LIME

AP-42 Section 11.17 .15
Reference 19
Report Sect. 4
Reference 16

1 coal-fired kiln controlled by baghouse
PM-filt, PM-cond, CO_2
← 3 runs → 1 (2 runs)

$\frac{\text{Stone}}{\text{lime}} = 1.89$

$\frac{\text{feed}}{\text{lime}} = 2.19$ (w/coal)

EXHIBIT

1

TEST CONDUCTED AT

PLANT NO. 1

AUGUST 9, 11, and 12, 1977

REPORT ON THE PARTICULATE EMISSIONS FROM A LIME KILN BAGHOUSE

PLANT NO. 1

August 9, 11, and 12, 1977

The complete report covering the above referenced stack test is attached.

Results of all tests conducted to date at Plant No. 1 are summarized below and are compared with the existing Pennsylvania State Code and the proposed Federal EPA code.

	TEST EMISSION RATE		ALLOWABLE EMISSION RATE (TOTAL BOTH BAGHOUSES)	
	AVERAGE/ STACK SECTION	TOTAL BOTH BAGHOUSES	PENNSYLVANIA	USEPA (PROPOSED)
Existing Bags August, 1977				
Total Catch[1]	8.87 #/hr	106.4 #/hr	61.1 #/hr	
Front Half[2]	7.16 #/hr	85.9 #/hr		21.4 #/hr
New Bags August, 1977				
Total Catch	5.14 #/hr	61.7 #/hr	61.3 #/hr	
Front Half	4.34 #/hr	52.0 #/hr		21.5 #/hr
Compliance Test July, 1975				
Total Catch	2.58 #/hr	31.0 #/hr	57.9 #/hr	
Front Half	1.95 #/hr (AVG)	≈ 23.4 #/hr		18.8 #/hr

[1] TOTAL CATCH: Includes particulate collected in probe, filter, and impingers. The Pennsylvania code is based on total catch.

[2] FRONT HALF: Includes particulate collected in probe and filter only. The USEPA code is based on the front half catch.

I. INTRODUCTION:

This report presents the results of three sets of Particulate Emission Tests conducted on August 9, 11, and 12, 1977 at Plant No. 1.

The tests included six two-hour runs designed to measure average emission rates from two baghouses used to control the combined emissions from three separate rotary lime kilns. Each baghouse is divided into six rectangular stack sections. The first four runs were conducted on stack sections venting the emissions from original bags. (Sections 1 and 4 of both baghouses A and B.)

The two additional runs were made on a stack section (Baghouse A - Section 4) after the installation of new bags.

Plant No. 1

PARTICULATE STACK TEST

		EXISTING BAGS				NEW BAGS	
Baghouse-Section		B-1	A-4	B-4	A-1	A-4	A-4
Run Number		1	2	3	4	5	6
Date		8-09-77	8-09-77	8-11-77	8-11-77	8-12-77	8-12-77
olume Gas Sampled SCFD		53.010	49.073	59.166	43.865	62.486	56.211
Moisture, Volume		5.0	5.1	4.5	5.1	4.2	4.5
verage Stack Temp. °F		324	351	356	327	340	343
CFM D		12,630	11,610	13,550	10,174	14,720	12,930
CFM		19,590	18,640	21,720	15,810	23,110	20,460
Isokinetic		102.5	103.3	106.6	105.4	103.8	106.2
eed Rate T/hr (Limestone only)		25.8	25.4	23.1	20.6	23.6	24.1
oal Feed T/r	Avg.	4.1	4.0	3.7	3.3	3.8	3.8
otal PWR	3	29.9	29.4	26.8	23.9	27.4	27.9
ime Production	Kilns	13.7	13.5	12.2	10.9	12.5	12.8
		6.45	6.35	5.78	5.15	5.9	6.03
rticulates - Probe & Filter Catch	(CO_2 (13/ton Prod)	3500	3300	4200	3500	4500	3800
		←		3800			
		176.1	319.4	283.7	126.0	126.6	148.4
/DSCF		0.051	0.100	0.074	0.044	0.031	0.041
/hr		5.62	10.16	8.88	3.98	4.02	4.65
/ton feed		0.87	1.60	1.54	0.77	0.68	0.77
			3.20		1.54	1.36	1.54
			AVG = 2.39			AVG = 1.45	
rticulates - Total Catch							
		256.5	360.8	321.2	182.3	151.9	174.2
/DSCF		0.075	0.113	0.084	0.064	0.037	0.048
/hr		8.19	11.47	10.06	5.75	4.82	5.46
/ton feed		1.27	1.81	1.74	1.12	0.82	0.91
Impinger Catch		31.4	11.4	11.7	30.8	16.6	14.8
		0.80	0.42	0.40	0.70	0.28	0.28
			AVG =				

TEST PROCEDURE

The results outlined above were an EPA Method 5 Sampling Train. The train is taken to the test site, set up, and checked out for an acceptable leakage rate. The test is now ready to be performed. The stack gas velocity head measurements are made with a reverse-type or Type "S" pitot tube and an inclined-vertical manometer. Stack gas temperatures are sensed by a Type "K" thermocouple and indicated on a readout at the control unit. Traverse points are based on the division of stack cross sectional area into equal area zones.

The metering rate to establish isokinetic sampling of stack gas is determined by measuring gas conditions in the stack at the sampling point and gas conditions at the meter while sampling. Other necessary data to determine isokinetic metering rate is determined by preliminary test. The probe with the pitot and thermocouple attachments, are inserted into the stack and continuous gas samples are withdrawn isokinetically at specific traverse points for specific intervals of time. The probe and teflon connecting line are electrically heated to prevent condensation. The gas then passes through a series of four impingers containing distilled water and silica gel set in an ice bath to condense water vapor. The gas, then, passes through the pump, totalizing gas meter, orifice meter and finally to the atmosphere. Needle valves are used to control the flow rates in the sampling train.

At the end of the run, the probe is held in a vertical position, nozzle up, and tapped on the nozzle to cause any dust sticking to the inside of the nozzle to enter the filter. The flow rate may be increased to assist in cleaning the nozzle or a stiff round bristle brush, used as a swab, can be used. The probe and teflon connecting capped or plugged probe tip, and impingers are brought back intact to the test laboratory. These procedures are followed to minimize sample loss or contamination.

PRODUCTION - PROCESS WEIGHT SUMMARY

	AVERAGE PER KILN IN TONS/HOUR LIME PRODUCED	STONE FEED	COAL FEED	PROCESS WEIGHT RATE
Baghouse B-Section 1 Run 1 8-09-77	13.7	6.45 25.8	4.1	29.9
Baghouse A-Section 4 Run 2 8-09-77	13.5	6.35 25.4	4.0	29.4
Baghouse B-Section 4 Run 3 8-11-77	12.2	5.78 23.1	3.7	26.8
aghouse A-Section 1 Run 4 8-11-77	10.9	5.15 20.6	3.3	23.3
Baghouse A-Section 4 Run 5 8-12-77	12.5	5.9 23.6	3.8	27.4
Baghouse A-Section 4 Run 6 8-12-77	12.8	6.03 24.1	3.8	27.9

PLANT NO. 1 PROCESS DATA

August 18, 1977

		STONE	LIME	COAL		
8/9/77	Kiln 1	24.11 T/hr	12.82	3.85	1.88	2.18
	2	24.85	13.17	3.95	1.89	2.19
	3	21.61	11.45	3.44	1.89	2.19
		70.57				
8/11/77	Kiln 1	24.25	12.85	3.86	1.89	2.19
	2	26.58	14.09	4.23	1.89	2.19
	3	14.16	7.51	2.25	1.89	2.19
		65.99				
8/12/77	Kiln 1	23.65	12.53	3.76	1.89	2.19
	2	27.10	14.33	4.30	1.89	2.19
	3	21.56	11.41	3.42	1.89	2.19
		72.31				
					Avg:	1.89 2.19

Baghouse Temperature: 475 - 500°F (Both Baghouses)

Baghouse Pressure:	BAG A	BAG B
8/9/77	4.5-3.8	3.0-3.5
8/11/77	3.2	3.2
8/12/77	2.7	2.7

Oxygen: 2 - 3%

All bags in place - None capped

PROCESS INFORMATION

Plant No. 1 Stack Test

I. BAGHOUSE PRESSURE (H_2O"):

TEST	BAGHOUSE A	BAGHOUSE B
Baghouse B - Section 1 8-09-77 Run 2	4.1	3.2
Baghouse A - Section 4 8-09-77 Run 2	3.8	3.1
Baghouse B - Section 4 8-11-77 Run 3	3.4	3.1
Baghouse A - Section 1 8-11-77 Run 4	3.3	3.1
Baghouse A - Section 4 8-12-77 Run 5	2.7	2.7
Baghouse A - Section 4 8-12-77 Run 6	2.8	2.6

II. BAGHOUSE TEMPERATURE:

475°F - 500°F throughout testing period.

III. % OXYGEN AT BACKEND

2% to 3% throughout testing period.

IV. All bags in place (none capped) in the rooms being tested.

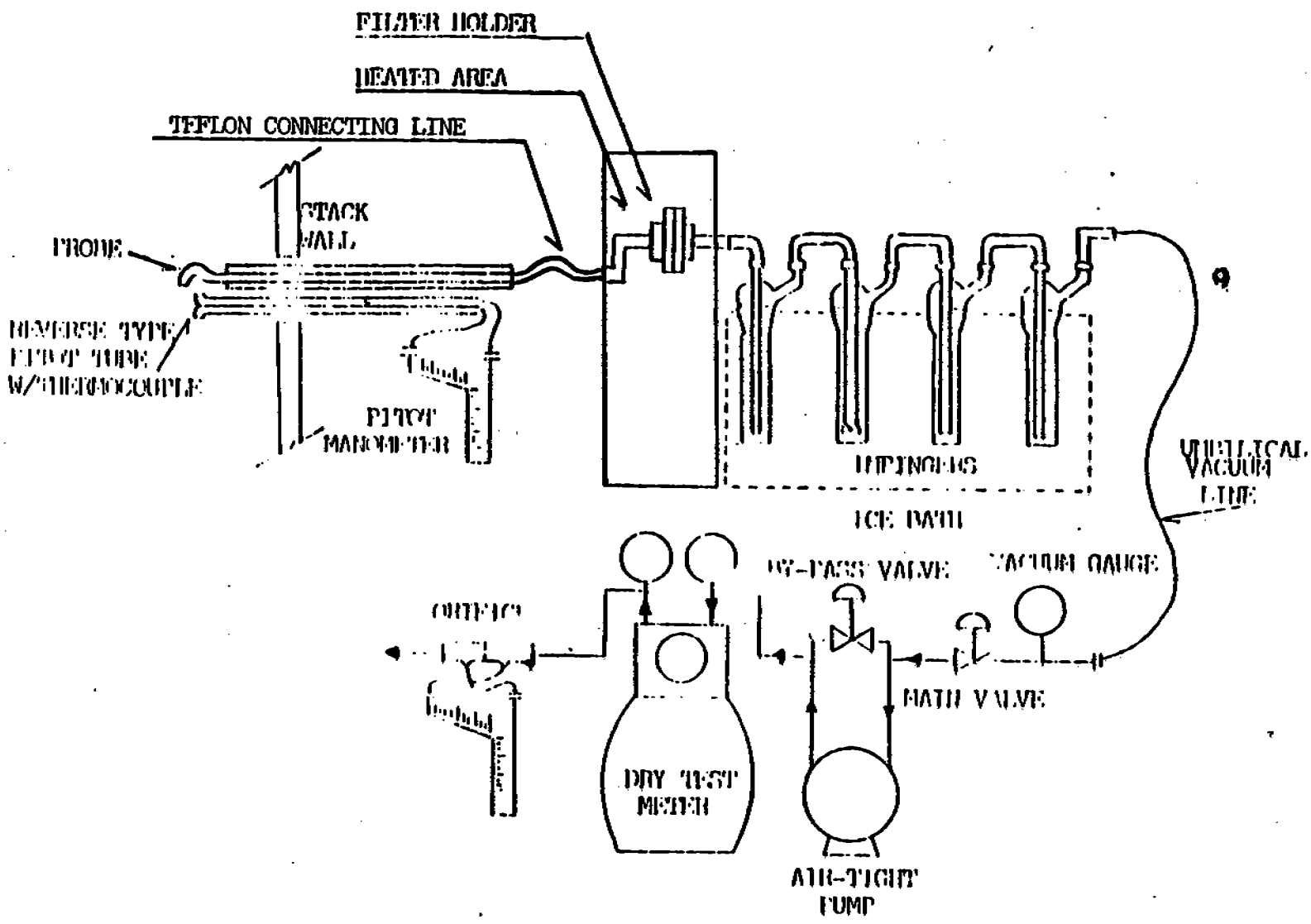
REVISIONS

DESTROY ALL PREVIOUS PRINTS

1		
2		
3		
4		

EPA METHOD 5 SAMPLING TRAIN

8-17-77



PARTICULATE SAMPLING TRAIN

EQUIPMENT TRAIN CHECKOUT

Prior to performing a run, the test equipment is thoroughly checked out:

(a) Teflon tape on all metal-to-metal joints.

(b) Silicone grease on all glass or metal ball joints.

(c) Plug vacuum line at the umbilical cord after impingers, turn on pump, open coarse valve and adjust vacuum to max. Vacuum with fine valve. Gas meter should register no flow.

(d) Assemble entire train including probe, plug probe tip and adjust valves to 15" Hg. Leakage, if any, should not exceed 0.02 CFM at 15" Hg. or correction must be made.

(e) Check operation of all sensors, meters, and equipment orientation.

The basic equipment is manufactured by SCIENTIFIC GLASS & INSTRUMENTS, INC. The Model AP-5000 Modular Stac-O-Lator consists of the following equipment:

(1) 0.50" I.D. button hook-type sampling probe tip, 316 SS
(Suitable diameter based on preliminary survey)

(2) Filter holder, with 102 mm, type A Glass Fiber Filter

(3) 5 ft. effective length pitobe with heated 316 SS inner liner with:

a. ½" I.D., 5/8" O.D. inner liner, heated
b. 3/8" O.D. 316 SS pitot tube
c. Type "K" thermocouple in ¼" O.D. jacket

(4) 12 LF of heated asbestos wrapped teflon connecting line

(5) Four impingers in ice bath

a. Absorber with 100 ml distilled water with ½" I.D. abosrbent tube.
b. Greenburgh-Smith impinger with 100 ml distilled water
c. Absorber with ½" I.D. absorber tube, dry
d. Absorber with 200 gms dry silica gel

(6) 50 LF umbilical cord to control case

(7) Vacuum gauge

(8) Needle control valves

(9) Thomas diaphragm pump, 4 SCFM at 0" Hg, 23" Hg. max.

(10) Dry gas meter rated at 0.1 ft. ^{3}/rev.

(11) Calibrated orifice plate

STACK GAS COMPOSITION

Stack: Plant No. 1

Date: 8-9-77 Time: A.M.

Method of Collection:

( ) Grab Sample ( ) Integrated Other _____

( ) Bomb (X) Bag ( ) Bottle Number _____

Analytical Method:

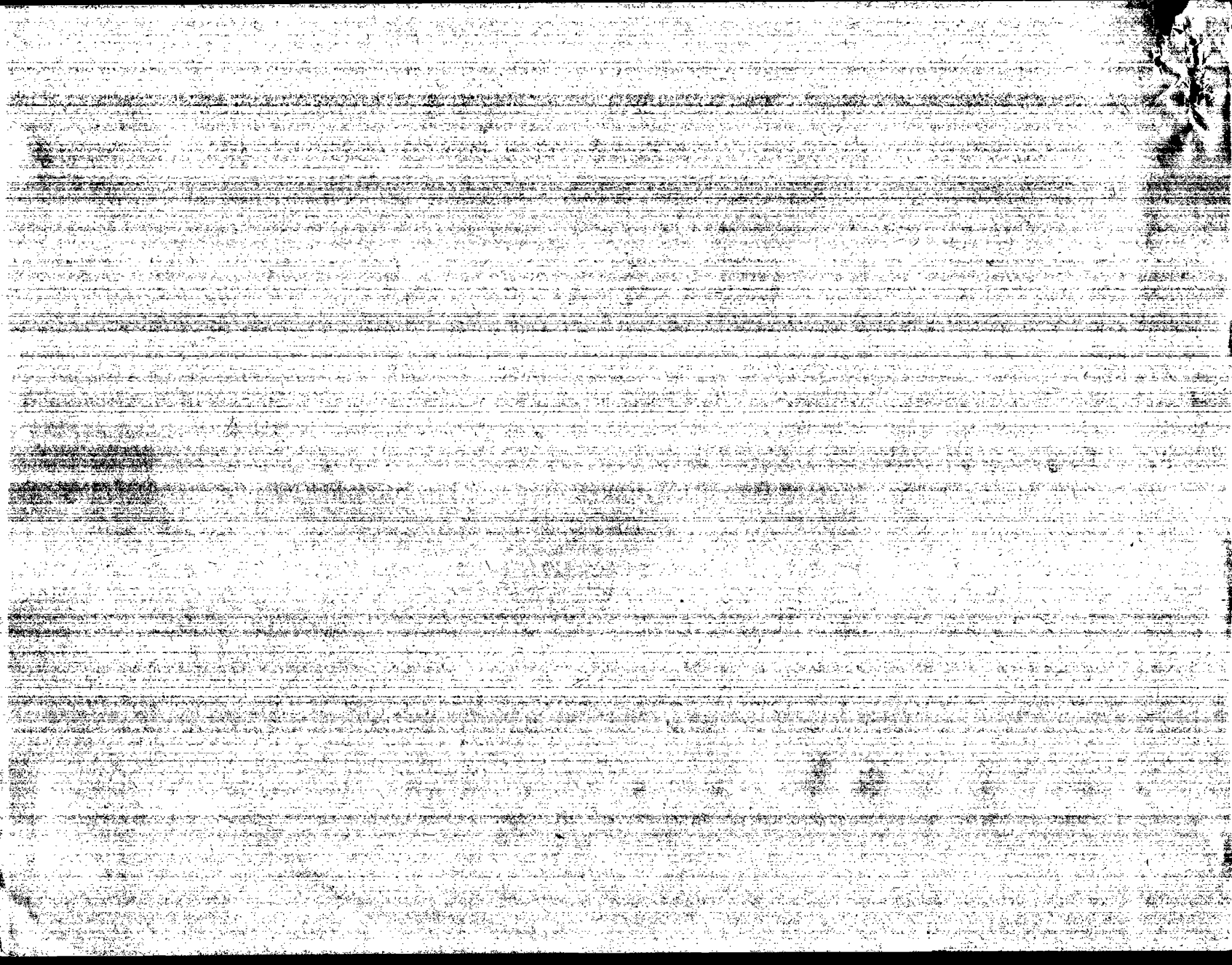
ORSAT for CO_2

_____ for O_2

_____ for CO

Test No.	CO_2 Reading	CO_2 %	O_2 Reading	O_2 %	CO Reading	CO %	Reading	
1		13.0		12.5		0		
2		13.0		12.5		0		
3								
4								
Avg.		13.0		12.5		0		

Test No.	Reading		Reading		Reading		Reading	
1								
2								
3								
4								
Avg.								



PARTICULATE FIELD DATA

PLANT No. 1

RUN NO. 1

LOCATION BAGHOUSE B SECTION 1

DATE 8-9-77

OPERATOR DC - RM - D.G.

SAMPLE BOX NO.

METER BOX NO.

AMBIENT TEMP. °F 80

BAR. PRESS. IN. Hg

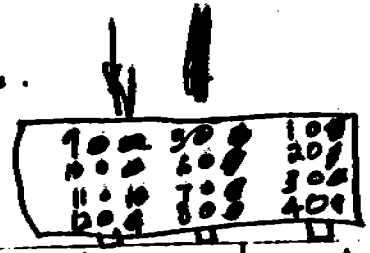
ASSUMED MOISTURE % 5

HEATER BOX SETTING °F

PROBE TIP DIA., IN. 0.5"

PROBE LENGTH 5'

PROBE HEATER SETTING



POINT	θ CLOCK TIME	V_m DRY GAS METER, Ft³	Δp test PITOT IN H_2O	ΔH ORIFICE IN. H_2O REQUIRED	ΔH ORIFICE IN. H_2O ACTUAL	t_m DRY GAS TEMP. °F 5 INLET	t_m DRY GAS TEMP. °F 6 OUTLET	PUMP VACUUM IN Hg GAUGE	BOX TEMP °F 3	t_c IMPINGER TEMP °F 4	P_s STACK PRESS IN H_2O	T_s STACK TEMP °F 1
	10:00AM	962.405										
1	10 MIN/PT	66.155	.01		.39	70	70	5.1	231	72	.05	302
2		69.865	.01	.39		71	70	5.1	243	71	.04	320
3		75.990	.02	.78		70	70	9.0	243	70	.04	330
4		79.535	.015	.59		71	71	7.0	236	71	.05	307
5		84.025	.015	.59		72	71	7.0	233	74	.04	278
6		89.180	.020	.78		72	71	9.1	226	73	.04	333
7		94.365	.020	.78		71	71	9.1	230	72	.04	339
8		98.900	.015	.59		73	72	7.0	234	74	.04	336
9		103.965	.02	.78		73	72	9.0	240	74	.04	336
10		109.140	.02	.78		74	72	9.0	241	75	.04	336
11		113.735	.015	.59		75	73	7.0	242	77	.04	331
12		117.495	.01	.39		74	74	5.0	242	77	.04	337
TOTAL						Avg	Avg					389
Average						Avg						324

PLANT #1 LOCATION E. Bag House

DATE 6-9-77 RUN NO. Run 1

MOISTURE CONTENT

Impinger No. 1	Gross	690.9
	Tare	662.8
	Net	28.1
Impinger No. 2	Gross	660.9
	Tare	650.4
	Net	10.5
Impinger No. 3	Gross	433.7
	Tare	430.8
	Net	2.9
Impinger No. 4	Gross	675.5
	Tare	661.0
	Net	14.5

No. 1	Net	28.1
No. 2	Net	10.5
No. 3	Net	2.9
No. 4	Net	14.5
	Total	56.0

No.	Δp	$\sqrt{\Delta p}$	V_m	t_c	V_{pc}	P_c	$P_c - V_{pm}$	V_c	V_{md}	T_m	P_m	V_{mc}
1	.010	.100	3.750						3.739	530	30.07	3.757
2	.010	.100	3.710						3.699	531	30.07	3.710
3	.020	.141	4.135						4.123	530	30.10	4.147
4	.015	.122	3.545						3.534	531	30.08	3.545
5	.015	.122	4.490						4.477	532	30.08	4.483
6	.020	.141	5.155						5.140	532	30.10	5.150
7	.020	.141	5.185						5.169	531	30.10	5.189
8	.015	.122	4.535						4.521	533	30.08	4.519
9	.020	.141	5.065						5.050	533	30.10	5.051
10	.020	.141	5.175						5.159	534	30.10	5.150
11	.015	.122	4.595						4.581	534	30.08	4.570
12	.010	.100	3.760						3.749	534	30.07	3.739
		1.493										53.010
		0.124									30.086	4.418

Name: PLANT #1
Source: BAGHOUSE B-S
Date: 8-9-77

Run No. 1

P_{bar} = 30.04 "

V_1 = _____

V_f = _____

$(t_s)_{avg}$ = 324.2

$(P_s)_{avg}$ = 30.04 "

A = 40.0 ft

θ = 120 m.

p_n = 0.50 "

$V = \left(\frac{V_{pc}}{P_c}\right) V_m$

$V_{md} = V_m - V_c$

V_{mc} = 17.71 $\left(\frac{ft^3}{m}\right)$

BAGHOUSE = SECTION 1

CALCULATION WORK SHEET

1. VOLUME OF GAS SAMPLE (DRY, STP) $V_{m_{std}}$:

$$V_{m_{std}} = V_{mc}$$
$$= V_{mc_1}$$
$$= \underline{53.010} \text{ SCFDG}$$

2. WATER CALCULATION:

A. Water Vapor Through Meter (SCF):

$$V_{c_{std}} = \left(\frac{B_{wc}}{1-B_{wc}}\right) V_{m_{std}}$$
$$= \left(\frac{0.003}{1-0.003}\right) (53.010)$$
$$= \underline{0.1595} \text{ SCF}$$

B. Collected Water (Impingers + Silica Gel)

V_{I_c}

$\underline{56.0}$ ml

C. Water Fraction Gas Stream, B_{wo} =

$$B_{wo} = \frac{(V_{c_{std}} + 0.0474\ V_{l_c})}{(V_{c_{std}} + 0.0474\ V_{l_c}) + V_{m_{std}}}$$
$$= \frac{0.1595) + 0.0474\ (560)}{0.1595) + 0.0474\ (56.0,} + (53.010)$$
$$= \underline{0.050}$$

D. Dry Gas Fraction, B_d :

$$B_d = 1 - B_{wo}$$
$$= \underline{0.950}$$

3. MOLECULAR WEIGHT CALCULATION:

$$M_d = \frac{1}{100} (\%\ CO_2)(M_{CO_2}) + (\%\ O_2)(M_{O_2}) + (\%\ CO)\ M_{CO}$$
$$+ (\%\ N_2)(M_{N_2})$$

3. MOLECULAR WEIGHT CALCULATIONS:(cont'd)

$$= \frac{1}{100}\left[(13.0)\ (44) + (12.5)\ (32) + (\ 0\ )\ (28) + (74.5)\ (28.2)\right]$$

$$= (\ 572\ ) + (\ 400\ ) + (\ 0.\ ) + (2,100?)$$

$$= \underline{30.73}$$

$$M_s = (M_d)\ (B_d) + 18\ B_{wo}$$

$$= (30.73)\ (\ .95\ ) + 18\ (\ .05\ )$$

$$= \underline{30.09}$$

4. VELOCITY CALCULATIONS:

$$V_s = 85.48\ (C_{p\ test})\ (\sqrt{\Delta P_{avg}})\ \sqrt{\frac{T_s}{P_s M_s}}$$

$$V_s = (85.48)\ (.827)\ (.124)\ \sqrt{\frac{784}{(30.04)\ (30.09)}}$$

$$V_s = \underline{8.164}\ \text{fps}$$

5. VOLUMETRIC FLOW IN STACK (STP), Q_s :

$$Q_s = 3600\ (V_s)\ (A)\ (B_d)\left(\frac{T_{std}}{T_{s\ avg}}\right)\left(\frac{P_{s\ avg}}{P_{std}}\right)$$

$$Q_s = 3600\ (8.164)\ (\ 40\ )\ (.95)\ \left(\frac{530}{784}\right)\left(\frac{30.04}{29.92}\right)$$

$$Q_s = \underline{758,031}\ \text{SCFHDG}$$

6. POLLUTANT MASS RATE, pmr

a. Area Ratio Method, pmr_a

$$pmr_a = 60\ \frac{(pm)\ (A)}{(\cancel{0})\ (An)} = 60\ \frac{(.000388)\ (\ 40\ )}{(\ 120\ )\ (.00364)}$$

$$= \underline{5.69}\ \#/hr \qquad + \text{IMPINGERS} = 8.29\ \#/hr.$$

b. Concentration Method, pmr_c

$$pmr_c = \frac{(pm)\ (Q_s)}{V_{m\ std}} = \frac{(.000388)\ (758,031)}{(53.010)}$$

$$= \underline{5.55}\ \#/hr \qquad + \text{IMPINGERS} = 8.08\ \#/hr$$

CALCULATION WORK SHEET - 3

c. Average pmr = $\frac{pmr_a + pmr_c}{2}$

= $\frac{(5.69) + (5.55)}{2}$ = 5.62 #/hr

+ IMPINGERS = 8.19 #/hr

7. ISOKINETIC RATIO, I_r:

$I_r = \frac{pmr_a}{pmr_c} = \frac{(5.69)}{5.55}$

= 1.025

8. ISOKINETIC VARIATION CHECK, I%:

$I\% = \frac{100\ (V_{m_{std}})\ (T_s)\ (P_{std})}{60\ (\theta)\ (A_n)\ (B_d)\ (V_s)\ (T_{std})\ (P_s)}$

= $\frac{100\ (\quad)\ (\quad)\ (\quad)}{60\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)}$

= _____ %

9. PARTICULATE LOADING, c'_s:

$c'_s = (0.01542)\ \frac{\text{(Total Particulate Catch, mg)}}{V_{m_{std}}}$

= (0.01542) $\left(\frac{176.1}{53.010}\right)$

FRONT ½ = 0.051 gr/SCFDG

+ IMPINGERS = .01542 $\left(\frac{256.5}{53.010}\right)$ = 0.075 gr/SCFDG

PARTICULATE FIELD DATA

PLANT PLANT #1

RUN NO. 2

LOCATION Baghouse A Section 4

DATE 8-9-77

OPERATOR D.C. - D.G. - R.M

SAMPLE BOX NO. _____

METER BOX NO. _____

AMBIENT TEMP. °F 80°

BAR. PRESS. IN. Hg _____

ASSUMED MOISTURE % 5

HEATER BOX SETTING °F _____

PROBE TIP DIA., IN. 0.50

PROBE LENGTH 5'

PROBE HEATER SETTING _____

POINT	θ CLOCK TIME	V_m DRY GAS METER, Ft³	Δp test PITOT IN. H_2O	ΔH ORIFICE IN. H_2O REQUIRED	ΔH ORIFICE IN. H_2O ACTUAL	t_m DRY GAS TEMP. °F INLET	t_m DRY GAS TEMP. °F OUTLET	PUMP VACUUM IN Hg GAUGE	BOX TEMP F	t_c IMPINGER TEMP F	P_s STACK PRESS IN H_2O	t_s STACK TEMP F
	2 300 cm	17.620										
	10 MIN / PT.	23.850	.02			85	83	12.0	240	78	.08	317
		27.955	.02			82	82	5.0	250	76	.06	336
		31.625	.01			80	82	5.2	272	76	.05	352
		35.210	.01			80	82	5.2	250	78	.05	354
		38.915	.01			81	82	5.2	254	80	.05	354
		42.840	.015			81	82	5.2	252	80	.05	354
		46.540	.01			81	82	5.1	252	80	.05	354
		50.515	.015			81	82	5.1	252	80	.05	354
		55.000	.015			80	82	5.1	252	80	.05	354
		59.550	.015			81	82	5.1	252	80	.05	354
		64.065	.015			81	82	5.1	255	80	.05	354
		67.755	.01			78	82	5.2	265	80	.04	354
TOTAL						Avg.	Avg.					
Average						Avg.						

PLANT #1 LOCATION A-BACHUSE

DATE 2-9-77 RUN NO. RCCA 4

RUN 2

MOISTURE CONTENT

Impinger No. 1	Gross	586.0
	Tare	567.0
	Net	19.0
Impinger No. 2	Gross	660.9
	Tare	647.3
	Net	13.6
Impinger No. 3	Gross	441.4
	Tare	437.7
	Net	3.7
Impinger No. 4	Gross	651.3
	Tare	635.0
	Net	16.3

No. 1	Net	19.0
No. 2	Net	13.6
No. 3	Net	3.7
No. 4	Net	16.3
	Total	52.6

NO.	Δp	$\sqrt{\Delta p}$	V_m	t_c	V_{ps}	P_c	$P_c - V_{ps}$	V_c	V_{md}	T_m	P_m	V_{mc}
1	.02	.141	5.230						5.214	544	30.11	5.111
2	.02	.141	5.105						5.090	542	30.11	5.008
3	.01	.100	3.670						3.654	541	30.08	3.603
4	.01	.100	3.585						3.574	541	30.08	3.519
5	.01	.100	3.765						3.754	544	30.08	3.676
6	.015	.122	3.866						3.853	546	30.09	3.761
7	.01	.100	3.700						3.689	546	30.08	3.599
8	.015	.122	4.035						4.023	544	30.09	3.941
9	.015	.122	4.425						4.412	542	30.09	4.338
10	.015	.122	4.550						4.536	543	30.09	4.452
11	.015	.122	4.515						4.501	540	30.09	4.442
12	.01	.100	3.690						3.679	541	30.08	3.623
Tot.		1.392										49.073
Avg.		0.116										4.089

Name: PLANT #1
Source: BAGHOUSE A-SIDE
Date: 8-9-77

Run No. 2

P_{bar} = 30.05

V_l = _____

V_f = _____

$(t_s)_{avg}$ = _____

$(P_s)_{avg}$ = 30.05

A = 40

θ = 120

D_n = 0.50

$$V = \left(\frac{V_{ps}}{P_c}\right) V_m$$

$$V_{md} = V_m - V_c$$

$$V_{mc} = 17.71 \left(\frac{P_m}{T_m}\right)$$

CALCULATION WORK SHEET

R-HOUSE A SECTION. RUN 2 8-9-77

1. VOLUME OF GAS SAMPLE (DRY, STP) $V_{m_{std}}$:

$V_{m_{std}} = V_{mc}$

$= V_{mc_i}$

$= \underline{49.073}$ SCFDG

2. WATER CALCULATION:

A. Water Vapor Through Meter (SCF):

$V_{c_{std}} = \left(\frac{B_{wc}}{1-B_{wc}}\right) V_{m_{std}}$

$= \left(\frac{.003}{1-.003}\right) (49.073)$

$= \underline{0.1477}$ SCF

B. Collected Water (Impingers + Silica Gel)

V_{l_c}

$\underline{52.6}$ ml

C. Water Fraction Gas Stream, B_{wo} =

$$B_{wo} = \frac{(V_{c_{std}} + 0.0474\, V_{l_c})}{(V_{c_{std}} + 0.0474\, V_{l_c}) + V_{m_{std}}}$$

$$= \frac{(0.1477) + 0.0474\,(52.6)}{(0.1477) + 0.0474\,(52.6)} + (49.073)$$

$= \underline{0.051}$

D. Dry Gas Fraction, B_d :

$B_d = 1 - B_{wo}$

$= \underline{0.949}$

3. MOLECULAR WEIGHT CALCULATION:

$M_d = \frac{1}{100} (\%\, CO_2)(M_{CO_2}) + (\%\, O_2)(M_{O_2}) + (\%\, CO)(M_C$

$+ (\%\, N_2)(M_{N_2})$

3. MOLECULAR WEIGHT CALCULATIONS: (cont'd)

$$= \frac{1}{100}\left[(13.0)\ (44) + (12.5)\ (32) + (0)\ (28) + (74.5)\ (28.2)\right]$$

$$= (572) + (400) + (0) + (2,100.9)$$

$$= 30.73$$

$$M_s = (M_d)\ (B_d) + 18\ B_{wo}$$

$$= (30.73)\ (0.949) + 18\ (0.051)$$

$$= 30.08$$

4. VELOCITY CALCULATIONS:

$$V_s = 85.48\ (C_p \text{ test})\ (\sqrt{\Delta P_{avg}})\ \sqrt{\frac{T_s}{P_s M_s}}$$

$$V_s = (85.48)\ (82.7)\ (0.116)\ \sqrt{\frac{811}{(30.05)(30.08)}}$$

$$V_s = 7.767 \text{ fps}$$

5. VOLUMETRIC FLOW IN STACK (STP), Q_s:

$$Q_s = 3600\ (V_s)\ (A)\ (B_d)\left(\frac{T_{std}}{T_{s\ avg}}\right)\left(\frac{P_{s\ avg}}{P_{std}}\right)$$

$$Q_s = 3600\ (7.767)\ (40)\ (0.949)\ \left(\frac{530}{811}\right)\left(\frac{30.05}{29.92}\right)$$

$$Q_s = 696,658 \text{ SCFHDG}$$

6. POLLUTANT MASS RATE, pmr

a. Area Ratio Method, pmr_a

$$pmr_a = 60\ \frac{(pm)\ (A)}{(\rho)\ (An)} = 60\ \frac{(.000704)\ (40)}{(120)\ (0.001364)}$$

$$= 10.32 \text{ \#/hr} \quad + \text{ IMPINGERS } 11.65 \text{ \#/hr}$$

b. Concentration Method, pmr_c

$$pmr_c = \frac{(pm)\ (Q_s)}{V_{m\ std}} = \frac{(.000704)\ (696,658)}{(49.073)}$$

$$= 9.99 \text{ \#/hr} \quad + \text{ IMPINGERS } 11.29 \text{ \#/hr.}$$

CALCULATION WORK SHEET - 3

c. Average pmr = $\frac{pmr_a + pmr_c}{2}$.

= $\frac{(10.32) + (9.99)}{2}$ = 10.16 #/hr

+ IMPINGERS = 11.47 #/hr.

7. ISOKINETIC RATIO, I_r:

$I_r = \frac{pmr_a}{pmr_c} = \frac{(10.32)}{9.99}$

= 103.3

8. ISOKINETIC VARIATION CHECK, I%:

$I\% = \frac{100\ (V_{m_{std}})\ (T_s)\ (P_{std})}{60\ (\theta)\ (A_n)\ (B_d)\ (V_s)\ (T_{std})\ (P_s)}$

= $\frac{100\ (\quad)\ (\quad)\ (\quad)}{60\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)}$

= _____ %

9. PARTICULATE LOADING, c'_s:

$c'_s = (0.01542)\ \frac{(\text{Total Particulate Catch, mg})}{V_{m_{std}}}$

= (0.01542) $\left(\frac{319.4}{49.073}\right)$

FRONT $\frac{1}{2}$ = 0.100 gr/SCFDG

+ IMPINGERS = .01542 $\left(\frac{360.8}{49.073}\right)$ = 0.113 gr/SCFDG

PARTICULATE FIELD DATA

PLANT PLANT #1

RUN NO. 3

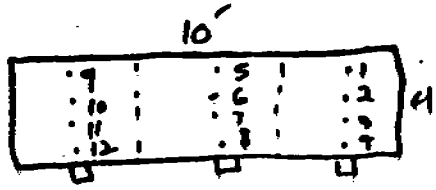
LOCATION BAGHOUSE B - SECTION 4

DATE 8-11-77

OPERATOR D.C. - D.G. - RM.

SAMPLE BOX NO.

METER BOX NO.



AMBIENT TEMP. °F 75°

BAR. PRESS. IN. Hg 30.10

ASSUMED MOISTURE % 5.0

HEATER BOX SETTING °F

PROBE TIP DIA., IN. 0.5?

PROBE LENGTH 5

PROBE HEATER SETTING

POINT	θ CLOCK TIME	V_m DRY GAS METER, Ft³	Δp test PITOT IN H_2O	ΔH ORIFICE IN. H_2O REQUIRED	ΔH ORIFICE IN. H_2O ACTUAL	t_m DRY GAS TEMP. °F INLET	t_m DRY GAS TEMP. °F OUTLET	PUMP VACUUM IN Hg GAUGE	BOX TEMP °F	t_c IMPINGER TEMP °F	P_s STACK PRESS IN H_2O	t_s STACK TEMP °F
Port/Pt.	9:30AM	67.920										
1 1	10 MIN/Pt.	73.110	.020	.78		77	77	7.5	229	70	.05	360
2		78.830	.025	.98		73	77	9.3	235	67	.05	366
3		84.530	.025	.96		72	75	9.2	247	68	.04	370
4		89.075	.015	.59		73	79	5.9	254	70	.05	360
5		94.200	.020	.78		72	74	7.9	239	67	.05	358
2 6		99.840	.025	.98		73	74	10.1	223	72	.05	361
7		105.005	.020	.78		73	72	8.0	229	74	.05	351
8		108.745	.010	.39		73	72	4.4	229	75	.04	346
9		113.205	.015	.59		75	73	6.2	227	75	.05	337
3 10		118.365	.020	.78		74	72	7.9	219	74	.05	354
11		123.520	.020	.78		73	71	7.9	224	73	.04	354
12		127.230	.010	.39		74	73	4.3	233	74	.04	359
TOTAL						Avg.	Avg.					4.27
Average						Avg.						356

PLANT P#1
DATE 8-11-77

LOCATION E T
RUN NO. 3

MOISTURE CONTENT

Impinger No. 1	Gross	672.4
	Tare	664.2
	Net	8.2
Impinger No. 2	Gross	669.7
	Tare	651.5
	Net	18.2
Impinger No. 3	Gross	438.2
	Tare	431.5
	Net	6.7
Impinger No. 4	Gross	682.7
	Tare	660.9
	Net	21.8

No. 1	Net	8.2
No. 2	Net	18.2
No. 3	Net	6.7
No. 4	Net	21.8
	Total	54.9

No.	Δp	$\sqrt{\Delta p}$	V_m	t_c	V_{pn}	P_c	$P_c - V_{ps}$	V_c	V_{md}	T_m	P_m	V_{mc}
1	.030	.141	5.190						5.174	537	30.16	5.146
2	.025	.158	5.720						5.703	535	30.17	5686
	.025	.158	5.700						5.683	534	30.17	5.686
	.015	.122	4.545						4.531	534	30.14	4.529
5	.020	.141	5.125						5.110	533	30.16	5.121
6	.025	.158	5.640						5.623	534	30.17	5.626
7	.020	.141	5.165						5.150	532	30.16	5.171
8	.010	.100	3.740						3.729	533	30.13	3.733
9	.015	.122	4.460						4.447	534	30.14	4.445
10	.020	.141	5.160						5.145	533	30.16	5.156
11	.020	.141	5.155						5.140	532	30.16	5.161
12	.010	.100	3.710						3.699	534	30.13	3.696
Tot.		1.623										59.166
Avg.		0.135										4.931

Name: PLANT #1
Source: Backside B. Stump
Date: 8-11-77

Run No. 3

P_{bar} = 30.10 "Hg
V_t = _____ m
V_r = _____ m
$(t_s)_{avg}$ = 356 °F
$(P_s)_{avg}$ = 30.10 "Hg
A = 40 ft²
θ = 120 min
D_n = 0.50 in

$$V = \left(\frac{V_{pn}}{P_c}\right) V_m$$

$$V_{md} = V_m - V_g$$

$$V_{mc} = 17.71 \left(\frac{P_m}{T_m}\right) V_t$$

Base B Section II
Run 3
8-11-77

CALCULATION WORK SHEET

1. VOLUME OF GAS SAMPLE (DRY, STP) $V_{m_{std}}$:

$$V_{m_{std}} = V_{mc}$$
$$= V_{mc_1}$$
$$= 59.166 \text{ SCFDG}$$

2. WATER CALCULATION:

A. Water Vapor Through Meter (SCF):

$$V_{c_{std}} = \left(\frac{B_{wc}}{1-B_{wc}}\right) V_{m_{std}}$$
$$= \left(\frac{0.003}{1-0.003}\right) (59.166)$$
$$= 0.1780 \text{ SCF}$$

B. Collected Water (Impingers + Silica Gel)

V_{l_c}

$$54.9 \text{ ml}$$

C. Water Fraction Gas Stream, B_{wo} =

$$B_{wo} = \frac{(V_{c_{std}} + 0.0474\, V_{l_c})}{(V_{c_{std}} + 0.0474\, V_{l_c}) + V_{m_{std}}}$$
$$= \frac{(0.1780) + 0.0474\ (54.9)}{(0.1780) + 0.0474\ (54.9)} + (59.166)$$
$$= 0.045$$

D. Dry Gas Fraction, B_d :

$$B_d = 1 - B_{wo}$$
$$= 0.955$$

3. MOLECULAR WEIGHT CALCULATION:

$$M_d = \frac{1}{100} (\%\, CO_2)\ (M_{CO_2}) + (\%\, O_2)\ (M_{O_2}) + (\%\, CO)\ (M_{CO}$$
$$+ (\%\, N_2)\ (M_{N_2})$$

CALCULATION WORK SHEET – 2

3. MOLECULAR WEIGHT CALCULATIONS:(cont'd)

$$= \frac{1}{100}\left[(13.0)\ (44) + (12.5)\ (32) + (\ 0\ )\ (28) + (74.5)\ (28.2)\right]$$

$$= (572) + (400) + (0) + (2100.7)$$

$$= \underline{30.73}$$

$$M_s = (M_d)\ (B_d) + 18\ B_{wo}$$

$$= (30.73)\ (0.955) + 18\ (0.045)$$

$$= \underline{30.16}$$

4. VELOCITY CALCULATIONS:

$$V_s = 85.48\ (C_p\ \text{test})\ (\sqrt{\Delta P_{avg}})\ \sqrt{\frac{T_s}{P_s M_s}}$$

$$V_s = (85.48)\ (.827)\ (.135)\ \sqrt{\frac{816}{(30.10)(30.16)}}$$

$$V_s = \underline{9.048}\ \text{fps}$$

5. VOLUMETRIC FLOW IN STACK (STP), Q_s :

$$Q_s = 3600\ (V_s)\ (A)\ (B_d)\left(\frac{T_{std}}{T_{s\ avg}}\right)\left(\frac{P_{s\ avg}}{P_{std}}\right)$$

$$Q_s = 3600\ (9.048)\ (40)\ (.955)\ \left(\frac{530}{816}\right)\ \left(\frac{30.10}{29.92}\right)$$

$$Q_s = \underline{813,035}\ \text{SCFHDG}$$

6. POLLUTANT MASS RATE, pmr

a. Area Ratio Method, pmr_a

$$pmr_a = 60\ \frac{(pm)\ (A)}{(B)\ (An)} = 60\ \frac{(.000625)\ (40)}{(120)\ (.001364)}$$

$$= \underline{9.16}\ \#/\text{hr} \quad + \text{IMPINGERS} = 10.38\ \#/\text{hr}$$

b. Concentration Method, pmr_c

$$pmr_c = \frac{(pm)\ (Q_s)}{V_{m\ std}} = \frac{(.000625)\ 813035}{(59.166)}$$

$$= \underline{8.59}\ \#/\text{hr} \quad + \text{IMPINGERS} = 9.73\ \#/\text{hr}.$$

CALCULATION WORK SHEET - 3

c. Average pmr = $\frac{pmr_a + pmr_c}{2}$

= $\frac{(9.16) + (8.59)}{2}$ = 8.88 #/hr

+ IMPINGERS = 10.06 #/hr.

7. ISOKINETIC RATIO, I_r:

$I_r = \frac{pmr_a}{pmr_c} = \frac{(9.16)}{8.59}$

= 1.066

8. ISOKINETIC VARIATION CHECK, I%:

$I\% = \frac{100\ (V_{m_{std}})\ (T_s)\ (P_{std})}{60\ (\theta)\ (A_n)\ (B_d)\ (V_s)\ (T_{std})\ (P_s)}$

= $\frac{100\ (\quad)\ (\quad)\ (\quad)}{60\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)}$

= _____ %

9. PARTICULATE LOADING, c'_s:

$c'_s = (0.01542)\ \frac{\text{(Total Particulate Catch, mg)}}{V_{m_{std}}}$

= (0.01542) $\left(\frac{283.7}{59.166}\right)$

FRONT = 0.074 gr/SCFDG

+ IMPINGERS = .01542 $\left(\frac{321.2}{59.166}\right)$ = 0.084 gr/SCFDG

PARTICULATE FIELD DATA

PLANT #1

RUN NO. 4

LOCATION Baghouse A - Section 1

DATE 8-11-77

OPERATOR D.C. - D.G. - R.M.

SAMPLE BOX NO. _____

METER BOX NO. _____

AMBIENT TEMP. °F 81°

BAR. PRESS. IN. Hg 30.12

ASSUMED MOISTURE % 5.0

HEATER BOX SETTING °F _____

PROBE TIP DIA., IN. 0.50"

PROBE LENGTH 5'

PROBE HEATER SETTING _____

POINT	θ CLOCK TIME	V_m DRY GAS METER, Ft³	Δp test PITOT IN. H₂O	ΔH ORIFICE IN. H₂O REQUIRED	ΔH ORIFICE IN. H₂O ACTUAL	t_m DRY GAS TEMP. °F INLET	t_m DRY GAS TEMP. °F OUTLET	PUMP VACUUM IN Hg GAUGE	BOX TEMP F	t_c IMPINGER TEMP F	P_s STACK PRESS IN H₂O	t_s STACK TEMP F
	2:20	27.365	.01	.39		79	80	4.6	225	76	.04	309
	10 min/Pt.	31.055	.01	.39		79	79	4.6	219	74	.04	317
		34.745	.01	.39		80	80	4.5	240	74	.05	322
		38.370	.01	.39		79	79	4.5	244	74	.07	350
		41.995	.01	.39		80	80	4.5	252	75	.04	283
		45.720	.01	.39		76	78	4.5	241	74	.05	314
		49.[illegible]	.01	.39		78	81	4.5	244	76		326
		53.[illegible]	.01	.39		79	81	4.4	246	76	.04	334
		[illegible]	.01	.39		78	81	4.6	253	76		
		61.[illegible]	.01	.39		78	81	4.6	253	74		
		[illegible]	.01	.39		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
		[illegible]	.01	.39		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
TOTAL						Avg.	Avg.					
						Avg.						

PLANT P #1 LOCATION 11-1
DATE 8-11-77 RUN NO.

MOISTURE CONTENT

Impinger No. 1	Gross	686.7
	Tare	666.6
	Net	20.1
Impinger No. 2	Gross	653.2
	Tare	644.0
	Net	9.2
Impinger No. 3	Gross	440.6
	Tare	437.9
	Net	2.7
Impinger No. 4	Gross	650.3
	Tare	635.2
	Net	15.1

No. 1	Net	20.1
No. 2	Net	9.2
No. 3	Net	2.9
No. 4	Net	15.1
	Total	47.3

NO.	Δp	$\sqrt{\Delta p}$	V_m	t_o	V_{pa}	P_o	$P_o - V_{pa}$	V_o	V_{md}	T_m	P_m	V_{mc}
1	.01	0.100	3.690						3.679	540	30.15	3.638
2	.01	0.100	3.690						3.679	539	30.15	3.645
3	.01	0.100	3.625						3.614	540	30.15	3.574
4	.01	0.100	3.615						3.604	539	30.15	3.570
5	.01	0.100	3.735						3.724	540	30.15	3.682
6	.01	0.100	3.680						3.669	537	30.15	3.648
7	.01	0.100	3.820						3.808	539	30.15	3.772
8	.01	0.100	3.770						3.759	539	30.15	3.724
9	.01	0.100	3.615						3.604	539	30.15	3.570
10	.01	0.100	3.725						3.714	538	30.15	3.686
11	.01	0.100	3.705						3.694	537	30.15	3.673
12	.01	0.100	3.715						3.704	537	30.15	3.683
Tot.		1.290										43.865
Avg.		0.100										3.655

Name: PLANT #1
Source: BARNWELL A-TEST
Date: 8-11-77

Run No. 4

P_{bar} = 30.12

V_1 =

V_c =

$(t_o)_{avg}$ =

$(P_o)_{avg}$ = 30.13

A = 40

θ = 120

D_n = .5

$V = \left(\frac{V_{pa}}{P_c}\right) V_m$

$V_{md} = V_m -$

$V_{mc} = 17.71 \left(\frac{P_m}{T_m}\right.$

CALCULATION WORK SHEET

1. VOLUME OF GAS SAMPLE (DRY, STP) $V_{m_{std}}$:

$$V_{m_{std}} = V_{mc}$$
$$= V_{mc_1}$$
$$= \underline{43.865} \text{ SCFDG}$$

2. WATER CALCULATION:

A. Water Vapor Through Meter (SCF):

$$V_{c_{std}} = \left(\frac{B_{wc}}{1-B_{wc}}\right) V_{m_{std}}$$
$$= \left(\frac{0.003}{1-0.003}\right) (43.865)$$
$$= \underline{0.1320} \text{ SCF}$$

B. Collected Water (Impingers + Silica Gel)

V_{l_c} $\underline{47.3}$ ml

C. Water Fraction Gas Stream, B_{wo} =

$$B_{wo} = \frac{(V_{c_{std}} + 0.0474\, V_{l_c})}{(V_{c_{std}} + 0.0474\, Vi_c) + V_{m_{std}}}$$
$$= \frac{(0.132) + 0.0474\ (47.3)}{(0.132) + 0.0474\ (47.3)} + (43.865)$$
$$= \underline{0.057}$$

D. Dry Gas Fraction, B_d :

$$B_d = 1 - B_{wo}$$
$$= \underline{0.949}$$

3. MOLECULAR WEIGHT CALCULATION:

$$M_d = \frac{1}{100} (\%\, CO_2)(M_{CO_2}) + (\%\, O_2)(M_{O_2}) + (\%\, CO)(M_{CO}) + (\%\, N_2)(M_{N_2})$$

CALCULATION WORK SHEET - 2

3. MOLECULAR WEIGHT CALCULATIONS: (cont'd)

$$= \frac{1}{100}\left[(13.0)\ (44) + (12.5)\ (32) + (\ a\ )\ (28) + (74.5)\ (28.2)\right]$$

$$= (\ 572\ ) + (400\ ) + (\ 0\ ) + (2100.9)$$

$$= \underline{30.73}$$

$$M_s = (M_d)\ (B_d) + 18\ B_{wo}$$

$$= (30.73)\ (0.949) + 18\ (.051)$$

$$= \underline{30.08}$$

4. VELOCITY CALCULATIONS:

$$V_s = 85.48\ (C_p\ test)\ (\sqrt{\Delta P_{avg}})\ \sqrt{\frac{T_{s\ avg}}{P_s M_s}}$$

$$V_s = (85.48)\ (.827)\ (.100)\ \sqrt{\frac{787}{(30.13)(30.08)}}$$

$$V_s = \underline{6.587}\ \text{fps}$$

5. VOLUMETRIC FLOW IN STACK (STP), Q_s:

$$Q_s = 3600\ (V_s)\ (A)\ (B_d)\left(\frac{T_{std}}{T_{s\ avg}}\right)\left(\frac{P_{s\ avg}}{P_{std}}\right)$$

$$Q_s = 3600\ (6.587)\ (40\ )\ (.949)\ \left(\frac{530}{787}\right)\left(\frac{30.13}{29.92}\right)$$

$$Q_s = \underline{610,457}\ \text{SCFHDG}$$

6. POLLUTANT MASS RATE, pmr

a. Area Ratio Method, pmr_a

$$pmr_a = 60\ \frac{(p_m)\ (A)}{(\theta)\ (A_n)} = 60\ \frac{(.000278)\ (\ 40\ )}{(120\ )\ (0.001364}$$

$$= \underline{4.08}\ \#/hr \quad + \text{IMPINGERS} = 5.90\ \#/hr$$

b. Concentration Method, pmr_c

$$pmr_c = \frac{(p_m)\ (Q_s)}{V_{m\ std}} = \frac{(.000278)\ (610,457)}{(43.865\ )}$$

$$= \underline{3.87}\ \#/hr \quad + \text{IMPINGERS} = 5.59\ \#/hr$$

APPENDIX E
FIELD DATA AND CALCULATIONS
BAGHOUSE A, SECTION 2 - RUN 5

CALCULATION WORK SHEET - 3

c. Average pmr = $\frac{pmr_a + pmr_c}{2}$

= $\frac{(4.08) + (3.87)}{2}$ = 3.98 #/hr

+ IMPINGERS = 5.75 #/hr

7. ISOKINETIC RATIO, I_r:

$I_r = \frac{pmr_a}{pmr_c} = \frac{(4.08)}{3.87}$

= 1.054

8. ISOKINETIC VARIATION CHECK, I%:

$I\% = \frac{100\ (V_{m_{std}})\ (T_s)\ (P_{std})}{60\ (\theta)\ (A_n)\ (B_d)\ (V_s)\ (T_{std})\ (P_s)}$

= $\frac{100\ (\quad)\ (\quad)\ (\quad)}{60\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)}$

= _____ %

9. PARTICULATE LOADING, c'_s:

$c'_s = (0.01542)\ \frac{(\text{Total Particulate Catch, mg})}{V_{m_{std}}}$

= $(0.01542)\ \frac{(126.0)}{43.865}$

FRONT HALF = 0.044 gr/SCFDG

+ IMPINGERS = $(0.01542)\ \frac{(182.3)}{}$ = 0.064 gr/SCFDG

PARTICULATE FIELD DATA

PLANT #1

RUN NO. 5

LOCATION BAGHOUSE A STACK # 4

DATE 8-12-77

OPERATOR D.C. - D.G. - F.M.

SAMPLE BOX NO. ____

METER BOX NO. ____

AMBIENT TEMP. °F 73

BAR. PRESS. IN. Hg 30.01

ASSUMED MOISTURE % 5.0

HEATER BOX SETTING °F ____

PROBE TIP DIA., IN. 0.50

PROBE LENGTH 5'

PROBE HEATER SETTING ____

POINT	θ CLOCK TIME	V_m DRY GAS METER, FT³	ΔP PITOT IN H_2O	ΔH ORIFICE IN H_2O REQUIRED	ΔH ORIFICE IN H_2O ACTUAL	t_m DRY GAS TEMP. °F INLET	t_m DRY GAS TEMP. °F OUTLET	PUMP VACUUM IN. Hg GAUGE	BOX TEMP °F	t_c IMPINGER TEMP °F	P_s STACK PRESS IN H_2O	t_s STACK TEMP °F
	9:00AM	72.080										
1	10MIN/PT	77.200	.02	.78		76	77	9.2	238	71	.03	350
2		82.935	.025	.98		73	76	13.0	241	70	.03	363
3		88.670	.025	.98		71	75	13.0	247	70	.05	362
4		93.540	.020	.78		70	74	9.5	243	72	.05	350
5		99.065	.025	.98		69	72	13.1	234	72	.06	335
6		104.730	.025	.98		69	71	13.0	233	72	.07	341
7		10.741	.03	1.17(1.02)		68	70	18.5	210	71	.07	346
8		15.485	.015	.59		68	68	6.8	262	69	.04	321
9		19.920	.015	.59		67	67	6.8	271	68	.05	318
10		24.375	.015	.59		69	68	6.8	266	70	.06	324
11		29.465	.02	.78		70	69	9.8	265	72	.05	325
12		34.570	.02	.78		70	68	9.8	250	72	.05	331
#8	SHUT DOWN - CKGD VACUUM LINES											
TOTAL						Avg.	Avg.					
						Avg.						

PLANT #1 LOCATION A-4 #1 Test

DATE 2-12-77 RUN NO.

MOISTURE CONTENT

Impinger No. 1	Gross	673.8
	Tare	663.8
	Net	10.0
Impinger No. 2	Gross	671.3
	Tare	656.2
	Net	15.1
Impinger No. 3	Gross	436.3
	Tare	431.6
	Net	4.7
Impinger No. 4	Gross	687.0
	Tare	663.3
	Net	23.7

No. 1	Net	10.0
No. 2	Net	15.1
No. 3	Net	4.7
No. 4	Net	23.7
	Total	53.5

NO.	Δp	$\sqrt{\Delta p}$	V_m	t_o	V_{pa}	P_o	$P_o - V_{pa}$	V_o	V_{md}	T_m	P_m	V_{mc}
1	.02	0.141	5.120						5.105	537	30.07	5.063
2	.025	0.158	5.735						5.718	535	30.08	5.694
3	.025	0.158	5.735						5.718	533	30.08	5.715
4	.02	0.141	4.870						4.855	532	30.07	4.860
5	.025	0.158	5.525						5.508	531	30.08	5.526
6	.025	0.158	5.665						5.648	531	30.08	5.666
7	.03	0.173	6.010						5.992	529	30.09	6.036
8	.015	0.122	4.745						4.731	528	30.05	4.769
9	.015	0.122	4.435						4.422	527	30.05	4.466
10	.015	0.122	4.455						4.442	529	30.05	4.469
11	.02	0.141	5.090						5.074	530	30.07	5.098
12	.02	0.141	5.105						5.090	529	30.07	5.124
Tot.		1.735										62.486
Avg.		0.145										5.207

Name: PLANT #1
Source: BARNWELL A-TECH
Date: 8-12-77

Run No. 5

P_{bar} = 30.01

V_1 = _____

V_f = _____

$(t_a)_{avg}$ = _____

$(P_a)_{avg}$ = 30.02

A = 40

θ = 120

D_n = .5

$$V = \left(\frac{V_{pa}}{P_o}\right) V_m$$

$$V_{md} = V_m - V_o$$

$$V_{mc} = 17.71 \left(\frac{P_m}{T_m}\right)$$

CALCULATION WORK SHEET

1. VOLUME OF GAS SAMPLE (DRY, STP) $V_{m_{std}}$:

$$V_{m_{std}} = V_{mc}$$
$$= V_{mc_1}$$
$$= 62.486 \text{ SCFDG}$$

2. WATER CALCULATION:

A. Water Vapor Through Meter (SCF):

$$V_{c_{std}} = \left(\frac{B_{wc}}{1-B_{wc}}\right) V_{m_{std}}$$
$$= \left(\frac{0.003}{1-0.003}\right) (62.486)$$
$$= 0.1880 \text{ SCF}$$

B. Collected Water (Impingers + Silica Gel)

V_{l_c}

$$53.5 \text{ ml}$$

C. Water Fraction Gas Stream, B_{wo} =

$$B_{wo} = \frac{(V_{c_{std}} + 0.0474\ V_{l_c})}{(V_{c_{std}} + 0.0474\ V_{l_c}) + V_{m_{std}}}$$
$$= \frac{(0.188) + 0.0474\ (53.5)}{(0.188) + 0.0474\ (53.5)} + (62.486)$$
$$= 0.042$$

D. Dry Gas Fraction, B_d :

$$B_d = 1 - B_{wo}$$
$$= 0.958$$

3. MOLECULAR WEIGHT CALCULATION:

$$M_d = \frac{1}{100} (\%\ CO_2)\ (M_{CO_2}) + (\%\ O_2)\ (M_{O_2}) + (\%\ CO)\ (M_{CO}) + (\%\ N_2)\ (M_{N_2})$$

CALCULATION WORK SHEET - 2

3. MOLECULAR WEIGHT CALCULATIONS: (cont'd)

$$= \frac{I}{100}\left[(13.0)\ (44) + (12.5)\ (32) + (\ 0\ )\ (28) + (74.5)\ (28.2)\right]$$

$$= (\ 572\ ) + (\ 400\ ) + (\ 0\ ) + (2100.9)$$

$$= \underline{30.73}$$

$$M_s = (M_d)\ (B_d) + 18\ B_{wo}$$

$$= (30.73)\ (0.958) + 18\ (0.042)$$

$$= \underline{30.20}$$

4. VELOCITY CALCULATIONS:

$$V_s = 85.48\ (C_p\ \text{test})\ (\sqrt{\Delta P_{avg}})\ \sqrt{\frac{T_s}{P_s M_s}}\ \text{avg}$$

$$V_s = (85.48)\ (.811)\ (.145)\ \sqrt{\frac{800}{(30.02)(30.20)}}$$

$$V_s = \underline{9.629}\ \text{fps}$$

5. VOLUMETRIC FLOW IN STACK (STP), Q_s:

$$Q_s = 3600\ (V_s)\ (A)\ (B_d)\left(\frac{T_{std}}{T_{s\ avg}}\right)\left(\frac{P_{s\ avg}}{P_{std}}\right)$$

$$Q_s = 3600\ (9.629)\ (40\ )\ (.958)\ \left(\frac{530}{800}\right)\left(\frac{30.02}{29.92}\right)$$

$$Q_s = \underline{882,966}\ \text{SCFHDG}$$

6. POLLUTANT MASS RATE, pmr

a. Area Ratio Method, pmr_a

$$pmr_a = 60\ \frac{(pm)\ (A)}{(\theta)\ (A_n)} = 60\ \frac{(.000279)\ (\ 40\ )}{(\ 120\ )\ (0.001364)}$$

$$= \underline{4.09}\ \#/\text{hr} \quad + \text{IMPINGERS} = 4.91\ \#/\text{hr}$$

b. Concentration Method, pmr_c

$$pmr_c = \frac{(pm)\ (Q_s)}{V_{m\ std}} = \frac{(.000279)\ (882,966)}{(62.486\ )}$$

$$= \underline{3.94}\ \#/\text{hr} \quad + \text{IMPINGERS} = 4.73\ \#/\text{hr}$$

CALCULATION WORK SHEET - 3

c. Average pmr = $\frac{pmr_a + pmr_c}{2}$

= $\frac{(4.09) + (3.94)}{2}$ = 4.02 #/hr

+ IMPINGERS = 4.82

7. ISOKINETIC RATIO, I_r:

$I_r = \frac{pmr_a}{pmr_c} = \frac{(4.09)}{3.94}$

= 1.038

8. ISOKINETIC VARIATION CHECK, I%:

$I\% = \frac{100\ (V_{m_{std}})\ (T_s)\ (P_{std})}{60\ (\theta)\ (A_n)\ (B_d)\ (V_s)\ (T_{std})\ (P_s)}$

$= \frac{100\ (\quad)\ (\quad)\ (\quad)}{60\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)}$

= _____ %

9. PARTICULATE LOADING, c'_s:

$c'_s = (0.01542)\ \left(\frac{\text{Total Particulate Catch, mg}}{V_{m_{std}}}\right)$

FRONT HALF = $(0.01542)\ \left(\frac{126.6}{62.486}\right)$

= 0.031 gr/SCFDG

+ IMPINGERS = $(0.01542)\ \left(\frac{151.9}{\quad}\right)$ - 0.037

PARTICULATE FIELD DATA

START ..... 1:26 PM
FINISH ..... 3:26 PM

PLANT #1
RUN NO. 6
LOCATION Baghouse A Section 4
DATE 8-12-77
OPERATOR D.C.-R.M.-D.G
SAMPLE BOX NO. _____
METER BOX NO. _____

AMBIENT TEMP. °F 75
BAR. PRESS. IN. Hg 30.01
ASSUMED MOISTURE % 5.0
HEATER BOX SETTING °F _____
PROBE TIP DIA., IN. 0.50
PROBE LENGTH 5'
PROBE HEATER SETTING _____

POINT	θ CLOCK TIME	V_m DRY GAS METER, Ft³	Δp test PITOT IN. H_2O	ΔH ORIFICE IN. H_2O REQUIRED	ΔH ORIFICE IN. H_2O ACTUAL	t_m DRY GAS TEMP. °F INLET	t_m DRY GAS TEMP. °F OUTLET	PUMP VACUUM IN. Hg GAUGE	BOX TEMP °F	t_c IMPINGER TEMP °F	P_s STACK PRESS IN H_2O	t_s STACK TEMP °F
	1:30 PM	234.715										
1	10 MIN/PT.	39.210	.015	.55		68	68	6.8	223	68	.05	350
2		43.755	.015	.59		69	69	6.8	230	67	.05	355
3		49.450	.025	.78		69	69	12.0	232	67	.05	367
4	SWITCH	54.365	.015	.55		69	69	6.8	235	68	.05	351
5		58.705	.015	.55		69	69	6.8	240	70	.05	338
6		63.460	.02	.76		69	69	9.2	233	70	.05	341
7		68.030	.015	.57		69	69	7.0	232	70	.04	346
8	SWITCH	71.790	.01	.37		69	69	4.9	234	69	.04	333
9	←	75.420	.01	.37		69	69	4.9	231	69	.04	321
10		80.515	.02	.76		69	69	9.2	234	69	.05	336
11		85.240	.02	.76		71	68	9.2	231	69	.05	342
12		90.150	.02	.76		72	69	9.5	229	71	.05	346
13												
14												
15												
16												
17												
18												
19												
20												
21												
22												
23												
TOTAL						Avg	Avg					4/12
Average						Avg						343

PLANT P#1 LOCAT 9-4 Test-2
DATE 8-12-77 RUN NO. C

MOISTURE CONTENT

Impinger No. 1	Gross	679.5
	Tare	664.6
	Net	14.7
Impinger No. 2	Gross	660.6
	Tare	646.0
	Net	14.6
Impinger No. 3	Gross	441.6
	Tare	438.0
	Net	3.6
Impinger No. 4	Gross	657.0
	Tare	638.1
	Net	18.9

No. 1	Net	14.7
No. 2	Net	14.6
No. 3	Net	3.6
No. 4	Net	18.9
Total		51.8

NO.	Δp	$\sqrt{\Delta p}$	V_m	t_o	V_{pB}	P_o	$P_o - V_{pB}$	V_o	V_{md}	T_m	P_m	V_{mc}
1	0.05	.122	4.495						4.482	528	30.05	4.518
2	0.015	.122	4.545						4.531	529	30.05	4558
3	0.025	0.158	5.695						5.678	529	30.08	5.718
4	0.015	.122	5.515						5.498	529	30.05	5531
5	0.015	.122	3.440						3.430	529	30.05	3.451
6	0.020	.141	5.055						5.040	529	30.07	5.074
7	0.015	0122	4.570						4.556	529	30.05	4.583
8	0.010	.100	3.760						3.749	529	30.04	3.770
9	0.010	.100	3.630						3.619	529	30.04	3.640
10	0.020	.141	5.095						5.080	528	30.07	5.124
11	0.020	.141	5.125						5.110	530	30.07	5.134
12	0.020	.141	5.110						5.095	531	30.07	5.110
Tot.		1532										56.211
Avg.		.128										4.684

Name: PLANT #1
Source: BAGHOUSE A SEC
Date: 5-12-77

Run No. 6

P_{bar} = 30.01

V_1 = ____

V_f = ____

$(t_s)_{avg}$ = 343

$(P_s)_{avg}$ = 30.01

A = 40

θ = 120

P_n = 0.50

$V = \left(\frac{V_{pn}}{P_o}\right)'$

$V_{md} = V_m - V_o$

$V_{mc} = 17.71 \left(\frac{P_m}{T_m}\right.$

Engelhard Pt-Sponge
Run 6
8-12-77

CALCULATION WORK SHEET

1. VOLUME OF GAS SAMPLE (DRY, STP) $V_{m_{std}}$:

$$V_{m_{std}} = V_{mc}$$
$$= V_{mc_1}$$
$$= 56.211 \text{ SCFDG}$$

2. WATER CALCULATION:

A. Water Vapor Through Meter (SCF):

$$V_{c_{std}} = \left(\frac{B_{wc}}{1-B_{wc}}\right) V_{m_{std}}$$
$$= \left(\frac{0.003}{1-0.003}\right) (56.211)$$
$$= 0.1691 \text{ SCF}$$

B. Collected Water (Impingers + Silica Gel)

V_{l_c}

$$51.8 \text{ ml}$$

C. Water Fraction Gas Stream, B_{wo} =

$$B_{wo} = \frac{(V_{c_{std}} + 0.0474\, V_{l_c})}{(V_{c_{std}} + 0.0474\, V_{l_c}) + V_{m_{std}}}$$
$$= \frac{(0.1691) + 0.0474\,(51.8)}{(0.1691) + 0.0474\,(51.8)} + (56.211$$
$$= 0.045$$

D. Dry Gas Fraction, B_d :

$$B_d = 1 - B_{wo}$$
$$= 0.955$$

3. MOLECULAR WEIGHT CALCULATION:

$$M_d = \frac{1}{100} (\%\, CO_2)\, (M_{CO_2}) + (\%\, O_2)\, (M_{O_2}) + (\%\, CO)\, (M_{CO}$$
$$+ (\%\, N_2)\, (M_{N_2})$$

3. MOLECULAR WEIGHT CALCULATIONS: (cont'd)

$$= \frac{1}{100}\left[(13.0)\ (44) + (12.5)\ (32) + (0)\ (28) + (74.5)\ (28.2)\right]$$

$$= (5.72) + (4.00) + (0) + (2.100.9)$$

$$= 30.73$$

$$M_s = (M_d)\ (B_d) + 18\ B_{wo}$$

$$= (30.73)\ (0.955) + 18\ (0.045)$$

$$= 30.16$$

4. VELOCITY CALCULATIONS:

$$V_s = 85.48\ (C_p\ test)\ (\sqrt{\Delta P_{avg}})\ \sqrt{\frac{T_s}{P_s M_s}}$$

$$V_s = (85.48)\ 0.87\ 0.128\ \sqrt{\frac{803}{(30.01)(30.16)}}$$

$$V_s = 8.523 \text{ fps}$$

5. VOLUMETRIC FLOW IN STACK (STP), Q_s :

$$Q_s = 3600\ (V_s)\ (A)\ (B_d)\left(\frac{T_{std}}{T_{s\ avg}}\right)\left(\frac{P_{s\ avg}}{P_{std}}\right)$$

$$Q_s = 3600\ (8.523)\ (40)\ (.955)\ \left(\frac{530}{803}\right)\ \left(\frac{30.01}{29.92}\right)$$

$$Q_s = 775,931 \text{ SCFHDG}$$

6. POLLUTANT MASS RATE, pmr

a. Area Ratio Method, pmr_a

$$pmr_a = 60\ \frac{(p_m)\ (A)}{(B)\ (A_n)} = 60\ \frac{(0.00027)\ (40)}{(120)\ (0.001364)}$$

$$= 4.79 \text{ \#/hr} \quad + \text{IMPINGERS } 5.62 \text{\#/hr}$$

b. Concentration Method, pmr_c

$$pmr_c = \frac{(p_m)\ (Q_s)}{V_{m\ std}} = \frac{(0.00027)\ (775,931)}{(56.211)}$$

$$= 4.51 \text{ \#/hr}$$

+ IMPINGERS 5.30 \#/hr

CALCULATION WORK SHEET – 3

c. Average pmr = $\frac{pmr_a + pmr_c}{2}$

= $\frac{(4.79) + (4.51)}{2}$ = 4.65 #/hr

+ IMPINGERS = 5.46 #/hr

7. ISOKINETIC RATIO, I_r:

$I_r = \frac{pmr_a}{pmr_c} = \frac{(4.79)}{4.51}$

= 1.062

8. ISOKINETIC VARIATION CHECK, I%:

$I\% = \frac{100\ (V_{m_{std}})\ (T_s)\ (P_{std})}{60\ (\theta)\ (A_n)\ (B_d)\ (V_s)\ (T_{std})\ (P_s)}$

= $\frac{100\ (\quad)\ (\quad)\ (\quad)}{60\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)\ (\quad)}$

= _____ %

9. PARTICULATE LOADING, c'_s:

$c'_s = (0.01542)\ \frac{(\text{Total Particulate Catch, mg})}{V_{m_{std}}}$

= (0.01542) $\frac{(1454)}{56.211}$

FRONT 1/2 = 0.041 gr/SCFDG

+ IMPINGERS = 0.01542 (1742) = 0.048 gr/SCFDG