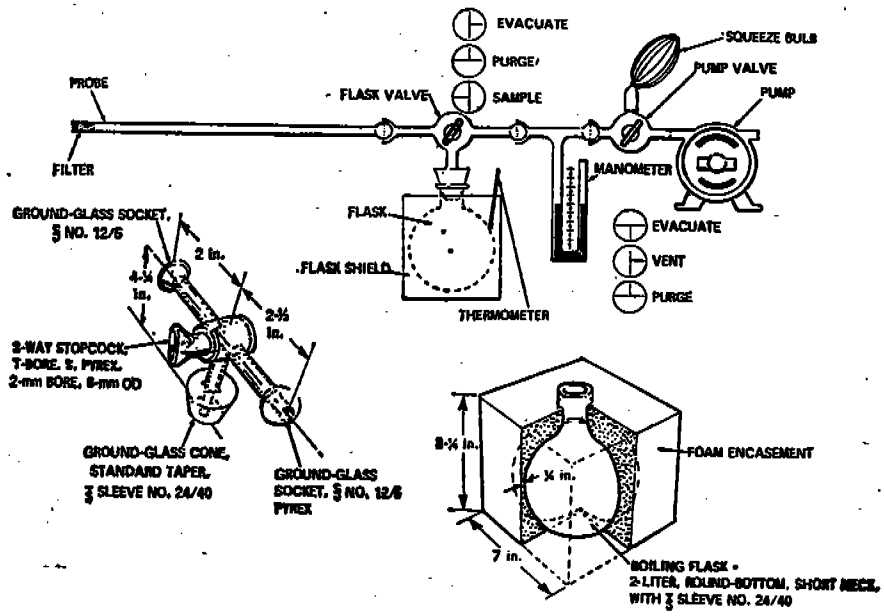

Figure 7-1. Sampling train, flask valve, and flask.

2.2.3 Glass wash bottle.

2.3 Analysis.

2.3.1 Steam bath.

2.3.2 Beakers or casseroles—250 ml., one for each sample and standard (blank).

2.3.3 Volumetric pipettes—1, 2, and 10 ml.

2.3.4 Transfer pipette—10 ml. with 0.1 ml. divisions.

2.3.5 Volumetric flask—100 ml., one for each sample, and 1,000 ml. for the standard (blank).

2.3.6 Spectrophotometer—To measure absorbance at 420 nm.

2.3.7 Graduated cylinder—100 ml. with 1.0 ml. divisions.

2.3.8 Analytical balance—To measure to 0.1 mg.

3. *Reagents.*

3.1 Sampling.

3.1.1 Absorbing solution—Add 2.8 ml. of concentrated H_2SO_4 to 1 liter of distilled water. Mix well and add 6 ml. of 3 percent hydrogen peroxide. Prepare a fresh solution weekly and do not expose to extreme heat or direct sunlight.

3.2 Sample recovery.

3.2.1 Sodium hydroxide (1*N*)—Dissolve 40 g. NaOH in distilled water and dilute to 1 liter.

3.2.2 Red litmus paper.

3.2.3 Water—Deionized, distilled.

3.3 Analysis.

3.3.1 Fuming sulfuric acid—15 to 18% by weight free sulfur trioxide.

3.3.2 Phenol—White solid reagent grade.

3.3.3 Sulfuric acid—Concentrated reagent grade.

3.3.4 Standard solution—Dissolve 0.5495 g. potassium nitrate (KNO_3) in distilled water and dilute to 1 liter. For the working standard solution, dilute 10 ml. of the resulting solution to 100 ml. with distilled water. One ml. of the working standard solution is equivalent to 25 μg. nitrogen dioxide.

3.3.5 Water—Deionized, distilled.

3.3.6 Phenoldisulfonic acid solution—Dissolve 25 g. of pure white phenol in 150 ml. concentrated sulfuric acid on a steam bath. Cool, add 75 ml. fuming sulfuric acid, and heat at 100° C. for 2 hours. Store in a dark, stoppered bottle.

4. *Procedure.*

4.1 Sampling.

4.1.1 Pipette 25 ml. of absorbing solution into a sample flask. Insert the flask valve stopper into the flask with the valve in the "purge" position. Assemble the sampling train as shown in Figure 7-1 and place the probe at the sampling point. Turn the flask valve and the pump valve to their "evacuate" positions. Evacuate the flask to at least 3 inches Hg absolute pressure. Turn the pump valve to its "vent" position and turn off the pump. Check the manometer for any fluctuation in the mercury level. If there is a visible change over the span of one minute, check for leaks. Record the initial volume, temperature, and barometric pressure. Turn the flask valve to its "purge" position, and then do the same with the pump valve. Purge the probe and the vacuum tube using the squeeze bulb. If condensation occurs in the probe and flask valve area, heat the probe and purge until the condensation disappears. Then turn the pump valve to its "vent" position. Turn the flask valve to its "sample" position and allow sample to enter the flask for about 15 seconds. After collecting the sample, turn the flask valve to its "purge" position and disconnect the flask from the sampling train. Shake the flask for 5 minutes.

4.2 Sample recovery.

4.2.1 Let the flask set for a minimum of 16 hours and then shake the contents for 2 minutes. Connect the flask to a mercury filled U-tube manometer, open the valve from the flask to the manometer, and record the flask pressure and temperature along with the barometric pressure. Transfer the flask contents to a container for shipment or to a 250 ml. beaker for analysis. Rinse the flask with two portions of distilled water (approximately 10 ml.) and add rinse water to the sample. For a blank use 25 ml. of absorbing solution and the same volume of distilled water as used in rinsing the flask. Prior to shipping or analysis, add sodium hydroxide (1*N*) dropwise into both the sample and the blank until alkaline to litmus paper (about 25 to 35 drops in each).

4.3 Analysis.

4.3.1 If the sample has been shipped in a container, transfer the contents to a 250 ml. beaker using a small amount of distilled water. Evaporate the solution to dryness on a steam bath and then cool. Add 2 ml. phenoldisulfonic acid solution to the dried residue and triturate thoroughly with a glass rod. Make sure the solution contacts all the residue. Add 1 ml. distilled water and four drops of concentrated sulfuric acid. Heat the solution on a steam bath for 3 minutes with occasional stirring. Cool, add 20 ml. distilled water, mix well by stirring, and add concentrated ammonium hydroxide dropwise with constant stirring until alkaline to litmus paper. Transfer the solution to a 100 ml. volumetric flask and wash the beaker three times with 4 to 5 ml. portions of distilled water. Dilute to the mark and mix thoroughly. If the sample contains solids, transfer a portion of the solution to a clean, dry centrifuge tube, and centrifuge, or filter a portion of the solution. Measure the absorbance of each sample at 420 nm. using the blank solution as a zero. Dilute the sample and the blank with a suitable amount of distilled water if absorbance falls outside the range of calibration.

5. *Calibration.*

5.1 Flask volume. Assemble the flask and flask valve and fill with water to the stopcock. Measure the volume of water to ±10 ml. Number and record the volume on the flask.

5.2 Spectrophotometer. Add 0.0 to 16.0 ml. of standard solution to a series of beakers. To each beaker add 25 ml. of absorbing solution and add sodium hydroxide (1*N*) dropwise until alkaline to litmus paper (about 25 to 35 drops). Follow the analysis procedure of section 4.3 to collect enough data to draw a calibration curve of concentration in μg. NO_2 per sample versus absorbance.

6. *Calculations.*

6.1 Sample volume.

$$V_{sc}=\frac{T_{std}(V_f-V_s)}{P_{std}}\left(\frac{P_f}{T_f}-\frac{P_i}{T_i}\right)=\left(17.71\ \frac{°R}{in.\ H_g}\right)(V_f-25\ ml.)\left(\frac{P_f}{T_f}-\frac{P_i}{T_i}\right)\quad \text{Equation 7-1}$$

where:

V_{sc} = Sample volume at standard conditions (dry basis), ml.

T_{std} = Absolute temperature at standard conditions, 530° R.

P_{std} = Pressure at standard conditions, 29.92 inches Hg.

V_f = Volume of flask and valve, ml.

V_s = Volume of absorbing solution, 25 ml.

P_f = Final absolute pressure of flask, inches Hg.

P_i = Initial absolute pressure of flask, inches Hg.

T_f = Final absolute temperature of flask, °R.

T_i = Initial absolute temperature of flask, °R.

6.2 Sample concentration. Read μg. NO_x for each sample from the plot of μg. NO_x versus absorbance.

$$C=\left(\frac{m}{V_{sc}}\right)\left(\frac{\frac{1\ lb.}{cu.\ ft.}}{1.6\times10^{4}\frac{\mu g.}{ml.}}\right)=\left(6.2\times10^{-5}\frac{lb./s.c.f.}{\mu g./ml.}\right)\left(\frac{m}{V_{sc}}\right)\quad \text{equation 7-2}$$

where:

C = Concentration of NO_x as NO_2 (dry basis), lb./s.c.f.

m = Mass of NO_2 in gas sample, μg.

V_{sc} = Sample volume at standard conditions (dry basis), ml.

7. *References.*

Standard Methods of Chemical Analysis. 6th ed. New York, D. Van Nostrand Co., Inc., 1962, vol. 1, p. 329–330.

Standard Method of Test for Oxides of Nitrogen in Gaseous Combustion Products (Phenoldisulfonic Acid Procedure). In: 1968 Book of ASTM Standards, Part 23, Philadelphia, Pa. 1968, ASTM Designation D-1608-60, p. 725–729.

Jacob, M. B., The Chemical Analysis of Air Pollutants, New York, N.Y., Interscience Publishers, Inc., 1960, vol. 10, p. 351–356.

METHOD 8—DETERMINATION OF SULFURIC ACID MIST AND SULFUR DIOXIDE EMISSIONS FROM STATIONARY SOURCES

1. *Principle and applicability.*

1.1 Principle. A gas sample is extracted from a sampling point in the stack and the acid mist including sulfur trioxide is separated from sulfur dioxide. Both fractions are measured separately by the barium-thorin titration method.

1.2 Applicability. This method is applicable to determination of sulfuric acid mist (including sulfur trioxide) and sulfur dioxide from stationary sources only when specified by the test procedures for determining compliance with the New Source Performance Standards.

2. *Apparatus.*

2.1 Sampling. See Figure 8-1. Many of the design specifications of this sampling train are described in APTD-0581.

2.1.1 Nozzle—Stainless steel (316) with sharp, tapered leading edge.

2.1.2 Probe—Pyrex [1] glass with a heating system to prevent visible condensation during sampling.

2.1.3 Pitot tube—Type S, or equivalent, attached to probe to monitor stack gas velocity.

2.1.4 Filter holder—Pyrex [1] glass.

2.1.5 Impingers—Four as shown in Figure 8-1. The first and third are of the Greenburg-Smith design with standard tip. The second and fourth are of the Greenburg-Smith design, modified by replacing the standard tip with a ½-inch ID glass tube extending to one-half inch from the bottom of the impinger flask. Similar collection systems, which have been approved by the Administrator, may be used.

2.1.6 Metering system—Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 5° F., dry gas meter with 2% accuracy, and related equipment, or equivalent, as required to maintain an isokinetic sampling rate and to determine sample volume.

2.1.7 Barometer—To measure atmospheric pressure to ±0.1 inch Hg.

[1] Trade name.

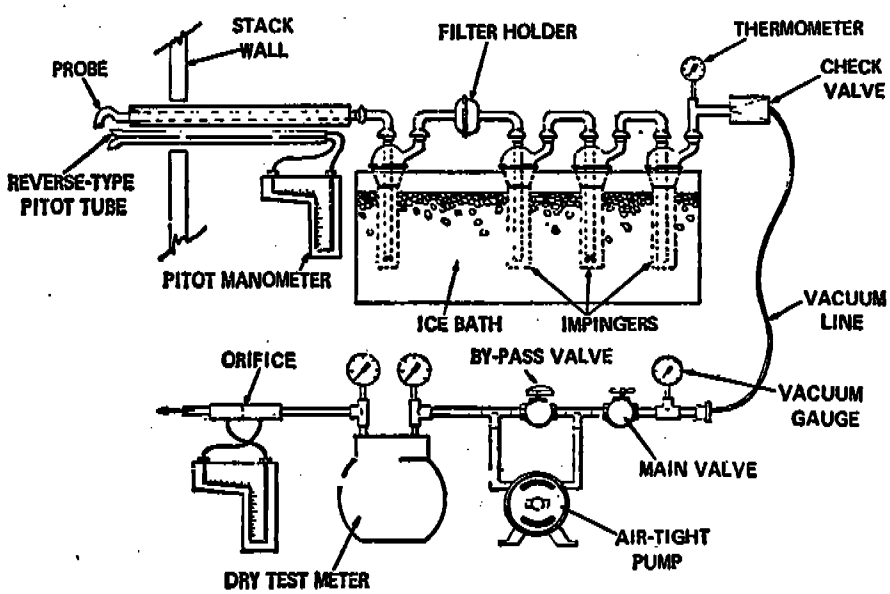

Figure 8-1. Sulfuric acid mist sampling train.

2.2 Sample recovery.

2.2.1 Wash bottles—Two.

2.2.2 Graduated cylinders—250 ml., 500 ml.

2.2.3 Glass sample storage containers.

2.2.4 Graduated cylinder—250 ml.

2.3 Analysis.

2.3.1 Pipette—25 ml., 100 ml.

2.3.2 Burette—50 ml.

2.3.3 Erlenmeyer flask—250 ml.

2.3.4 Graduated cylinder—100 ml.

2.3.5 Trip balance—300 g. capacity, to measure to ±0.05 g.

2.3.6 Dropping bottle—to add indicator solution.

3. *Reagents.*

3.1 Sampling.

3.1.1 Filters—Glass fiber, MSA type 1106 BH, or equivalent, of a suitable size to fit in the filter holder.

3.1.2 Silica gel—Indicating type, 6–16 mesh, dried at 175° C. (350° F.) for 2 hours.

3.1.3 Water—Deionized, distilled.

3.1.4 Isopropanol, 80%—Mix 800 ml. of isopropanol with 200 ml. of deionized, distilled water.

3.1.5 Hydrogen peroxide, 3%—Dilute 100 ml. of 30% hydrogen peroxide to 1 liter with deionized, distilled water.

3.1.6 Crushed ice.

3.2 Sample recovery.

3.2.1 Water—Deionized, distilled.

3.2.2 Isopropanol, 80%.

3.3 Analysis.

3.3.1 Water—Deionized, distilled.

3.3.2 Isopropanol.

3.3.3 Thorin indicator—1-(o-arsonophenylazo)-2-naphthol-3, 6-disulfonic acid, disodium salt (or equivalent). Dissolve 0.20 g. in 100 ml. distilled water.

3.3.4 Barium perchlorate (0.01*N*)—Dissolve 1.95 g. of barium perchlorate [$Ba(ClO_4)_2 \cdot 3\ H_2O$] in 200 ml. distilled water and dilute to 1 liter with isopropanol. Standardize with sulfuric acid.

3.3.5 Sulfuric acid standard (0.01*N*)—Purchase or standardize to ± 0.0002 *N* against 0.01 *N* NaOH which has previously been standardized against primary standard potassium acid phthalate.

4. *Procedure.*

4.1 Sampling.

4.1.1 After selecting the sampling site and the minimum number of sampling points, determine the stack pressure, temperature, moisture, and range of velocity head.

4.1.2 Preparation of collection train. Place 100 ml. of 80% isopropanol in the first impinger, 100 ml. of 3% hydrogen peroxide in both the second and third impingers, and about 200 g. of silica gel in the fourth impinger. Retain a portion of the reagents for use as blank solutions. Assemble the train without the probe as shown in Figure 8-1 with the filter between the first and second impingers. Leak check the sampling train at the sampling site by plugging the inlet to the first impinger and pulling a 15-inch Hg vacuum. A leakage rate not in excess of 0.02 c.f.m. at a vacuum of 15 inches Hg is acceptable. Attach the probe and turn on the probe heating system. Adjust the probe heater setting during sampling to prevent any visible condensation. Place crushed ice around the impingers. Add more ice during the run to keep the temperature of the gases leaving the last impinger at 70° F. or less.

4.1.3 Train operation. For each run, record the data required on the example sheet shown in Figure 8-2. Take readings at each sampling point at least every 5 minutes and when significant changes in stack conditions necessitate additional adjustments in flow rate. To begin sampling, position the nozzle at the first traverse point with the tip pointing directly into the gas stream. Start the pump and immediately adjust the flow to isokinetic conditions. Maintain isokinetic sampling throughout the sampling period. Nomographs are available which aid in the

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APPENDIX E

LABORATORY REPORT

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LABORATORY REPORT

E.1 ON-SITE HANDLING AND TRANSFER, PARTICULATE

After the completion of a test run, the probe and nozzle were disconnected from the impinger train and all open ends sealed immediately to avoid contamination. At the laboratory facility, the nozzle was disconnected from the probe and very carefully washed with acetone, using a fine bristled brush. All acetone washings were collected in a clean glass jar, the jar itself being placed on a large piece of clean aluminum foil. The probe was then washed using a long handled brush rotated through it under a continuous stream of acetone. The brush was also carefully cleaned, and all washings collected in the glass jar. The probe was finally checked visually for any residue.

The impinger train was initially wiped clean on the outside and all glassware connectors, including the filter, removed carefully and all exposed surfaces wiped clean. All the connectors were placed on a piece of aluminum foil ready for washing. The first three impingers were then analyzed for water collection by transferring the water through the outlet port into a graduated cylinder and noting the volume. The impingers were not dismantled and all transfers and washings were performed through the inlet and outlet ports. All of the glassware in the back half of the filter, up to the fourth impinger was then carefully washed with distilled water and the washings collected. This was followed by an acetone wash which was again collected in a separate jar.

Acetone washings from the glassware in the front half of the filter were collected in the same jar as the probe and nozzle wash. The filter was carefully removed from the holder and placed in a plastic dish which was then sealed with tape. Silica gel in the fourth impinger was weighed in a previously tared glass jar using a triple-beam balance.

All acetone jars had aluminum lined lid , or aluminum foil was used before screwing on the lids. The following designations were used for labeling the containers:

Container #1: Filter

Container #2: Acetone wash front half from filter

Container #3: Water wash back half from filter

Container #4: Silica gel

Container #5: Acetone wash back half from filter

E.2 LABORATORY HANDLING AND ANALYSIS, PARTICULATE

E.2.1 Filter Transfer

Clean plastic dishes were desiccated for 24 hours, labeled and tared on an electronic balance. The filter containers were unsealed and desiccated for 24 hours before carefully transferring the filters to the tared dishes using a fine pair of tweezers. Care was taken to place a piece of aluminum foil under the transfer operation. A "staticmaster" brush was used to brush any fine particles adhering to the container or foil. All transfers were performed near the balance and the weight reported to the nearest 0.1 mg. The plastic dishes were then sealed for shipment.

E.2.2 Acetone Washes

The 250 ml. beakers to be used for the acetone wash transfers were leached for 24 hours in 50% nitric acid, washed thoroughly and oven dried overnight. These were then desiccated for 24 hours and tared. Once tared, the beakers were sealed with "parafilm" and handled with tongs or "Kimwipes".

The jars containing the acetone washes were left loosely covered in a hood until the acetone was evaporated. Once the acetone was evaporated, the glass jar was rinsed with acetone, using a rubber policeman, and the washings collected in the tared beaker.

After the acetone had evaporated, the beakers were desiccated for 24 hours and weighed to a constant weight. Where water was present in the acetone wash, it was evaporated in an oven at 90°C after the acetone had all evaporated.

E.2.3 Water Washes

The level of water in the collection bottles was marked for later volume measurement. Each water wash was then transferred into a 2000 ml. separatory funnel and extracted three times with 25 ml. portions of chloroform. Often where a large volume of water was collected (above 500 ml.), a fourth extraction was used. The chloroform extracts were collected directly in a tared beaker prepared in the same manner as described in the previous section.

Extraction with three 50 ml. portions of ether followed, collecting the water portion in the original jars. The ether extracts were combined with the chloroform extracts. These were then washed

with distilled water in the separatory funnel and returned to the tared beaker for evaporation in the hood. The residues were desiccated and weighed.

The water portion was transferred to tared beakers, oven dried at 90°C, desiccated, and weighed. All beakers were "parafilm" sealed for shipment. Particle size analysis was not performed per instruction from the Project Officer. A summary of weight measurements is shown in Table E-1.

TABLE E-1 - SUMMARY OF WEIGHT MEASUREMENTS

	Run 1					Run 2					Run 3				
	Final (g)	Tare (g)	Gross (mg)	Blank (mg)	Net (mg)	Final (g)	Tare (g)	Gross (mg)	Blank (mg)	Net (mg)	Final (g)	Tare (g)	Gross (gm)	Blank (mg)	Net (mg)
Container #1 (Filter)	8.1710	8.0790	92.0	-	92.0	8.2030	8.1015	101.5	-	101.5	8.2085	8.1145	94.0	-	94.0
Container #2 (Acetone wash front half)	88.0860	87.9135	172.5	3.0	169.5	93.8415	93.7345	107.0	2.0	105.0	91.8990	91.7500	149.0	1.0	148.0
Container #3a (Organic extract)	99.5340	99.5290	5.0	0.0	5.0	99.5090	99.5000	9.0	0.0	9.0	96.5790	96.5710	8.0	0.0	8.0
Container #3b (Water after extraction)	100.5075	100.4465	61.0	0.0	61.0	99.4915	99.4375	54.0	0.0	54.0	97.9745	97.9240	50.5	0.0	50.5
Container #5 (Acetone wash back half)	94.5905	94.5805	10.0	0.5	9.5	98.3490	98.3370	12.0	1.0	11.0	101.6575	101.6430	14.5	1.0	13.5
	Probe, cyclone, filter, mg.				261.5	Probe, cyclone, filter, mg.				206.5	Probe, cyclone, filter, mg.				242.0
			Total, mg.		337.0			Total, mg.		280.5			Total, mg.		314.0

	Run 4					Run 5				
	Final (g)	Tare (g)	Gross (mg)	Blank (mg)	Net (mg)	Final (g)	Tare (g)	Gross (mg)	Blank (mg)	Net (mg)
Container #1 (Filter)	7.7760	7.7120	64.0	-	64.0	7.7905	7.7125	78.0	-	78.0
Container #2 (Acetone wash front half)	96.0070	95.8995	107.5	2.0	105.5	93.4980	93.4020	96.0	1.0	95.0
Container #3a (Organic Extract)	97.3620	97.3530	9.0	0.0	9.0	99.3770	99.3690	8.0	0.0	8.0
Container #3b (Water after extraction)	98.1750	98.1425	32.5	0.0	32.5	98.5585	98.5280	30.5	0.0	30.5
Container #5 (Acetone wash back half)	95.5405	95.5300	10.5	1.0	9.5	98.5695	98.5550	14.5	1.0	13.5
	Probe, cyclone, filter, mg.				169.5	Probe, cyclone, filter, mg.				173.0
			Total, mg.		220.5			Total, mg.		225.0

E.3 NO_x ANALYSIS

Immediately after each NO_x flask sample was taken, the flask containing the absorbing solution and the gas sample was shaken for five minutes. The flask was then allowed to sit until the following morning when it was shaken again for two minutes. Following this final shake, the flask pressure was measured with a mercury manometer. Each flask was then carefully wiped off and the stopcocks removed. The absorbing solutions were then transferred to glass shipping bottles with two 10 ml. washes of distilled water. Just prior to shipping, the samples were neutralized with 1.0 N sodium hydroxide (approximately 40 drops). At this time solution blanks were made for each set of samples. The blanks contained 25 ml. of NO_x absorbing solution and 20 ml. of distilled water and were neutralized with 1.0 N. sodium hydroxide. At the end of the test period all samples were transported to the laboratory for analysis.

All NO_x samples were analyzed by the Phenoldisulfonic acid procedure. Prior to analysis, a calibration curve was established for a suitable range of NO_x concentrations. From a standard potassium nitrate solution with an equivalent concentration of 25 μg NO_2 per ml. four aliquots of 4, 8, 12 and 16 ml. were added to respective 250 ml. beakers. Twenty-five ml. of NO_x absorbing solution was added to each of these beakers and the analysis procedure described below was followed. These solutions were read against a blank containing no standard solution and a calibration curve of % absorbance versus μg NO_2 was plotted.

Upon arrival at the laboratory, each sample was transferred to a 250 ml. beaker and evaporated to dryness on a steam bath. After cooling, 2 ml. of phenoldisulfonic acid was added and each sample was triturated thoroughly with a glass stirring rod. One ml. of distilled water and four drops of concentrated sulfuric acid were added and the samples were returned to the steam bath for three minutes. The samples were then cooled and 20 ml. of distilled water was added. Concentrated ammonium hydroxide was then added dropwise until each sample was alkaline to litmus paper. The samples were transferred to 100 ml. volumetric flasks with distilled water and portions of each solution were read at 420 mμ on a Bausch and Lomb Spectronic 20 Colorimeter. The solution blanks run with each set of samples were used for a colorimeter zero reference. The absorbances read for each sample were then converted to μg NO_2 via the previously established calibration curve. NO_x concentrations were calculated as ppm NO_2 following the procedure described in Appendix B. The laboratory data recorded for each analysis is included as Table E-2.

E.4 ORSAT ANALYSIS

A total of five integrated bag samples were analyzed by Orsat during the three day test period. Each five liter Tedlar sample bag was equipped with a Teflon sample tube fitted with an airtight syringe cap. Prior to sampling, each bag was flushed with pure, dry nitrogen and sealed with the syringe cap.

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TABLE E-2 - NO_x ANALYSIS DATA

Run No.	Date	Sample Number	Absorbance @ 420 mμ	NO_x Concentration (μg NO_2)
1	3/20/72	1	0.160	119.7
		2	0.227	169.8
		3	0.205	153.3
2	3/22/72	1	0.242	181.0
		2	0.240	179.5
		3	(lost)	
3	3/22/72	1	0.170	127.1
		2	0.208	155.6
		3	0.050	37.4
4	3/23/72	1	0.256	191.5
		2	0.037	27.7
		3	0.230	172.0
5	3/23/72	1	0.93	69.6
		2	0.260	194.4
		3	0.199	148.8

At the end of each sampling day the sample bags were returned to the field laboratory where they were analyzed for CO, CO_2 and O_2 by Orsat.

Each bag was connected to the Orsat analyzer by carefully removing the syringe cap and inserting the Teflon tube securely into the Orsat sample tube. The Orsat analyzer was then purged by squeezing the Tedlar bag and forcing the sample through the Orsat bypass. Successive 100 ml. samples were drawn into the Orsat sample burette and then passed through each of the three absorbing solutions (potassium hydroxide - CO_2, alkaline pyrogallate - O_2, and acid cuprous chloride - CO). Repetitive passes were made through each absorbing solution until good duplication of results occurred. At least three 100 ml. samples were analyzed from each Tedlar sample bag. The data recorded for each Orsat analysis is included in Table E-3.

E.5 TOTAL HYDROCARBON ANALYSIS

Immediately following each Orsat analysis the remainder of the sample contained in each Tedlar bag was analyzed for hydrocarbons via a Beckman Model 108-A Total Hydrocarbon Analyzer. This instrument utilized a flame ionization detector and the following operating conditions were maintained during each analysis:

Sample Backpressure:	2.50	psi
Fuel Pressure:	23.0	psi
Oxidant Pressure:	11.0	psi
Range:	100	X

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TABLE E-3 - ORSAT ANALYSIS DATA

Run No.	Date	Sample Number	Component	Analysis Number	Bunette Volume (ml) Initial	Final	Difference
1	3/20/72	1	CO_2	1	100.0	99.8	0.2
				2		99.8	0.2
			O_2	1	99.8	81.6	18.2
				2		81.6	18.2
			CO	1	81.6	81.6	0.0
				2		81.6	0.0
		2	CO_2	1	1100.0	99.8	0.2
				2		99.8	0.2
			O_2	1	99.8	81.7	18.1
				2		81.7	18.1
			CO	1	81.7	81.7	0.0
				2		81.7	0.0
		3	CO_2	1	100.0	99.8	0.2
				2		99.8	0.2
			O_2	1	99.8	81.6	18.2
				2		81.6	18.2
			CO	1	81.6	81.6	0.0
				2		81.6	0.0
2	3/22/72	1	CO_2	1	100.0	99.7	0.3
				2		99.7	0.3
			O_2	1	99.7	80.1	19.6
				2		80.1	19.6
			CO	1	80.1	80.1	0.0
				2		80.1	0.0
		2	CO_2	1	100.0	99.8	0.2
				2		99.8	0.2
			O_2	1	99.8	80.1	19.7
				2		80.1	19.7
			CO	1	80.1	80.1	0.0
				2		80.1	0.0
		3	CO_2	1	100.0	99.7	0.3
				2		99.7	0.3
			O_2	1	99.7	80.1	19.6
				2		80.1	19.6
			CO	1	80.1	80.1	0.0
				2		80.1	0.0

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TABLE E-3 - ORSAT ANALYSIS DATA

(continued)

Run No.	Date	Sample Number	Component	Analysis Number	Bunette Volume (ml) Initial	Final	Difference
3	7/22/72	1	CO_2	1	100.0	99.8	0.2
				2		99.8	0.2
			O_2	1	99.8	80.4	19.4
				2		80.4	19.4
			CO	1	80.4	80.4	0.4
				2		80.4	0.0
		2	CO_2	1	100.0	99.8	0.2
				2		99.8	0.2
			O_2	1	99.8	80.4	19.4
				2		80.4	19.4
			CO	1	80.4	80.4	0.0
				2		80.4	0.0
		3	CO_2	1	100.0	99.7	0.3
				2		99.7	0.3
			O_2	1	99.7	80.3	19.5
				2		80.3	19.5
			CO	1	80.3	80.3	0.0
				2		80.3	0.0
4	7/23/72	1	CO_2	1	100.0	99.7	0.3
				2		99.7	0.3
			O_2	1	99.7	79.9	19.8
				2		79.9	19.8
			CO	1	79.9	79.9	0.0
				2		79.9	0.0
		2	CO_2	1	100.0	99.6	0.4
				2		99.6	0.4
			O_2	1	99.6	79.9	19.7
				2		79.9	19.7
			CO	1	79.9	79.9	0.0
				2		79.9	0.0
		3	CO_2	1	100.0	99.7	0.3
				2		99.7	0.3
			O_2	1	99.7	79.9	19.8
				2		79.9	19.8
			CO	1	99.9	79.9	0.0
				2		79.9	0.0

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TABLE E-3 - ORSAT ANALYSIS DATA

(continued)

Run No.	Date	Sample Number	Analysis Component	Analysis Number	Bunette Volume (ml) Initial	Final	Difference
5	3/23/72	1	CO_2	1	100.0	99.6	0.4
				2		99.6	0.4
			O_2	1	99.6	79.8	19.8
				2		79.8	19.8
			CO	1	79.8	79.8	0.0
				2		79.8	0.0
		2	CO_2	1	100.0	99.6	0.4
				2		99.6	0.4
			O_2	1	99.6	79.8	19.8
				2		79.8	19.8
			CO	1	79.8	79.8	0.0
				2		79.8	0.0
		3	CO_2	1	100.0	99.5	0.5
				2		99.5	0.5
			O_2	1	99.5	79.7	19.8
				2		79.7	19.8
			CO	1	79.7	79.7	0.0
				2		79.7	0.0

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The Scott compressed gases used during each analysis were:

Fuel: 40% hydrogen in nitrogen

Oxidant: Blended Air

Zero: Hydrocarbon Free Air (<0.1 ppm-C)

Span: 99.9 ppm propane (±2.0% analysis) in nitrogen

Just prior to introducing each sample into the analyzer, the instrument was zeroed and spanned on range 100. The Tedlar sample bag was then connected to the analyzer via a Teflon tube and the sample was drawn into the analyzer until a stable reading was recorded on the meter. The bag was then disconnected and resealed with the syringe cap. The instrument zero and span points were rechecked to insure that the calibration had not changed during the analysis. The complete analytical procedure was then repeated until good duplication of results were obtained. All meter readings recorded for each sample are included as Table E-4.

The meter readings were then converted to parts per million carbon by the following formula:

$$\text{ppm-C} = \text{meter units} \times \frac{99.9\ \text{ppm-}C_3H_8}{100\ \text{units-Span}} \times \frac{3\ \text{ppm-C}}{\text{ppm-}C_3H_8}$$

The final data with example calculations are included in Appendix B of this report.

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TABLE E-4 - TOTAL HYDROCARBON DATA

Run No.	Date	Sample No.	Range	Meter Units Sample	Meter Units Span
1	3/20/72	1	100	69.5	100.0
		2	100	69.5	100.0
2	3/22/72	1	100	35.0	100.0
		2	100	33.0	100.0
3	3/22/72	1	100	16.0	100.0
		2	100	16.0	100.0
4	3/23/72	1	100	10.5	100.0
		2	100	10.5	100.0
5	3/23/72	1	100	5.0	100.0
		2	100	7.0	100.0

APPENDIX F

TEST LOG

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TEST LOG

On Monday, March 20, 1972, the Scott test team arrived at the Wentz Plant of Westmoreland Coal Company in Stonega, Virginia, and began to set up the test equipment. Upon arrival at the site it was learned that a wildcat strike had just started, but that there was enough Osaka coal to continue processing for 8 or 9 hours. The process was switched to Osaka coal around noon by which time Scott was set up and prepared to start testing. Preliminary velocity and temperature traverses were performed and a nozzle size selected. The first run was started at 1523. Twenty-four points were traversed in each port for a period of 2½ minutes each. The pitot line became clogged with water at one point and had to be blown out. The first run was completed at 1825. An Orsat and total hydrocarbon sample was collected from 1512 to 1607. NO_x samples were collected at 1540, 1628, and 1807. During the test a brownish plume was observed trailing off from the stack.

The sample train was dismantled and the spare system was assembled for the second run. A leak test was performed and found to be satisfactory. When the pump was turned on to start the test, all of the power went off. Apparently the plant had turned on night lights between the tests and the circuit was not large enough to carry everything. Several attempts were made to supply alternate power but with no success. Thus, it was decided to be ready for a test early the next morning. The samples were returned to the motel where all sample transfers were performed and a new system, as well as a backup unit were prepared. The Orsat and hydrocarbon samples were analyzed and the NO_x samples transferred to sample bottles.

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It was believed that there would be enough coal to perform a run first thing Tuesday morning even if the strike continued. Thus, the Scott team arrived at the plant early and began setting up for a test run. It was soon learned that the entire plant was now striking and that no testing could be performed. The strike was settled late in the afternoon and preparations were made to test on Wednesday.

Wednesday the Scott team arrived at the plant and prepared to run a test while the plant was processing Osaka coal. A leak test was performed and the filter holder was found to leak slightly, but it was acceptable. The run was started at 940 and continued to 1142. The Orsat and hydrocarbon sample was collected from 935 to 1030. NO_x samples were collected at 950, 1025, and 1115. The sample train was disassembled and the second system was set up and leak tested.

The third run was then started at 1305 and ran until 1515. The Orsat and hydrocarbon sample was collected from 1304 to 1404. The first sample for NO_x was collected at 1325. Other NO_x samples were taken at 1430 and 1520. During both tests a slight brownish plume was observed trailing off from the stack.

The sample train was dismantled and taken back to the motel where both sample trains were cleaned and the samples transferred to sample bottles. During the cleanup and transfer, it was noted that the filters were being torn by the gasket in the filter holder. This did not affect the test, but made the cleanup procedure difficult. The Orsat and hydrocarbon samples were analyzed while the NO_x samples were transferred. The sample trains were then prepared for more tests.

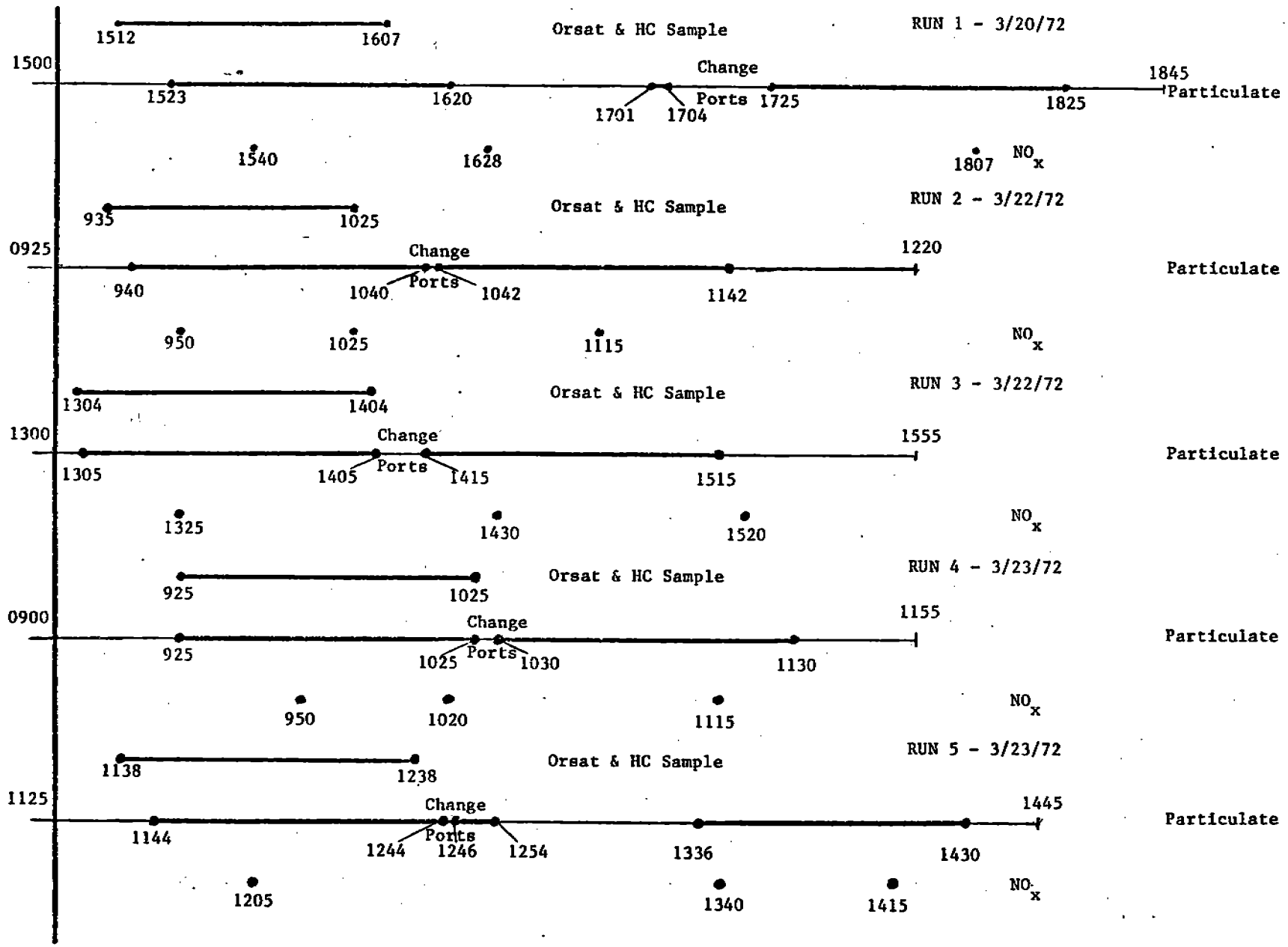
On Thursday the Scott team arrived at the plant and set up to perform tests while the plant was processing Wentz coal. The sample train was put in place and a leak test performed. It was found to be satisfactory and the test was started at 925 and ran until 1130. It was snowing and very windy during the test. At 1045 the wind blew over the manometer being used to measure the draft. Thus, no readings were taken after 1045. The Orsat and hydrocarbon sample was collected from 925 to 1025. The NO_x samples were collected at 950, 1020, and 1115. The sample train was disassembled and the second unit prepared to start testing.

A leak test was performed and found to be satisfactory. The test was started at 1144. It had to be stopped at 1254 because of a coal blockage in the plant operation. The test was restarted at 1336 and continued until 1430. The Orsat and hydrocarbon sample was collected from 1138 to 1238. The NO_x samples were taken at 1205, 1340, and 1415. Because of the weather conditions it was difficult to obtain a good visible description of the stack plume.

The sampling train was disassembled and all of the test equipment was removed from the test site. Back at the motel the sample transfer and analyses were performed. The Scott team traveled home on Friday.

Figure F-1 illustrates the test program schedule.

FIGURE F-1 SUMMARY OF TEST PROGRAM



SCOTT RESEARCH LABORATORIES, INC.

APPENDIX G

PROJECT PARTICIPANTS AND TITLES

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PROJECT PARTICIPANTS AND TITLES

The personnel taking part in the project include:

Thomas Ward	Project Officer - EPA
Charles Sedman	Project Engineer - EPA
Larry Jones	Project Engineer - EPA
Norman Troxel	Senior Engineer - SRL
Joseph Wilson	Field Team Leader - SRL
Jyotin Sachdev	Engineer - SRL
William Scott	Technician - SRL
Zenophon Tomaras	Chemist - SRL
Margaret Husic	Technician - SRL
Louis Reckner	Manager, Atmospheric Chemistry & Industrial Emissions Dept.