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Title: **Air Pollution Emission Test**

Bunge Corporation
Destrehan, LA

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AIR POLLUTION EMISSION TEST

BUNGE CORPORATION
(PLANT NAME)

Destrehan, Louisiana
(PLANT ADDRESS)

U. S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Water Programs
Office of Air Quality Planning and Standards
Emission Standards and Engineering Division

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Emission Testing Report
EMB Test No.: 74-GRN-7

BUNGE CORPORATION

Destrehan, Louisiana

Project Officer
Roger O. Pfaff

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

January 1974

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INTRODUCTION

Under the Clean Air Act, as amended, the Environmental Protection Agency is responsible for establishing Federal performance standards for new stationary sources which contribute significantly to air pollution or cause or contribute to the endangerment of public health or welfare. Grain handling facilities have been included among those sources.

The Office of Air Quality Planning and Standards establishes performance standards from emission data gathered from the best demonstrated emission control systems. Source testing firms under contract to the Emission Measurement Branch perform source tests at facilities determined to be among those best controlled.

The barge unloading facility at the Bunge Corporation grain elevator in Destrehan, Louisiana was tested for particulate and particle size. Battelle Memorial Institute conducted three particulate tests at the inlet and outlet of the control system from October 29 to October 31, 1973. Two particle size tests were run at the outlet.

The control system is a Carter Day 144RJ96 filter.

DISCUSSION OF RESULTS

Visual inspection of test filters from the outlet particulate tests showed some large particles, indicative of a bag failure in the control system. The bags were old, giving further support to this possibility. Also, the average grain loading at the outlet of 0.0261 gr/DSCF is higher than expected. Emission rates averaged 8.40 lbs/hr.

Inlet emission rates averaged 1,956 lbs/hr. However, a percent isokinetic of 19.5 for Run #1 may have caused the result for Run #1 to be higher than the actual value. The low isokinetics were caused by an inability to pull the required sample rate. A larger nozzle than normally required was used because the high grain loading plugged up smaller nozzles. On Runs #2 and #3, the plugging problem did not occur, and the smaller nozzle was used.

Use Runs #2 & 3 only!

In the particle size tests, the filter was not weighed, eliminating one size cut. The probe and cyclone rinse in Run #1 was destroyed, so the value reported is estimated from Run #2.

Bhouse Inlet

Inlet

Run Number	1	2	3	Average
Date	10-30-73	10-30-73	10-31-73	
Volume of Gas Sampled - DSCF[a]	45.97	72.68	146.93	
Percent Moisture by Volume	0.9	1.0	0.9	
Average Stack Temperature - °F	66.9	69.4	72.1	
Stack Volumetric Flow Rate - DSCFM[b]	37,684	37,985	39,101	38,257
Stack Volumetric Flow Rate - ACFM[c]	38,234	38,957	40,539	39,244
Percent Isokinetic	19.5	92.4	90.7	
Particulates - probe, cyclone, and filter catch				
mg	7,364.0	40,148.0	65,483.0	37,665.0
gr/DSCF	2.47	8.51	6.86	5.95
gr/ACF	2.43	8.29	6.62	5.78
lb/hr	797	2,770	2,300	1,956
Particulates - total catch				
mg	7,371.5	40,152.5	65,486.5	37,670.2
gr/DSCF	2.47	8.51	6.86	5.95
gr/ACF	2.43	8.29	6.62	5.78
lb/hr	798	2,770	2,300	1,956
Percent impinger catch	0.1	0.0	0.0	0.0

[a] Dry standard cubic feet at 70°F, 29.92 in. Hg.

[b] Dry standard cubic feet per minute at 70°F, 29.92 in. Hg.

[c] [illegible] cubic feet per minute

Run Number	1	2	3	Average
Date	10-30-73	10-30-73	10-31-73	
Volume of Gas Sampled - $\underline{Nm}^3$ [a]	1.30	2.06	4.16	
Percent Moisture by Volume	0.9	1.0	0.9	
Average Stack Temperature - °C	19.4	20.8	22.3	
Stack Volumetric Flow Rate - $\underline{Nm}^3$/min. [b]	1067	1076	1107	1083
Stack Volumetric Flow Rate - $\bar{m}^3$/min. [c]	1083	1103	1148	1111
Percent Isokinetic	19.5	92.4	90.7	
Particulates - probe, cyclone, and filter catch				
mg	7,364.0	40,148.0	65,483.0	37,665.0
mg/$\underline{Nm}^3$	5,645	19,466	15,706	13,606
mg/$\bar{m}^3$	5,561	18,970	15,140	13,224
kg/hr	361	1,256	1,043	887
Particulates - total catch				
mg	7,371.5	40,152.5	65,486.5	37,670.2
mg/$\underline{Nm}^3$	5,651	19,469	15,707	13,609
mg/$\bar{m}^3$	5,566	18,972	15,141	13,226
kg/hr	362	1,256	1,043	887
Percent impinger catch	0.1	0.0	0.0	0.0

[a] Dry normal cubic meter at 21.1°C, 760mm Hg.

[b] Dry normal cubic meters per minute at 21.1°C, 760mm Hg.

[c] Actual cubic meters per minute

Bhouse Outlet

Run Number	1	2	3	Average
Date	10-30-73	10-30-73	10-31-73	
Volume of Gas Sampled - DSCF[a]	84.00	92.53	95.04	
Percent Moisture by Volume	0.8	0.5	1.1	
Average Stack Temperature - °F	68.8	84.8	84.6	
Stack Volumetric Flow Rate - DSCFM[b]	36,160	37,752	38,751	37,554
Stack Volumetric Flow Rate - ACFM[c]	36,196	39,004	40,533	38,578
Percent Isokinetic	93.5	98.7	98.7	97.0

Particulates - probe, cyclone, and filter catch

	1	2	3	Average
mg	115.5	604.5	135.0	151.7
gr/DSCF	0.0212	0.0340	0.0219	0.0257
gr/ACF	0.0211	0.0329	0.0209	0.0250
lb/hr	6.56	11.01	7.27	8.28

Particulates - total catch

	1	2	3	Average
mg	117.0	207.0	137.5	153.8
gr/DSCF	0.0214	0.0344	0.0223	0.0261
gr/ACF	0.0214	0.0333	0.0213	0.0253
lb/hr	6.65	11.15	7.40	8.40
Percent impinger catch	1.3	1.2	1.8	1.4

---

[a] Dry standard cubic feet at 70°F, 29.92 in. Hg.

[b] Dry standard cubic feet per minute at 70°F, 29.92 in. Hg.

... feet per minute

Run Number	1	2	3	Average
Date	10-30-73	10-30-73	10-31-73	
Volume of Gas Sampled - Nm^3 (a)	2.38	2.62	2.69	
Percent Moisture by Volume	0.8	0.5	1.1	
Average Stack Temperature - °C	20.4	29.3	29.2	
Stack Volumetric Flow Rate - Nm^3/min. (b)	1024	1069	1097	1063
Stack Volumetric Flow Rate - m^3/min. (c)	1025	1104	1148	1092
Percent Isokinetic	93.5	98.7	98.7	97.0

Particulates - probe, cyclone, and filter catch				
mg	115.5	604.5	135.0	151.7
mg/Nm^3	48.5	77.9	50.1	58.8
mg/m^3	48.4	75.3	47.8	57.2
kg/hr	2.98	5.00	3.30	3.76

Particulates - total catch				
mg	117.0	207.0	137.5	153.8
mg/Nm^3	49.1	78.8	51.0	59.6
mg/m^3	49.0	76.3	48.7	58.0
kg/hr	3.02	5.06	3.36	3.81
Percent impinger catch	1.3	1.2	1.8	1.4

[a] Dry normal cubic meter at 21.1°C, 760mm Hg.

[b] Dry normal cubic meters per minute at 21.1°C, 760mm Hg.

[c] Actual cubic meters per minute

Particle Size Results

Run 1

Stage	Characteristic Diameter, Dn µm	µg	Weight Percent	Cumulative Weight Percent, <Dn
Probe & cyclone		22,450		
1	3.14	1,480	71.5	28.5
2	1.63	190	9.2	19.3
3	1.10	210	10.1	9.2
4	0.57	120	5.8	3.4
5	0.33	70	3.4	
	TOTAL	2,070		

Run 2

Stage	Characteristic Diameter, Dn µm	µg	Weight Percent	Cumulative Weight Percent, <Dn
Probe & cyclone		44,900		
1	3.14	1,260	87.5	12.6
2	1.63	90	6.3	6.3
3	1.10	30	2.1	4.2
4	0.57	40	2.8	1.4
5	0.33	20	1.4	
	TOTAL	1,440		

Barges full of grain are brought down the Mississippi River from Minnesota, Illinois, Iowa, Missouri, etc. The barges are "staged" or anchored in groups along the river near the Bunge grain elevator. A barge is brought into the elevators' receiving "slip" according to its location in the staging area and the available storage space in the elevator for the particular grain in the barge. The covers are removed from the barge and the "marine leg" is lowered into the front end. The "marine leg" is a group of four bucket elevators which are lowered into the barge and lift the grain out.

The leg burrows its way to the bottom of the barge. Steel guards protect the buckets by holding them about one-foot above the bottom. The barge is pulled forward slowly to feed the grain into the leg. After about 1/4 of the grain has been removed, a front-end loader is lowered into the barge to scrape the remaining grain into the leg. This process generates a significant amount of fugitive dust.

When the barge is about 3/4 empty, the Longshore men begin replacing the covers. After the marine leg has removed all the grain it can, it is lifted out of the barge and a pneumatic suction system removes the last portion of grain. The front-end loader is lifted out of the barge and the remaining covers are replaced.

The buckets of the marine leg discharge the grain which continuously feeds it onto a conveyor belt. Two short conveyors transfer the grain to the final conveyor which carries it from the levee to the elevator. The leg and the two short conveyors plus the control system ducts, raise and lower several feet in and out of the barge. The leg is entirely enclosed except for the bottom five feet where the grain enters. Metal plates covered portions of this area at the time of the presurvey in March, 1973. The primary point of emission from the leg is at the back where the empty buckets emerge from the enclosure. The buckets act as the blades of a fan which suck dust and air from the surge bin.

The control system aspirates dust from the front and back of the leg, the surge bin, and the conveyor transfer points. The belt conveyors are covered to protect the grain from the wind and weather.

Equipment Tested

Carter Day 144RJ96 filter
39000 cfm
6" ΔP water gauge
19 oz Dacron felt bags
A/C ratio 13/1

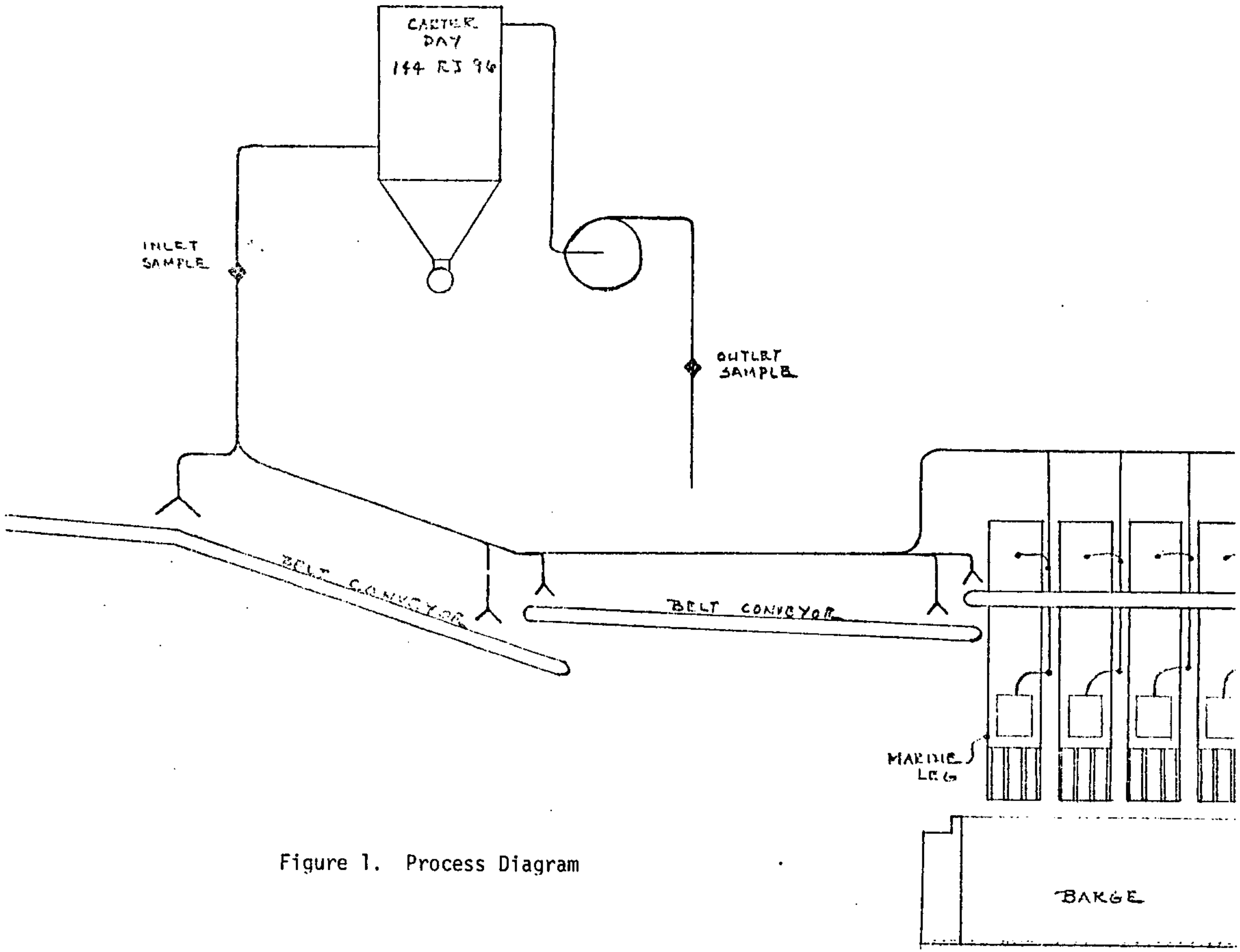

Figure 1. Process Diagram

PROCESS OPERATION

Three particulate emission test runs were conducted in accordance with EPA Method 5 at the filter inlet and outlet. Particle size classification tests were conducted with a Brinks Impactor at the filter inlet and outlet, also.

Test Run #1 was conducted on October 30, 1973 between 11:14 a.m. and 2:53 p.m. Two complete barges and a portion of the third barge were unloaded during the test. The leg operated about 45 minutes in each barge.

Visible emissions of fugitive dust from the barge were read continuously from 11:16 a.m. to 12:15 p.m. while #2 yellow soybeans with 1.0 percent foreign matter were unloaded. Visible emissions of 0 to 10 percent opacity were read during the first 16 minutes when the leg operated in the barge alone. Visible emissions of 5 percent to 20 percent opacity were read while the leg and front-end loader operated in the barge. Visible emissions of 100 percent opacity were read during a period when the filter was not operating.

No visible emissions were seen coming from the filter exhaust which was observed continuously between 1:00 p.m. and 2:45 p.m.

The start of the second test run was delayed due to a breakdown in the elevator's conveying and distribution system.

Test Run #2 was conducted on October 30, 1973 between 5:40 p.m. and 9:03 p.m. Two complete barges and a portion of the third barge were unloaded during the test. No visible emission readings were made since only artificial light illuminated the site.

Mr. Pfaff, noted that large beeswing type particles were being caught by the sampler at the filter outlet, indicating a torn or loose bag in the filter. Since it was anticipated that the third test run could be completed early on the 31st, it was decided to proceed with the test schedule.

Test Run #3 was conducted on October 31, 1973 between 10:20 a.m. and 1:46 p.m. Two complete barges and a portion of the third barge were unloaded during the test.

Visible emissions of fugitive dust from the barge were read continuously from 10:29 a.m. to 11:15 a.m. while yellow corn with 4.7 percent foreign material was unloaded. Strong westerly winds blew across the area resulting in visible emissions of 10 percent to 100 percent opacity throughout the test. The filter outlet was observed between 11:40 and 12:37 p.m. Under direct sunlight, emissions of 5 percent opacity could be seen, however, no emissions were visible under the diffuse light when clouds blocked the sun. Visible emissions from the barge were observed again from 1:30 p.m. to 1:46 p.m. when the test was completed. Yellow soybeans with 0.7 percent foreign material were unloaded during this period and emissions of 10 percent to 40 percent opacity were observed. The wind was strong at this time, also.

LOCATION OF SAMPLING POINTS

Distance to nearest upstream disturbance: 19 feet
Type of disturbance: Bend

Distance to nearest downstream disturbance: 7 feet
Type of disturbance: Bend

Diameter of duct: 40 inches
Number of traverse points: 24

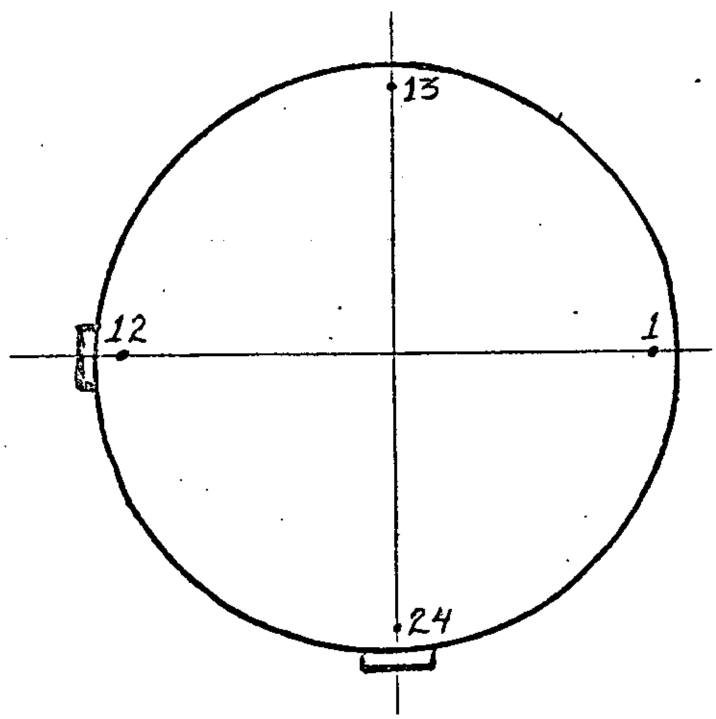

Figure 2. Inlet to Baghouse

Distance to nearest upstream
Type of disturbance: Bend

Distance to nearest downstream disturbance: 6.5 feet
Type of disturbance: End of duct

Diameter of duct: 40 inches
Number of traverse points: 12

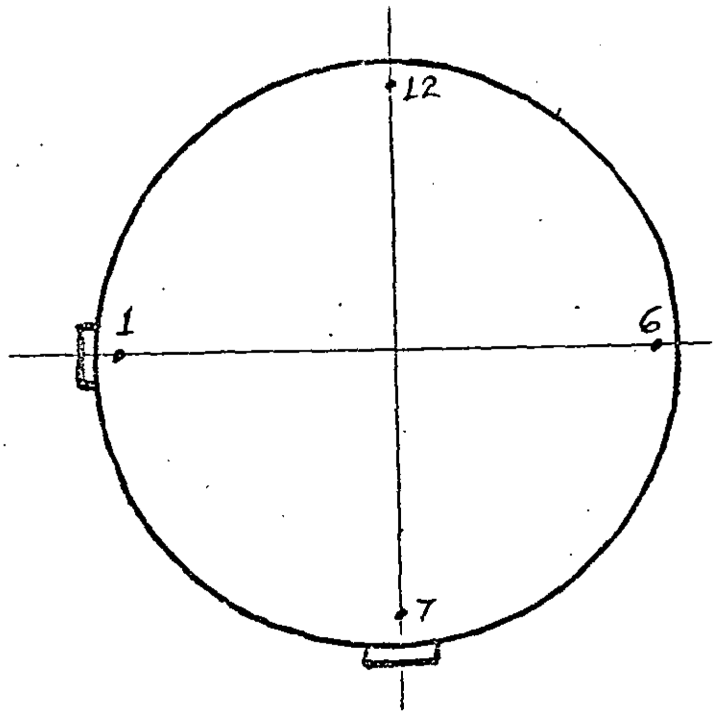

Figure 3. Outlet to Baghouse

SAMPLING AND ANALYTICAL PROCEDURES

Particulate samples were taken and analyzed according to Method 5 of the August 17, 1971, Federal Register. The probe in the outlet train was not heated in Run #2 and the last half of Run #1.

Particle size samples were taken with a Brinks Model B Cascade Impactor. Details are in the Appendix.

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APPENDIX A

Complete Particulate Results and Sample Calculations

1. Volume of dry gas sampled at standard conditions[a], DSCF

$$V_{m_{std}} = \frac{17.7 \times V_m \left(P_b + \frac{P_m}{13.6}\right)}{(T_m + 460)} = \frac{17.7 \times 87.62 \left(\quad + \frac{1.68}{13.6}\right)}{(96.7+460)} = 83.95 \text{ DSCF}$$

2. Volume of water vapor at standard conditions[b], SCF

$$V_{w_{gas}} = 0.0474 \times V_w = 0.0474 \times 14.9 = 0.71 \text{ SCF}$$

3. Percent moisture in stack gas

$$\% M = \frac{100 \times V_{w_{gas}}}{V_{m_{std}} + V_{w_{gas}}} = \frac{100 \times 0.71}{83.95 + 0.71} = 0.84$$

4. Mole fraction of dry gas

$$M_d = \frac{100 - \% M}{100} = \frac{100 - 0.84}{100} = 0.992$$

5. Molecular weight of dry stack gas

$$MW_d = \left(\%CO_2 \times \frac{44}{100}\right) + \left(\%O_2 \times \frac{32}{100}\right) + \left[\left(\%CO + \%N_2\right) \times \frac{28}{100}\right] =$$

$$\left(0.0 \times \frac{44}{100}\right) + \left(21.0 \times \frac{32}{100}\right) + \left(79.0 \times \frac{28}{100}\right) = 28.84$$

6. Molecular weight of wet stack gas

$$MW = MW_d \times M_d + 18\ (1 - M_d) = 28.84 \times 0.992 + 18\ (1 - 0.992) = 28.75$$

7. Stack gas velocity at stack conditions, fpm[c]

$$V_s = 5128.8 \times Cp \times \sqrt{\Delta P_s \times (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2} =$$

$$5128.8 \times 0.85 \times 27.98 \left[\frac{1}{30.08 \times 28.75}\right]^{1/2} = 4148 \text{ fpm}$$

8. Stack gas volumetric flow rate at standard conditions[d], DSCFM

$$Q_s = \frac{0.123 \times V_s \times A_s \times M_d \times P_s}{(T_s + 460)} = \frac{0.123 \times 4148 \times 1257 \times 0.992 \times 30.08}{(68.8 + 460)} = 36{,}189 \text{ DSCFM}$$

9. Stack gas volumetric flow rate at stack conditions, ACFM

$$Q_a = \frac{.05645 \times Q_s\ (T_s + 460)}{P_s \times M_d} = \frac{.05645 \times 36189\ (68.8 + 460)}{30.08 \times 0.992} = 36{,}203 \text{ ACFM}$$

10. Percent isokinetic

$$\%I = \frac{1{,}032 \times (T_s + 460) \times V_{m_{std}}}{V_s \times T_t \times P_s \times M_d \times (D_n)^2} = \frac{1{,}032 \times (68.8 + 460) \times 83.95}{4148 \times 120 \times 30.08 \times 0.992 \times (0.182)^2} = 93.1$$

11. Particulate - probe, cyclone, and filter, gr/DSCF

$$C_{an} = 0.0154 \times \frac{m_f}{V_{m_{std}}} = 0.0154 \times \frac{115.5}{83.95} = 0.0212 \text{ gr/DSCF}$$

12. Particulate - total, gr/DSCF

$$C_{ao} = 0.0154 \times \frac{m_t}{V_{m_{std}}} = 0.0154 \times \frac{117.0}{83.95} = 0.0215 \text{ gr/DSCF}$$

13. Particulate - probe, cyclone, and filter at stack conditions, gr/ACF

$$C_{at} = \frac{17.7 \times C_{an} \times P_s \times M_d}{(T_s + 460)} = \frac{17.7 \times 0.0212 \times 30.08 \times 0.992}{(68.8 + 460)} = 0.0212 \text{ gr/ACF}$$

14. Particulate - total at stack conditions, gr/ACF

$$C_{aw} = \frac{17.7 \times C_{ao} \times P_s \times M_d}{(T_s + 460)} = \frac{17.7 \times 0.0215 \times 30.08 \times 0.992}{(68.8 + 460)} = 0.0215 \text{ gr/ACF}$$

15. Particulate - probe, cyclone, and filter, lb/hr

$$C_{aw} = 0.00857 \times C_{an} \times Q_s = 0.00857 \times 0.0212 \times 36{,}189 = 6.57 \text{ lb/hr}$$

16. Particulate - total, lb/hr

$$C_{ax} = 0.00857 \times C_{ao} \times Q_s = 0.00857 \times 0.0215 \times 36{,}189 = 6.67 \text{ lb/hr}$$

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[a] Dry standard cubic feet at 70°F, 29.92 in. Hg.

[b] Standard conditions at 70°F, 29.92 in. Hg.

[c] $\sqrt{\Delta P_s \times (T_s + 460)}$ is determined by averaging the square root of the product of the velocity head (ΔPs) and the absolute stack temperature from each sampling point.

[d] Dry standard cubic feet per minute at 70°F, 29.92 in. Hg.

Inlet

DESCRIPTION	UNITS	1	2	3	Average
DATE OF RUN		10-30-73	10-31-73	10-31-73	
STACK AREA	FT2	8.726	8.726	8.726	
NET TIME OF RUN	MIN	60.0	60.0	120.0	
BAROMETRIC PRESSURE	IN.HG	30.01	29.85	29.65	
AVG ORIFICE PRES DROP	IN.H2O	1.700	4.490	4.660	
VOL DRY GAS-METER COND	DCF	46.99	71.99	148.29	
AVG GAS METER TEMP	DEG.F	85.5	69.4	76.1	
VOL DRY GAS-STD COND	DSCF	45.97	72.68	146.93	
TOTAL H2O COLLECTED	ML	8.8	14.9	26.8	
VOL H2O VAPOR-STD COND	SCF	0.42	0.71	1.27	
PERCENT MOISTURE BY VOL		0.9	1.0	0.9	
MOLE FRACTION DRY GAS		0.991	0.990	0.991	
MOLECULAR WT-DRY STK GAS		28.84	28.84	28.84	
MOLECULAR WT-STK GAS		28.74	28.74	28.75	
AVG STACK TEMPERATURE	DEG.F	66.9	69.4	72.1	
STACK PRESSURE, ABSOLUTE	IN.HG	29.59	29.43	29.23	
AVG STACK GAS VELOCITY	FPS	73.024	74.405	77.427	74.952
STK FLOWRATE, DRY, STD CN	DSCFM	37684.	37985.	39101.	38257.
ACTUAL STACK FLOWRATE	ACFM	38234.	38957.	40539.	39244.
PERCENT ISOKINETIC		19.5	92.4	90.7	67.6
PARTICULATE WT-PARTIAL	MG	7364.00	40148.00	65483.00	37664.99
PARTICULATE WT-TOTAL	MG	7371.50	40152.50	65486.50	37670.16
PERC IMPINGER CATCH		0.1	0.0	0.0	0.0
PART. LOAD-PTL, STD CN	GR/DSCF	2.46680	8.50661	6.86339	5.94560
PART. LOAD-TTL, STD CN	GR/DSCF	2.46932	8.50757	6.86376	5.94688
PART. LOAD-PTL, STK CN	GR/ACF	2.42997	8.28965	6.61620	5.77861
PART. LOAD-TTL, STK CN	GR/ACF	2.43245	8.29058	6.61655	5.77986
PARTIC EMIS-PARTIAL	LB/HR	796.81	2769.66	2300.31	1955.59
PARTIC EMIS-TOTAL	LB/HR	797.62	2769.97	2300.43	1956.01

Outlet

DESCRIPTION	UNITS	1	2	3	Average
DATE OF RUN		10-30-73	10-30-73	10-31-73	
STACK AREA	FT2	8.726	8.726	8.726	
NET TIME OF RUN	MIN	120.0	120.0	120.0	
BAROMETRIC PRESSURE	IN.HG	30.01	29.85	29.65	
AVG ORIFICE PRES DROP	IN.H2O	1.680	1.880	2.010	
VOL DRY GAS-METER COND	DCF	87.62	93.72	96.89	
AVG GAS METER TEMP	DEG.F	96.7	77.9	78.0	
VOL DRY GAS-STD COND	DSCF	84.00	92.53	95.04	
TOTAL H2O COLLECTED	ML	14.9	9.5	21.9	
VOL H2O VAPOR-STD COND	SCF	0.71	0.45	1.04	
PERCENT MOISTURE BY VOL		0.8	0.5	1.1	
MOLE FRACTION DRY GAS		0.992	0.995	0.989	
MOLECULAR WT-DRY STK GAS		28.84	28.84	28.84	
MOLECULAR WT-STK GAS		28.75	28.79	28.72	
AVG STACK TEMPERATURE	DEG.F	68.8	84.8	84.6	
STACK PRESSURE, ABSOLUTE	IN.HG	30.08	29.92	29.72	
AVG STACK GAS VELOCITY	FPS	69.132	74.494	77.415	73.680
STK FLOWRATE, DRY, STD CN	DSCFM	36160.	37752.	38751.	37554.
ACTUAL STACK FLOWRATE	ACFM	36196.	39004.	40533.	38578.
PERCENT ISOKINETIC		93.5	98.7	98.7	97.0
PARTICULATE WT-PARTIAL	MG	115.50	2 604.50	135.00	151.67
PARTICULATE WT-TOTAL	MG	117.00	207.00	137.50	153.83
PERC IMPINGER CATCH		1.3	1.2	1.8	1.4
PART. LOAD-PTL, STD CN	GR/DSCF	0.02118	0.03403	0.02188	0.02570
PART. LOAD-TTL, STD CN	GR/DSCF	0.02145	0.03445	0.02228	0.02606
PART. LOAD-PTL, STK CN	GR/ACF	0.02114	0.03292	0.02090	0.02499
PART. LOAD-TTL, STK CN	GR/ACF	0.02142	0.03333	0.02129	0.02534
PARTIC EMIS-PARTIAL	LB/HR	6.56	11.01	7.27	8.28
PARTIC EMIS-TOTAL	LB/HR	6.65	11.15	7.40	8.40

Inlet

DESCRIPTION	UNITS	1	2	3	Average
DATE OF RUN		10-30-73	10-30-73	10-31-73	
STACK AREA	M2	0.811	0.811	0.811	
NET TIME OF RUN	MIN	60.0	60.0	120.0	
BAROMETRIC PRESSURE	MM.HG	762.25	758.19	753.11	
AVG ORIFICE PRES DROP	MM.H2O	43.180	114.046	118.364	
VOL DRY GAS-METER CN	DM3	1.33	2.04	4.20	
AVG GAS METER TEMP	DEG.C	29.7	20.8	24.5	
VOL DRY GAS-STD COND	DNM3	1.30	2.06	4.16	
TOTAL H2O COLLECTED	ML	8.8	14.9	26.8	
VOL H2O VAPOR-STD COND	NM3	0.01	0.02	0.04	
PERCENT MOISTURE BY VOL		0.9	1.0	0.9	
MOLE FRACTION DRY GAS		0.991	0.990	0.991	
MOLECULAR WT-DRY STK GAS		28.84	28.84	28.84	
MOLECULAR WT-STK GAS		28.74	28.74	28.75	
AVG STACK TEMPERATURE	DEG.C	19.4	20.8	22.3	
STACK PRESSURE, ABSOLUTE	MM.HG	751.59	747.52	742.44	
AVG STACK GAS VELOCITY	M/S	22.258	22.679	23.600	22.845
STK FLOWRATE, DRY, STD CN	DNM3/M	1067.	1076.	1107.	1083.
ACTUAL STACK FLOWRATE	AM3/M	1083.	1103.	1148.	1111.
PERCENT ISOKINETIC		19.5	92.4	90.7	67.6
PARTICULATE WT-PARTIAL	MG	7364.00	40148.00	65483.00	37664.99
PARTICULATE WT-TOTAL	MG	7371.50	40152.50	65486.50	37670.16
PERCE IMPINGER CATCH		0.1	0.0	0.0	0.0
PART. LOAD-PTL, STD CN	MG/NM3	5644.98	19466.34	15706.02	13605.78
PART. LOAD-TTL, STD CN	MG/NM3	5650.73	19468.52	15706.86	13608.70
PART. LOAD-PTL, STK CN	MG/AM3	5560.70	18969.85	15140.36	13223.63
PART. LOAD-TTL, STK CN	MG/AM3	5566.36	18971.97	15141.17	13226.50
PARTIC EMIS-PARTIAL	KG/HR	361.43	1256.32	1043.42	887.06
PARTIC EMIS-TOTAL	KG/HR	361.80	1256.46	1043.48	887.25

Outlet

DESCRIPTION	UNITS	1	2	3	Average
DATE OF RUN		10-30-73	10-30-73	10-31-73	
STACK AREA	M2	0.811	0.811	0.811	
NET TIME OF RUN	MIN	120.0	120.0	120.0	
BAROMETRIC PRESSURE	MM.HG	762.25	758.19	753.11	
AVG ORIFICE PRES DROP	MM.H2O	42.672	47.752	51.054	
VOL DRY GAS-METER CN	DM3	2.48	2.65	2.74	
AVG GAS METER TEMP	DEG.C	35.9	25.5	65.6	
VOL DRY GAS-STD COND	DNM3	2.38	2.62	2.69	
TOTAL H2O COLLECTED	ML	14.9	9.5	21.9	
VOL H2O VAPOR-STD COND	NM3	0.02	0.01	0.03	
PERCENT MOISTURE BY VOL		0.8	0.5	1.1	
MOLE FRACTION DRY GAS		0.992	0.995	0.989	
MOLECULAR WT-DRY STK GAS		28.84	28.84	28.84	
MOLECULAR WT-STK GAS		28.75	28.79	28.72	
AVG STACK TEMPERATURE	DEG.C	20.4	29.3	29.2	
STACK PRESSURE, ABSOLUTE	MM.HG	764.03	759.97	754.89	
AVG STACK GAS VELOCITY	M/S	21.071	22.706	23.596	22.458
STK FLOWRATE, DRY, STD CN	DNM3/M	1024.	1069.	1097.	1063.
ACTUAL STACK FLOWRATE	AM3/M	1025.	1104.	1148.	1092.
PERCENT ISOKINETIC		93.5	98.7	98.7	97.0
PARTICULATE WT-PARTIAL	MG	115.50	604.50	135.00	151.67
PARTICULATE WT-TOTAL	MG	117.00	207.00	137.50	153.83
PERCE IMPINGER CATCH		1.3	1.2	1.8	1.4
PART. LOAD-PTL, STD CN	MG/NM3	48.46	77.88	50.06	58.80
PART. LOAD-TTL, STD CN	MG/NM3	49.09	78.83	50.99	59.64
PART. LOAD-PTL, STK CN	MG/AM3	48.38	75.34	47.83	57.19
PART. LOAD-TTL, STK CN	MG/AM3	49.01	76.26	48.72	58.00
PARTIC EMIS-PARTIAL	KG/HR	2.98	5.00	3.30	3.76
PARTIC EMIS-TOTAL	KG/HR	3.02	5.06	3.36	3.81

APPENDIX B

Complete Particle Size Results and Sample Calculations

TABLE I. NOMOGRAPH DATA

PLANT Bunge

DATE 10-30-73

SAMPLING LOCATION OUTLET

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.72
AVERAGE METER TEMPERATURE (AMBIENT + 20°F), °F	$T_{m_{avg.}}$	90
PERCENT MOISTURE IN GAS STREAM BY VOLUME, estimated	B_{wo}	0
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	29.85
STATIC PRESSURE IN STACK, in. Hg (P_m ± 0.073 x STACK GAUGE PRESSURE in in. H_2O)	P_s	29.85 -0.51 29.34
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	0.98 ~~1.0~~
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	70
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	1.80
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	2.05
C FACTOR		.94
CALCULATED NOZZLE DIAMETER, in.		.188
ACTUAL NOZZLE DIAMETER, in.		.182
		. /

Md = mole fraction of dry gas

$$= \frac{100 - \% M}{100} = \frac{100 - 0}{100} = 1$$

MWd = mole weight of dry stack gas

$$= CO_2\ (0.44) + O_2\ (.32) + N_2 + CO\ (0.28)$$

$$= 0 + 21.8\ (0.32) + 78.2\ (0.28)$$

$$= 28.87$$

MW = mole weight of stack gas

$$= MWd \times Md + 18\ (1 - Md)$$

$$= 28.87\ (1.0) + 18\ (1 - 1)$$

$$= 28.87$$

V_s = stack gas velocity at stack conditions, fps

$$= 72.5 \sqrt{\frac{\Delta pS\ (T_s + 460)}{P_s\ (MW)}}$$

$$= 72.4 \sqrt{\frac{1.80\ (70 + 460)}{29.24\ (28.87)}}$$

$$= 77 \text{ fps}$$

states that from the probe selection chart, which I have labeled Figure 1, a nozzle diameter must be selected which will give the calculated isokinetic sampling velocity (77 fps) at 0.1 to 0.15 cfm. The 2-mm nozzle was the only selection available. It was necessary to maintain 0.155 cfm in order to maintain 77 fps at the nozzle. After selecting the 2 mm nozzle, paragraph 5 of page 4 requires that, from the calibration curve for "Brinks Model B Cascade Impactor" Figure 2, you are to determine the Δp (in. H_g) which will give the selected flow rate of 0.155 cfm. Extrapolation of the curve shows approximately 17 in. H_g Δp was necessary to obtain 0.155 cfm. Sampling was accomplished using these values and the following calculations, based on a reprint supplied by Monsanto Enviro-Chem, were used to determine the characteristic diameter under the existing sampling condition.

Calculations for Stage 1 Characteristic Diameter

$$Dpc = \frac{-15.3\ \mu}{\sqrt{g_c \rho P_2}} + \sqrt{\frac{234\ \mu^2}{g_c \rho P_2} + \frac{2.05 \times 10^8\ \mu D_c^3\ P_2}{\rho_p V_o P_o}}$$

$$= \frac{-15.3(1.81 \times 10^{-4})}{\sqrt{1.18 \times 10^{-3}}} + \sqrt{\frac{234(1.81 \times 10^{-4})^2}{1.18 \times 10^{-3}} + \frac{2.05 \times 10^8 (1.81 \times 10^{-4})(0.249)^3(1.03)}{70(0.98)}}$$

$$= \frac{-28.14 \times 10^{-4}}{0.344 \times 10^{-1}} + \sqrt{\frac{792 \times 10^{-8}}{1.18 \times 10^{-3}} + \frac{5.88 \times 10^2}{68.6}}$$

$$= -79.29 \times 10^{-3} + \sqrt{6.71 \times 10^{-3} + 8.57}$$

$$= -0.08 + 2.93$$

$$Dpc = 2.85\ \mu$$

It was assumed that the size distribution for each stage would be proportional to the existing calculated sizes supplied in Table II of the reprint; therefore the characteristic diameter for stage 1 was computed using the supplied equation and the following calculations were made to determine characteristic-diameters for remaining stages.

Proportioning Table II

If Dpc from Table II = 3.14 for Jet #1

then $\frac{2.85^{*}}{3.14}$ x 1.63 for Jet #2 = 1.48 μ

0.91 x 1.10 for Jet #3 = 1.00 μ

0.91 x 0.57 for Jet #4 = 0.52 μ

0.91 x 0.33 for Jet #5 = 0.30 μ

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* Ratio of characteristic diameter calculated for Stage 1 to characteristic diameter for Stage 1 from Table II of reprint.

$D_c = 0.249$ cm

$P_o = 29.34/29.92 = 0.98$ atm

$P_2 = P_o$ (assumed)

$V_o = 0.15 \times 28.32 \times 10^3\ cm^3 \times 60\ sec = \frac{70\ cm^3}{sec}$

$\rho = 1.205 \times 10^{-3}\ gm/cm^3$

$\rho_p = 1\ gm/cm^3$ (assumed)

$\mu = 1.81 \times 10^{-4}\ gm/cm^3$

T_s = average stack-gas temperature, F

Δps = average pressure head, inches H_2O

P_s = average stack pressure, inches Hg

Dpc = characteristic particle diameter for impactor stage, micron

APPENDIX A

Complete Particulate Results and Sample Calculations

Sample Calculations

Run 1 - Outlet

1. Volume of dry gas sampled at standard conditions[a], DSCF

$$V_{m_{std}} = \frac{17.7 \times V_m \left(P_b + \frac{P_m}{13.6}\right)}{(T_m + 460)} = \frac{17.7 \times 87.62 \qquad \frac{1.68}{13.6})}{(\ 96.7+460\ )} = 83.95 \text{ DSCF}$$

2. Volume of water vapor at standard conditions[b], SCF

$$V_{w_{gas}} = 0.0474 \times V_w = 0.0474 \times 14.9 = 0.71 \text{ SCF}$$

3. Percent moisture in stack gas

$$\% M = \frac{100 \times V_{w_{gas}}}{V_{m_{std}} + V_{w_{gas}}} = \frac{100 \quad \times \quad 0.71}{83.95 \quad + \quad 0.71} = 0.84$$

4. Mole fraction of dry gas

$$M_d = \frac{100 - \% M}{100} = \frac{100 - 0.84}{100} = 0.992$$

5. Molecular weight of dry stack gas

$$MW_d = (\%CO_2 \times \frac{44}{100}) + (\%O_2 \times \frac{32}{100}) + \left[(\%CO + \%N_2) \times \frac{28}{100} \right] =$$

$$(0.0 \times \frac{44}{100}) + (21.0 \times \frac{32}{100}) + (79.0 \times \frac{28}{100}) = 28.84$$

6. Molecular weight of wet stack gas

$$MW = MW_d \times M_d + 18\,(1 - M_d) = 28.84 \times 0.992 + 18\,(1 - 0.992) = 28.75$$

7. Stack gas velocity at stack conditions, fpm[c]

$$V_s = 5128.8 \times Cp \times \sqrt{\Delta P_s \times (T_s + 460)} \left[\frac{1}{P_s \times MW}\right]^{1/2} =$$

$$5128.8 \times 0.85 \times 27.98 \left[\frac{1}{30.08 \times 28.75}\right]^{1/2} = 4148 \text{ fpm}$$

8. Stack gas volumetric flow rate at standard conditions[d], DSCFM

$$Q_s = \frac{0.123 \times V_s \times A_s \times M_d \times P_s}{(T_s + 460)} = \frac{0.123 \times 4148 \times 1257 \times 0.992 \times 30.08}{(68.8 + 460)} = 36{,}189 \text{ DSCFM}$$

9. Stack gas volumetric flow rate at stack conditions, ACFM

$$Q_a = \frac{.05645 \times Q_s\,(T_s + 460)}{P_s \times M_d} = \frac{.05645 \times 36189\,(68.8 + 460)}{30.08 \times 0.992} = 36{,}203 \text{ ACFM}$$

10. Percent isokinetic

$$\%I = \frac{1{,}032 \times (T_s + 460) \times V_{m_{std}}}{V_s \times T_t \times P_s \times M_d \times (D_n)^2} = \frac{1{,}032 \times (68.8 + 460) \times 83.95}{4148 \times 120 \times 30.08 \times 0.992 \times (0.182)^2} = 93.1$$

11. Particulate - probe, cyclone, and filter, gr/DSCF

$$C_{an} = 0.0154 \times \frac{m_f}{V_{m_{std}}} = 0.0154 \times \frac{115.5}{83.95} = 0.0212 \text{ gr/DSCF}$$

12. Particulate - total, gr/DSCF

$$C_{ao} = 0.0154 \times \frac{m_t}{V_{m_{std}}} = 0.0154 \times \frac{117.0}{83.95} = 0.0215 \text{ gr/DSCF}$$

13. Particulate - probe, cyclone, and filter at stack conditions, gr/ACF

$$C_{at} = \frac{17.7 \times C_{an} \times P_s \times M_d}{(T_s + 460)} = \frac{17.7 \times 0.0212 \times 30.08 \times 0.992}{(68.8 + 460)} = 0.0212 \text{ gr/ACF}$$

14. Particulate - total at stack conditions, gr/ACF

$$C_{aw} = \frac{17.7 \times C_{ao} \times P_s \times M_d}{(T_s + 460)} = \frac{17.7 \times 0.0215 \times 30.08 \times 0.992}{(68.8 + 460)} = 0.0215 \text{ gr/ACF}$$

15. Particulate - probe, cyclone, and filter, lb/hr

$$C_{aw} = 0.00857 \times C_{an} \times Q_s = 0.00857 \times 0.0212 \times 36{,}189 = 6.57 \text{ lb/hr}$$

16. Particulate - total, lb/hr

$$C_{ax} = 0.00857 \times C_{ao} \times Q_s = 0.00857 \times 0.0215 \times 36{,}189 = 6.67 \text{ lb/hr}$$

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[a] Dry standard cubic feet at 70°F, 29.92 in. Hg.

[b] Standard conditions at 70°F, 29.92 in. Hg.

[c] $\sqrt{\Delta P_s \times (T_s + 460)}$ is determined by averaging the square root of the product of the velocity head (ΔPs) and the absolute stack temperature from each sampling point.

[d] Dry standard cubic feet per minute at 70°F, 29.92 in. Hg.

Particulate Summary in English Units

Inlet

DESCRIPTION	UNITS	1	2	3	Average
DATE OF RUN		10-30-73	10-31-73	10-31-73	
STACK AREA	FT2	8.726	8.726	8.726	
NET TIME OF RUN	MIN	60.0	60.0	120.0	
BAROMETRIC PRESSURE	IN.HG	30.01	29.85	29.65	
AVG ORIFICE PRES DROP	IN.H2O	1.700	4.490	4.660	
VOL DRY GAS-METER COND	DCF	46.99	71.99	148.29	
AVG GAS METER TEMP	DEG.F	85.5	69.4	76.1	
VOL DRY GAS-STD COND	DSCF	45.97	72.68	146.93	
TOTAL H2O COLLECTED	ML	8.8	14.9	26.8	
VOL H2O VAPOR-STD COND	SCF	0.42	0.71	1.27	
PERCENT MOISTURE BY VOL		0.9	1.0	0.9	
MOLE FRACTION DRY GAS		0.991	0.990	0.991	
MOLECULAR WT-DRY STK GAS		28.84	28.84	28.84	
MOLECULAR WT-STK GAS		28.74	28.74	28.75	
AVG STACK TEMPERATURE	DEG.F	66.9	69.4	72.1	
STACK PRESSURE, ABSOLUTE	IN.HG	29.59	29.43	29.23	
AVG STACK GAS VELOCITY	FPS	73.024	74.405	77.427	74.952
STK FLOWRATE, DRY, STD CN	DSCFM	37684.	37985.	39101.	38257.
ACTUAL STACK FLOWRATE	ACFM	38234.	38957.	40539.	39244.
PERCENT ISOKINETIC		19.5	92.4	90.7	67.6
PARTICULATE WT-PARTIAL	MG	7364.00	40148.00	65483.00	37664.99
PARTICULATE WT-TOTAL	MG	7371.50	40152.50	65486.50	37670.16
PERC IMPINGER CATCH		0.1	0.0	0.0	0.0
PART. LOAD-PTL, STD CN	GR/DSCF	2.46680	8.50661	6.86339	5.94560
PART. LOAD-TTL, STD CN	GR/DSCF	2.46932	8.50757	6.86376	5.94688
PART. LOAD-PTL, STK CN	GR/ACF	2.42997	8.28965	6.61620	5.77861
PART. LOAD-TTL, STK CN	GR/ACF	2.43245	8.29058	6.61655	5.77986
PARTIC EMIS-PARTIAL	LB/HR	796.81	2769.66	2300.31	1955.59
PARTIC EMIS-TOTAL	LB/HR	797.62	2769.97	2300.43	1956.01

Particulate Summary in English Units

Outlet

DESCRIPTION	UNITS	1	2	3	Average
DATE OF RUN		10-30-73	10-30-73	10-31-73	
STACK AREA	FT2	8.726	8.726	8.726	
NET TIME OF RUN	MIN	120.0	120.0	120.0	
BAROMETRIC PRESSURE	IN.HG	30.01	29.85	29.65	
AVG ORIFICE PRES DROP	IN.H2O	1.680	1.880	2.010	
VOL DRY GAS-METER COND	DCF	87.62	93.72	96.89	
AVG GAS METER TEMP	DEG.F	96.7	77.9	78.0	
VOL DRY GAS-STD COND	DSCF	84.00	92.53	95.04	
TOTAL H2O COLLECTED	ML	14.9	9.5	21.9	
VOL H2O VAPOR-STD COND	SCF	0.71	0.45	1.04	
PERCENT MOISTURE BY VOL		0.8	0.5	1.1	
MOLE FRACTION DRY GAS		0.992	0.995	0.989	
MOLECULAR WT-DRY STK GAS		28.84	28.84	28.84	
MOLECULAR WT-STK GAS		28.75	28.79	28.72	
AVG STACK TEMPERATURE	DEG.F	68.8	84.8	84.6	
STACK PRESSURE, ABSOLUTE	IN.HG	30.08	29.92	29.72	
AVG STACK GAS VELOCITY	FPS	69.132	74.494	77.415	73.680
STK FLOWRATE, DRY, STD CN	DSCFM	36160.	37752.	38751.	37554.
ACTUAL STACK FLOWRATE	ACFM	36196.	39004.	40533.	38578.
PERCENT ISOKINETIC		93.5	98.7	98.7	97.0
PARTICULATE WT-PARTIAL	MG	115.50	2 604.50	135.00	151.67
PARTICULATE WT-TOTAL	MG	117.00	207.00	137.50	153.83
PERC IMPINGER CATCH		1.3	1.2	1.8	1.4
PART. LOAD-PTL, STD CN	GR/DSCF	0.02118	0.03403	0.02188	0.02570
PART. LOAD-TTL, STD CN	GR/DSCF	0.02145	0.03445	0.02228	0.02606
PART. LOAD-PTL, STK CN	GR/ACF	0.02114	0.03292	0.02090	0.02499
PART. LOAD-TTL, STK CN	GR/ACF	0.02142	0.03333	0.02129	0.02534
PARTIC EMIS-PARTIAL	LB/HR	6.56	11.01	7.27	8.28
PARTIC EMIS-TOTAL	LB/HR	6.65	11.15	7.40	8.40

Particulate Summary In Metric Units

Inlet

DESCRIPTION	UNITS	1	2	3	Average
DATE OF RUN		10-30-73	10-30-73	10-31-73	
STACK AREA	M2	0.811	0.811	0.811	
NET TIME OF RUN	MIN	60.0	60.0	120.0	
BAROMETRIC PRESSURE	MM.HG	762.25	758.19	753.11	
AVG ORIFICE PRES DROP	MM.H2O	43.180	114.046	118.364	
VOL DRY GAS-METER CN	DM3	1.33	2.04	4.20	
AVG GAS METER TEMP	DEG.C	29.7	20.8	24.5	
VOL DRY GAS-STD COND	DNM3	1.30	2.06	4.16	
TOTAL H2O COLLECTED	ML	8.8	14.9	26.8	
VOL H2O VAPOR-STD COND	NM3	0.01	0.02	0.04	
PERCENT MOISTURE BY VOL		0.9	1.0	0.9	
MOLE FRACTION DRY GAS		0.991	0.990	0.991	
MOLECULAR WT-DRY STK GAS		28.84	28.84	28.84	
MOLECULAR WT-STK GAS		28.74	28.74	28.75	
AVG STACK TEMPERATURE	DEG.C	19.4	20.8	22.3	
STACK PRESSURE, ABSOLUTE	MM.HG	751.59	747.52	742.44	
AVG STACK GAS VELOCITY	M/S	22.258	22.679	23.600	22.845
STK FLOWRATE, DRY, STD CN	DNM3/M	1067.	1076.	1107.	1083.
ACTUAL STACK FLOWRATE	AM3/M	1083.	1103.	1148.	1111.
PERCENT ISOKINETIC		19.5	92.4	90.7	67.6
PARTICULATE WT-PARTIAL	MG	7364.00	40148.00	65483.00	37664.99
PARTICULATE WT-TOTAL	MG	7371.50	40152.50	65486.50	37670.16
PERCE IMPINGER CATCH		0.1	0.0	0.0	0.0
PART. LOAD-PTL, STD CN	MG/NM3	5644.98	19466.34	15706.02	13605.78
PART. LOAD-TTL, STD CN	MG/NM3	5650.73	19468.52	15706.86	13608.70
PART. LOAD-PTL, STK CN	MG/AM3	5560.70	18969.85	15140.36	13223.63
PART. LOAD-TTL, STK CN	MG/AM3	5566.36	18971.97	15141.17	13226.50
PARTIC EMIS-PARTIAL	KG/HR	361.43	1256.32	1043.42	887.06
PARTIC EMIS-TOTAL	KG/HR	361.80	1256.46	1043.48	887.25

Particulate Summary in Metric Units

Outlet

DESCRIPTION	UNITS	1	2	3	Average
DATE OF RUN		10-30-73	10-30-73	10-31-73	
STACK AREA	M2	0.811	0.811	0.811	
NET TIME OF RUN	MIN	120.0	120.0	120.0	
BAROMETRIC PRESSURE	MM.HG	762.25	758.19	753.11	
AVG ORIFICE PRES DROP	MM.H2O	42.672	47.752	51.054	
VOL DRY GAS-METER CN	DM3	2.48	2.65	2.74	
AVG GAS METER TEMP	DEG.C	35.9	25.5	65.6	
VOL DRY GAS-STD COND	DNM3	2.38	2.62	2.69	
TOTAL H2O COLLECTED	ML	14.9	9.5	21.9	
VOL H2O VAPOR-STD COND	NM3	0.02	0.01	0.03	
PERCENT MOISTURE BY VOL		0.8	0.5	1.1	
MOLE FRACTION DRY GAS		0.992	0.995	0.989	
MOLECULAR WT-DRY STK GAS		28.84	28.84	28.84	
MOLECULAR WT-STK GAS		28.75	28.79	28.72	
AVG STACK TEMPERATURE	DEG.C	20.4	29.3	29.2	
STACK PRESSURE, ABSOLUTE	MM.HG	764.03	759.97	754.89	
AVG STACK GAS VELOCITY	M/S	21.071	22.706	23.596	22.458
STK FLOWRATE, DRY, STD CN	DNM3/M	1024.	1069.	1097.	1063.
ACTUAL STACK FLOWRATE	AM3/M	1025.	1104.	1148.	1092.
PERCENT ISOKINETIC		93.5	98.7	98.7	97.0
PARTICULATE WT-PARTIAL	MG	115.50	604.50	135.00	151.67
PARTICULATE WT-TOTAL	MG	117.00	207.00	137.50	153.83
PERCE IMPINGER CATCH		1.3	1.2	1.8	1.4
PART. LOAD-PTL, STD CN	MG/NM3	48.46	77.88	50.06	58.80
PART. LOAD-TTL, STD CN	MG/NM3	49.09	78.83	50.99	59.64
PART. LOAD-PTL, STK CN	MG/AM3	48.38	75.34	47.83	57.19
PART. LOAD-TTL, STK CN	MG/AM3	49.01	76.26	48.72	58.00
PARTIC EMIS-PARTIAL	KG/HR	2.98	5.00	3.30	3.76
PARTIC EMIS-TOTAL	KG/HR	3.02	5.06	3.36	3.81

APPENDIX B

Complete Particle Size Results and Sample Calculations

APPENDIX B

TABLE I. NOMOGRAPH DATA

PLANT Bunge

DATE 10-30-73

SAMPLING LOCATION OUTLET

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.72
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m_{avg.}}$	90
PERCENT MOISTURE IN GAS STREAM BY VOLUME, estimated	B_{wo}	0
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	29.85
STATIC PRESSURE IN STACK, in. Hg (P_m ± 0.073 x STACK GAUGE PRESSURE in in. H_2O)	P_s	29.85 -0.51 29.34
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	0.98 ~~1.0~~
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	70°
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	1.80
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	2.05
C FACTOR	.94	
CALCULATED NOZZLE DIAMETER, in.	.188	
ACTUAL NOZZLE DIAMETER, in.	.182	
REFERENCE Δp, in. H_2O	1.6	

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4/72

Md = mole fraction of dry gas

$$= \frac{100 - \% M}{100} = \frac{100 - 0}{100} = 1$$

MWd = mole weight of dry stack gas

$$= CO_2\ (0.44) + O_2\ (.32) + N_2 + CO\ (0.28)$$

$$= 0 + 21.8\ (0.32) + 78.2\ (0.28)$$

$$= 28.87$$

MW = mole weight of stack gas

$$= MWd \times Md + 18\ (1 - Md)$$

$$= 28.87\ (1.0) + 18\ (1 - 1)$$

$$= 28.87$$

V_s = stack gas velocity at stack conditions, fps

$$= 72.5 \sqrt{\frac{\Delta pS\ (T_s + 460)}{P_s\ (MW)}}$$

$$= 72.4 \sqrt{\frac{1.80\ (70 + 460)}{29.24\ (28.87)}}$$

$$= 77 \text{ fps}$$

From page 4 of the Brinks BMS-11 Sampler-Sampling Instructions, paragraph 4 states that from the probe selection chart, which I have labeled Figure 1, a nozzle diameter must be selected which will give the calculated isokinetic sampling velocity (77 fps) at 0.1 to 0.15 cfm. The 2-mm nozzle was the only selection available. It was necessary to maintain 0.155 cfm in order to maintain 77 fps at the nozzle. After selecting the 2 mm nozzle, paragraph 5 of page 4 requires that, from the calibration curve for "Brinks Model B Cascade Impactor" Figure 2, you are to determine the Δp (in. H_g) which will give the selected flow rate of 0.155 cfm. Extrapolation of the curve shows approximately 17 in. H_g Δp was necessary to obtain 0.155 cfm. Sampling was accomplished using these values and the following calculations, based on a reprint supplied by Monsanto Enviro-Chem, were used to determine the characteristic diameter under the existing sampling condition.

Calculations for Stage 1 Characteristic Diameter

$$Dpc = \frac{-15.3\ \mu}{\sqrt{g_c \rho P_2}} + \sqrt{\frac{234\ \mu^2}{g_c \rho P_2} + \frac{2.05 \times 10^8\ \mu D_c^{\ 3}\ P_2}{\rho_p V_o P_o}}$$

$$= \frac{-15.3(1.81\times10^{-4})}{\sqrt{1.18\times10^{-3}}} + \sqrt{\frac{234(1.81\times10^{-4})^2}{1.18\times10^{-3}} + \frac{2.05\times10^8(1.81\times10^{-4})(0.249)^3(1.03)}{70(0.98)}}$$

$$= \frac{-28.14 \times 10^{-4}}{0.344 \times 10^{-1}} + \sqrt{\frac{792 \times 10^{-8}}{1.18 \times 10^{-3}} + \frac{5.88 \times 10^2}{68.6}}$$

$$= -79.29 \times 10^{-3} + \sqrt{6.71 \times 10^{-3} + 8.57}$$

$$= -0.08 + 2.93$$

$$Dpc = 2.85\ \mu$$

It was assumed that the size distribution for each stage would be proportional to the existing calculated sizes supplied in Table II of the reprint; therefore the characteristic diameter for stage 1 was computed using the supplied equation and the following calculations were made to determine characteristic-diameters for remaining stages.

Proportioning Table II

If Dpc from Table II = 3.14 for Jet #1

then $\frac{2.85^*}{3.14}$ x 1.63 for Jet #2 = 1.48 μ

0.91 x 1.10 for Jet #3 = 1.00 μ

0.91 x 0.57 for Jet #4 = 0.52 μ

0.91 x 0.33 for Jet #5 = 0.30 μ

---

* Ratio of characteristic diameter calculated for Stage 1 to characteristic diameter for Stage 1 from Table II of reprint.

NOMENCLATURE

D_c = 0.249 cm

P_o = 29.34/29.92 = 0.98 atm

P_2 = P_o (assumed)

$V_o = 0.15 \times 28.32 \times 10^3 \text{ cm}^3 \times 60 \text{ sec} = \frac{70 \text{ cm}^3}{\text{sec}}$

$\rho = 1.205 \times 10^{-3} \text{ gm/cm}^3$

$\rho_p = 1 \text{ gm/cm}^3$ (assumed)

$\mu = 1.81 \times 10^{-4} \text{ gm/cm}^3$

T_s = average stack-gas temperature, F

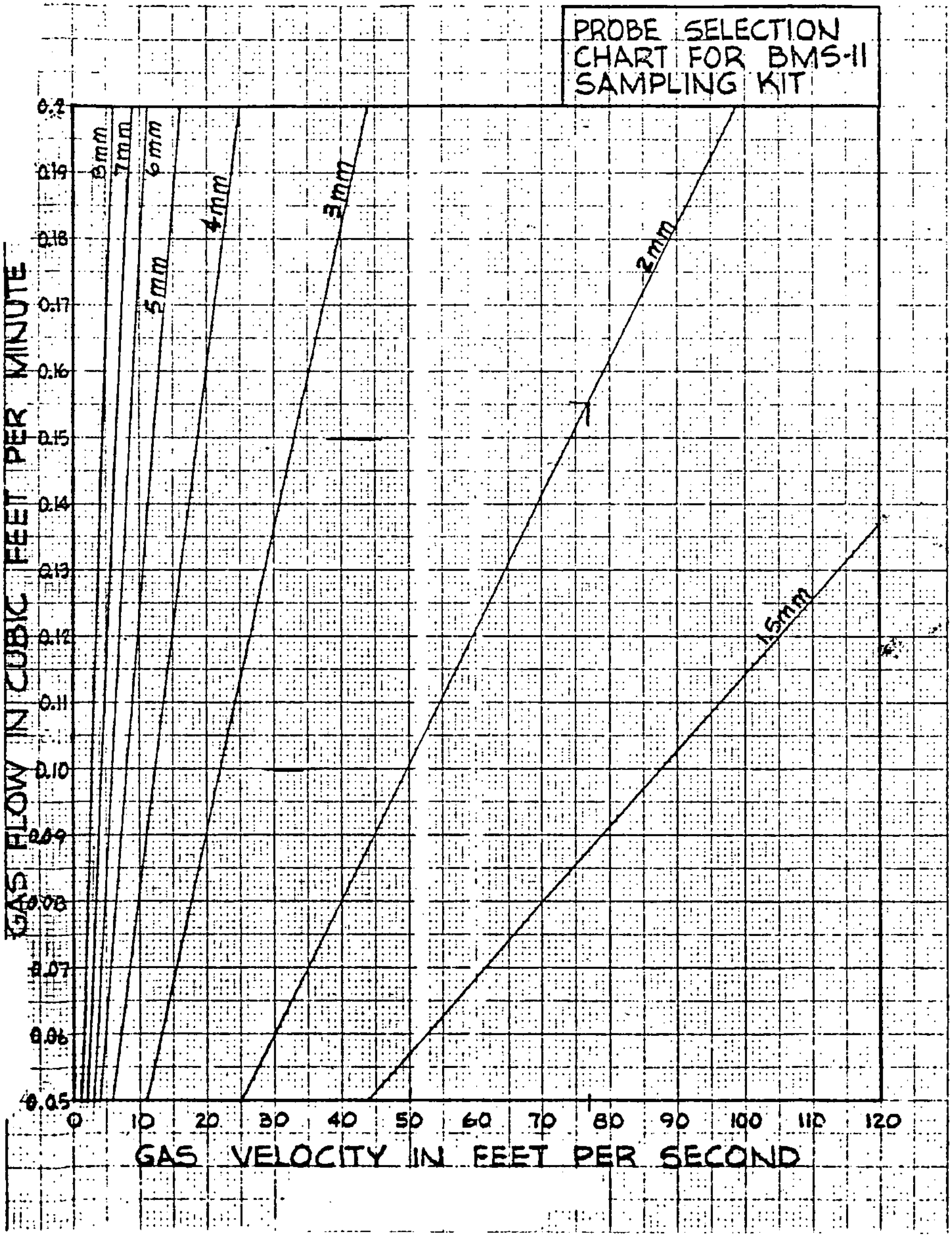
Δps = average pressure head, inches H_2O

P_s = average stack pressure, inches Hg

Dpc = characteristic particle diameter for impactor stage, micron

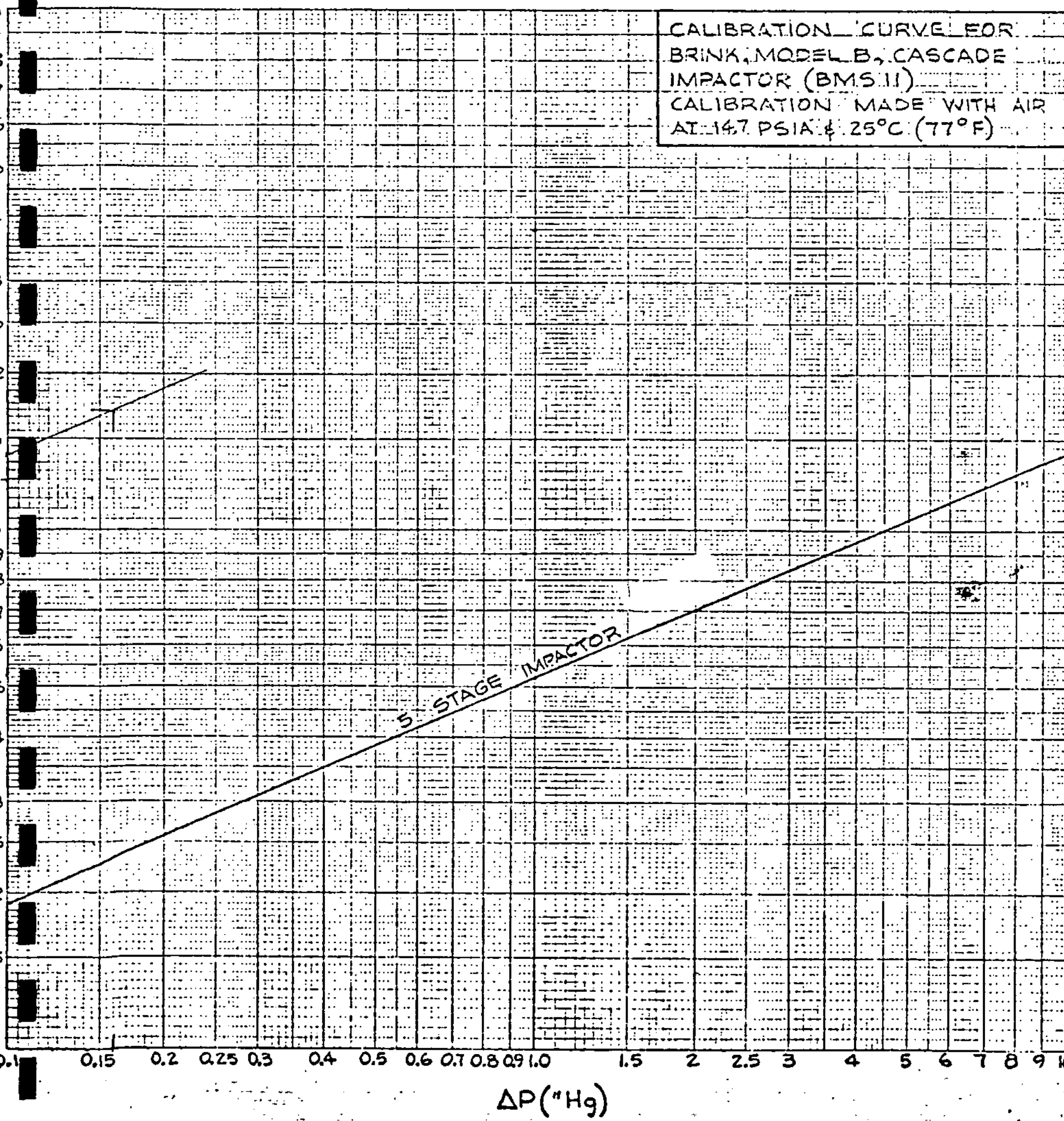
Figure 1

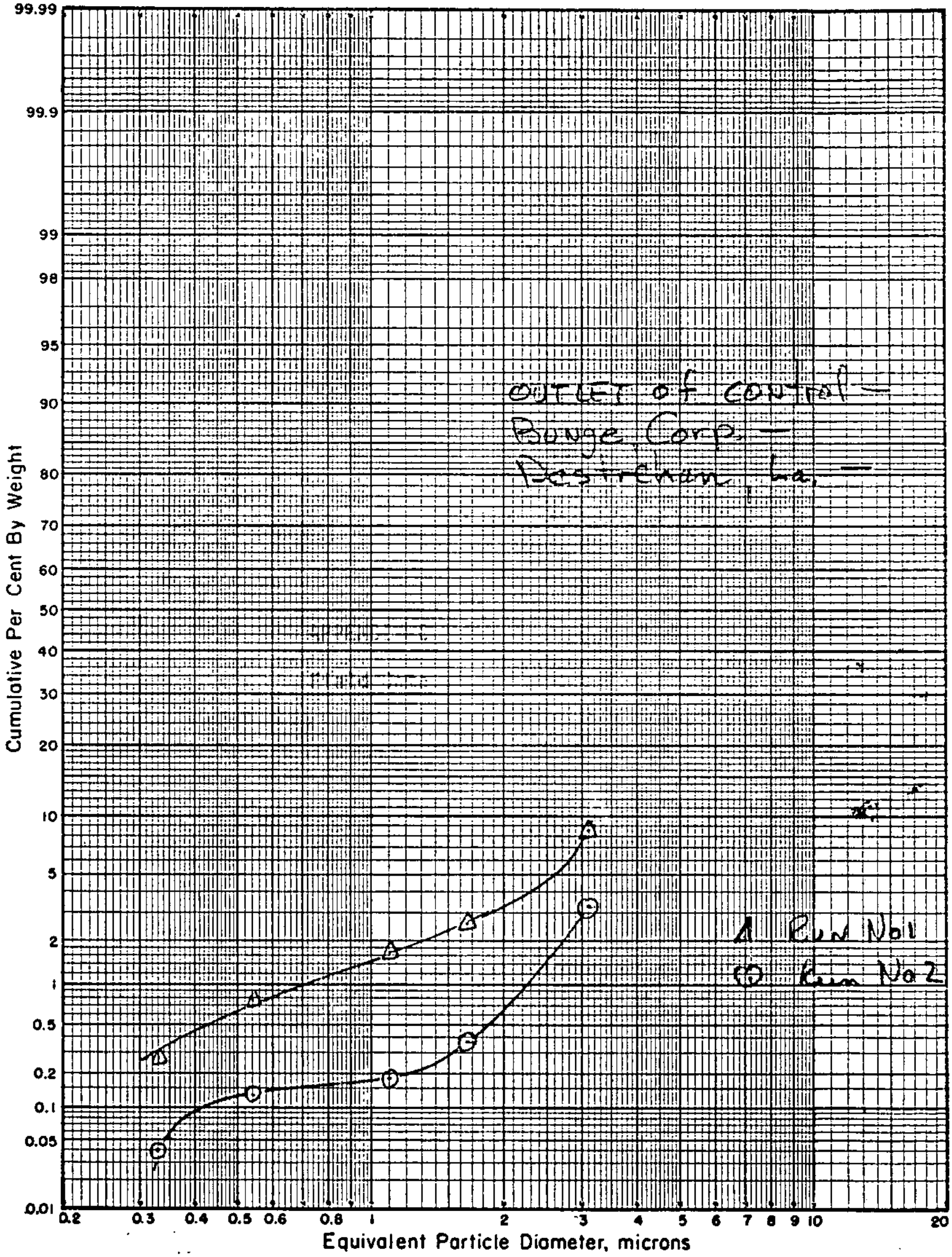
Monsanto
Enviro-Chem
Systems Inc.
800 NORTH LINDBERGH BLVD. / ST. LOUIS, MISSOURI 63166 / (314) 694-1000



Monsanto Enviro-Chem Systems Inc.
800 NORTH LINDBERGH BLVD. / ST. LOUIS, MISSOURI 63166 / (314) 694-1000

Figure 9





99.99
99.9
99
98
95
90
80
70
60
50
40
30
20
10
5
2
1
0.5
0.2
0.1
0.05
0.01
Cumulative Per Cent By Weight
0.2
0.3
0.4
0.5
0.6
0.8
1
2
3
4
5
6
7
8
9
10
20
Equivalent Particle Diameter, microns
OUTLET of control —
Bunge Corp. —
Destrehan, La. —
Δ Run No 1
⊙ Run No 2

Figure 1

APPENDIX C

Field Data

[illegible]	[illegible]
[illegible]	[illegible]
C FACTOR	
[illegible]	[illegible]
ACTUAL NOZZLE DIAMETER, in.	[illegible]
REFERENCE Δp, in. H_2O	[illegible]

NOMOGRAPH DATA

PLANT Bunge

DATE 10/30/80

SAMPLING LOCATION [illegible] 1-A

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.70
AVERAGE METER TEMPERATURE (AMBIENT + 20°F), °F	$T_{m\,avg.}$	70
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	2
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	30.01
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	30.01 + .07 = 30.08
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	1.00
AVERAGE STACK TEMPERATURE, °F	$T_{s\,avg.}$	70
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	1.69
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	2.0
C FACTOR		.96
CALCULATED NOZZLE DIAMETER, in.		.180
ACTUAL NOZZLE DIAMETER, in.		.235
REFERENCE Δp, in. H_2O		.63

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~ 7 " H_2O

→ (.073) × (7) = 0.511 " H_g

NOMOGRAPH DATA

PLANT Bunge

DATE 10-30-73

SAMPLING LOCATION Outlet

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.72
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m_{avg.}}$	90
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	0
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	29.85
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	29.85 −0.51 29.34
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	0.98 ~~1.0~~
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	70°
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	1.80
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	2.05
C FACTOR	.94	
CALCULATED NOZZLE DIAMETER, in.	.188	
ACTUAL NOZZLE DIAMETER, in.	.182	
REFERENCE Δp, in. H_2O	1.6	

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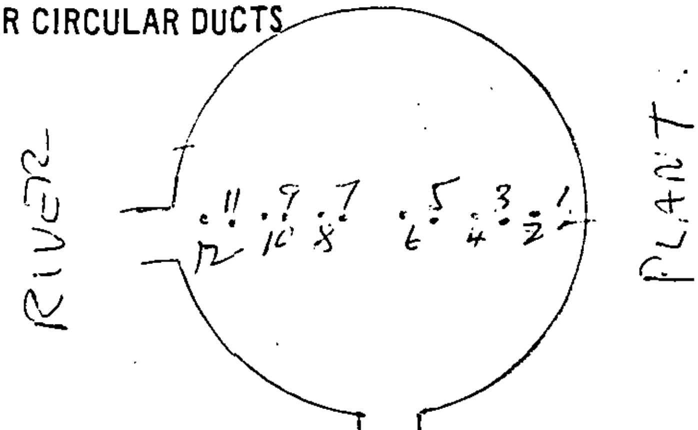
4/72

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT Bunge Corp
DATE 10/29/73
SAMPLING LOCATION Inlet
INSIDE OF FAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE A) 46 1/2"
INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE B) 6 1/2"
STACK I.D., (DISTANCE A - DISTANCE B) 40"
NEAREST UPSTREAM DISTURBANCE 7 ft
NEAREST DOWNSTREAM DISTURBANCE 19 ft
CALCULATOR P. Webb

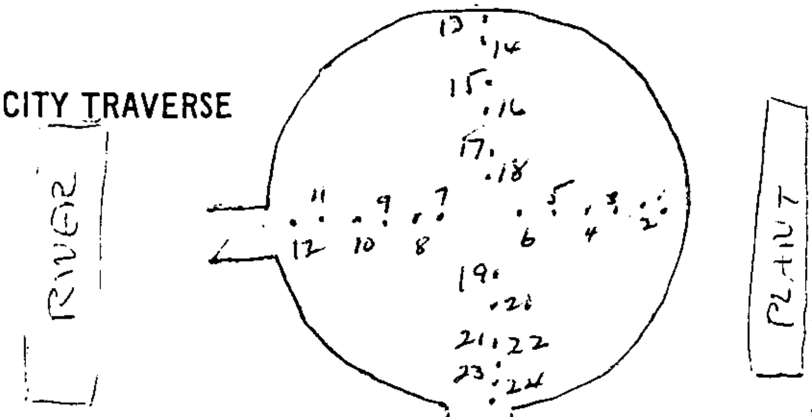


SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	% FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	2.1	40	3/4	6 1/2	7 1/4
2	6.7	"	2 3/4	"	9 1/4
3	11.8	"	4 3/4	"	11 1/4
4	17.7	"	7	"	13 1/2
5	25.0	"	10	"	16 1/2
6	35.5	"	14 1/4	"	20 3/4
7	64.5	"	25 3/4	"	32 1/4
8	75.0	"	30	"	36 1/2
9	82.3	"	33	"	39 1/2
10	88.2	"	35 1/4	"	41 3/4
11	93.3	"	37 1/4	"	43 3/4
12	97.9	"	39 1/4	"	45 3/4

PRELIMINARY VELOCITY TRAVERSE

PLANT Bunge Corp
DATE 10/29/73
LOCATION INLET
STACK I.D. 40"
BAROMETRIC PRESSURE, in. Hg
STACK GAUGE PRESSURE, in. H_2O - 5.75
OPERATORS Leonard, Clark



SCHEMATIC OF TRAVERSE POINT LAYOUT

*Ambient

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
1	1.85	64
2	1.90	
3	1.85	
4	1.65	
5	1.55	
6	1.50	
7	1.85	
8	1.95	
9	1.90	
10	1.85	
11	1.30	
12	1.80	
13	1.85	
14	2.00	
15	1.95	
16	1.80	
17	1.70	
18	1.60	
19	1.45	
20	1.40	
21	1.50	
22	1.55	
23	1.40	
24	1.35	
AVERAGE	1.69	

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

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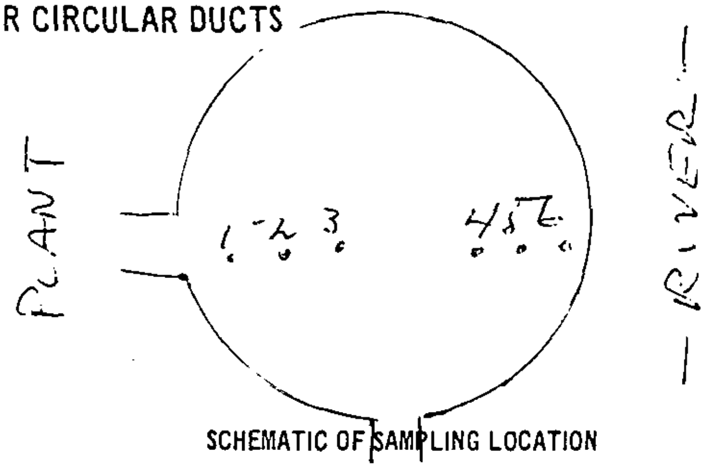
TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT: Bunge
DATE: 10/29/73
SAMPLING LOCATION: OUTLET
INSIDE OF FAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE A): 46 1/2
INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE B): 6 1/2
STACK I.D., (DISTANCE A - DISTANCE B): 40
NEAREST UPSTREAM DISTURBANCE: 30'
NEAREST DOWNSTREAM DISTURBANCE: 6'8"
CALCULATOR: FURNESS

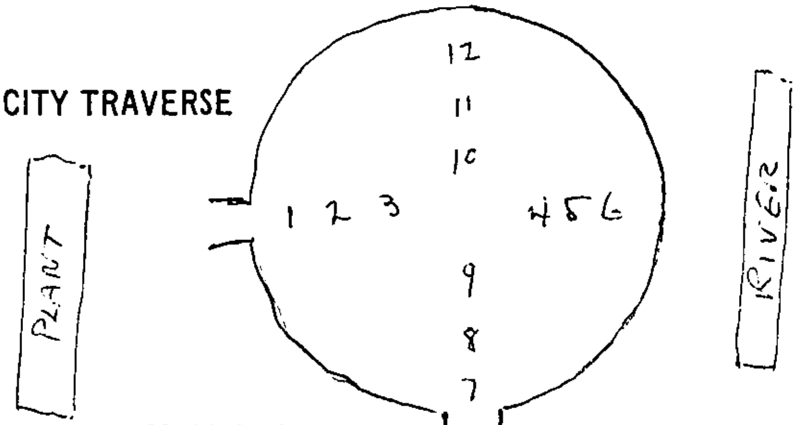


SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	% FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	4.4	40	1 3/4	6 1/2	8 1/4
2	14.7	"	6	"	12 1/2
3	29.5	"	11 3/4	"	18 1/4
4	70.5	"	28 1/4	"	34 3/4
5	85.3	"	34	"	40 1/2
6	95.6	"	38 1/4	"	44 3/4

PRELIMINARY VELOCITY TRAVERSE

PLANT Bunge Corp.
DATE 10/29/73
LOCATION OUTLET
STACK I.D. 40"
BAROMETRIC PRESSURE, in. Hg ______
STACK GAUGE PRESSURE, in. H_2O + 1.0
OPERATORS FURNESS, TURNER



SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F *AMBIENT
1	1.65	72
2	1.95	
3	1.95	
4	1.75	
5	2.15	
6	1.55	
7	1.60	
8	1.90	
9	1.95	
10	1.75	
11	2.15	
12	1.55	
AVERAGE	1.825	

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

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4/72

FIELD DATA

PLANT Bunge Corp.
DATE 10/30/73
SAMPLING LOCATION [illegible]
SAMPLE TYPE [illegible]
RUN NUMBER #1
OPERATOR [illegible]
AMBIENT TEMPERATURE 70°
BAROMETRIC PRESSURE 30.01
STATIC PRESSURE, (P_s)
FILTER NUMBER (s) 0-3329

Pfaff's watch 13:02
12:375 off
12:55
[36?.34 Final Vol.]
34?.?

* 0.25 [illegible]
[illegible]
Project [illegible]
to use 0.40? [illegible]

PROBE LENGTH AND TYPE [illegible]
NOZZLE I.D. 0.235 [illegible]
ASSUMED MOISTURE, % [illegible]
SAMPLE BOX NUMBER
METER BOX NUMBER 2
METER $\Delta H_@$ 1.70
C FACTOR .9?
PROBE HEATER SETTING [illegible]
HEATER BOX SETTING [illegible]
REFERENCE Δp .630

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

192 probe 24

(probe)	TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH, in. H_2O) DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
		0	322.35									
	1	11:08 (11:13)	46.11	(27.31)		1.70	[illegible]	[illegible]	[illegible]			
		11:09 off	324.32			*						
114	1	11:22 on	32?	1.95		1.70	6?	2?	85	4.0	16?	57
132	2	11:305	326.6	1.9?		1.??	65	89	86	6.5	16?	5?
148	3	11:33	328.2	.70 ↓		1.70	[illegible]	[illegible]	[illegible]	16.0	1?5	61
164	4	11:39	330.0	1.57		1.??	67	[illegible]	[illegible]	4.0	[illegible]	[illegible]
165	5	11:415	331.?	1.??		1.??	[illegible]	[illegible]	[illegible]	4.0	[illegible]	66
167	6	11:44	335.7	1.??		1.??	69	[illegible]	[illegible]	4.0	[illegible]	67
165	7	11:465	338.1	1.60		1.70	69	[illegible]	[illegible]	4.5	[illegible]	[illegible]
166	8	11:49	340.3	1.50		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
169	9	11:515	342.0	1.70		1.??	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
171	10	11:54	343.9	1.65		1.70	[illegible]	93	84	4.5	[illegible]	61
175	11	11:565	345.?	1.65		1.70	[illegible]	93	[illegible]	4.5	[illegible]	
	12	11:58 off	346.78									
236	13	12:28 on	346.78	2.10		1.70	[illegible]	83	80	5.0	[illegible]	[illegible]
219	14	12:305	348.3	2.20		1.70	65	[illegible]	79	5.0	[illegible]	[illegible]
198	15	12:33	350.3	[illegible]		1.??	[illegible]	[illegible]	78	5.0	[illegible]	[illegible]
186	16	12:355	352.2	2.05		1.70	65	82	78	5.0		[illegible]
178	17	12:38	354.1	1.95		1.70	66	83	78	5.0	[illegible]	[illegible]
175	18	12:405	356.1	1.85		1.70	66	65	78	5.0	[illegible]	68
169	19	12:43	358.1	1.60		1.70	66	[illegible]	[illegible]	5.0	[illegible]	66
169	20	12:455	360.0	1.40		1.70	69	81	78	5.0	[illegible]	[illegible]
	21	12:4?5 off	36?									
185	COMMENTS:	12:??5	361.?	1.80		1.??						
186	22	12:5??	36?.?	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	23	12:5?5	365.?	1.4?		[illegible]						

FIELD DATA

PLANT: BUNGE
DATE: 10-30-73
SAMPLING LOCATION: OUTLET
SAMPLE TYPE: PARTICULATE
RUN NUMBER: 1-8
OPERATOR: FURNESS
AMBIENT TEMPERATURE: 70
BAROMETRIC PRESSURE: 30.01
STATIC PRESSURE, (P_s): [illegible]
FILTER NUMBER (s): 0.3331

PROBE LENGTH AND TYPE: 4' GLASS
NOZZLE I.D.: .182
ASSUMED MOISTURE, %: 5%
SAMPLE BOX NUMBER: 5
METER BOX NUMBER: 5
METER $\Delta H_@$: 1.72
C FACTOR: .94
PROBE HEATER SETTING: 150
HEATER BOX SETTING: 250
REFERENCE Δp:

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 10 MINUTES

PROBE	TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH, in. H_2O) DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
		120		87.671									
260	1	10	11:13	54.744	1.45	1.65	1.65	62	90	—	3.0	150	62
233	2	10	11:23	63.33	1.65	1.85	1.85	57	88	—	3.1	203	65
238	3	10	11:33	70.24	1.60	1.81	1.82	57	88	—	3.1	203	61
230	4	10	11:43	77.89	1.45	1.65	1.65	59	94	—	3.1	279	67
	5	10	11:53	85.27	1.35	1.55	1.55	60	[illegible]				
		DOWN AT 12:01:20 SEC											
		RESTART AT		12:43	PROBE HEATER SMOKING, TURNED OFF @ 12:00								
		FINISH		88.33									
85	6	10	12:45	96.437	1.30	1.50	1.50	65	105	—	2.9	233	70
80	7	Start	1:00	103.78	1.30	1.50	1.50	80	99	—	2.8	218	68
90	8	10 (off 3 min)	1:10	111.37	1.50	1.70	1.70	85	99	—	3.0	204	68
85	9	10	1:20	119.00	1.50	1.70	1.70	73	98	—	3.0	260	66
		Start 2:20			~~1.60~~	~~1.80~~	~~1.80~~						
81	10		2:24	126.10	1.60	1.80	1.80	74	100	—	3.2	257	70
84	11		2:34	134.70	1.60	1.80	1.80	77	106	—	3.2	248	70
85	12		2:47	142.365	1.50	1.70	1.70	76	104	—	3.0	240	73
		120		87.671	[illegible]		[illegible]	[illegible]	96.7				

COMMENTS:

FIELD DATA

PLANT [illegible]
DATE 10/30/7[illegible]
SAMPLING LOCATION [illegible]
SAMPLE TYPE [illegible]
RUN NUMBER 2-A
OPERATOR [illegible]
AMBIENT TEMPERATURE [illegible]
BAROMETRIC PRESSURE 29.95
STATIC PRESSURE, (P_s)
FILTER NUMBER (s) 0.3276

PROBE LENGTH AND TYPE 4 [illegible]
NOZZLE I.D. [illegible]
ASSUMED MOISTURE, % [illegible]
SAMPLE BOX NUMBER 3
METER BOX NUMBER 2
METER $\Delta H_@$ 1.70
C FACTOR 0.[illegible]
PROBE HEATER SETTING [illegible]
HEATER BOX SETTING [illegible]
REFERENCE Δp [illegible]

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

129 probe 24 8:33 off 8:305 441.73 440.1 1.20 3.2 3.2 75 86 740 67 9.0 216 65

	TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
		(60)	369.740	2.1[illegible]			14					
158	1	7:03	369.[illegible]	1.95	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
136	2	7:035		1.70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
121	3	7:08	373.[illegible]	1.5[illegible]	4.1	4.1	[illegible]	[illegible]	[illegible]	[illegible]	18[illegible]	[illegible]
113	4	7:105	378.6	1.45	3.8	3.8	67	77	67	7.5		
108	5	7:13	381.5	1.30	3.5	3.5	67	78	67	7.6	180	67
106	6	7:155	384.3	1.35	3.6	3.6	67	79	66	6.5	197	67
107	7	7:18	387.0	2.20	5.8	5.8	67	80	67	6.5	194	67
111	8	7:205	390.0	1.90	5.0	5.0	67	82	67	10.5	195	66
113	9	7:23	393.3	2.00	5.3	5.3	68	84	67	9.5	178	68
116	10	7:255	396.5	2.00	5.3	5.3	69	84	68	10.0	187	69
117	11	7:28	399.7	2.10	5.5	5.5	68	85	68	10.0	184	68
119	12	7:305	402.9	2.00	5.3	5.3	68	86	68	10.5	184	67
		7:33 off	406.205							10.5	185	67
149	13	7:40	406.205	2.00	5.3	5.3	68	75	67	10.0	161	61
132	14	7:425	409.4	2.00	5.3	5.3	68	82	66	10.0	179	63
123	15	7:45	412.5	1.95	5.2	5.2	67	83	66	10.5	191	63
	16	7:475 off	418.754									
	17	8:08 on										
	17	8:09 off	420.213	2.10	5.5	5.5	[illegible]					
156	17	8:14 on	421.3	1.90	5.0	5.0	69	78	65	11.0	213	62
134	18	8:155	424.5	1.70	4.5	4.5	72	84	66	10.5	213	64
126	19	8:18	427.6	1.30	3.5	3.5	72	87	66	9.0	213	64
124	20	8:205	430.5	1.20	3.2	3.2	74	85	67	7.0	213	64
125	21	8:23	433.2	1.30	3.5	3.5	73	87	67	7.0	216	64
127	22	8:255	435.8	1.30	3.5	3.5	73	87	67	7.0	216	64
128	23	8:28	438.2	1.20	3.2	3.2	7[illegible]	87	67	9.0	215	64

FIELD DATA

PLANT Bunge
DATE 10-30-73
SAMPLING LOCATION OUTLET
SAMPLE TYPE PARTICULATE
RUN NUMBER 2-B
OPERATOR Furness
AMBIENT TEMPERATURE
BAROMETRIC PRESSURE ~~30.01~~ 29.85
STATIC PRESSURE, (P_s)
FILTER NUMBER (s) 0.3236

PROBE LENGTH AND TYPE 6' GLASS
NOZZLE I.D. .182
ASSUMED MOISTURE, % 2
SAMPLE BOX NUMBER 2
METER BOX NUMBER 5
METER $\Delta H_@$ 1.72
C FACTOR .94
PROBE HEATER SETTING 250
HEATER BOX SETTING 250
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 10 MINUTES

Probe T heated ~~HOS~~

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH, in. H_2O) DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
1	10	5:51	144.488	1.8	2.0	2.0	84	88	—	2.5	245	73
2	10	6:01	152.10	1.8	2.0	2.0	87	79	—	2.6	233	75
3	10	6:11	160.00	1.8	2.0	2.0	83	79	—	2.5	254	75
4	10	6:27	168.35	1.65	1.85	1.85	83	79	—	2.5	256	75
5	10	6:37	176.72	1.65	1.85	1.85	92	75	—	2.5	268	72
6 (down)	10	7:11	184.80	1.30	1.50	1.50	92	76	—	2.0	257	74
7	10	7:23	191.766	1.55	1.80	1.83	84	77	—	2.5	240	75
8	10	7:33	199.37	1.80	2.0	2.0	83	78	—	2.5	242	76
9	10	7:43	207.40	1.80	2.0	2.0	87	73	—	2.5	270	73
10	10	8:11	215.14	1.85	2.05	2.05	86	74	—	2.5	267	94
11	10	8:37	223.70	1.50	1.75	1.75	89	77	—	2.5	265	77
12	10	8:47	230.76	1.56	1.75	1.75	87	78	—	2.5	253	76
FINAL			238.208									
	(120)		([illegible])	([illegible])			[illegible]	[illegible]				

COMMENTS:

EPA [illegible]

FIELD DATA

PLANT Bungl
DATE 10/31/73
SAMPLING LOCATION inlet
SAMPLE TYPE particulate
RUN NUMBER 3
OPERATOR Leonard
AMBIENT TEMPERATURE 67
BAROMETRIC PRESSURE 29.65
STATIC PRESSURE, (P_s)
FILTER NUMBER (s) 03264, 3317

PROBE LENGTH AND TYPE 4 ft
NOZZLE I.D. .235
ASSUMED MOISTURE, % 2
SAMPLE BOX NUMBER 4
METER BOX NUMBER 2
METER $\Delta H_@$ 1.70
C FACTOR .98
PROBE HEATER SETTING 250
HEATER BOX SETTING 250
REFERENCE Δp .60

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

	TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH, in. H_2O) DESIRED	ORIFICE PRESSURE DIFFERENTIAL (ΔH, in. H_2O) ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\ in}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m\ out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
		120	148.714 / 441.973	38.81			72.1					
157	1	10:25	441.973	1.9	5.3	5.0	72	73	72	15.0	148	61
130	2	10:30	448.2	1.9	5.3	5.0	77	75	72	15.0	156	68
124	3	10:35	455.3	2.1	5.8	5.0	72	76	71	15.5	154	69
119	4	10:40	461.2	1.9	5.3	5.0	73	77	72	15.5	157	69
120	5	10:45	467.5	1.8	5.0	5.0	75	77	73	15.5	157	68
123	6	10:50	473.9	1.8	5.0	5.0	73	78	73	16.0	158	68
123	7	10:55	480.4	1.8	5.0	5.0	74	76	73	16.0	161	67 / 63
120	8	11:00	486.1	1.7	4.7	4.7	73	79	73	16.5	166	68
123	9	11:05	492.9	1.8	5.0	4.9	73	77	74	16.5	168	67
121	10	11:10	499.1	1.65	4.6	3.9	72	76	74	17.0	167	66
123	11	11:15	504.6	1.60	4.5	3.5	71	76	74	17.5	163	67
125	12	11:20	510.7	1.60	4.5	3.5	70	76	73	18.0	174	67
		11:25 off	515.212		change filter &			cyclone & flask,				
145	13	11:40	515.212	2.0	5.6	5.0	71	79	77	15.0	159	65
133	14	11:45	521.5	2.1	5.8	4.9	74	82	79	16.0	120	68
128	15	11:50	528.4	2.1	5.8	5.1	73	80	78	16.5	169	66
126	16	11:55	535.3	2.1	5.8	5.1	71	80	77	16.5	185	66
124	17	12:00	540.7	2.1	5.8	5.1	72	80	77	17.0	107	65
125	18	12:05	547.2	1.95	5.4	5.1	73	78	76	17.0	174	66
122	19	12:10	553.8	1.7	4.7	4.7	70	79	73	16.0	179	64
126	20	12:15	560.2	1.6	4.5	4.5	71	79	76	15.5	182	65
127	21	12:20	566.4	1.6	4.5	4.5	71	79	74	15.5	190	65
128	22	12:25	572.6	1.6	4.5	4.5	68	78	73	15.5	194	62
131	23	12:30	578.8	1.4	3.9	3.9	70	78	76	13.5	190	64
133	24	12:35	584.9	1.4	3.9	3.9	71	79	76	13.5	193	67
		off	590.267									

COMMENTS:

FIELD DATA

PLANT Bunge
DATE 10-31-73
SAMPLING LOCATION Outlet
SAMPLE TYPE Particulate
RUN NUMBER 3 - 1
OPERATOR Furness
AMBIENT TEMPERATURE
BAROMETRIC PRESSURE 29.65
STATIC PRESSURE, (P_s) 1.0 " H_2O
FILTER NUMBER (s) 0.3306

PROBE LENGTH AND TYPE 4' Glass
NOZZLE I.D. .182
ASSUMED MOISTURE, % 2
SAMPLE BOX NUMBER 5
METER BOX NUMBER 1.
METER $\Delta H_@$ 1.80
C FACTOR 1.05
PROBE HEATER SETTING 6
HEATER BOX SETTING 6
REFERENCE Δp ~~1.85~~ 1.60

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 10 MINUTES

BE	TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24 hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				893.515									
16	1	10	10:25	901.72	1.60	~~1.80~~	2.10	84	75	75	3.2	230	69
01	2	10	10:35	910.09	1.85	2.05	2.05	85	77	76	3.5	210	70
18	3	10	10:45	918.04	1.90	2.10	2.05	87	77	76	3.4	202	72
22	4	10 STOP	10:55	925.99	1.80	2.00	2.00	86	77	76	3.2	224	72
45	5	10	11:38	934.03	1.75	1.95	1.90	84	78	77	3.0	219	71
34	6	10	11:48	941.52	1.45	1.65	1.65	85	79	78	2.8	216	73
:01	7	10	12:00	949.29	1.70	1.92	1.90	84	80	79	3.0	247	74
238	8	10	12:10	957.52	1.90	2.15	2.15	85	80	80	3.5	246	74
238	9	10	12:20	965.80	1.90	2.15	2.15	85	80	79	3.5	237	74
228	10	10	12:30	974.28	1.95	2.20	2.20	84	80	79	3.5	244	75
249	11	10	1:25	STOP 12:32 982.80	2.00	2.20	2.20	84	79	79	3.5	242	74
233	12	10	1:35	990.405	1.80	1.80	1.80	82	79	78	3.0	247	73
		(120)		([illegible])	[illegible]		[illegible]	[illegible]	(78.[illegible])				

.9¼ma

COMMENTS:

APPENDIX D

Laboratory Report

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT Bunge

DATE 10-30-73

SAMPLING LOCATION INLeT

SAMPLE TYPE PART

RUN NUMBER 1-A

SAMPLE BOX NUMBER

CLEAN-UP MAN Faught

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER

CONTAINER 136 — 6979.0 mg

FILTER NUMBER 07181 — 0.3329

Tare 0.3329

Net 0.3852

CONTAINER 5-73-002-137 — 385.0 mg

FRONT HALF SUBTOTAL 9364.0 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

CONTAINER 138-139 — 4.0 mg

ETHER-CHLOROFORM EXTRACTION — 1.0 mg

CONTAINER 140 — 2.5 mg

BACK HALF SUBTOTAL 7.5 mg

TOTAL WEIGHT 7371.5 mg

MOISTURE

IMPINGERS

FINAL VOLUME	200	ml
INITIAL VOLUME	200	ml
NET VOLUME	0	ml

SILICA GEL

FINAL WEIGHT	483.8 g	g	g
INITIAL WEIGHT	475.0 g	g	g
NET WEIGHT	8.8 g	g	g

TOTAL MOISTURE 8.8 g

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4/72

ANALYTICAL DATA

PLANT Bunge

DATE 10-30-73

SAMPLING LOCATION OuTLeT 1

SAMPLE TYPE Particulate

RUN NUMBER 1-B

SAMPLE BOX NUMBER # 1

CLEAN-UP MAN Faught

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER	CONTAINER 141	88.0 mg
FILTER NUMBER 0.3605 − 0.3331; Tare −0.3331; net 0.0274	CONTAINER 5-73-002-142	27.5 mg
	FRONT HALF SUBTOTAL	115.5 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER	CONTAINER 143-144	1.5 mg
	ETHER-CHLOROFORM EXTRACTION	0.0 mg
ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER	CONTAINER 145	0.0 mg
	BACK HALF SUBTOTAL	1.5 mg
	TOTAL WEIGHT	117.0 mg

MOISTURE

IMPINGERS

FINAL VOLUME 202 ml

INITIAL VOLUME 200 ml

NET VOLUME 2 ml

SILICA GEL

FINAL WEIGHT	487.9 g	g	g
INITIAL WEIGHT	475.0 g	g	g
NET WEIGHT	12.9 g	g	g

TOTAL MOISTURE 14.9 g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT Bunge

DATE 10-30-73

SAMPLING LOCATION inLeT #2

SAMPLE TYPE Part

RUN NUMBER 2-A

SAMPLE BOX NUMBER

CLEAN-UP MAN Faught

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER

CONTAINER 146 — 36802.0 mg

FILTER NUMBER 3.6735 ~~0.3276~~
Tare -0.3276
Net 3.3459

CONTAINER 5-73-002-147 — 3346.0 mg

FRONT HALF SUBTOTAL 40148.0 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

CONTAINER 148-149 — 4.0 mg

ETHER-CHLOROFORM EXTRACTION — 0.5 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

CONTAINER 150 — 0.0 mg

BACK HALF SUBTOTAL 4.5 mg

TOTAL WEIGHT 40152.5 mg

MOISTURE

IMPINGERS

FINAL VOLUME 200 ml
INITIAL VOLUME 200 ml
NET VOLUME 0 ml

SILICA GEL

FINAL WEIGHT	489.9 g	g	g
INITIAL WEIGHT	475.0 g	g	g
NET WEIGHT	14.9 g	g	g

TOTAL MOISTURE 14.9 g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT Bunge

DATE 10-30-73

SAMPLING LOCATION outlet 2-B

SAMPLE TYPE Part

RUN NUMBER 2-B

SAMPLE BOX NUMBER

CLEAN-UP MAN Faught

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER		CONTAINER 151	176.0 mg
FILTER NUMBER	0.3520 / 0.3236	CONTAINER 5-73-002-152	28.5 mg
Tare	- 0.3236		
Net	.0284		
		FRONT HALF SUBTOTAL	204.5 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER	CONTAINER 153-154	2.0 mg
	ETHER-CHLOROFORM EXTRACTION	0.0 mg
ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER	CONTAINER 155	0.5 mg
	BACK HALF SUBTOTAL	2.5 mg
	TOTAL WEIGHT	209.0 mg

MOISTURE

IMPINGERS

FINAL VOLUME	192 ml
INITIAL VOLUME	200 ml
NET VOLUME	-8 ml

SILICA GEL

FINAL WEIGHT	492.5 g	g	g
INITIAL WEIGHT	475.0 g	g	g
NET WEIGHT	17.5 g	g	g
	-8.0		
	9.5		

TOTAL MOISTURE ~~17.5~~ 9.5 g

ANALYTICAL DATA

PLANT Bunge

DATE 10-31-73

SAMPLING LOCATION INLET 3-A

SAMPLE TYPE PART

RUN NUMBER 3-A

SAMPLE BOX NUMBER

CLEAN-UP MAN Faugtt

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER 156 — 60871.0 mg

FILTER NUMBER

Gross	Tare	Net
2.3718	0.3317	2.040
2.8987	0.3264	2.5723

CONTAINER S-73-002 157 — 4612.0 mg

FRONT HALF SUBTOTAL 65483.0 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 158-159 — 3.0 mg

ETHER-CHLOROFORM EXTRACTION — 0.0 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 160 — 0.5 mg

BACK HALF SUBTOTAL 3.5 mg

TOTAL WEIGHT 65486.5 mg

MOISTURE

IMPINGERS

- FINAL VOLUME 210 ml
- INITIAL VOLUME 200 ml
- NET VOLUME 10 ml

SILICA GEL

FINAL WEIGHT	491.8 g	g	g
INITIAL WEIGHT	475.0 g	g	g
NET WEIGHT	16.8 g	g	g

TOTAL MOISTURE 26.8 g

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4/72

ANALYTICAL DATA

PLANT Bunge

DATE 10-31-73

SAMPLING LOCATION OUTLET 3-B

SAMPLE TYPE PART

RUN NUMBER 3-B

SAMPLE BOX NUMBER

CLEAN-UP MAN Faught

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER

CONTAINER 161 — 120.0 mg

FILTER NUMBER 0.3459 ~~0.3306~~

Tare -0.3306

net 0.0153

CONTAINER 5-73-002-162 — 15.0 mg

FRONT HALF SUBTOTAL 135.0 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER

CONTAINER 163-164 — 2.0 mg

ETHER-CHLOROFORM EXTRACTION — 0.5 mg

CONTAINER 165 — 0.0 mg

BACK HALF SUBTOTAL 2.5 mg

TOTAL WEIGHT 137.5 mg

MOISTURE

IMPINGERS

FINAL VOLUME 208 ml

INITIAL VOLUME 200 ml

NET VOLUME 8 ml

SILICA GEL

FINAL WEIGHT	488.9 g	g	g
INITIAL WEIGHT	475.0 g	g	g
NET WEIGHT	13.9 g	g	g

21.9

TOTAL MOISTURE 21.9 g

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4/72

APPENDIX E

Process Data

Process Data

TEST RUN	BARGE NO.	GRAIN	TEST WEIGHT lb/bu	% MOISTURE	% FOREIGN MATERIAL	AMOUNT UNLOADED 1 bu	PROCESS RATE DURING TEST lb/hr
1	Bunge 33	SB	55.0	13.2	1.0	43340	2,919,000
	Maury 15	SB	55.5	13.3	3.3	42151	2,599,000
	Bunge 6	Corn	55.0	13.2	4.2	47195	3,115,000
AVE							2,878,000
2	FM 49	SB	57.0	12.5	0.9	50563	3,263,000
	Mary T 13	Corn	55.5	13.1	4.5	50540	3,300,000
	AGS 511	Corn	57.5	14.3	3.6	52678	3,304,000
AVE							3,289,000
3	CW 64	Corn	57.5	13.1	4.7	50400	3,050,000
	Bunge 31	Corn	55.5	12.7	3.8	49031	2,551,000
	FM 22	SB	57.5	12.8	0.7	50785	2,368,000
AVE							2,656,000

APPENDIX F

Sampling and Analytical Procedures

BMS-11 SAMPLER - SAMPLING INSTRUCTIONS

SCOPE

These instructions are intended to give a step-by-step procedure for determining the particle size distribution of a liquid mist or solid loading in a gas flowing through a duct. Because of the specific nature of a given process, some changes of the procedures given may be necessary. However, the essential features of the method should be retained if reliable results are to be obtained.

EQUIPMENT

A) For sampling

1) BMS-11 sampler
2) One (1) set of probe tips
3) Sample probe for entering gas stream
4) Vacuum source (vacuum pump or ejector)
5) Stopwatch
6) Heating tape 110 V 3 ft. long
7) Bottles to collect cyclone samples (4 oz. French square)
8) Mercury for manometer
9) Two (2) wash bottles, one with distilled H_2O and one with acetone or methanol

10) Rubber tubing to connect BMS-10 to vacuum source and sample probe

11) A source of 110 V electrical power must be provided at the sampling location

12) Suitable platforms must be provided at the sampling location for placing the BMS-10 along side the sampling port and for working sapce for the operator (NOTE: See attached drawing for type of platforms usually required)

B) For analysis

The analytical equipment and chemical required will vary considerably depending on the composition of the collected material. The equipment and chemicals given below are for typical acid mist.

1) 1,000 ML beaker
2) 250 ML beaker
3) Glass or stainless steel stirring rod (1/16 inch dia. by 6 inches long)
4) N/10 NAOH
5) N/100 NAOH
6) Phenolphthalein indicator solution
7) N/100 Hcl or H_2SO_4
8) 50 ML Buret

9) Four place analytical balance (if any gravimetric work is to be done)

PRELIMINARY CALCULATIONS#

An important consideration in sampling for aerosols in gases is to withdraw the gas sample at the same velocity as exists in the duct at the collection point (isokinetic sampling). This, in theory, requires measuring the gas velocity in the duct at the sampling point and running many samples to traverse the duct.

The sampling conditions determined by the method described below allow a fairly accurate determination of the amount of particles less that 7u and an estimate of the amount of particles greater than 7u.

1) The flow of gas at the sample point must be determined along with the gas temperature and pressure.

2) The actual CFM is calculated as follows:

$$ACFM = SCFM \times \left(\frac{460 + T_d}{460 + 32}\right) \left(\frac{29.92}{\text{Bar. Press} \pm P_d}\right)$$

3) Calculate the gas velocity at the sample point. ft/sec

$$V_d = \frac{ACFM}{A_d \cdot (60)}$$

duct area in ft²

4) From the probe selection chart, select a probe that will give a sampling rate (F_s) between 0.1 - 0.15 CFM.

5) Using the calibration curve for Brink Model B Cascade Impactor supplied with the BMS-11, select ΔP_c corresponding to (F_s).

6) Estimate orifice ΔP (ΔP_{es}) under sampling conditions.

$$\Delta P_{es} = \Delta P \times \frac{\text{MW Gas}}{\text{MW Air}} \times \frac{460 + T_c\ (^\circ F)}{460 + T_d\ (^\circ F)} \times \frac{\text{Bar. Press} \pm (P_s\ \text{est})}{29.92}$$

BMS-11 SAMPLING PROCEDURES

1) Ready the sampling equipment by filling the manometer on the left (flow manometer) with Hg, and the manometer on the right with H_2O or Hg depending on the amount of pressure in the duct. (NOTE: If the manometers should have been filled prior to shipping, the clamps on the rubber tubing leading to each manometer should be opened at this time.)

2) Turn the sampler around and insert the glass cyclone (if not already installed in sampler) in its proper place on the left side of the sampler.

3) Pack the small glass filter tube with #800 Pyrex brand

glass wool. The filter tube should be packed as firmly as possible by hand to a depth of two inches.

4) Place the small packed filter tube upside down on the rubber stopper at bottom of impactor.

5) Insert the impactor and packed filter into its proper place on the right-hand side of the sampler.

6) Connect the cyclone and the top horizontal nipple of the impactor with a short piece of neoprene tubing.

7) Two pieces of neoprene tubing are extending through the center panel of the sampler. Connect the top piece to the vert. nipple extending down from the top of impactor, and connect the bottom piece of tubing to the vert. nipple extending up from the bottom of impactor.

8) The short piece of tubing extending down from the control valve should be connected to the small packed filter tube.

9) Put a #4 rubber stopper onto the bottom of cyclone and place a 4 o. . bottle onto the rubber stopper.

10) Make sure that all of the connections that have been made are tight and place the insulated cover on the back of sampler.

11) Assemble probe to the proper length using previously selected probe tip. All joints in the probe should be sealed with teflon tape and the direction of probe tip marked on the outlet of probe assembly.

12) A short piece of rubber tubing should be placed on the outlet end of the probe and then sealed off with a tubing clamp placed in the center of the rubber tubing.

13) Place vacuum source as close to the sampling table as is necessary to connect a vacuum hose from the sampler to the vacuum source.

14) Connect the electrical cord from the sampler to a 115V outlet.

15) Measure the temperature of gases to be sampled and record it on data sheet.

16) With the tubing clamp closed on the probe, insert the probe into the duct with the probe tip pointing down stream with the gas flow.

17) Place the blower switch in the on position (indicator light on) and then turn on the heater switch (indicator light on).

18) The temperature at blower inlet should be adjusted to 5 to 10°F above stack gas temperature. This can be done by rotating the thermoswitch dial counter clockwise to raise the temperature and clockwise to lower the temperature.

19) Check the control valve in sampler and make sure it is closed. Connect the rubber vacuum tubing from the vacuum source to the metal nipple protruding from the side of the sampler. Turn on vacuum source. (NOTE: If vacuum is turned on with control valve open the H_2O or Hg manometer may blow.)

20) After sampler has heated up to the proper temp, turn the probe until the probe tip is facing into the gas stream. (This can be done by using the mark previously placed on the probe outlet.)

21) Connect the rubber tubing of the prob. to the glass cyclone protruding from the side of sampler.

22) With the probe tubing clamp closed, "very slowly" open the sampler control valve. Draw 5 to 6 inches H_2O vacuum on system as indicated on the H_2O manometer. Clow the control valve. The vacuum should drop off very slowly since the gases inside the sampler are being heated. If the vacuum drops off rapidly, leaks are present and must be eliminated before proceeding with the sampling. Repeat Step 22 until the leak has been found.

23) Open probe tubing clamp "slowly" to bleed off vacuum. (NOTE: If probe clamp is left closed while the sampler is heating up when connected to the probe, the H_2O will blow.)

24) Plug electrical heating tape into auxiliary outlet on sampler and loosely wrap it around the outlet of probe, rubber tubing and inlet of cyclone.

25) Turn on auxiliary outlet switch (indicator light on), and give a few minutes to heat up.

26) Recheck the direction of the probe tip and the sampling box temperature. If both are OK, open the control valve, start stopwatch, and adjust the Hg manometer to the predetermined value (ΔP_{es}) and check static pressure (P_s) (H_2O manometer).

27) Monitor and record inlet and outlet temperatures, static pressure and flow rate during sampling.

28) At the end of desired sampling time, close control valve.

29) Disconnect vacuum, turn off heaters and blower.

30) Close probe tubing clamp and unwrap the heater tape.

31) Disconnect sampler from probe at the cylone rubber tubing connection.

32) Remove probe from duct, wash the outside of probe with distilled H_2O, being careful not to get any of the outside washings into the open probe tip. Set probe aside with probe tip pointing up.

33) Remove back of sampler; and using a plastic squeeze bottle, wash cyclone with distilled H_2O through the inlet, trying to get a swirling action of the H_2O which will wash the walls of the cyclone as well as the center. (Use about 3 oz. of H_2O.)

34) Remove bottle containing washings. cap and place in plastic bag.

35) Wash the inside of the probe with distilled H_2O and catch the washings in a 4 oz. bottle. Cap and store the bottle in the plastic bag with the cyclone bottle.

36) Disconnect all tubing from the impactor and remove it from the sampler.

37) Remove the small glass thimble and store it in the plastic bag with the two washing bottles.

38) Unscrew the top section of impactor (section marked in) and set aside.

39) Unscrew the section marked one (1) and thoroughly wash the inside with distilled H_2O. Let the washings run through the orifice in the bottom and drain into a widemouthed jar. Turn the section on its side and wash the area below the orifice making sure all washings are caught in the widemouthed jar.

40) With tweezers very carefully remove the collection cup that is located in the top of Section #2. Wash the top and bottom of the cup into the widemouthed jar that section (1) was washed into.

41) Remove Section #2 and wash the inside (including spring) and bottom with distilled H_2O into a new widemouthed jar. Remove the cup from Stage 3 and wash it. Follow the same procedure for each stage.

42) After all stages have been washed, put samples aside and reassemble the impactor. Make sure the cups are riding free on their respective spring and that each stage is in its proper place.

43) Place the impactor into the sampler and connect all tubing to the proper place.

44) Put a new small packed glass thimble onto the impactor and connect the proper piece of tubing.

45) Put a new 4 oz. bottle on the cyclone and place the insulated back on the sampler.

46) Sampler is now ready for next sample.

CALCULATION OF ACTUAL GAS FLOW AFTER SAMPLING

1) Using the actual measured pressure drop across the impactor, the gas temp, static pressure, and time, the actual gas flow can be calculated as follows.

2) $\Delta P_e = \Delta P_{as} \times \frac{MW\ Air}{MW\ Gas} \times \frac{460 + T_d\ (°F)}{460 + T_c\ (°F)} \times \frac{29.92}{Bar.\ Press \pm P_s}$ ("Hg)

3) Using the calibration curve for the Brink Model B Cascade Impactor, select the CFM corresponding to ΔP_e.

4) To find the total CFM drawn through the impactor, simply multiply the total sample time, times CFM.

ANALYTICAL PROCEDURE (WET CHEMISTRY)

Different chemical analyses are required depending on the nature of the dust or mist collected. An example procedure for H_2SO_4 mist is suggested as follows.

1) Pour the probe and cyclone washings into the 500 ML beaker and add four or five drops of phenolpholein indicator.

2) Titrate with standardized NaOH. A low N Na OH (.01 to 0.1 N NaOH) should be used first and if necessary then a stronger N NaOH should be used as required.

3) Record the titer and normality on the sample sheet.

4) Using the stainless steel rod (that has been washed with distilled H_2O), push glass wool from filter tube into a 500 ML beaker.

5) Wash the inside of the filter tube into the 500 ML beaker. Be careful not to wash the outside of filter tube.

6) Add sufficient H_2O to the glass wool until a slurry is formed.

7) Add four or five drops phenolphthalein and titrate to the glass wool and H_2O with a suitable N. NAOH. Be sure to stir the mixture well to insure that all the acid has been leached from the glass wool.

8) The impactor cup washings can either be analyzed while in the widemouthed jar or they can be transferred to a beaker. In either case, add four or five drops of phenolphthalein to each sample and titrate with a soitable N. NAOH. (Record all titers on sample sheet.)

9) Convert the titers of each stage to total mg H_2SO_4.

GRAVIMETRIC ANALYSIS OF SOLID MATERIAL

To gravimetrically analyze most solid material, the individual samples must be dried in some manner. The following procedure assumes that the collected material will not be vaporized while drying.

1) Before the assembly of the impactor, thoroughly dry the impactor cups and pack glass wool thimble in a hot air oven, and desiccate until cool.

2) Tare each cup and packed glass wool thimble with a good four balance and place the cups inside the impactor, and the thimble on the impactor.

3) After the sample has been collected, return the impactor to the lab and very carefully remove the cups with a small set of tweezers. Place each cup in a hot air oven until dry and then desiccate them until cool.

4) Weigh each cup again and subtract the tare weight. The result is the total mg material collected on each cup.

5) Wash the cyclone and probe with a suitable washing liq. and put the washings in a tared evaporation dish.

6) Place the dish and washings on a steam bath and evaporate the liq.

7) Remove the dish from steam bath and place it in a hot air oven until thoroughly dry.

8) Desiccate the dried dish until cool, and then weigh it. Subtract the tare weight from the gross weight to determine the amount of collected material.

9) The packed glass wool thimble can either be dried and desiccated to determine the weight or material collected or the material may be leached from the glass wool, if it is scluable in the washing liq. (The proper method of leaching the glass wool is as follows.)

a) Place the filter on a small suction flask and pull 100 ML of washing liq. through the glass wool.

b) Repeat step a several times using the original 100 MLS of washing liq.

c) Wash the glass wool several more times using a fresh washing solution each time.

d) Wash the glass wool enough to insure that all the material has been leached out, but at the same time attempt to keep the total washing liq. at a minimum due to the evaporation and drying of the sample.

10) If the leaching method was used, evaporate the sample on a steam bath, and dry it in a hot air oven. Desiccate until cool and weigh.

<u>DETERMINATION OF CUMMULATIVE % D_{pc}</u>

1) Determine the mg of material collected on each stage of the impactor.

2) In reference to the total sample collect in the impactor, find the % collected on each stage.

3) Starting with Stage #5, accumulate each stage to arrive at the cumulative % smaller than D_{pc}.

DETERMINATION OF mg PER ACF

1) Total the mg of sample in the impactor and glass wool filter and divide by the actual sample gas flow to determine the mg/ACF < 7 u.

2) Divide the mg of sample collected in the probe and cyclone by the actual sample gas flow to determine the mg/ACF > 7 u.

APPENDIX G

Test Log

Tuesday, October 30, 1973

8:40 a.m.	Test crew arrived at plant. Equipment problems causing delay.
11:20	Started Run #1 inlet and outlet particulate.
12:00	Outlet probe heater smoking. Turned off.
12:04 p.m.	Unloading stopped. Stopped test. Nozzle plugged at inlet at start of test. Switched to larger nozzle.
12:34	Restarted inlet.
12:46	Restarted outlet.
12:51	Stopped.
12:52	Restarted inlet
1:02	Finished inlet.
1:03	Restarted outlet.
2:20	Stopped outlet.
2:23	Restarted.
2:47	Finished outlet. Plant shut down to change barges and did not restart on time because of plant problems.
5:51	Started Run #2 outlet.
6:44	Stopped to change barges.
7:05	Started Run #2 inlet.
7:08	Restarted Run #2 outlet.
7:49	Stopped to change barges.
8:19	Restarted.

Tuesday (Con't.)

8:45 p.m.	Inlet Run #2 finished.
9:03	Outlet Run #2 finished.
9:15	Left plant.

Wednesday, October 31, 1973

9:00 a.m.	Arrived at plant.
10:25	Started Run #3 inlet.
10:35	Started Run #3 outlet.
11:05	Stopped outlet.
11:25	Stopped inlet to change filter and cyclone.
11:38	Restarted outlet and inlet.
12:35 p.m.	Finished Run #3 inlet.
12:42	Stopped outlet.
1:17	Restarted.
1:45	Finished Run #3 outlet.

APPENDIX H

Test Participants

Battelle Memorial Institute

Paul Webb - Test Team Leader

John Faught - Chemist

Harry Leonard - Technician

Ron Clark - Technician

Ben Furness - Technician

Carl Turner - Technician

Environmental Protection Agency

Roger Pfaff - Project Test Officer

Ken Woodard - Project Engineer

APPENDIX H

Test Participants

Battelle Memorial Institute

Paul Webb - Test Team Leader

John Faught - Chemist

Harry Leonard - Technician

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