ENVIRONMENTAL DEP

AP-42 Section 11.6
Reference 20
Report Sect. 4
Reference 13

LONE STAR INDUSTRIES, INC.

Cement & Construction Materials Group

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

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

PARTICULATE EMISSIONS TESTING

GREENCASTLE PLANT

May 8 - June 22, 1977

CENTRAL RESEARCH LABORATORY

P. O. BOX 2148

HOUSTON, TEXAS 77001

CTR-G-6301

Source category: Portland Cement
Plant name : Lone Star Industries
Test date : 5/8 - 6/22/77
Process : wet

Date: 01/15/93
Location: Greencastle, IN
Ref. No.: 13
Basis for process rate : feed/production
Ratio: 1.6446281

Source	Type of control	Pollutant	Run No.	Emission rate, lb/hr	Process rate, ton/hr	Emission factor kg/Mg	Emission factor lb/ton	Volumetric flow rate, DSCFM	Concen. ppm
rotary kiln	ESP	BASED ON DRY SOLIDS FEED RATE; INSUFFLATION RATE NOT SPECIFIED							
		filt. PM	1	4.93	135	0.0183	0.0365		
		filt. PM	3	30.18	135	0.112	0.224		
		filt. PM	5	0.77	135	0.00285	0.00570		
					average	0.0443	0.0886	Rating:	B
		con. inorg. PM	1	16.12	135	0.0597	0.119		
		con. inorg. PM	3	26.06	135	0.0965	0.193		
		con. inorg. PM	5	8.05	135	0.0298	0.0596		
					average	0.0620	0.124	Rating:	B
		BASED ON DRY SOLIDS FEED RATE; INSUFFLATION RATE NOT SPECIFIED; FOLLOWING ESP UPGRADE							
		filt. PM	21	28.58	138	0.104	0.207		
		filt. PM	23	14.75	138	0.0534	0.107		
		filt. PM	25	13.9	138	0.0504	0.101		
					average	0.0691	0.138	Rating:	B
		con. inorg. PM	21	13.66	138	0.0495	0.0990		
		con. inorg. PM	23	16.23	138	0.0588	0.118		
		con. inorg. PM	25	28	138	0.101	0.203		
					average	0.0699	0.140	Rating:	B
	none	BASED ON DRY SOLIDS FEED RATE; 6 TONS/HR INSUFFLATION							
		filt. PM	9	9782	125	39.1	78.3		
		filt. PM	11	9938	125	39.8	79.5		
		filt. PM	13	10283	125	41.1	82.3		
					average	40.0	80.0	Rating:	B
		con. inorg. PM	9	18	125	0.0720	0.144		
		con. inorg. PM	11	82	125	0.328	0.656		
		con. inorg. PM	13	57	125	0.228	0.456		
					average	0.209	0.419	Rating:	B
	ESP	BASED ON DRY SOLIDS FEED RATE; 6 TONS/HR INSUFFLATION							
		filt. PM	10	4.4	125	0.0176	0.0352		
		filt. PM	12	13.2	125	0.0528	0.106		
		filt. PM	14	33.1	125	0.132	0.265		
					average	0.0676	0.135	Rating:	B
		con. inorg. PM	10	9.6	125	0.0384	0.077		
		con. inorg. PM	12	14.8	125	0.0592	0.118		
		con. inorg. PM	14	28.9	125	0.116	0.231		
					average	0.0711	0.142	Rating:	B
	none	BASED ON DRY SOLIDS FEED RATE; 12 TONS/HR INSUFFLATION							
		filt. PM	15	10058	125	40.2	80.5		
		filt. PM	17	9372	125	37.5	75.0		
		filt. PM	19	11183	125	44.7	89.5		
					average	40.8	81.6	Rating:	B
		con. inorg. PM	15	142	125	0.568	1.14		
		con. inorg. PM	17	607	125	2.43	4.86		
		con. inorg. PM	19	256	125	1.02	2.05		
					average	1.34	2.68	Rating:	B
	ESP	BASED ON DRY SOLIDS FEED RATE; 12 TONS/HR INSUFFLATION							
		filt. PM	16	1.94	125	0.00776	0.0155		
		filt. PM	18	26.3	125	0.105	0.210		
		filt. PM	20	35.3	125	0.141	0.282		
					average	0.0847	0.169	Rating:	B
		con. inorg. PM	16	12.06	125	0.0482	0.0965		
		con. inorg. PM	18	15.7	125	0.0628	0.126		
		con. inorg. PM	20	14.7	125	0.0588	0.118		
					average	0.0566	0.113	Rating:	B

Source	Type of control	Pollutant	Run No.	Emission rate, lb/hr	Process rate, ton/hr	Emission factor kg/Mg	Emission factor lb/ton	Volumetric flow rate, DSCFM	Concen. ppm
rotary kiln	ESP	BASED ON CLINKER PRODUCTION RATE; INSUFFLATION RATE NOT SPECIFIED							
		filt. PM	1	4.93	81	0.0304	0.0609		
		filt. PM	3	30.18	79	0.1910	0.3820		
		filt. PM	5	0.77	79	0.00487	0.00975		
					average	0.0754	0.151	Rating:	B
		con. inorg. PM	1	16.12	81	0.0995	0.199		
		con. inorg. PM	3	26.06	79	0.165	0.330		
		con. inorg. PM	5	8.05	79	0.0509	0.102		
					average	0.105	0.210	Rating:	B
		BASED ON CLINKER PRODUCTION RATE; INSUFFLATION RATE NOT SPECIFIED; AFTER ESP UPGRADE							
		filt. PM	21	28.58	88	0.162	0.325		
		filt. PM	23	14.75	87	0.0848	0.170		
		filt. PM	25	13.9	88	0.0790	0.158		
					average	0.109	0.217	Rating:	B
		con. inorg. PM	21	13.66	88	0.0776	0.155		
		con. inorg. PM	23	16.23	87	0.0933	0.187		
		con. inorg. PM	25	28	88	0.159	0.318		
					average	0.110	0.220	Rating:	B
	none	BASED ON CLINKER PRODUCTION RATE; 6 TONS/HR INSUFFLATION							
		filt. PM	9	9782	74	66.1	132.2		
		filt. PM	11	9938	75	66.3	132.5		
		filt. PM	13	10283	76	67.7	135.3		
					average	66.7	133.3	Rating:	B
		con. inorg. PM	9	18	74	0.122	0.243		
		con. inorg. PM	11	82	75	0.547	1.093		
		con. inorg. PM	13	57	76	0.375	0.750		
					average	0.348	0.696	Rating:	B
	ESP	BASED ON CLINKER PRODUCTION RATE; 6 TONS/HR INSUFFLATION							
		filt. PM	10	4.4	74	0.0297	0.0595		
		filt. PM	12	13.2	75	0.0880	0.176		
		filt. PM	14	33.1	76	0.218	0.436		
					average	0.112	0.224	Rating:	B
		con. inorg. PM	10	9.6	74	0.0649	0.130		
		con. inorg. PM	12	14.8	75	0.0987	0.197		
		con. inorg. PM	14	28.9	76	0.190	0.380		
					average	0.118	0.236	Rating:	B
	none	BASED ON CLINKER PRODUCTION RATE; 12 TONS/HR INSUFFLATION							
		filt. PM	15	10058	76	66.2	132.3		
		filt. PM	17	9372	75	62.5	125.0		
		filt. PM	19	11183	77	72.6	145.2		
					average	67.1	134.2	Rating:	B
		con. inorg. PM	15	142	76	0.934	1.87		
		con. inorg. PM	17	607	75	4.05	8.09		
		con. inorg. PM	19	256	77	1.66	3.32		
					average	2.21	4.43	Rating:	B
	ESP	BASED ON CLINKER PRODUCTION RATE; 12 TONS/HR INSUFFLATION							
		filt. PM	16	1.94	76	0.0128	0.0255		
		filt. PM	18	26.3	75	0.175	0.351		
		filt. PM	20	35.3	77	0.229	0.458		
					average	0.139	0.278	Rating:	B
		con. inorg. PM	16	12.06	76	0.0793	0.159		
		con. inorg. PM	18	15.7	75	0.105	0.209		
		con. inorg. PM	20	14.7	77	0.0955	0.191		
					average	0.0932	0.186	Rating:	B

Source	Type of control	Pollutant	Run No.	Emission rate, lb/hr	Process rate, ton/hr	Emission factor kg/Mg	Emission factor lb/ton	Volumetric flow rate, DSCFM	Concen. ppm
rotary kiln		BASED ON DRY SOLIDS FEED RATE; INSUFFLATION RATE NOT SPECIFIED.							
		SOx	2	384.2	135	1.42	2.85		
		SOx	4	89.27	135	0.331	0.661		
		SOx	6	84.13	135	0.312	0.623		
					average	0.688	1.38	Rating:	B
		SOx	22	1083.27	138	3.92	7.85		
		SOx	24	925.95	138	3.35	6.71		
		SOx	26	1259.97	138	4.57	9.13		
					average	3.95	7.90	Rating:	B
rotary kiln		BASED ON CLINKER PRODUCTION RATE; INSUFFLATION RATE NOT SPECIFIED.							
		SOx	2	384.2	81	2.37	4.74		
		SOx	4	89.27	79	0.565	1.13		
		SOx	6	84.13	79	0.532	1.06		
					average	1.16	2.31	Rating:	B
		SOx	22	1083.27	88	6.15	12.3		
		SOx	24	925.95	87	5.32	10.6		
		SOx	26	1259.97	88	7.16	14.3		
					average	6.21	12.4	Rating:	B

SUMMARY

PLANT: LONE STAR [illegible]

LOCATION: GREENCASTLE IND [illegible]

TEST/IDENTIFICATION CTR-G-6301/6304 DATE: APR-JUNE 1977

TESTING BY: LONE STAR - MOBILE ENVIRONMENTAL TEST LAB 11235

KILN/COOLER NO. 1

PERFORMANCE

Kiln Production	Ton/Hr.	87.7	@ 1.574	K.F. Factor
Kiln Feed Rate	Ton/Hr.	138		
Fuel Rate (Coal)	Ton/Hr.	12.0	@ 11238	BTU/lb.
" " (Oil)	Gal/Hr.	—		
Fuel Ash	%			
Fuel Sulphur	%			Feed S.
KILN (Stack)				
Exhaust Gas Flow	DSCFM			
Part. Concen.	lb/SCF			
Emission Rate	lb/Ton			
SOX (Kiln) (Concentration)	PPM			
Emission Rate	lb/Ton			
Emission Rate	lb/MMBTU			
NOX (Kiln) (Concentration)	PPM			
Emission Rate	lb/Ton	N.A.		
COOLER (Stack)				
Exhaust Gas Flow	DSCFM	NA		
Part. Concen.	lb/SCF	NA		
Emission Rate	lb/Ton	NA		

Reference 24*: Coal-fired wet kiln w/ ESP

Inlet/Outlet Tests & SO_x/NO_x Tests

Process description lacking; no calib. sheets

Rating: B

REMARKS:

ENVIRONMENTAL DEPT COPY

LONE STAR INDUSTRIES, INC.

Cement & Construction Materials Group

CENTRAL RESEARCH LABORATORY

P. O. BOX 2148

HOUSTON, TEXAS 77001

CTR-G-6301

PARTICULATE EMISSIONS TESTING

GREENCASTLE PLANT

May 8 - June 22, 1977

Interoffice Memo

LONE STAR INDUSTRIES, INC.

P. O. Box 2148, Houston, Texas 77001

Originating Office: Central Research Laboratory

Date: July 1, 1977

PERSONAL & BUSINESS CONFIDENTIAL

TO: D. C. Coppinger

FROM: W. W. Hurst

SUBJECT: Stack Particulate Emissions at Greencastle Plant

CC: S. S. Fritts
C. D. Fehnel
C. W. Moore

Stack emissions and precipitator input gases were tested on selected days between May 8 and June 22. Survey included 12 runs on stack and 6 on precipitator input for particulates. Testing was conducted in accordance with EPA Methods 1-5 for stationary sources as given in Fed. Register, Vol. 35, No. 247 dated December 23, 1971 and amended June 8, 1976.

Objectives were:

(1) Determine normal level of stack particulate emissions.

(2) Determine normal precipitator separating efficiency.

(3) Estimate the effect of increasing kiln dust insufflation rate on dust losses from stack.

(4) Evaluate influence of upgrading south section of precipitator on stack emission levels.

Results showed: 46.5 EPA @ 0.3 #/Ton Feed Solids

(1) Normal stack particulate emissions @ approx. 90% capacity averaged 28.7 lbs/hr; whereas, the allowable per Indiana rule is 223 lbs/hr. at the production level during test. (See Table I and IV)

(2) During normal insufflation, the average for 3 runs of testing simultaneously, the stack and precipitator input duct, showed the precipitator efficiency at 99.6 (See Table II).

(3) Under conditions of curtailed production @ approx. 80% capacity, doubling the insufflation rate from 6 to 12 T/Hr had little to no effect on the dust loading to the precipitator or the rate of particulate emissions from the stack. The precipitator efficiency remained at 99.6% (See Table II).

(4) Upgrading precipitator south section undoubtedly improved dust abatement but the effect was offset by heavier loads resulting from increasing kiln operation to near full capacity. Actually, the results showed a slight increase in emissions from 28.7 lbs/hr. to 38.4 lbs/hr. (See Table I)

Respectfully submitted,

W. W. Hurst, P.E.

WWH/po

Encl.

TABLE OF CONTENTS

Table I shows the Particulate Emission rate from the stack for every run, (p.1)

Table II indicates the precipitator performance during testing period, (p.2)

Table III shows the fuel rate, consumption and production rate during testing period, (p.3).

Table IV calculates the allowable limit for particulate emissions, according to Indiana Air Pollution Control Board, (p.4).

Table V itemizes the exhaust gas characteristics, (p.5).

Table VI tabulates gas flow rate data, (p.6).

Table VII gives data relative to gas collected during testing and the parameters needed to make this information meaningful, (p.7).

Table VIII shows gas composition, on the dry basis, (p.9).

Table IX records coal analysis given by the local plant personnel, (p.10).

Table X indicates average chemical characteristics of raw mix feed, product clinker and waste dust, (p.11).

Table XI shows meterological conditions during testing period, (p.12).

Material Balance Sample Calculation for Runs 1 - 5 is presented after Table XI. The results for all three parts (Runs 1 - 5, Runs 7 - 20, and Runs 21 - 25) were calculated by Computer Program and presented following the Sample Calculation. (pp.13-28).

Appendix:

* % Isokinetic Sample Calculation for Stack Run No. 1.(p.30).
* Schematic Diagrams for Material Balances, (p.34).
* Sample Traverse Plans, (p.37).
* Pittsburgh Testing Laboratory Coal Analysis, (p.39).

TABLE I

GREENCASTLE STACK EMISSIONS SURVEY

PARTICULATE EMISSION RATE

1977

Run No.	Date (1977)	Exhaust Gas Temp. °F.	Exhaust Gas Volume ACFM	Particulate Emission Rate Grains/SCF Dry	Particulate Emission Rate Lbs/SCF Dry X10^{-6}	Particulate Emission Rate Lbs/Hr.	Particulate Emission Rate Ton/Day
Normal Operation:							
1	5 - 8	332	239,200	.020	2.87	21.05	0.25
3	5 - 9	331	249,100	.058	8.29	56.24	0.68
5	5 - 10	334	240,700	.009	1.31	8.82	0.11
Ave.			243,000			28.70	0.35
Operation Following Precipitator Upgrading:							
21	6 - 20	310	232,900	.043	6.16	42.24	0.51
23	6 - 21	316	239,900	.032	4.65	30.98	0.37
25	6 - 22	307	236,700	.042	6.00	41.90	0.50
Ave.			236,500			38.37	0.46

TABLE II

GREENCASTLE EMISSION SURVEY

PRECIPITATOR PERFORMANCE

Run No.	Insufflation Rate T/Hr	Exhaust Gas: Precip. Input ACFM	Exhaust Gas: Precip. Output ACFM	Dust Load: Precip. Input T/Hr	Dust Load: Precip. Output T/Hr		Dust Load: Precip. Efficiency %
Normal Insufflation Rate:							
9, 10	6	238,300	216,800	4.90	.007		99.8
11, 12	6	234,300	222,200	5.01	.014		99.7
13, 14	6	228,800	219,900	5.17	.031		99.4
Ave.				5.03	.017	34	99.6
Elevated Insufflation Rate:							
15, 16	12	231,800	214,900	5.10	.007	14	99.8
17, 18	12	224,100	215,100	4.99	.021	42	99.6
19, 20	12	228,100	216,400	5.72	.025	50	99.5
Ave.				5.27	.018	36	99.6

TABLE III

GREENCASTLE EMISSION SURVEY

PROCESS RATES, CONSUMPTION AND PRODUCTION

Run No.	Date (1977)	Type of Fuel	Fuel Rate T/Hr	Kiln Feed T/Hr	% Slurry Water	Clinker Produced T/Hr	Dust Disposed T/Hr
1	5 - 8	Coal	18.5	135	31.1	81	.146
3	5 - 9	Coal	18.0	135	33.3	79	.146
5	5 - 10	Coal	17.5	135	33.3	79	.146
Ave.			18.0	135	32.6	79.7	.146
7	5 - 12	Coal	18.0	135	33.3	77	.146
9, 10	5 - 19	Coal	16.5	125	33.1	74	.146
11, 12	5 - 20	Coal	16.0	125	33.1	75	.146
13, 14	5 - 21	Coal	15.75	125	33.5	76	.146
15, 16	5 - 22	Coal	16.0	125	33.1	76	.146
17, 18	5 - 23	Coal	16.0	125	33.4	75	.146
19, 20	5 - 24	Coal	16.5	125	33.1	77	.146
Ave.			16.4	126	33.2	75.7	.146
21	6 - 20	Coal	18.75	138	33.2	88	.125
23	6 - 21	Coal	18.75	138	33.2	87	.125
25	6 - 22	Coal	19.50	138	33.3	88	.125
Ave.			19.00	138	33.2	87.7	.125

TABLE IV

ALLOWABLE PARTICULATES EMITTED FROM STACK

PER

INDIANA AIR POLLUTION CONTROL BOARD

REGULATIONS 5 & 13

In accordance with Indiana APC Board and their definition of Process Weight, we are allowed:

Coal	- 18.5	T/Hr.
Raw Mix Solids	- 136.5	T/Hr.
Raw Mix Water	- 66.9	T/Hr.
TOTAL	221.9	T/Hr.

Particulate Emissions:

$$E = 15.0\ p^{0.5}$$

where E = rate of particulate emissions in Lbs/Hr.

P = Process weight in Tons/Hr.

$$E = (15.0)(221.9)^{0.5}$$

$$= (15)(14.90)$$

$$= \underline{223.5}\ \text{lbs/hr.}$$

TABLE V
GREENCASTLE EMISSION STUDY
EXHAUST GAS CHARACTERISTICS
1977

Run No.	Pitot Tube Factor	Temp. °R. T_s	% Water in Gas	Gas Density Lbs/Lb-Mole	Stack Gas Press. "Hg.	Static Gas Press. "H_2O
1	.80	792	22	28.79	29.34	-0.64
3	.80	791	31	27.42	29.41	-0.71
5	.80	794	29	28.43	29.43	-0.70
7	.78	744	29	28.28	29.41	-2.60
9	.78	701	32	27.45	29.30	-2.40
10	.80	788	31	27.58	29.44	-0.57
11	.78	700	33	27.26	29.25	-2.50
12	.80	793	31	27.54	29.40	-0.51
13	.78	709	31	27.75	29.19	-2.40
14	.80	785	30	27.89	29.33	-0.57
15	.78	696	32	27.70	29.24	-2.45
16	.80	779	31	27.84	29.38	-0.54
17	.78	649	34	27.53	29.33	-2.65
18	.80	779	33	27.67	29.49	-0.56
19	.78	683	33	27.56	29.35	-2.60
20	.80	790	32	27.71	29.49	-0.60
21	.80	770	27	28.57	29.22	-0.56
23	.80	776	31	28.02	29.39	-0.64
25	.80	767	27	28.52	29.31	-0.58

TABLE VI
GREENCASTLE EMISSION SURVEY
EXHAUST GAS FLOW RATE
1977

Run No.	Barometric Press. "Hg.	Stack Area Sq. Ft.	ΔP "H_2O	Velocity Ft./Sec.	Volume ACFM	Volume CFH @ 29.92 & 70°F. X 10^6	
1	29.39	109.5	.55	36.41	239,200	7.338	S
3	29.46	109.5	.56	37.91	249,100	6.784	S
5	29.48	109.5	.55	36.63	240,700	6.721	S
7	29.60	133.0	.51	32.17	256,700	7.649	I
9	29.48	133.0	.48	29.86	238,300	7.190	I
10	29.48	109.5	.49	33.00	216,800	5.934	S
11	29.44	133.0	.47	29.36	234,300	6.964	I
12	29.44	109.5	.50	33.81	222,200	6.033	S
13	29.37	133.0	.46	28.67	228,800	6.900	I
14	29.37	109.5	.50	33.47	219,900	6.106	S
15	29.42	133.0	.47	29.05	231,800	7.031	I
16	29.42	109.5	.49	32.70	214,900	5.935	S
17	29.53	133.0	.47	28.08	224,100	7.096	I
18	29.53	109.5	.49	32.74	215,100	5.792	S
19	29.54	133.0	.47	28.58	228,100	6.971	I
20	29.54	109.5	.49	32.94	216,400	5.832	S
21	29.26	109.5	.54	35.45	232,900	6.850	S
23	29.44	109.5	.55	36.52	239,900	6.657	S
25	29.35	109.5	.55	36.03	236,700	7.010	S

I S
71,144,000 64,598,000
107,360
67,146,000
111,900 CFM

TABLE VII
GREENCASTLE EMISSION SURVEY
GAS SAMPLING AND TESTING PARAMETERS
1977

Run No.	Date 1977	Test Nozzle Size Sq.Ft.	Test Duration Minutes	Meter Temp. °R.	Meter Vol. Meter Cond. Cu.Ft.	Meter Vol. Std.Cond. @ 29.92 & 70 Cu.Ft.	Meter Press. "Hg.	Meter Press. ΔH "H_2O	% Iso-kinetic
1	5 - 8	.000341	144	528	56.51	55.78	29.43	.53	101.7
3	5 - 9	"	"	531	57.45	56.52	29.50	.55	111.3
5	5 - 10	"	"	536	54.85	53.48	29.51	.50	107.1
7	5 - 12	"	"	543	46.10	44.53	29.62	.34	95.4
9	5 - 19	"	"	529	43.23	42.69	29.50	.30	97.5
10	5 - 19	"	"	529	51.01	50.37	29.50	.26	114.2
11	5 - 20	"	"	530	41.00	40.36	29.46	.27	95.5
12	5 - 20	"	"	531	48.23	47.39	29.46	.24	106.3
13	5 - 21	"	"	531	39.26	38.47	29.38	.23	91.3
14	5 - 21	"	"	531	47.93	46.95	29.38	.24	104.3
15	5 - 22	"	"	532	40.34	39.53	29.44	.25	91.6
16	5 - 22	"	"	530	46.73	45.95	29.43	.23	104.0

TABLE VII
GREENCASTLE EMISSION SURVEY
GAS SAMPLING AND TESTING PARAMETERS
1977

Run No.	Date 1977	Test Nozzle Size Sq.Ft.	Test Duration Minutes	Meter Temp. °R.	Meter Vol. Meter Cond. Cu.Ft.	Meter Vol. Std.Cond. @ 29.92 & 70 Cu.Ft.	Meter Press. "Hg.	Meter Press. ΔH "H_2O	% Iso-kinetic
17	5- 23	.000341	144	533	44.26	43.46	29.55	.31	100.3
18	5 - 23	"	"	531	46.44	45.75	29.54	.22	106.3
19	5 - 24	"	"	534	38.09	37.33	29.55	.22	87.5
20	5 - 24	"	"	533	45.39	44.56	29.55	.21	103.5
21	6 - 20	"	"	532	52.38	51.05	29.28	.28	100.9
23	6 - 21	"	"	529	50.08	49.39	29.46	.25	100.4
25	6 - 22	"	"	531	51.76	50.70	29.37	.28	97.5

TABLE VIII

GREENCASTLE EMISSION SURVEY
GAS ANALYSIS

Run No.	Date	Gas Composition - %		
		CO_2	O_2	N_2
1	5 - 8	22.0	8.0	70.0
3	5 - 9	21.0	7.6	71.4
5	5 - 10	26.0	6.2	67.8
7	5 - 12	27.0	4.0	69.0
9 & 10	5 - 19	22.5	7.4	70.1
11 & 12	5 - 20	22.0	8.0	70.0
13 & 14	5 - 21	24.0	7.6	68.4
15 & 16	5 - 22	25.0	6.8	68.2
17 & 18	5 - 23	26.0	7.2	66.8
19 & 20	5 - 24	25.0	7.0	68.0
21	6 - 20	26.5	6.4	67.1
23	6 - 21	27.0	5.0	68.0
25	6 - 22	26.0	6.2	67.8

TABLE IX
GREENCASTLE EMISSION SURVEY
PLANT COAL ANALYSIS
1977

Results were recorded based on Coal "as fed to kiln" and "as used".*

	Run 1 -6 (May 8 - 10)		Runs 7 - 20 (May 12 - 24)		Runs 21 - 26 (June 20 - 22)	
	"As Fed"	"As Used"	"As Fed"	"As Used"	"As Fed"	"As Used"
H_2O:	5.16	12.00	6.09	12.50	5.74	11.20
V.C.:	36.45	33.82	33.58	33.15	34.10	32.12
F.C.:	45.59	42.30	46.17	43.02	46.42	43.73
Ash:	12.80	11.88	12.16	11.33	13.74	12.94
S:	2.44	2.26	2.14	1.99	2.98	2.81
** Btu/Lb:	12,045	11,176	12,175	11,344	11,883	11,195

* "As ~~Eed~~ Fired" refers to moisture condition of coal as it was actually fed to the kiln.

"As Used" refers to moisture condition of coal as it enters Coal Mill and not as fed to kiln. [illegible]

** Average Heat content of coal was 11,238 Btu/lb. as used.

TABLE X
GREENCASTLE EMISSION STUDY
CHEMICAL ANALYSIS
1977

DATE (1977)	RAW FEED TO KILN			CLINKER	DUST
	% CaO	% MgO	% SO_3	% SO_3	% SO_3
5/8 - 5/12	43.75	0.45	0.30	1.43	17.24
5/19 - 5/24	43.88	0.50	0.36	1.51	16.29
6/20 - 6/22	44.19	0.50	0.37	1.33	22.76

TABLE XI
GREENCASTLE STACK EMISSION SURVEY
METEOROLOGICAL CONDITIONS
1977

Run No.	Relative Humidity	Ambient Temp. °F.	Barometric Pressure "Hg
1	40	72	29.39
3	53	53	29.46
5	43	59	29.48
7	44	74	29.60
9 & 10	59	83	29.48
11 & 12	58	80	29.44
13 & 14	55	82	29.37
15 & 16	68	76	29.42
17 & 18	75	75	29.53
19 & 20	78	74	29.54
21	54	86	29.26
23	72	68	29.44
25	100	67	29.35

MATERIAL BALANCE CALCULATIONS

(Sample Calculations for Runs 1 - 5)

I. Fuel Consumption Calculation - Molal Basis

A. Coal Analysis

See copy of letter enclosed from Pittsburgh Testing Laboratory showing ultimate analysis of average sample gathered during testing. Also, see Table IX for moisture and sulfur level of coal "as used". Accordingly, ultimate coal analysis in states of interest, are:

% Component	Dry Basis	Coal Mill Feed * "As Used"	Coal Mill Feed** "As Used"	Coal Mill Feed*** "As Used"
Carbon	69.33	60.86	60.70	61.04
Hydrogen	4.88	4.28	4.27	4.29
Nitrogen	1.72	1.51	1.51	1.52
Oxygen	8.29	7.28	7.25	7.30
Sulfur	2.33	2.26	1.99	2.81
Water	None	12.00	12.50	11.20
Ash	13.45	11.81	11.78	11.84
Total	100	100	100	100
Btu/Lb.	12,517	11,176	11,344	11,195

* P.T.L. Analysis was corrected for moisture @ 12% and Sulfur @ 2.26% and Btu/lb, for Runs 1 - 5.

** P.T.L. Analysis was corrected for moisture @ 12.5% and Sulfur @ 1.99% and Btu/lb. for Runs 9 - 20.

*** P.T.L. Analysis was corrected for moisture @ 11.2% and Sulfur @ 2.81% and Btu/lb. for Runs 21 - 25.

B. Distribution of Combustables and Products

Line	Fuel Constituent	Fuel, Oxygen & Air per 100 lbs. Coal: Lbs. per 100 Lbs. Coal	Mol. Wt. Divisor	Moles Fuel Constituent	O_2 Multiplier	O_2 Moles Theo. Req'd.	Moles/100 Lbs. Coal "As Used": CO_2 & SO_2	O_2	N_2	H_2O
1	C to CO_2	60.86	12	5.07	1	5.07	5.07	--	--	--
2	H_2 to H_2O	4.28	2	2.14	0.5	1.07	--	--	--	2.14
3	S to SO_2	2.26	32	0.07	1	0.07	0.07	--	--	--
4	O_2 (Deduct)	7.28	32	0.23	--	-0.31	--	--	--	--
5	N_2	1.51	28	0.05	--	0	--	--	0.05	--
6	Ash	11.81	--	--	--	0	--	--	--	--
7	Water	12.00	18	0.67	--	0	--	--	--	0.67
8	Cl_2	--	70	0	--	0	--	--	--	--
9	Total	100	--	8.23	--	5.90				

Line					
10	Therefore, O_2 req'd. is O_2, Line 9, -	5.90			
11	Recall, Mole ratio of N_2 to O_2 in Air is 3.76				
12	Then, N_2 with Air = (5.9)(3.76) =	22.18		22.18	
13	Air Dry (Supplied in Line 10 + 12) =	28.08			
14	H_2O in Air = (.0082*)(28.08) =	0.23			0.23
15	Air (Wet) supplied in Line 13 + 14 =	28.31			
16	Flue Gas Constituents (Lines 1-15) Total =		5.14	22.23	3.04

Total Moles Wet Flue Gas/100 Lbs. Coal (As Used) = 30.41

Total Moles Dry Flue Gas/100 Lbs. Coal (As Used) = 27.37

* Molal Humidity for Ambient Air @ 61°F., 29.44"Hg and 45% Relative Humidity.

II. Theoretical Combustion Gas Quantities - (No Excess Air)

1. The average fuel coal used by kiln during testing period from May 8 to May 10 was 18 ton/hr.

or

$$\frac{(18)(2000)}{60} = 600 \text{ lbs/min.}$$

Accordingly, 100 lbs. coal supplies fuel for -

$$\frac{100}{600} = 0.167 \text{ min. of kiln operation}$$

2. Therefore, referring to I-B:

$$CO_2 = \frac{(5.07)(44)}{0.167} = \underline{1335.81} \text{ lbs/min. produced}$$

$$H_2O = \frac{(3.04)(18)}{0.167} = \underline{327.66} \text{ lbs/min. produced}$$

$$N_2 = \frac{(22.23)(28)}{0.167} = \underline{3727.18} \text{ lbs/min. produced}$$

$$SO_2 = \frac{(0.07)(64)}{0.167} = \underline{26.83} \text{ lbs/min. produced}$$

3. Breakdown of Water Source

(a) Combustion Water:

$$\frac{(2.14)(18)}{(.167)} = 230.66 \text{ lb/min. produced}$$

230.66
72.21
24.79
327.66

(b) Free Water in Coal "As Used":

$$\frac{(0.67)(18)}{(.167)} = 72.21 \text{ lb/min.}$$

(c) Free Water in Coal "As Fed to Kiln":

$$\frac{5.16 \times \frac{(100 - 12)}{(100 - 5.16)}}{12} \times 72.21 = 28.81 \text{ lb/min.}$$

Loss Water = 72.21 - 28.81 = 43.4 lb/min.

(d) Water in Combustion Air:

$$\frac{(0.23)(18)}{.167} = 24.79 \text{ lb/min.}$$

III. Liberation of CO_2 and H_2O from Raw Mix

Average raw mix feed rate during test was 135 ton/hr. or 4500 lb/min. dry solids.

Raw Mix Chemical Analysis was used to determine the available CO_2 liberated from $CaCO_3$ and $MgCO_3$:

$$(\%\ CaO) \times \frac{100}{56} = \%\ CaCO_3$$

$$= 43.75 \times \frac{100}{56} = 78.125$$

$$(\%\ MgO) \times \frac{84}{40} = \%\ MgCO_3$$

$$= 0.45 \times \frac{84}{40} = 0.945$$

From $CaCO_3$, $CO_2 = \frac{(78.125)(44)}{(100)} = 34.375$ lb.

From $MgCO_3$, $CO_2 = \frac{(0.945)(44)}{84} = 0.495$ lb.

Total CO_2 = 34.87 lb/100 lb. Raw Mix

or,

$$CO_2 = \frac{(34.87)(4500)}{100}$$

$$= \underline{1569.15}\ \text{lb/min.}$$

Average % Slurry Water was 32.6, which amounts to:

$$H_2O = \frac{4500}{(1 - 0.326)} - 4500$$

$$= \underline{2176.56}\ \text{lb/min.}$$

IV. Theoretical Kiln Exit Gas - (No Excess Air)

1. Total Exit Gas Quantities (per min. of kiln operation)

Source	CO_2(lb)	H_2O(lb)	N_2(lb)
(a) Combustion Process	1335.81	284.26	3727.18
(b) Raw Mix Liberation	1569.15	2176.56	--
TOTAL	2904.96	2460.82	3727.18

2. Exit Gas Analysis - Wet Basis

$$CO_2 \text{ (Mole)} = \frac{2904.96}{44} = 66.02$$

$$H_2O \text{ (Mole)} = \frac{2460.82}{18} = 136.71$$

$$N_2 \text{ (Mole)} = \frac{3727.18}{28} = 133.11$$

TOTAL 335.84 Moles/Min.

Hence:

$$CO_2 = \frac{66.02}{335.84} = 19.66\%$$

$$H_2O = \frac{136.71}{335.84} = 40.71\%$$

$$N_2 = \frac{133.11}{335.84} = 39.63\%$$

3. Exit Gas Analysis - Dry Basis

$$CO_2 = \frac{19.66}{(1 - .4071)} = 33.16\%$$

$$N_2 = \frac{39.63}{(1 - .4071)} = 66.84\%$$

4. Theoretical Exit Gas Volume

At Standard Conditions (70°F. and 29.92"Hg)

Volume = (335.84)(387) = 129,970 SCFM (Wet)

or = (129,970)(1 - .4071) = 77,059 SCFM (Dry)

V. Actual Kiln Exit Gas at Sampling Ports

1. Exhaust Gas included not only Theoretical Combustion Air and Excess Combustion Air but also Infiltrated Air at kiln exit, precipitators, etc. From here forward, the term Excess Air will be used instead of Excess and Infiltrated Air.

2. Average Orsat Analysis taken from Exhaust gas are showing along with Theoretical Gas Analysis:

ORSAT ANALYSIS (DRY)	THEO. ANALYSIS (DRY)
CO_2 - 23.0	CO_2 - 33.1
O_2 - 7.3	O_2 - 0
N_2 - 69.7	N_2 - 66.9

3. Excess Air Calculation - CO_2 Balance (Using Above Analyses)

$$(\text{Vol. Comb. Gas})(\%\ CO_2) + (\text{Vol. Excess Air})(\%\ CO_2) = (\text{Vol. Actual Gas})(\%\ CO_2)$$

Let X = Vol. Comb. Gas (Relative)
100-X = Vol. Excess Air (Relative)
100 = Vol. Actual Gas (Relative)

Then -

$$(X)(33.1) + (100 - X)(0) = (100)(23)$$

$$33.1X = 2300$$

$$X = 69.5\% \text{ Comb. Gas}$$

$$100-X = \underline{30.5\%} \text{ Excess Air}$$

From IV-4, Above, the Theoretical Dry Exit Gas was 77,059 SCFM, therefore, Actual Kiln Exit Gas (Dry)was:

$$\frac{77,059}{.695} = 110,876 \text{ SCFM - Dry}$$

$$\text{Excess Air} = (110,876 - 77,059)$$

$$= \underline{33,817} \text{ SCFM - Dry}$$

4. Oxygen Balance (Using Above Analyses)

$$(\text{Vol. Comb. Gas})(\%\ O_2) + (\text{Vol. Excess Air})(\%\ O_2) = (\text{Vol. Actual Gas})(\%\ O_2)$$

Using the same symbol X as above,

$$(X)(0) + (100 - X)(21) = (100(7.3)$$

$$X = \frac{2100 - 730}{21}$$

$$= 65.2\% \text{ Comb Gas}$$

$$100 - X = \underline{34.8\%} \text{ Excess Air}$$

Hence,

$$\text{Actual Kiln Exit Gas} = \frac{77{,}059}{.652} = 118{,}188 \text{ SCFM - Dry}$$

$$\text{Excess Air} = (118{,}188 - 77{,}059)$$

$$= \underline{41{,}129} \text{ SCFM - Dry}$$

5. Reconciliation of Balance

The CO_2 and O_2 balances should give the same quantity of excess air for a given location. They do not agree exactly due to experimental error, but they are close enough so that an average of the balances should accurately represent the true condition.

$$\text{(Average) Excess Air} = \frac{33{,}817 + 41{,}129}{2}$$

$$= \underline{37{,}473} \text{ SCFM - Dry}$$

6. Weight of Excess Air Components

Lb/min. of kiln operation

$$O_2 = \frac{(37{,}473)(.21)(32)}{(387)} = \underline{650.69} \text{ lb/min.}$$

$$N_2 = \frac{(37{,}473)(.79)(28)}{(387)} = \underline{2141.87} \text{ lb/min.}$$

$$H_2O = \frac{(37{,}473)(.0082)(18)}{(387)} = \underline{14.29} \text{ lb/min.}$$

$$\text{or } \frac{(14.29)(387)}{18} = 307 \text{ SCFM}$$

(Recall 0.0082 was the Molal Humidity @ Testing Period)

7. Actual Kiln Exit Gas Volume:

(a) Theoretical Kiln Exit Gas (IV-4) = 129,970 SCFM (Wet)

(b) Excess Air (V-5 and V-6) = 37,473 + 307

= 37,780 SCFM (Wet)

(c) Actual Kiln Exit Gas (a) + (b) = 167,750 SCFM (Wet)

(1) Stack conditions $= \frac{(167,750)(792)(29.92)}{(530)(29.39)}$

= 255,196 ACFM (Wet)

VI. Stack Gas

1. Gas Volume (Measured)

Averaged volume of gas measured was 243,000 ACFM @ average stack conditions of 792°R(or 332°F) and 29.39"Hg. Therefore, at standard conditions (70°F and 29.92"Hg), stack gas volume:

$$(243{,}000)\frac{(530)(29.39)}{(792)(29.92)} = 159{,}733 \text{ SCFM - (Wet)}$$

2. Gas Components

(a) On the average, 27.3% of stack gas was water vapor based on condensate collected during test. This was 27.3% by volume since we compared moisture content of stack gas while H_2O was in vapor state. Therefore, stack gas contained:

$$(159{,}733)(.273) = 43{,}607 \text{ SCFM Vapor}$$

or,

$$\frac{(43{,}607)(18)}{(387)} = \underline{2028.2} \text{ Lb/Min. } H_2O$$

(b) Orsat Analysis shows 23% CO_2, 7.3% O_2 and 69.7% N_2 on the dry basis. With 27.3% H_2O, the analysis is reported on the wet basis as follows:

CO_2	- (23.0)(1 - .273)	= 16.7
O_2	- (7.3)(1 - .273)	= 5.3
N_2	- (69.7)(1 - .273)	= 50.7
H_2O	- 27.3	= 27.3
	TOTAL	100

(c) From VI-1 above, the total volume of stack gas was 159,733 SCFM (Wet). The rate of each gaseous component emitted from the stack can be calculated:

$$CO_2 = \frac{(159{,}733)(.167)(44)}{(387)} = \underline{3032.9} \text{ lb/min.}$$

$$O_2 = \frac{(159{,}733)(.053)(32)}{(387)} = \underline{700.0} \text{ lb/min.}$$

$$N_2 = \frac{(159{,}733)(.507)(28)}{(387)} = \underline{5859.3} \text{ lb/min.}$$

$$H_2O = \underline{2082.2} \text{ lb/min (from VI-2-a)}$$

VII. Gas Balance

(1) CO_2

CO_2 Input = 2905.0 lb/min. (from IV-1)

CO_2 Output = 3032.9 lb/min. (from VI-2-c)

Measuring Efficiency 104.4%

(2) O_2

O_2 Input = 650.7 lb/min. (from V-6)

O_2 Output = 700.0 lb/min. (from VI-2-c)

Measuring Efficiency 107.6%

(3) N_2

N_2 Input = 5869.0 lb/min. (from IV-1 and V-6)

N_2 Output = 5859.3 lb/min. (from VI-2-c)

Measuring Efficiency 99.8%

(4) H_2O

H_2O Input = 2475.1 lb/min. (from IV-1 and V-6)

H_2O Output = 2082.2 (from VI-2-c)

Measuring Efficiency 84.1%

MATERIAL BALANCE CALCULATIONS FOR KILN OPERATED WITH COAL AS FUEL

EMISSION TESTING AT GREENCASTLE PLANT, MAY & JUNE / 1977

RUNS 1-5 (MAY/8-MAY/10, 1977)

DATA INPUT

CARBON WEIGHT% IN COAL= 60.48
HYDROGEN WEIGHT% IN COAL= 4.28
NITROGEN WEIGHT% IN COAL= 1.51
OXYGEN WEIGHT% IN COAL= 7.28
SULFUR WEIGHT% IN COAL= 2.26
WATER WEIGHT% IN COAL= 12
WATER WEIGHT% IN COAL AS FED TO KILN = 5.16
CAO WEIGHT% IN RAW MIX = 43.75
MGO WEIGHT% IN RAW MIX = .45
H2O WEIGHT% IN RAW MIX = 33.6
CO2 VOL.%, ORSAT ANALYSIS = 23
OXY VOL.%, ORSAT ANALYSIS = 7.3
N2 VOL.%, ORSAT ANALYSIS = 69.7
AVE.RAW FEED, TON/HR = 135
AVE.CLINKER PRODUCED, TON/HR = 79.7
AVE.DUST REMOVED, TON/HR = .146
AVE.FUEL COAL RATE, TON/HR= 18 = 6.0 # min
MOLAL HUMIDITY OF AMBIENT AIR = 8.20000000E-03
AVE.VOL.OF STACK GAS (WET), ACFM = 243000
AVE.VOL.% OF H2O IN STACK GAS = 27.3
AVE.TEMP.OF STACK GAS, DEG.R = 792
AVE.PRES.OF STACK GAS, IN.HG.= 29.39

RESULTS

BASIS 100 LB FUEL COAL (AS USED)

THEORETICAL AIR REQUIRED :
DRY AIR = 65824.55 SCFM
WET AIR = 66364.31 SCFM

EXCESS AIR CALCULATED :
BASED ON CO2 BALANCE, DRY = 33257.23 SCFM
BASED ON OXY BALANCE, DRY = 41365.36 SCFM
AVERAGE, DRY = 37311.29 SCFM
AVERAGE, WET = 37617.25 SCFM

TOTAL THEO.VOL.OF KILN EXIT GAS (WET) = 171262.81 SCFM
TOTAL MEAS.VOL.OF KILN EXIT GAS (WET) = 159733.11 SCFM
TOTAL GAS MEAS. EFFICIENCY = 93.26 %

CARBON DIOXIDE BALANCE :

CO2 FROM COMBUSTION PROCESS	=	1330.56 LB/MIN
CO2 LIBERATED FROM RAW MIX	=	1569.15 LB/MIN
TOTAL INPUT	=	2899.71 LB/MIN
CO2 MEASURED FROM STACK	=	3036.67 LB/MIN
TOTAL OUTPUT	=	3036.67 LB/MIN
MEASURING EFFICIENCY (O/I)	=	104.72 %

OXYGEN BALANCE :

O2 IN EXCESS AIR	=	647.88 LB/MIN
TOTAL INPUT	=	647.88 LB/MIN
O2 MEASURED FROM STACK	=	700.95 LB/MIN
TOTAL OUTPUT	=	700.95 LB/MIN
MEAS. EFFICIENCY (O/I)	=	108.19 %

NITROGEN BALANCE :

N2 IN COMBUSTION AIR	=	3771.43 LB/MIN
N2 IN EXCESS AIR	=	2132.62 LB/MIN
TOTAL INPUT	=	5904.06 LB/MIN
N2 MEASURED FROM STACK	=	5856.10 LB/MIN
TOTAL OUTPUT	=	5856.10 LB/MIN
MEAS. EFFICIENCY (O/I)	=	99.18 %

WATER BALANCE :

H2O FROM COMBUSTION PROCESS	=	231.12 LB/MIN
H2O IN COMBUSTION AIR	=	25.10 LB/MIN
H2O IN EXCESS AIR	=	14.23 LB/MIN
H2O IN SLURRY	=	2277.10 LB/MIN
H2O IN FUEL COAL	=	28.72 LB/MIN
TOTAL INPUT	=	2576.29 LB/MIN
H2O MEASURED FROM STACK	=	2028.23 LB/MIN
TOTAL OUTPUT	=	2028.23 LB/MIN
MEASURING EFFICIENCY (O/I)	=	78.72 %

MATERIAL BALANCE CALCULATIONS FOR KILN OPERATED WITH COAL AS FUEL

EMISSION TESTING AT GREENCASTLE PLANT, MAY & JUNE / 1977

RUNS 7-20 (MAY/12-MAY/24, 1977)

DATA INPUT

CARBON WEIGHT% IN COAL= 60.7
HYDROGEN WEIGHT% IN COAL= 4.27
NITROGEN WEIGHT% IN COAL= 1.51
OXYGEN WEIGHT% IN COAL= 7.25
SULFUR WEIGHT% IN COAL= 1.99
WATER WEIGHT% IN COAL= 12.5
WATER WEIGHT% IN COAL AS FED TO KILN = 6.09
CAO WEIGHT% IN RAW MIX = 43.88
MGO WEIGHT% IN RAW MIX = .5
H2O WEIGHT% IN RAW MIX = 33.2
CO2 VOL.%, ORSAT ANALYSIS = 24.5
OXY VOL.%, ORSAT ANALYSIS = 6.86
N2 VOL.%, ORSAT ANALYSIS = 68.64
AVE.RAW FEED, TON/HR = 126
AVE.CLINKER PRODUCED, TON/HR = 75.7
AVE.DUST REMOVED, TON/HR = .146
AVE.FUEL COAL RATE, TON/HR= 16.4
MOLAL HUMIDITY OF AMBIENT AIR = 2.02000000E-02
AVE.VOL.OF STACK GAS (WET), ACFM = 226700
AVE.VOL.% OF H2O IN STACK GAS = 31.7
AVE.TEMP.OF STACK GAS, DEG.R = 738
AVE.PRES.OF STACK GAS, IN.HG.= 29.35

RESULTS

BASIS 100 LB FUEL COAL (AS USED)

THEORETICAL AIR REQUIRED :
DRY AIR = 60057.43 SCFM
WET AIR = 61270.59 SCFM

EXCESS AIR CALCULATED :
BASED ON CO2 BALANCE, DRY = 25292.65 SCFM
BASED ON OXY BALANCE, DRY = 34542.68 SCFM
AVERAGE, DRY = 29917.66 SCFM
AVERAGE, WET = 30522.00 SCFM

TOTAL THEO.VOL.OF KILN EXIT GAS (WET) = 153800.99 SCFM
TOTAL MEAS.VOL.OF KILN EXIT GAS (WET) = 159704.64 SCFM
TOTAL GAS MEAS. EFFICIENCY = 103.83 %

CARBON DIOXIDE BALANCE :

CO2 FROM COMBUSTION PROCESS	=	1216.69	LB/MIN
CO2 LIBERATED FROM RAW MIX	=	1471.14	LB/MIN
TOTAL INPUT	=	2687.83	LB/MIN
CO2 MEASURED FROM STACK	=	3038.40	LB/MIN
TOTAL OUTPUT	=	3038.40	LB/MIN
MEASURING EFFICIENCY (O/I)	=	113.04	%

OXYGEN BALANCE :

O2 IN EXCESS AIR	=	519.50	LB/MIN
TOTAL INPUT	=	519.50	LB/MIN
O2 MEASURED FROM STACK	=	618.73	LB/MIN
TOTAL OUTPUT	=	618.73	LB/MIN
MEAS. EFFICIENCY (O/I)	=	119.10	%

NITROGEN BALANCE :

N2 IN COMBUSTION AIR	=	3440.99	LB/MIN
N2 IN EXCESS AIR	=	1710.02	LB/MIN
TOTAL INPUT	=	5151.01	LB/MIN
N2 MEASURED FROM STACK	=	5417.04	LB/MIN
TOTAL OUTPUT	=	5417.04	LB/MIN
MEAS. EFFICIENCY (O/I)	=	105.16	%

WATER BALANCE :

H2O FROM COMBUSTION PROCESS	=	210.08	LB/MIN
H2O IN COMBUSTION AIR	=	56.42	LB/MIN
H2O IN EXCESS AIR	=	28.10	LB/MIN
H2O IN SLURRY	=	2087.42	LB/MIN
H2O IN FUEL COAL	=	31.01	LB/MIN
TOTAL INPUT	=	2413.06	LB/MIN
H2O MEASURED FROM STACK	=	2354.71	LB/MIN
TOTAL OUTPUT	=	2354.71	LB/MIN
MEASURING EFFICIENCY (O/I)	=	97.58	%

MATERIAL BALANCE CALCULATIONS FOR KILN OPERATED WITH COAL AS FUEL

EMISSION TESTING AT GREENCASTLE PLANT, MAY & JUNE / 1977

RUNS 21-25 (JUNE/20-JUNE/22, 1977)

DATA INPUT

CARBON WEIGHT% IN COAL= 61.04
HYDROGEN WEIGHT% IN COAL= 4.29
NITROGEN WEIGHT% IN COAL= 1.52
OXYGEN WEIGHT% IN COAL= 7.3
SULFUR WEIGHT% IN COAL= 2.81
WATER WEIGHT% IN COAL= 11.2
WATER WEIGHT% IN COAL AS FED TO KILN = 5.74
CAO WEIGHT% IN RAW MIX = 44.19
MGO WEIGHT% IN RAW MIX = .5
H2O WEIGHT% IN RAW MIX = 33.2
CO2 VOL.%, ORSAT ANALYSIS = 26.5
OXY VOL.%, ORSAT ANALYSIS = 5.9
N2 VOL.%, ORSAT ANALYSIS = 67.6
AVE.RAW FEED, TON/HR = 138
AVE.CLINKER PRODUCED, TON/HR = 87.7
AVE.DUST REMOVED, TON/HR = .125
AVE.FUEL COAL RATE, TON/HR= 19
MOLAL HUMIDITY OF AMBIENT AI R = 2.08000000E-02
AVE.VOL.OF STACK GAS (WET), ACFM = 236500
AVE.VOL.% OF H2O IN STACK GAS = 29.7
AVE.TEMP.OF STACK GAS, DEG.R = 771
AVE.PRES.OF STACK GAS, IN.HG.= 29.31

RESULTS

BASIS 100 LB FUEL COAL (AS USED)

THEORETICAL AIR REQUIRED :
DRY AIR = 70248.62 SCFM
WET AIR = 71709.79 SCFM

EXCESS AIR CALCULATED :
BASED ON CO2 BALANCE, DRY = 18529.61 SCFM
BASED ON OXY BALANCE, DRY = 32183.17 SCFM
AVERAGE, DRY = 25356.39 SCFM
AVERAGE, WET = 25883.80 SCFM

TOTAL THEO.VOL.OF KILN EXIT GAS (WET) = 165648.43 SCFM
TOTAL MEAS.VOL.OF KILN EXIT GAS (WET) = 159260.05 SCFM
TOTAL GAS MEAS. EFFICIENCY = 96.14 %

CARBON DIOXIDE BALANCE :

CO2 FROM COMBUSTION PROCESS	=	1417.48 LB/MIN
CO2 LIBERATED FROM RAW MIX	=	1622.45 LB/MIN
TOTAL INPUT	=	3039.93 LB/MIN
CO2 MEASURED FROM STACK	=	3373.25 LB/MIN
TOTAL OUTPUT	=	3373.25 LB/MIN
MEASURING EFFICIENCY (O/I)	=	110.96 %

OXYGEN BALANCE :

O2 IN EXCESS AIR	=	440.29 LB/MIN
TOTAL INPUT	=	440.29 LB/MIN
O2 MEASURED FROM STACK	=	546.20 LB/MIN
TOTAL OUTPUT	=	546.20 LB/MIN
MEAS. EFFICIENCY (O/I)	=	124.05 %

NITROGEN BALANCE :

N2 IN COMBUSTION AIR	=	4024.87 LB/MIN
N2 IN EXCESS AIR	=	1449.31 LB/MIN
TOTAL INPUT	=	5474.18 LB/MIN
N2 MEASURED FROM STACK	=	5475.90 LB/MIN
TOTAL OUTPUT	=	5475.90 LB/MIN
MEAS. EFFICIENCY (O/I)	=	100.03 %

WATER BALANCE :

H2O FROM COMBUSTION PROCESS	=	244.53 LB/MIN
H2O IN COMBUSTION AIR	=	67.96 LB/MIN
H2O IN EXCESS AIR	=	24.53 LB/MIN
H2O IN SLURRY	=	2286.22 LB/MIN
H2O IN FUEL COAL	=	34.24 LB/MIN
TOTAL INPUT	=	2657.49 LB/MIN
H2O MEASURED FROM STACK	=	2200.01 LB/MIN
TOTAL OUTPUT	=	2200.01 LB/MIN
MEASURING EFFICIENCY (O/I)	=	82.78 %

DISCUSSION OF RESULTS

(1) Stack Emissions

Solid stack emissions at the point in time of testing averaged 28.7 lbs/hr. The mode of operation at this time was labeled "normal" in the sense that operation was smooth and in accordance with plans presumably applicable to market needs. Normal operation contributing to this level of emissions means the kiln was operated at about 90% capacity with the precipitator in good but not excellent condition (upgrading of the south half of the precipitator was done later).

In 1975, test showed 17.2 lbs/hr. were emitted when operating at approx. 80% capacity and in 1973, 18 lbs/hr. were emitted at 90% kiln capacity. Though current stack particulate emissions are higher than measured previously, the rise in light of the allowable at 230 lbs/hr. is not significantly substantial to warrant an in-depth study to justify its existance. We are confident the precipitator upgrading project performed over the weekend of June 10 restored emission levels to around the 20 lb/hr. level and comparable with results obtained in 1973 and 1975 at the same reduced level of kiln operation.

As an adjunct to our original program, we did make a series of runs to reflect the results of precipitator upgrading program. We found particulate emissions had not subsided, as anticipated, but actually increased to 38.4 lbs/hr. Close examination of the data showed a sudden jump in production level from 80% to 100% capacity with significant increase in fuel use and clinker production (see Table III). Therefore, results could very well reflect the kiln operation in a slightly unstable condition. However, results tend to show at top production, even when the precipitator is in excellent condition, the realistic particulate emission from the stack should probably be in the range of 30 - 40 lb/hr. or approx. 20% of the allowable limit rather than 20 lb/hr. we have been led to believe is normal. All previous work was performed at curtailed production levels of 80-90% full capacity which is probably the main reason for the favorable emission levels obtained in previous years.

(2) Precipitator Efficiency

Test showed the precipitator was operating at a very respectable efficiency of 99.6%. Though this level was slightly less than the 99.8% measured in 1975, the difference was not significant and, therefore, we did not recheck the unit following work done on the south half of the precipitator.

Doubling the normal insufflation load from 6 - 12 T/Hr. had practically no effect on the emission load though it did increase the input load about 6%. The precipitator efficiency remained unchanged which coincides with the findings in 1975. (See Table II).

(3) Stack Sampling Ports

For the record and so that all concerned will not lose sight of technical restrictions placed on test data, we are including a statement of status originally recorded in the 1975 report,

During the interim between 1973 and 1975 test, the Greencastle plant obtained an Envirometric continuous analyzer. As an expediancy, the monitoring unit was installed so that one of our 4 symetrical test ports was used as the access hold for the Envirometric sample collector. Accordingly, all test runs in 1975 and 1977 were conducted by testing at only 3 of the 4 rest quandrants. Prior to testing, all concerned were made aware that testing would have to procede by an unconventional plan that would preclude use of test port equipped with the monitor sampler. Further, all were informed test data, though probably essentially correct, would be for in house consideration only and no attempt would be made to use data for compliance purposes. At this time, it is respectfully suggested that the Envirometric sample unit be relocated when convenient and before further stack testing is planned at Greencastle. Thus, we will be able to proceed in strict accordance with regulatory rule and test methods will be completely creditable.

A P P E N D I X

SAMPLE CALCULATION FOR STACK RUN 1

NOMENCLATURE

A_n	-	Cross-sectional area of sample nozzle, sq. ft.
A	-	Cross-sectional area of stack, $ft.^3$
B_{wo}	-	Proportion by volume of water vapor in the gas stream, dimensionless
C_p	-	Pitot tube coefficient, dimensionless
$C_{p\ std.}$	-	Pitot tube coef. of standard type tube @ .99
$C_{p\ test}$	-	Pitot tube coefficient of type "S" pitot tube
$c's$	-	Concentration of particulate matter in stack gas, gr./s.c.f. dry basis
c_s	-	Concentration of particulate matter in stack gas, lb/s.c.f.
D_s	-	Inside diameter of stack at sample port, Ft.
E	-	Particulate emission rate
ΔH	-	Average pressure drop across the orifice meter, inches H_2O
I	-	Percent of Iso Kinetic sampling. Test acceptable between 90% - I - 110%
K_p	-	$85.48\ \frac{ft.}{sec.}\ \frac{lbs.}{lb\text{-}mole\ ^\circ R}$
M_d	-	Dry molecular weight of stack gas
M_{H_2O}	-	Molecular weight of water, 18 lb/lb-mole
M_s	-	Molecular weight of stack gas (wet basis) lbs/lb-mole $M_d\ (1-B_{wo}) + 18\ B_{wo}$
M_m	-	Total amount of particule matter collected, mg.
P_{bar}	-	Barometric pressure at the orifice meter, inches Hg.
$P_{std.}$	-	Absolute pressure at standard conditions, 29.92 inches Hg.
P_s	-	Absolute stack gas pressure, inches Hg.

$\Delta P_{std.}$	-	Velocity head measured by standard type pitot tube
ΔP_{test}	-	Velocity head measured by type "S" pitot tube
$\sqrt{\Delta P}_{ave.}$	-	Ave. velocity head of stack gas, inches H_2O
Q_s	-	Volumetric flow rate, dry basis, standard conditions, $ft.^3/hr.$
R	-	Ideal gas constant
°R	-	Degrees of temperature, Rankin (F+460)
ρH_2O	-	Density of water, 1 gm./ml.
$(T_s)_{ave}$	-	Average absolute stack gas temperature, °R
$T_{std.}$	-	Absolute temperature at standard conditions, 530°R
T_m	-	Average dry gas meter temperature, °R
θ	-	Total sampling time, min.
$V_{m\ std.}$	-	Volume of gas sample through the dry gas meter (standard conditions), cu. ft.
$V_{s\ (ave)}$	-	Stack gas velocity, feet per second (f.p.s.)
V_m	-	Volume of gas sample through the dry gas meter (meter conditions) cu. ft.
V_{ic}	-	Total volume of liquid collected in impingers and silica gel
17.71	-	°R per inch. Hg @ std. cond. of 530 & 29.92
24.1	-	Liters water per gram-mole
28.3	-	Liters dry air per cu. ft.
1.667	-	100/60 min/sec
13.6	-	Specific gravity of mercury
2.205×10^{-6}	-	mg/lb.
0.0154	-	Grains per mg.
32	-	Molecular weight of oxygen

1. Pitot Tube Calibration

Using "S" type, Tube "b" 4' length calibrated Feb. 1, 1977.

$$Cp\ test = Cp\ std. \sqrt{\frac{P_{std}}{P_{std}}}$$

Forward

$$Cp\ test = (.99) \sqrt{\frac{.58}{.88}}$$

$$Cp = .80$$

Reverse

$$Cp\ test = (.99) \sqrt{\frac{.56}{.87}}$$

$$= .79$$

$$Cp\ ave. = .80$$

2. Velocity of Stack Gas

$$V_{s\ ave.} = K_p\ C_p \sqrt{\Delta P_{ave}} \sqrt{\frac{T_{s\ ave.}}{P_s\ M_s}}$$

$$V_{s\ ave.} = (85.48)(.80)(.55) \sqrt{\frac{(792)}{(29.34)(28.79)}}$$

$$V_{s\ ave.} = 36.41\ ft/sec$$

3. Volume of Gas (Actual) from Stack

$$Volume = (V_{s\ ave.})\ (A)\ (60)$$

$$Volume = (36.41)(109.5)(60) = 239{,}214\ ACFM$$

4. Volume Dry Gas @ Standard Conditions

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

$$Q_s = 3600\ (1 - .22)(36.41)(109.5) \frac{(530)}{(792)} \frac{(29.34)}{(29.92)}$$

$$Q_s = 7.34 \times 10^6\ SCFH$$

5. Sample Gas Volume @ Standard Conditions

$$V_m \text{ std.} = 17.71\ V_m \left(\frac{P_{bar} + \Delta H/13.6}{Tm} \right)$$

$$V_m \text{ std.} = (17.71)(56.51) \left(\frac{29.39 + \frac{.53}{13.6}}{528} \right)$$

$$V_m \text{ std.} = 55.78 \text{ cu.ft.}$$

6. Percent of Isokinetic - EPA Method

$$I = \frac{(1.667\ Ts) \left[(.00267)\ (Vic) + \left(\frac{Vm}{Tm}\ (P\ bar + \frac{\Delta H}{13.6}) \right) \right]}{(\theta)\ (Vs)\ (Ps)\ (A_n)}$$

$$I = \frac{(1.667)(792)(.894 + 3.150)}{(144)(36.41)(29.34)(.000341)}$$

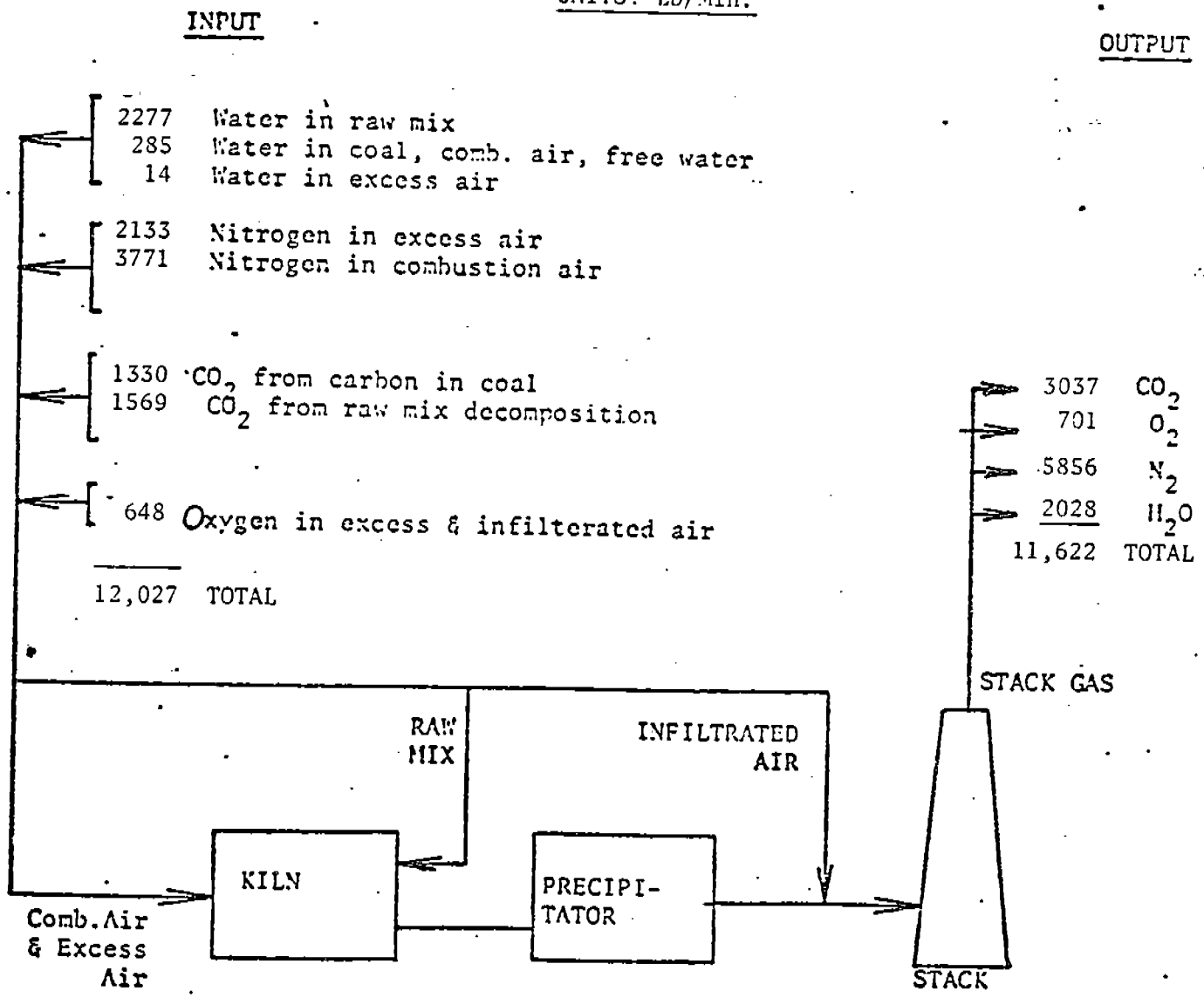
$$I = \underline{101.7\%}$$

% Isokinetic for all runs (from Run No. 1 to Run No. 25) were calculated using the same method as above, and are presented in Table VII .

RUNS 1 - 5

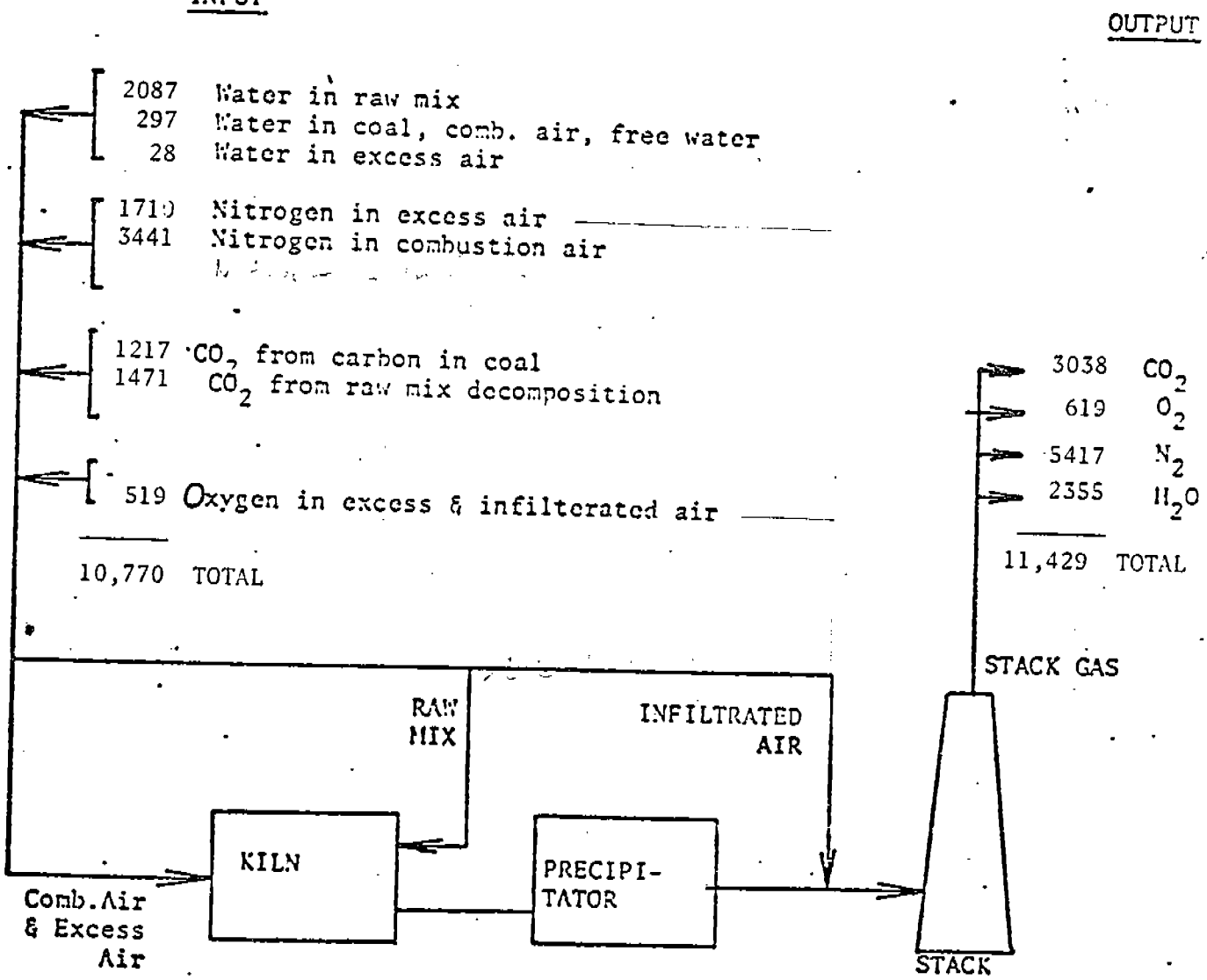
SUMMARY SCHEMATIC
GAS BALANCE

UNITS: Lb/Min.



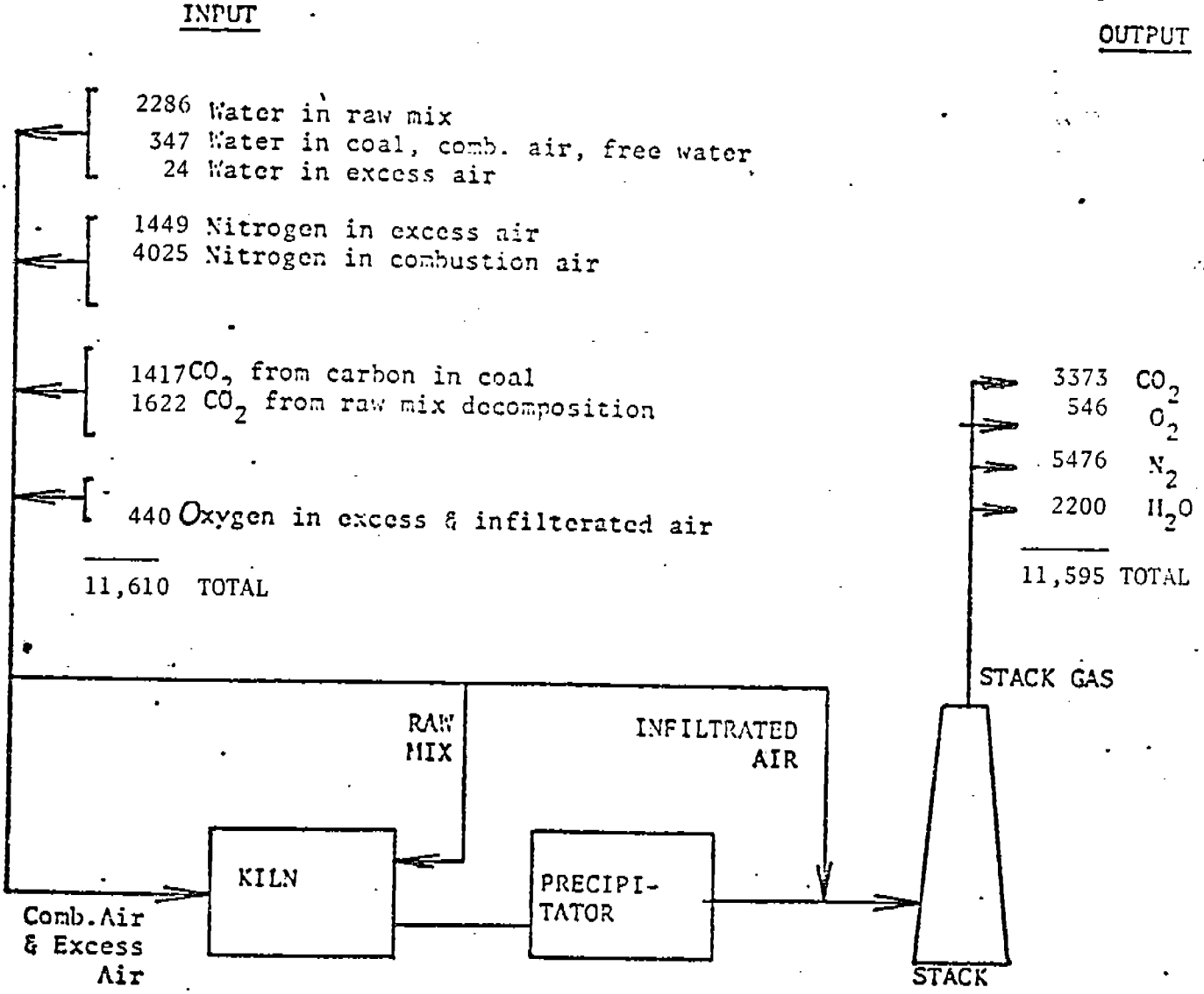
RUNS 7 - 20

SUMMARY SCHEMATIC
GAS BALANCE
UNITS: Lb/Min.



RUNS 21 - 25

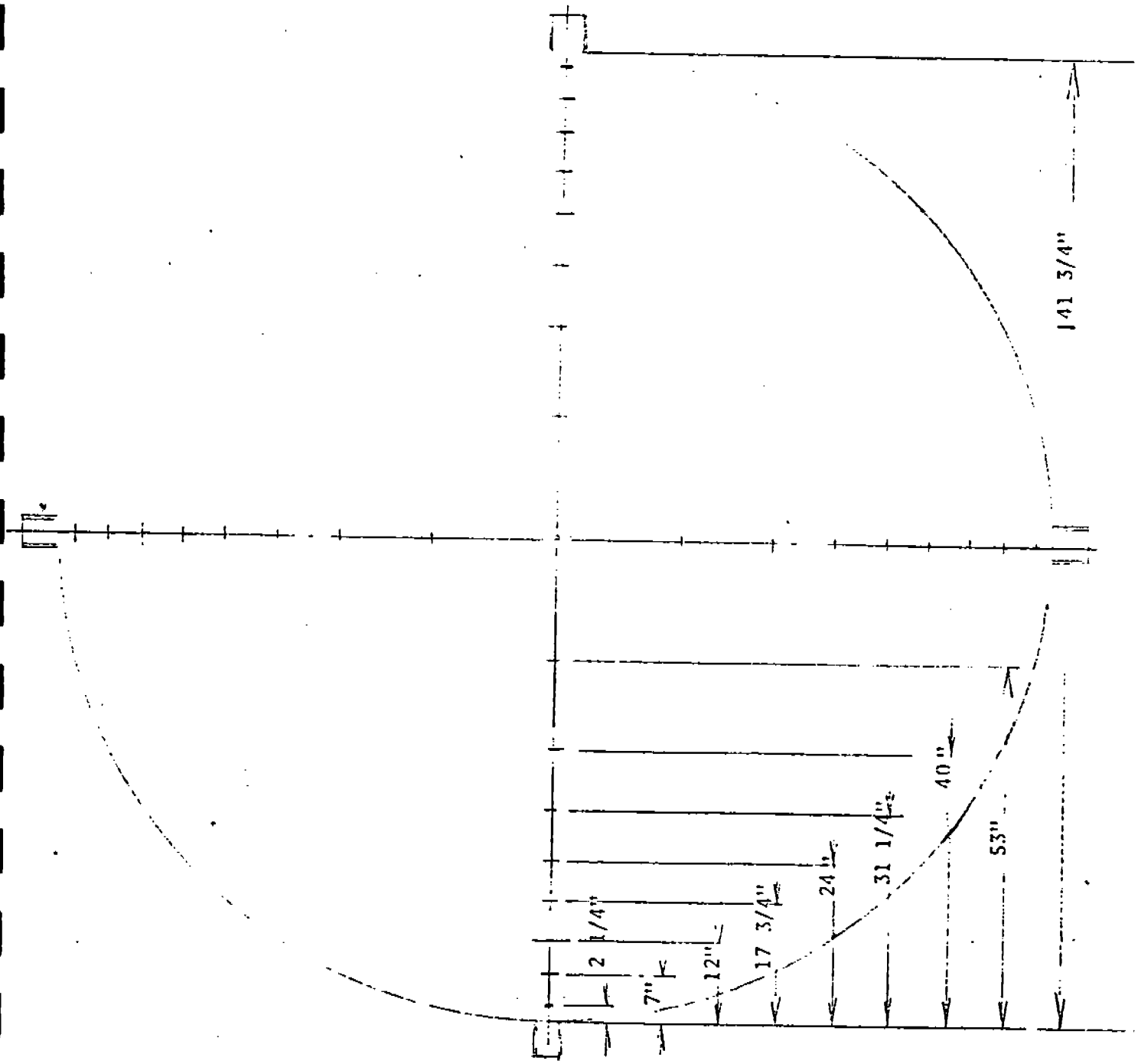
SUMMARY SCHEMATIC
GAS BALANCE
UNITS: LB/MIN.



GREENCASTLE EMISSION SURVEY

KILN STACK

VELOCITY, PARTICULATE & SULFUR SAMPLING TRAVERSE

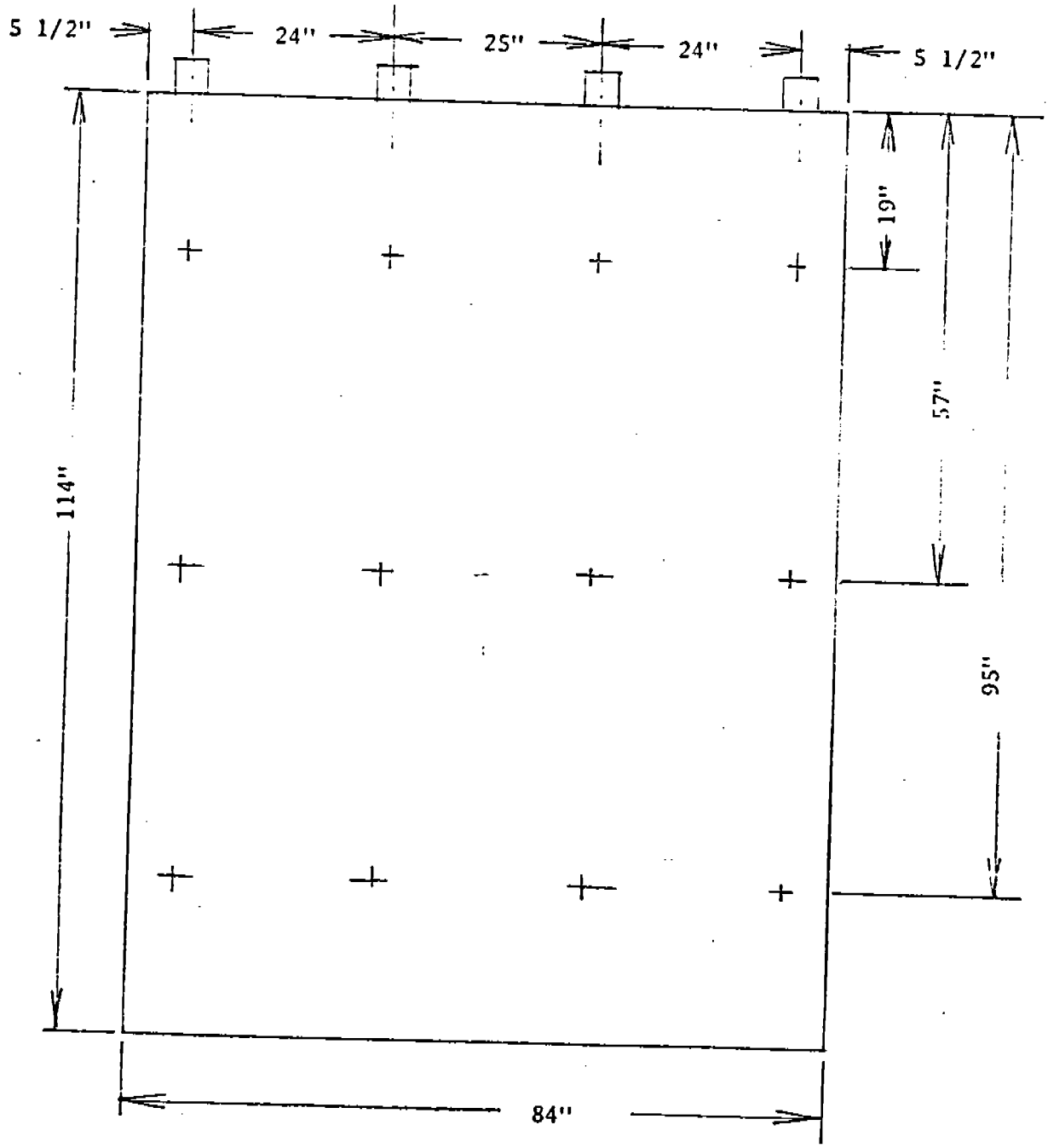


PLAN VIEW

* SAMPLING LOCATIONS

CROSS SECTIONAL AREA 109.5 Sq.Ft.

GREENCASTLE PRECIPITATOR
WEST SIDE ENTRANCE DUCT
SOUTH HALF
VELOCITY & SAMPLING TRAVERSE



PLAN VIEW

SAMPLE POINT LOCATION
CROSS SECTIONAL AREA 66.5 Sq.Ft.

FORM 407 REV. 2-39

PITTSBURGH TESTING LABORATORY

ESTABLISHED 1881
850 POPLAR STREET, PITTSBURGH, PA. 15220

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PLEASE REPLY TO
P. O. BOX 1646
PITTSBURGH, PA. 15

AREA CODE 412 TELEPHONE 922-4000

LABORATORY No. 776358

CLIENT'S No.

ORDER No. PG-6218

REPORT

June 24, 1977

Analysis of: COAL

Marked: "Green Castle - Coal sample - May 77"

Submitted by: Lone Star Industries, Inc.

Reported to: Lone Star Industries, Inc.
P. O. Box 2148
Houston, Texas 77001

	As Received	Dry Basis
Carbon	-	69.33%
Hydrogen	-	4.88%
Oxygen	-	8.29%
Nitrogen	-	1.72%
Sulfur	-	2.33%
Ash	12.84 %	13.45%
Moisture	4.55 %	None
BTU Per Pound	11,947	12,517

PITTSBURGH TESTING LABORATORY

Robert J. King
Manager, Chemical Department

3 - Client
Attn: Clyde W. Moore

pd

(SCAN)

PARTICULATE FIELD DATA

Run No. 1
Location STACK
Date 5/8/77
Operator D.V.V.

Amb. Temp. °F 57°F W.B. / 72°F D.B.
Bar. Press. "Hg. 29.39"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 4'
Inp. Nos. 1 → 4
Sample Box No. PART.
δ = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O ΔP	Pitot In. H_2O $\sqrt{\Delta P}$	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:50	80.31												
A -1	:56	82.12	.16	.40	.25	.32	65	67	2.5	109	81	368	303	
2	10:02	84.17	.28	.53	.46	.42	65	67	3.0	119	80	351	308	
3	:08	86.58	.33	.57	.56	.60	66	69	3.5	143	80	345	331	
4	:14	89.09	.35	.59	.62	.65	65	70	3.5	144	82	346	340	
5	:20	91.57	.38	.61	.65	.62	65	70	3.5	229	85	347	339	
6	:26	94.19	.41	.64	.70	.69	65	71	4.0	249	89	348	346	
7	:32	96.82	.40	.63	.68	.71	65	71	4.5	251	90	335	349	
8	:38	94.47	.40	.63	.68	.70	65	72	5.0	212	89	328	338	
B-1	11:00/00	100.88	.13	.36	.21	.18	66	68	3.0	140	72	335	301	
2	:12	102.96	.25	.50	.42	.42	66	69	4.0	172	78	339	332	
3	:18	105.31	.30	.55	.53	.56	66	70	4.0	205	87	341	339	
4	:24	107.78	.35	.59	.62	.62	67	72	4.5	223	88	342	334	
5	:30	110.35	.38	.61	.65	.68	67	72	4.5	235	88	347	320	
6	:36	112.71	.37	.61	.65	.56	67	73	4.0	240	89	335	336	
7	:42	115.07	.40	.63	.68	.56	68	73	5.0	205	90	342	345	
8	:48	117.51	.38	.61	.65	.60	68	73	5.0	207	90	341	341	
C-1	12:24/30	119.13	.15	.38	.24	.25	65	69	3.5	150	90	339	311	
2	:36	121.01	.21	.46	.34	.34	65	70	4.0	169	89	329	325	
3	:42	123.16	.28	.53	.46	.48	66	70	4.5	198	91	339	336	
4	:48	125.34	.30	.55	.53	.48	66	71	4.5	207	90	347	338	
5	:54	127.80	.35	.59	.62	.62	66	71	5.0	241	91	348	340	
6	13:00	130.19	.35	.59	.62	.60	66	72	5.0	214	89	344	340	
7	:06	132.60	.33	.57	.56	.60	67	71	5.5	251	91	335	341	
8	:12	134.96	.33	.57	.56	.56	67	72	5.0	196	92	339	339	
TOTAL				13.30		12.82	1584	1693					7972	
AVERAGE				0.55		0.53	66	70					332	
							(528)						(792)	

STATIC PRESSURE = -.64

CORRECTED SAMPLE VOLUME = Meter Volume 54.65 Ft.^{3} X Dry Meter Calibration Factor 1.034 = 56.51 Ft.^{3}

RUN NO. 1

PARTICULATE & WATER CATCH

IMPINGER NO. 1	Final Weight 807.08 Initial Weight 533.65 Increase	WATER WEIGHT GAIN	IMPINGER 1 273.43
			IMPINGER 2 39.20
IMPINGER NO. 2	Final Weight 628.14 Initial Weight 588.94 Increase		IMPINGER 3 3.15
			IMPINGER 4 19.42
IMPINGER NO. 3	Final Weight 451.61 Initial Weight 448.46 Increase		TOTAL 335.20
			ORSAT
IMPINGER NO. 4	Final Weight 793.57 Initial Weight 774.15 Increase		CO_2 22.0
			O_2 8.0
FILTER NO. 1	Final Weight .9081 Initial Weight .8621 Part. Catch .0460		CO —
			N_2 70.0

.0728 gm 15.43 56.51 ft³ = 2.1159

SOLID WEIGHT GAIN

Carbon BEAKER NO. 16	Final Weight 143.4333 Initial Weight 142.2590 Increase .1743		BEAKER 1
			BEAKER 2
IN. Carbon BEAKER NO. 17	Final Weight 142.6992 Initial Weight 142.6353 Increase .0639		BEAKER 3
			BEAKER 4
			TOTAL
BEAKER NO. 18	Final Weight 143.8157 Initial Weight 143.6889 Increase .0268	Fet. - .0460 Probe - .0268 .0728 Imp. .2382 Total .3110	
BEAKER NO. 19 PROBE WASH	Final Weight ____ Initial Weight ____ Increase ____		

Moisture Content: Sample Vol. 56.51 ft.³ x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (528) X 28.3 L/ft.³ = 1605 L Dry Gas

Water Weight $\frac{335.2 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 449 L H_2O Vapor

Total = 2054 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{449 \text{ L}}{2054 \text{ L}}$ x 100 = 22 %

(JOHN)

PARTICULATE FIELD DATA

Run No. 3
Location STACK
Date 5/9/77
Operator D.V.V.

Amb. Temp. °F 45°F W.B. 53°F D.B.
Bar. Press. "Hg. 29.46"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 4'
Inp. Nos. 9 → 12
Sample Box No. PART
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:20	135.32	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:26	136.94	.15	.39	.25	.25	60	61	2.5	140	35	302	333	
2	:32	138.88	.23	.48	.39	.36	60	62	2.5	175	36	318	328	
3	:38	141.09	.28	.53	.48	.50	60	68	3.0	225	38	346	334	
4	:44	143.36	.32	.56	.56	.53	61	68	3.5	195	45	367	332	
5	:50	145.73	.35	.59	.62	.56	60	69	4.5	216	52	377	333	
6	:56	148.12	.35	.59	.62	.60	61	69	5.0	245	68	385	338	
7	10:02	150.70	.38	.61	.65	.69	62	70	5.5	192	76	390	335	
8	:08	153.23	.38	.61	.65	.65	66	73	5.0	214	75	388	334	
B - 1	10:29/35	154.82	.14	.37	.23	.23	67	72	2.0	92	47	228	325	
2	:41	156.84	.25	.50	.42	.39	68	75	3.0	108	48	280	329	
3	:47	159.17	.32	.56	.56	.56	70	78	3.5	121	49	305	330	
4	:53	161.65	.38	.61	.65	.62	70	78	4.0	157	50	342	332	
5	:59	164.26	.40	.63	.68	.69	71	78	4.5	164	51	365	333	
6	11:05	166.85	.40	.63	.68	.69	71	78	4.5	195	53	345	331	
7	:11	169.33	.38	.61	.65	.62	71	79	4.5	198	58	401	332	
8	:17	171.84	.38	.61	.65	.65	72	79	4.5	255	61	398	331	
C - 1	11:32/38	173.76	.20	.45	.34	.37	71	75	3.0	92	50	247	314	
2	:44	175.92	.28	.53	.48	.47	71	77	4.0	198	55	315	326	
3	:50	178.27	.34	.58	.59	.56	72	79	4.5	232	61	258	331	
4	:56	180.78	.38	.61	.65	.65	73	79	5.0	265	64	218	331	
5	12:02	183.28	.40	.63	.68	.62	73	81	5.5	251	68	198	333	
6	:08	185.86	.40	.63	.68	.68	73	81	5.5	215	71	210	332	
7	:14	188.35	.38	.61	.65	.62	73	82	6.0	152	85	190	335	
8	:20	190.88	.40	.63	.68	.65	74	82	6.0	192	88	188	333	
TOTAL				13.55		13.21	1630	1793					7945	
AVERAGE				0.56		0.55	68	75					331	

STATIC PRESSURE = - .[redacted]71 " H_2O

CORRECTED SAMPLE VOLUME = 55.56 (531) Meter Volume Ft.³ X 1.034 (791) Dry Meter Calibration Factor = 57.45 Ft.³

RUN NO. 3 Part.

PARTICULATE & WATER CATCH

IMPINGER NO. 9	Final Weight 809.04 Initial Weight 535.34 Increase	WATER WEIGHT GAIN	IMPINGER 1 273.70
			IMPINGER 2 152.57
IMPINGER NO. 10	Final Weight 735.88 Initial Weight 583.31 Increase		IMPINGER 3 49.88
			IMPINGER 4 61.08
IMPINGER NO. 11	Final Weight 489.93 Initial Weight 440.05 Increase		TOTAL 537.23
			ORSAT
IMPINGER NO. 12	Final Weight 870.18 Initial Weight 809.10 Increase		CO_2 21.0
			O_2 7.6
FILTER NO. 2	Final Weight .9924 Initial Weight Part. Catch .8508 .1416		CO —
			N_2 71.4

SOLID WEIGHT GAIN

Carbon BEAKER NO. 19	Final Weight 143.7685 Initial Weight 143.6396 Increase .1293		BEAKER 1
			BEAKER 2
IMP. Carbon BEAKER NO. 23	Final Weight 146.0319 Initial Weight 146.0012 Increase .0307		BEAKER 3
			BEAKER 4
		Filt. .1416 Probe .0437 .1853	TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
		Imp. .1600 .3453	
BEAKER NO. 4 PROBE WASH	Final Weight 115.6100 Initial Weight 115.5663 Increase .0437		

Moisture Content: Sample Vol. 57.45 $ft.^3$ x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (531) X 28.3 $L/ft.^3$ = 1623 L Dry Gas

Water Weight $\frac{537.23 \text{ gm.}}{18 \text{ gm./mol.}}$ x 24.1 $\frac{L}{mol.}$ = 719 L H_2O Vapor

Total = 2342 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{719 \text{ L}}{2342 \text{ L}}$ x 100 = 31 %

(JOHN)

PARTICULATE FIELD DATA

Run No. 5
Location STACK
Date 5/10/77
Operator D.V.V.

Amb. Temp. °F 48°F W.B. 59°F D.B.
Bar. Press. "Hg. 29.48"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 4'
Inp. Nos. 17 → 20
Sample Box No. PART
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:11	191.24	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A-1	:17	192.84	.18	.42	.30	.23	65	70	3.0	98	40	318	335	
2	:23	194.87	.28	.53	.47	.42	66	70	3.5	121	41	231	332	
3	:29	197.15	.34	.58	.60	.53	65	71	5.0	142	35	183	335	
4	:35	199.49	.36	.60	.62	.56	68	75	6.0	199	45	241	335	
5	:41	201.89	.40	.63	.68	.60	69	77	7.5	230	50	351	337	
6	:47	204.37	.40	.63	.68	.63	70	78	8.0	185	65	345	338	
7	:53	206.84	.38	.61	.65	.62	72	79	8.0	188	66	401	335	
8	:59	209.33	.38	.61	.65	.63	73	81	8.0	201	68	405	338	
B-1	10:09/15	210.94	.16	.40	.25	.25	72	78	3.0	89	70	225	325	
2	:21	212.89	.24	.49	.42	.37	73	79	4.0	92	65	212	330	
3	:27	215.11	.30	.55	.53	.50	75	80	5.0	101	59	199	335	
4	:33	217.44	.33	.57	.56	.56	75	81	5.0	170	55	240	334	
5	:39	219.92	.38	.61	.65	.62	77	83	5.5	181	55	333	337	
6	:45	222.45	.40	.63	.68	.63	78	82	6.0	178	60	382	336	
7	:51	224.97	.38	.61	.65	.65	80	83	6.0	241	62	396	338	
8	:57	227.51	.38	.61	.65	.65	80	85	6.0	200	63	401	336	
C-1	11:12/18	229.00	.14	.37	.23	.21	75	79	3.0	255	63	212	328	
2	:24	230.79	.21	.46	.34	.32	75	79	3.5	215	65	243	330	
3	:30	232.80	.25	.50	.42	.39	78	81	4.0	115	65	191	332	
4	:36	234.98	.31	.55	.53	.47	78	81	5.0	180	62	265	335	
5	:42	237.26	.33	.57	.56	.53	78	82	5.5	215	63	352	336	
6	:48	239.55	.33	.57	.56	.53	78	82	5.5	198	65	392	338	
7	:54	241.93	.35	.59	.62	.56	78	83	6.0	209	72	402	338	
8	12:00	244.29	.33	.57	.56	.56	78	83	6.5	215	75	405	336	
TOTAL				13.26		12.02	1776	1902					8029	
AVERAGE				.55		.50	74	79					334	

(536) (794)

STATIC PRESSURE = -0.70

CORRECTED SAMPLE VOLUME = 53.05 Ft.³ (Meter Volume) X 1.034 (Dry Meter Calibration Factor) = 54.85 Ft.³

RUN NO. 5

PARTICULATE & WATER CATCH

Parte.

IMPINGER NO. 17	Final Weight 940.33 Initial Weight 546.06 Increase	WATER WEIGHT GAIN	IMPINGER 1 394.27
			IMPINGER 2 -38.873
IMPINGER NO. 18	Final Weight 508.30 Initial Weight 542.03 Increase		IMPINGER 3 50.15
			IMPINGER 4 64.08
IMPINGER NO. 19	Final Weight 490.91 Initial Weight 440.76 Increase		TOTAL 474.77
			ORSAT
IMPINGER NO. 20	Final Weight 883.21 Initial Weight 819.13 Increase		CO_2 26.0
			O_2 6.2
FILTER NO. 3	Final Weight .8369 Initial Weight Part. Catch .8289 .0080		CO —
			N_2 67.8

SOLID WEIGHT GAIN

BEAKER NO. 25	Final Weight 148.8701 Initial Weight 148.6618 Increase .2083		BEAKER 1
			BEAKER 2
IMP. BEAKER NO. 28	Final Weight 141.0400 Initial Weight 140.9135 Increase .1265		BEAKER 3
			BEAKER 4
		Fel.- .0080 Org. .0235 .0319	TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
		Inorg .3348 .3667	
BEAKER NO. 29 PROBE WASH	Final Weight 141.9300 Initial Weight 141.9061 Increase .0239		

Moisture Content: Sample Vol. 54.85 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (536) X 28.3 L/ft.^{3} = 1535 L Dry Gas

Water Weight 474.77 gm. / 18 gm./mol. x 24.1 L/mol. = 636 L H_2O Vapor

Total = 2171 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{636 \text{ L}}{2171 \text{ L}}$ x 100 = 29 %

BOB

PARTICULATE FIELD DATA

Run No. 7
Location PPR. INPUT
Date 5/12/77
Operator D.V.V.

Amb. Temp. °F 60 °F W.B. / 74 °F D.B.
Bar. Press. "Hg. 29.60"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In 1/4"
Probe Length 10'
Inp. Nos. 25 → 28
Sample Box No. PPR. INPUT
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	11:36	244.30	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:42	246.32	.28	.53	.48	.40	75	81	4.0		55		278	
2	:48	248.28	.25	.50	.42	.37	76	81	4.0		58		305	
3	:54	250.70	.41	.64	.72	.60	75	81	6.0		65		313	
B - 1	12:00	252.71	.25	.50	.42	.40	76	82	5.0		66		294	
2	:06	254.95	.34	.58	.60	.50	76	82	7.0		68		310	
3	:12	257.39	.42	.65	.75	.60	78	85	8.5		70		328	
C - 1	:18	259.43	.15	.39	.25	.42	79	87	7.0		69		256	
2	:24	261.39	.28	.53	.47	.36	79	88	8.5		70		312	
3	12:30/36	263.25	.20	.45	.34	.34	80	85	7.5		65		325	
D - 1	:42	264.96	.14	.37	.23	.27	81	86	7.5		66		202	
2	:48	266.55	.16	.40	.25	.23	81	88	8.0		68		259	
3	:54	268.10	.13	.36	.20	.23	82	88	8.0		70		309	
E - 1	13:00	269.86	.34	.58	.60	.30	80	87	11.0		69		210	
2	:06	271.92	.32	.56	.56	.42	81	88	14.0		68		269	
3	:12	273.89	.41	.64	.72	.40	81	88	14.5		69		308	
F - 1	:18	275.88	.17	.41	.27	.40	82	89	14.5		69		282	
2	13:24/30	277.49	.20	.45	.34	.25	81	85	10.5		70		293	
3	:36	279.33	.38	.61	.65	.32	81	87	14.0		70		303	
G - 1	:42	281.03	.17	.41	.27	.27	82	88	15.0		69		288	
2	:48	282.71	.28	.53	.48	.27	82	88	15.0		68		293	
3	:54	284.35	.40	.63	.68	.25	82	89	15.5		70		298	
H - 1	14:00	286.13	.15	.39	.25	.30	82	88	15.5		69		243	
2	:06	287.47	.32	.56	.56	.16	82	89	16.0		70		263	
3	:12	288.89	.23	.48	.39	.20	82	89	16.0		69		278	
TOTAL				12.15		8.26	1916	2069					6819	
AVERAGE				0.51		0.34	80	86					284	

STATIC PRESSURE = −2.6" H_2O

CORRECTED SAMPLE VOLUME = (543) Meter Volume 44.59 Ft.³ X Dry Meter Calibration Factor 1.034 = (744) 46.10 Ft.³

RUN NO. 7 PPR. INPUT

PARTICULATE & WATER CATCH

IMPINGER NO. 25	Final Weight 758.10 Initial Weight 560.41 Increase	WATER WEIGHT GAIN	IMPINGER 1 197.69
			IMPINGER 2 178.13
IMPINGER NO. 26	Final Weight 748.17 Initial Weight Increase 570.04		IMPINGER 3 1.25
			IMPINGER 4 20.73
IMPINGER NO. 27	Final Weight 457.48 Initial Weight Increase 456.23		TOTAL 397.80
			ORSAT
IMPINGER NO. 28	Final Weight 817.85 Initial Weight Increase 797.12		CO_2 27.0
			O_2 4.0
(THIMBLE) FILTER NO. # 42	Final Weight 66.6684 Initial Weight 37.3070 Part. Catch		CO —
	29.3614		N_2 69.0

SOLID WEIGHT GAIN

BEAKER NO. 30	Final Weight 143.0082 Initial Weight 142.9053 Increase .1029		BEAKER 1
			BEAKER 2
BEAKER NO. 31	Final Weight 144.3663 Initial Weight 144.2794 Increase .0869	Thimble 29.3614 Probe 1580 29.5194	BEAKER 3
			BEAKER 4
			TOTAL
BEAKER NO.	Final Weight Initial Weight Increase	Imp. .1898 Total 29.7092	
BEAKER NO. 32 PROBE WASH	Final Weight 145.2827 Initial Weight 145.1247 Increase .1580		

Moisture Content: Sample Vol. 46.10 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (543) X 28.3 L/ft.^{3} = 1273 L Dry Gas

Water Weight $\frac{397.8 \text{ gm.}}{18 \text{ gm./mol.}}$ x 24.1 $\frac{L}{mol.}$ = 532 L H_2O Vapor

Total = 1805 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{532 \text{ L}}{1805 \text{ L}}$ x 100 = 29 %

PARTICULATE FIELD DATA

Run No. 8
Location STACK
Date 5/12/77
Operator D.V.V.

Amb. Temp. °F 60 °F W.B. / 74 °F D.B.
Bar. Press. "Hg. 29.60"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In 1/4"
Probe Length 4'
Inp. Nos. 29 → 32
Sample Box No. STACK
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	11:39	459.0	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:45	461.03	.14	.37	.15	.25	75	78	12.0	195	68	221	312	
2	:51	463.20	.24	.49	.25	.28	75	79	12.0	251	67	210	320	
3	:57	465.79	.30	.55	.32	.41	75	79	10.0	272	68	215	325	
4	12:03	468.24	.33	.57	.33	.37	75	81	10.0	218	68	304	328	
5	:09	470.60	.38	.61	.39	.33	76	82	9.0	245	69	362	325	
6	:15	473.15	.35	.59	.37	.39	76	82	9.0	282	68	375	322	
7	:21	475.43	.37	.61	.39	.32	77	83	9.0	241	69	278	326	
8	:27	477.85	.35	.59	.37	.35	78	83	4.0	215	71	405	323	
B - 1	12:33/39	479.60	.13	.36	.14	.18	80	82	1.0	301	68	131	316	
2	:45	481.53	.23	.48	.24	.23	81	84	2.0	230	70	138	320	
3	:51	483.52	.25	.50	.25	.24	81	85	2.0	274	69	145	322	
4	:57	485.78	.32	.56	.34	.30	82	86	2.5	256	69	149	323	
5	13:03	488.15	.35	.59	.37	.33	81	85	2.5	211	71	156	322	
6	:09	490.35	.37	.61	.34	.28	80	84	2.0	238	71	160	323	
7	:15	492.90	.35	.59	.37	.39	81	86	3.0	286	72	165	325	
8	:21	495.24	.33	.57	.33	.33	82	88	2.5	246	72	172	323	
C - 1	13:27/33	497.17	.13	.36	.14	.22	81	87	2.0	206	69	135	318	
2	:39	498.76	.19	.43	.20	.15	82	89	2.0	253	70	126	320	
3	:45	501.15	.23	.48	.24	.35	82	88	2.0	213	71	131	322	
4	:51	503.27	.27	.52	.28	.27	83	88	2.0	198	71	144	323	
5	:57	505.48	.30	.55	.32	.30	83	89	2.0	212	73	141	322	
6	14:03	507.49	.32	.56	.33	.24	83	89	2.0	168	73	165	328	
7	:09	509.79	.33	.57	.33	.32	82	88	2.5	154	75	169	328	
8	:15	512.18	.33	.57	.33	.35	83	89	2.5	206	74	173	327	
TOTAL				12.68		7.18	1914	2034					7743	
AVERAGE				0.53		0.30	80	85					322	

STATIC PRESSURE = − 0.61 " H_2O

CORRECTED SAMPLE VOLUME = 53.18 Ft.³ (542) Meter Volume X 1.021 Dry Meter Calibration Factor (782) = 54.29 Ft.³

RUN NO. 8

PARTICULATE & WATER CATCH

STACK

IMPINGER NO. 29	Final Weight ____ Initial Weight 548.48 Increase	WATER WEIGHT GAIN	IMPINGER 1 ____
			IMPINGER 2 ____
IMPINGER NO. 30	Final Weight ____ Initial Weight 544.01 Increase		IMPINGER 3 ____
			IMPINGER 4 ____
IMPINGER NO. 31	Final Weight ____ Initial Weight 439.63 Increase	LEAKED	TOTAL ____
			ORSAT
IMPINGER NO. 32	Final Weight ____ Initial Weight 745.17 Increase		CO_2 27.0
			O_2 4.0
FILTER NO. 4	Final Weight ____ Initial Weight Part. Catch ____		CO —
			N_2 69.0

SOLID WEIGHT GAIN

BEAKER NO. ____	Final Weight ____ Initial Weight Increase ____	BEAKER 1 ____
		BEAKER 2 ____
BEAKER NO. ____	Final Weight ____ Initial Weight Increase ____	BEAKER 3 ____
		BEAKER 4 ____
		TOTAL ____
BEAKER NO. ____	Final Weight ____ Initial Weight Increase ____	
BEAKER NO. ____ PROBE WASH	Final Weight ____ Initial Weight Increase ____	

Moisture Content: Sample Vol. ____ $ft.^3$ x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ X 28.3 $L/ft.^3$ = ____ L Dry Gas

Water Weight ____ gm. x 24.1 $\frac{L}{mol.}$ = ____ L H_2O Vapor

$\frac{18 \text{ gm.}}{\text{mol.}}$

Total = ____ L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ ____ $\frac{L}{L}$ x 100 = ____ %

(BoB)

PARTICULATE FIELD DATA

Run No. 9
Location PPR. INPUT
Date 5/19/77
Operator DVV

Amb. Temp. °F 72 °F W.B. / 83 °F D.B
Bar. Press. "Hg. 29.48"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 10'
Inp. Nos. 33 → 36
Sample Box No. PPR. INPUT
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:17	289.08	ΔP	$\sqrt{\Delta P}$	Desired	Actual	Inlet	Outlet						
A - 1	:23	291.01	.21	.46	.34	.36	71	72	4.5		60		265	
2	:29	293.28	.32	.56	.56	.53	69	70	5.0		61		263	
3	:35	295.68	.37	.61	.65	.60	68	70	6.0		61		264	
B - 1	:41	297.46	.15	.39	.25	.30	67	70	4.5		62		243	
2	:47	299.48	.28	.53	.48	.39	67	70	6.5		63		254	
3	:53	301.81	.41	.64	.72	.56	67	72	9.0		65		261	
C - 1	:59	303.63	.14	.37	.23	.32	67	71	7.0		67		246	
2	10:05	305.50	.25	.50	.42	.34	67	71	8.5		67		235	
3	10:15/21	307.26	.20	.45	.34	.30	68	70	6.0		72		236	
D - 1	:27	309.05	.16	.40	.25	.32	67	70	9.0		72		226	
2	:33	310.67	.15	.39	.25	.25	67	71	9.0		72		228	
3	:39	312.45	.23	.48	.40	.30	67	70	11.0		71		228	
E - 1	:45	314.25	.22	.47	.36	.32	67	71	12.5		73		208	
2	:51	315.99	.34	.58	.60	.30	67	71	12.5		72		249	
3	:57	317.67	.40	.63	.69	.27	68	71	13.0		74		264	
F - 1	11:03	319.29	.18	.42	.30	.25	68	71	14.0		75		202	
2	11:10/16	320.97	.20	.45	.34	.27	68	71	13.0		77		216	
3	:22	322.61	.28	.53	.48	.25	68	71	14.0		76		266	
G - 1	:28	324.18	.17	.41	.27	.23	68	71	15.0		77		195	
2	:34	325.57	.25	.50	.42	.18	68	71	15.0		76		241	
3	:40	327.02	.28	.53	.48	.20	67	70	15.0		76		244	
H - 1	:46	328.39	.14	.37	.23	.18	66	68	15.0		75		249	
2	:52	329.72	.21	.46	.34	.16	67	70	15.5		76		253	
3	11:58	331.01	.18	.42	.30	.15	67	70	15.5		77		255	
TOTAL				11.55		7.33	1621	1693					5791	
AVERAGE				0.48		.30	67	70					241	

STATIC PRESSURE = −2.40" H_2O

CORRECTED SAMPLE VOLUME = (529) Meter Volume 41.93 Ft.^{3} X Dry Meter Calibration Factor (701) 1.034 = 43.23 Ft.^{3}

RUN NO. 9 PPR. INPUT

PARTICULATE & WATER CATCH

IMPINGER NO. 37	Final Weight 966.73 Initial Weight 556.99 Increase	WATER WEIGHT GAIN	IMPINGER 1 409.74
			IMPINGER 2 6.81
IMPINGER NO. 38	Final Weight 553.64 Initial Weight 546.83 Increase		IMPINGER 3 2.80
			IMPINGER 4 20.65
IMPINGER NO. 39	Final Weight 450.66 Initial Weight 447.86 Increase		TOTAL 440.0
			ORSAT
IMPINGER NO. 40	Final Weight 818.74 Initial Weight 798.09 Increase		CO_2 22.5
			O_2 7.4
THIMBLE ~~FILTER~~ NO. #43	Final Weight 75.4585 Initial Weight 49.1741 Part. Catch 26.2848		CO —
			N_2 70.1

SOLID WEIGHT GAIN

BEAKER NO. 33	Final Weight 146.0855 Initial Weight 146.2047 Increase .1192 Bulk	Bulk 26.2848 .1192 0474	BEAKER 1 ____
			BEAKER 2 ____
BEAKER NO. 34	Final Weight 146.5729 Initial Weight 146.5255 Increase .0474	Total 26.4514	BEAKER 3 ____
			BEAKER 4 ____
			TOTAL ____
BEAKER NO. ____	Final Weight ____ Initial Weight ____ Increase ____		
BEAKER NO. ____ PROBE WASH	Final Weight ____ Initial Weight ____ Increase ____		

Moisture Content: Sample Vol. 43.23 ft.^{3} x $\frac{(530)\ 460 + 70}{460 + \text{Meter}\ (529)\ \text{Temp.}}$ X 28.3 L/ft.^{3} = 1226 L Dry Gas

Water Weight $\frac{440\ \text{gm.}}{18\ \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 589 L H_2O Vapor

Total = 1815 L

$\frac{H_2O\ \text{Vol.}}{\text{Total}}$ $\frac{589\ \text{L}}{1815\ \text{L}}$ x 100 = 32 %

(JOHN)

PARTICULATE FIELD DATA

72 °F W.B.

Run No. 10
Location STACK
Date 5/19/77
Operator DVV

Amb. Temp. °F 83 °F D.B.
Bar. Press. "Hg. 29.48"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In 1/4"
Probe Length 4'
Inp. Nos. 37 → 40
Sample Box No. STACK
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:20	512.46	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:26	514.00	.11	.33	.12	.14	71	72	2.0	244	67	190	317	
2	:32	515.77	.15	.39	.16	.18	69	70	2.0	254	65	279	318	
3	:38	517.78	.21	.46	.21	.24	68	69	2.5	251	65	273	321	
4	:44	519.87	.24	.49	.25	.27	67	69	3.0	225	71	330	331	
5	:50	522.04	.26	.51	.27	.28	67	69	3.0	245	72	392	332	
6	:56	524.30	.28	.53	.29	.30	68	70	3.0	255	74	429	334	
7	10:02	526.56	.28	.53	.29	.30	67	70	3.0	215	76	447	334	
8	:08	528.71	.26	.51	.27	.28	68	70	3.0	158	76	293	336	
B - 1	10:18/24	530.31	.09	.30	.10	.15	68	70	2.0	255	81	221	309	
2	:30	532.11	.16	.40	.18	.20	67	69	2.5	267	82	250	323	
3	:36	534.15	.23	.48	.24	.25	67	70	3.0	277	79	248	331	
4	:42	536.28	.28	.53	.29	.27	67	70	3.0	254	83	266	332	
5	:48	538.60	.32	.56	.33	.32	67	70	3.5	212	84	375	333	
6	:54	540.97	.33	.57	.34	.33	68	71	3.5	205	85	401	333	
7	11:00	543.24	.30	.55	.32	.32	68	72	3.0	249	85	402	335	
8	:06	545.45	.30	.55	.32	.30	68	72	3.0	279	86	427	336	
C - 1	11:13/19	547.28	.12	.34	.13	.20	69	71	2.5	197	87	197	316	
2	:25	549.00	.20	.45	.21	.17	68	70	2.5	155	87	198	319	
3	:31	551.09	.25	.50	.26	.27	69	71	3.0	249	88	201	329	
4	:37	553.23	.28	.53	.29	.27	68	71	3.0	260	88	207	328	
5	:43	555.55	.31	.55	.32	.32	68	71	3.5	198	85	215	328	
6	:49	557.83	.33	.57	.34	.32	67	70	3.5	242	87	225	329	
7	:55	560.13	.33	.57	.34	.32	67	71	3.5	257	88	237	332	
8	12:01	562.42	.31	.55	.32	.32	67	71	4.0	265	86	278	335	
TOTAL				11.75		6.32	1628	1690					7871	
AVERAGE				.49		.26	68	70					328	

STATIC PRESSURE = − .57" H_2O

CORRECTED SAMPLE VOLUME = 49.96 Ft.³ (529) Meter Volume X 1.021 Dry Meter Calibration Factor = 51.01 Ft.³ (788)

RUN NO. 10 STACK

PARTICULATE & WATER CATCH

IMPINGER NO. 33	Final Weight 972.89 Initial Weight 553.90 Increase	WATER WEIGHT GAIN	IMPINGER 1	418.99
			IMPINGER 2	21.04
IMPINGER NO. 34	Final Weight 583.45 Initial Weight Increase 562.41		IMPINGER 3	12.48
			IMPINGER 4	35.90
IMPINGER NO. 35	Final Weight 453.83 Initial Weight Increase 441.35		TOTAL	488.41
			ORSAT	
IMPINGER NO. 36	Final Weight 850.34 Initial Weight Increase 814.44		CO_2	22.5
			O_2	7.4
FILTER ~~WHOLE FILTER~~ NO. # 5	Final Weight .8786 Initial Weight Part. Catch .8496 .0290		CO	—
			N_2	70.1

SOLID WEIGHT GAIN

BEAKER NO. 23	Final Weight 117.7337 Initial Weight Increase 117.6658 .0679	Fref - .0290	BEAKER 1	
		Pbk - .0276 .0566	BEAKER 2	
BEAKER NO. 24	Final Weight 148.4850 Initial Weight Increase 148.4280 .0570	Imp .1249 .1815	BEAKER 3	
			BEAKER 4	
			TOTAL	
BEAKER NO.	Final Weight Initial Weight Increase			
BEAKER NO. 20 PROBE WASH	Final Weight 144.2400 Initial Weight Increase 144.2124 .0276			

Moisture Content: Sample Vol. 51.01 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (529) X 28.3 L/ft.^{3} = 1446 L Dry Gas

Water Weight $\frac{488.41 \text{ gm.}}{18 \text{ gm./mol.}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 654 L H_2O Vapor

Total = 2100 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{654 \text{ L}}{2100 \text{ L}}$ x 100 = 31 %

(BoB)

PARTICULATE FIELD DATA

Run No. 11
Location PPR. INPUT
Date 5/20/77
Operator D.V.V.

Amb. Temp. °F 69°F W.B. / 80°F D.B.
Bar. Press. "Hg. 29.44"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN

Probe Tip Dia., In. 1/4"
Probe Length 10'
Inp. Nos. 41 → 44
Sample Box No. PPR. INPUT
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	10:59	331.38	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:59	333.19	.21	.46	.34	.32	67	68	4.0		69		247	
2	:05	335.14	.28	.53	.47	.37	68	69	5.0		71		254	
3	:11	337.29	.34	.58	.60	.48	69	70	6.0		72		264	
B - 1	:17	339.20	.16	.40	.25	.36	69	71	5.0		76		244	
2	:23	341.07	.25	.50	.42	.34	69	71	6.0		79		248	
3	:29	343.12	.31	.55	.53	.42	68	72	7.0		79		265	
C - 1	:35	344.84	.12	.34	.20	.27	68	73	6.5		79		203	
2	:41	346.58	.20	.45	.34	.30	68	73	7.5		79		206	
3	11:47/53	348.24	.18	.42	.30	.25	67	70	8.0		81		205	
D - 1	11:59	349.81	.22	.47	.36	.23	68	72	8.0		82		254	
2	12:05	351.50	.25	.50	.42	.27	69	72	8.5		83		266	
3	:11	353.14	.30	.55	.53	.25	69	72	9.0		83		242	
E - 1	:17	354.57	.19	.43	.32	.20	70	73	9.5		82		268	
2	:23	356.18	.27	.52	.47	.25	70	73	10.0		81		282	
3	:29	357.75	.32	.56	.56	.23	70	74	11.0		80		288	
F - 1	:35	359.04	.20	.45	.34	.15	70	74	11.5		82		199	
2	12:48/50	360.97	.18	.42	.30	.37	70	72	12.0		80		228	
3	:56	362.60	.32	.56	.56	.25	69	71	12.5		80		252	
G - 1	13:02	364.05	.19	.43	.32	.20	68	70	13.5		78		225	
2	:08	365.53	.25	.50	.42	.20	68	70	14.0		78		248	
3	:14	366.97	.27	.52	.47	.20	69	71	14.0		79		249	
H - 1	:20	368.41	.12	.34	.20	.20	67	70	14.5		77		203	
2	:26	369.73	.14	.37	.23	.16	68	71	15.0		78		213	
3	:32	371.03	.15	.39	.25	.15	67	70	15.0		77		208	
TOTAL				11.24		6.42	1645	1712					5761	
AVERAGE				.47		.27	68	71					240	

STATIC PRESSURE = − 2.5" H_2O

CORRECTED SAMPLE VOLUME = 39.65 (530) Ft.³ X 1.034 (700) = 41.00 Ft.³

Meter Volume — Dry Meter Calibration Factor

RUN NO. 11 PPR. INPUT

PARTICULATE & WATER CATCH

IMPINGER NO. 41	Final Weight 984.92 Initial Weight 569.14 Increase	WATER WEIGHT GAIN	IMPINGER 1 415.78
			IMPINGER 2 2.97
IMPINGER NO. 42	Final Weight 558.97 Initial Weight Increase 556.00		IMPINGER 3 1.85
			IMPINGER 4 18.82
IMPINGER NO. 43	Final Weight 446.29 Initial Weight Increase 444.44		TOTAL 439.42
			ORSAT
IMPINGER NO. 44	Final Weight 829.63 Initial Weight Increase 810.81		CO_2 22.0
			O_2 8.0
THIMBLE ~~FILTER~~ NO. # 44	Final Weight 28.5751 Initial Weight Part. Catch 52.6317 25.9434		CO —
			N_2 70.0

SOLID WEIGHT GAIN

BEAKER NO. 6	Final Weight 117.2258 Initial Weight Increase 116.9978 0.2280	Thimble. 25.9434 .2280 .2163 Total 26.3877	BEAKER 1 ____
			BEAKER 2 ____
BEAKER NO. 7	Final Weight 117.7230 Initial Weight Increase 117.5067 .2163		BEAKER 3 ____
			BEAKER 4 ____
			TOTAL ____
BEAKER NO. ____	Final Weight ____ Initial Weight Increase ____		
BEAKER NO. ____ PROBE WASH	Final Weight ____ Initial Weight Increase ____		

Moisture Content: Sample Vol. 41 $ft.^3$ x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (530) X 28.3 $L/ft.^3$ = 1160 L Dry Gas

Water Weight $\frac{439.42 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{L}{mol.}$ = 588 L H_2O Vapor

Total = 1748 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{588 \text{ L}}{1748 \text{ L}}$ x 100 = 33 %

(Cont.)

PARTICULATE FIELD DATA

Run No. 12
Location STACK
Date 5/20/77
Operator D.V.V.

Amb. Temp. °F 69 °F W.B. / 80°F D.B.
Bar. Press. "Hg. 29.44"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS. @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 4'
Inp. Nos. 45 → 48
Sample Box No. STACK
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	10:56	566.30	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	11:02	567.91	.12	.34	.13	.16	68	69	3.0	155	75	154	318	
2	:08	569.68	.23	.48	.24	.18	68	70	3.0	168	76	197	331	
3	:14	571.65	.27	.52	.29	.24	68	71	3.5	245	76	224	336	
4	:20	573.76	.30	.55	.32	.27	68	71	4.0	157	79	235	337	
5	:26	575.96	.30	.55	.32	.28	68	72	4.5	251	80	251	338	
6	:32	578.21	.33	.57	.34	.30	68	72	5.0	211	81	268	335	
7	:38	580.43	.31	.55	.32	.30	69	73	4.5	169	78	279	335	
8	:44	582.63	.30	.55	.32	.28	69	73	4.5	218	82	332	338	
B - 1	11:50/56	584.12	.11	.33	.12	.14	69	71	3.0	124	82	280	328	
2	12:02	585.74	.18	.42	.18	.18	70	73	3.0	228	81	234	332	
3	:08	587.58	.25	.50	.26	.21	70	73	3.5	249	81	224	334	
4	:14	589.67	.31	.55	.32	.27	71	73	4.0	251	78	246	337	
5	:20	591.88	.33	.57	.34	.30	73	76	4.5	288	79	255	328	
6	:26	594.10	.31	.55	.32	.30	72	75	4.5	243	81	235	336	
7	:32	596.50	.32	.56	.33	.35	73	76	4.5	217	79	254	337	
8	:38	598.48	.31	.55	.32	.24	73	76	4.5	229	83	292	339	
C - 1	12:47/53	599.75	.10	.31	.10	.10	72	74	2.5	115	82	195	319	
2	:59	601.36	.17	.41	.18	.16	71	73	3.0	244	83	201	322	
3	:05	603.21	.23	.48	.24	.21	71	73	4.0	258	84	245	331	
4	:11	605.22	.24	.49	.26	.24	71	73	4.5	215	83	249	332	
5	:17	607.27	.28	.53	.28	.25	71	73	5.0	203	85	267	336	
6	:23	609.39	.30	.55	.32	.27	70	73	5.0	241	86	286	335	
7	:29	611.49	.30	.55	.32	.27	70	74	5.0	266	86	285	337	
8	:35	613.54	.31	.55	.32	.26	71	74	5.0	218	87	281	338	
TOTAL				12.01		5.76	1684	1757					7989	
AVERAGE				.50		.24	70	73					333	

STATIC PRESSURE = −.51 " H_2O

CORRECTED SAMPLE VOLUME = 47.24 Ft.³ (Meter Volume) X 1.021 (Dry Meter Calibration Factor) = 48.23 Ft.³

(531) (793)

RUN NO. 12 (STACK)

PARTICULATE & WATER CATCH

IMPINGER NO. 45	Final Weight 885.52 Initial Weight 559.74 Increase	WATER WEIGHT GAIN	IMPINGER 1	325.78
			IMPINGER 2	89.73
IMPINGER NO. 46	Final Weight 643.40 Initial Weight Increase 553.67		IMPINGER 3	12.99
			IMPINGER 4	38.55
IMPINGER NO. 47	Final Weight 469.98 Initial Weight Increase 456.99		TOTAL	467.05
			ORSAT	
IMPINGER NO. 48	Final Weight 893.50 Initial Weight Increase 854.95		CO_2	22.0
			O_2	8.0
FILTER NO. # 6	Final Weight .9316 Initial Weight Part. Catch .8533 .0783		CO	—
			N_2	70.0

SOLID WEIGHT GAIN

BEAKER NO. 14	Final Weight 141.4115 Initial Weight Increase 141.3365 .0750	Filt. .0783 Probe .0202 .0985	BEAKER 1	
			BEAKER 2	
BEAKER NO. 15	Final Weight 146.6762 Initial Weight Increase 146.6412 .0350	Imp. .1100 Tot. .2085	BEAKER 3	
			BEAKER 4	
			TOTAL	
BEAKER NO.	Final Weight Initial Weight Increase			
BEAKER NO. 3 PROBE WASH	Final Weight 113.1288 Initial Weight Increase 113.1086 .0202			

Moisture Content: Sample Vol. 48.23 ft.^{3} x $\frac{460 + 70 \ (530)}{460 + \text{Meter Temp.} \ (531)}$ X 28.3 L/ft.^{3} = 1362 L Dry Gas

Water Weight $\frac{467.05 \text{ gm.}}{18 \text{ gm./mol.}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 625 L H_2O Vapor

Total = 1987 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{625 \text{ L}}{1987 \text{ L}}$ x 100 = 31 %

(BOB)

PARTICULATE FIELD DATA

Run No. 13
Location PPR. INPUT
Date 5/21/77
Operator D.V.V.

Amb. Temp. °F 70°F W.B. 82°F D.B.
Bar. Press. "Hg. 29.37"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 10'
Inp. Nos. 49 → 52
Sample Box No. PPR. INPUT
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:38	371.38	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:44	372.91	.15	.39	.25	.21	68	70	3.5		71		246	
2	:50	374.59	.18	.42	.30	.27	69	70	4.0		73		258	
3	:56	376.34	.32	.56	.56	.30	69	70	4.5		72		264	
B - 1	10:02	378.02	.16	.40	.25	.27	67	69	5.5		71		248	
2	:08	379.90	.24	.49	.42	.34	67	70	6.5		71		263	
3	:14	381.73	.28	.53	.47	.32	67	71	7.0		72		261	
C - 1	:20	383.54	.14	.37	.23	.32	66	70	7.5		71		208	
2	:26	385.21	.20	.45	.34	.27	65	71	8.5		70		245	
3	10:34/40	386.85	.18	.42	.30	.25	68	72	7.0		72		258	
D - 1	:46	388.48	.15	.39	.25	.25	69	72	8.0		71		217	
2	:52	390.02	.17	.41	.27	.21	70	73	8.0		73		228	
3	:58	391.53	.20	.45	.34	.21	70	73	8.5		74		249	
E - 1	:04	393.02	.16	.40	.25	.21	72	75	9.0		73		229	
2	:10	394.44	.25	.50	.42	.18	72	74	9.0		73		281	
3	:16	395.90	.35	.59	.62	.20	72	74	10.0		74		279	
F - 1	:22	397.60	.18	.42	.30	.27	73	75	12.0		75		236	
2	11:28/34	399.31	.20	.45	.34	.27	72	74	9.5		76		265	
3	:40	400.81	.32	.56	.56	.21	73	74	11.0		76		267	
G - 1	:46	402.29	.19	.43	.32	.20	72	74	12.0		76		214	
2	:52	403.75	.22	.47	.36	.20	73	74	13.0		77		255	
3	:58	405.23	.35	.59	.62	.21	74	75	13.0		78		248	
H - 1	12:04	406.64	.13	.36	.21	.18	72	73	14.0		78		264	
2	:10	408.00	.22	.47	.36	.16	74	75	14.0		78		265	
3	:16	409.35	.25	.50	.42	.16	73	74	14.5		78		226	
TOTAL				11.02		5.67	1687	1742					5974	
AVERAGE				.46		.23	70	72					249	

STATIC PRESSURE = − 2.40 " H_2O

CORRECTED SAMPLE VOLUME = (531) Meter Volume 37.97 Ft.³ X Dry Meter Calibration Factor 1.034 = (709) 39.26 Ft.³

PPR. INPUT

RUN NO. 13

PARTICULATE & WATER CATCH

IMPINGER NO. 49
Final Weight 895.64
Initial Weight 542.03
Increase

IMPINGER NO. 50
Final Weight 553.66
Initial Weight
Increase 551.27

IMPINGER NO. 51
Final Weight 442.87
Initial Weight
Increase 440.75

IMPINGER NO. 52
Final Weight 817.37
Initial Weight
Increase 799.04

THIMBLE ~~FILTER~~ NO. # 19
Final Weight 69.9450
Initial Weight
Part. Catch 44.2131
25.7319

WATER WEIGHT GAIN

IMPINGER 1 353.59
IMPINGER 2 2.39
IMPINGER 3 2.12
IMPINGER 4 18.33
TOTAL 376.43

ORSAT

CO_2 24.0
O_2 7.6
CO —
N_2 68.4

SOLID WEIGHT GAIN

Carbon BEAKER NO. 16
Final Weight 154.4540
Initial Weight
Increase 154.1440
.3100

Carbon BEAKER NO. 19
Final Weight 143.7545
Initial Weight
Increase 143.6104
.1441

Thimble 25.7319
.3100
.1441
Total - 26.1860

BEAKER 1
BEAKER 2
BEAKER 3
BEAKER 4
TOTAL

BEAKER NO.
Final Weight
Initial Weight
Increase

BEAKER NO. PROBE WASH
Final Weight
Initial Weight
Increase

Moisture Content: Sample Vol. 39.26 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (531) X 28.3 L/ft.^{3} = 1109 L Dry Gas

Water Weight $\frac{376.43 \text{ gm.}}{18 \text{ gm./mol.}}$ x 24.1 $\frac{L}{mol.}$ = 504 L H_2O Vapor

Total = 1613 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{504 \text{ L}}{1613 \text{ L}}$ x 100 = 31 %

(JOHN)

PARTICULATE FIELD DATA

Run No. 14
Location STACK
Date 5/21/77
Operator D.V.V.

Amb. Temp. °F 70°F W.B. 82°F D.B.
Bar. Press. "Hg. 29.37"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In 1/4"
Probe Length 4'
Inp. Nos. 53 → 56
Sample Box No. STACK
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:41	613.82	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A – 1	:47	615.27	.11	.33	.12	.13	71	72	2.0	248	77	202	323	
2	:53	616.78	.15	.39	.16	.14	70	71	2.0	257	77	200	331	
3	:59	618.29	.22	.47	.23	.14	69	70	2.5	272	78	212	330	
4	:05	620.71	.26	.51	.27	.35	68	70	3.0	219	77	285	331	
5	:11	622.69	.28	.53	.28	.24	68	71	2.5	228	76	403	337	
6	:17	624.72	.28	.53	.28	.26	69	72	3.0	237	75	316	338	
7	:23	626.78	.30	.55	.32	.26	68	71	3.0	261	74	408	336	
8	:29	628.95	.30	.55	.32	.28	68	71	3.5	258	73	421	336	
B – 1	10:37/43	630.29	.10	.31	.10	.10	69	72	2.5	99	75	115	307	
2	:49	632.04	.20	.45	.21	.19	69	72	3.5	94	76	213	315	
3	:55	633.90	.25	.50	.25	.21	69	72	4.0	123	77	242	321	
4	11:01	636.00	.30	.55	.32	.27	70	73	7.0	182	76	203	322	
5	:07	637.88	.32	.56	.33	.21	71	74	9.5	249	77	243	326	
6	:13	640.00	.32	.56	.33	.27	69	73	10.0	286	78	171	328	
7	:19	642.50	.32	.56	.33	.37	70	74	10.0	245	78	209	328	
8	:25	644.81	.30	.55	.32	.32	69	73	3.5	180	78	258	330	
C – 1	11:31/37	646.37	.14	.37	.15	.15	71	74	2.5	91	79	243	312	
2	:43	648.09	.20	.45	.21	.17	69	72	3.0	194	80	278	315	
3	:49	650.06	.27	.52	.28	.24	70	73	3.5	197	80	256	323	
4	:55	652.19	.31	.55	.32	.27	71	73	3.5	203	81	269	324	
5	12:01	654.32	.32	.56	.32	.27	71	74	3.5	214	83	263	325	
6	:07	656.47	.31	.55	.32	.28	70	73	4.0	197	83	245	313	
7	:13	658.62	.32	.56	.32	.28	71	75	4.0	235	84	398	325	
8	:19	660.77	.32	.56	.32	.28	71	75	4.0	254	85	405	325	
TOTAL				12.02		5.68	1671	1740					7801	
AVERAGE				.50		.24	69	72					325	

STATIC PRESSURE = – .57" H_2O

(531) Meter Volume

Dry Meter Calibration Factor (785)

CORRECTED STANDARD VOLUME

STACK

RUN NO. 14

PARTICULATE & WATER CATCH

IMPINGER NO. 53	Final Weight 887.73 Initial Weight 538.09 Increase	WATER WEIGHT GAIN	IMPINGER 1 349.64
IMPINGER NO. 54	Final Weight 612.32 Initial Weight Increase 564.00		IMPINGER 2 48.32
IMPINGER NO. 55	Final Weight 453.01 Initial Weight Increase 439.73		IMPINGER 3 13.28
IMPINGER NO. 56	Final Weight 856.16 Initial Weight Increase 820.44		IMPINGER 4 35.72
			TOTAL 446.96
FILTER NO. #7	Final Weight .8705 Initial Weight Part. Catch .8433 .0272		ORSAT CO_2 24.0 O_2 7.6 CO — N_2 68.4

SOLID WEIGHT GAIN

BEAKER NO. 23 (Carbon)	Final Weight 146.0217 Initial Weight 145.9746 Increase .0471	Filter .0272 Probe .1903 Imp. .1905 Total .4080	BEAKER 1
BEAKER NO. 25 (IMP.)	Final Weight 148.7737 Initial Weight 148.6303 Increase .1434		BEAKER 2
			BEAKER 3
			BEAKER 4
			TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
BEAKER NO. 27 PROBE WASH	Final Weight 130.7440 Initial Weight 130.5537 Increase .1903		

Moisture Content: Sample Vol. 47.93 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (531) X 28.3 L/ft.^{3} = 1354 L Dry Gas

Water Weight $\frac{446.96 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 598 L H_2O Vapor

Total = 1952 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{598 \text{ L}}{1952 \text{ L}}$ x 100 = 30 %

(Bob)

PARTICULATE FIELD DATA

Run No. 15
Location PPR. INPUT
Date 5/22/77
Operator D. V. V.

Amb. Temp. °F 68°F W.B. / 76°F D.B.
Bar. Press. "Hg. 29.42"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN

Probe Tip Dia., In. 1/4"
Probe Length 10'
Inp. Nos. 57 → 60
Sample Box No. PPR. INPUT
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:07	409.71	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:13	411.48	.19	.43	.32	.30	73	74	4.0		66		249	
2	:19	413.30	.28	.53	.47	.32	71	72	4.5		64		261	
3	:25	415.21	.34	.58	.60	.37	71	72	5.5		62		254	
B - 1	:31	417.06	.14	.37	.23	.34	70	73	6.0		61		232	
2	:37	418.84	.23	.48	.39	.30	70	73	6.5		61		238	
3	:43	420.67	.34	.58	.60	.33	69	72	7.5		59		241	
C - 1	:49	422.48	.13	.36	.21	.32	71	74	8.0		61		218	
2	:55	424.20	.25	.50	.42	.29	71	74	8.5		62		224	
3	10:00/06	426.05	.23	.48	.39	.34	71	73	8.0		62		232	
D - 1	:12	427.75	.14	.37	.23	.27	71	74	8.0		63		208	
2	:18	429.38	.11	.33	.18	.25	72	74	8.5		63		212	
3	:24	430.94	.19	.43	.32	.23	72	74	9.0		64		210	
E - 1	:30	432.51	.24	.49	.42	.23	72	74	9.5		64		257	
2	:36	433.99	.32	.56	.56	.20	72	74	10.0		63		282	
3	:42	435.44	.34	.58	.60	.20	72	74	10.0		63		229	
F - 1	:48	436.88	.16	.40	.25	.20	72	74	11.0		63		228	
2	10:54/00	438.57	.15	.39	.25	.27	72	73	11.5		64		234	
3	11:06	440.13	.33	.57	.56	.23	72	73	12.0		64		249	
G - 1	:12	441.61	.15	.39	.25	.21	72	73	13.0		64		239	
2	:18	443.06	.28	.53	.47	.20	72	73	13.5		64		238	
3	:24	444.48	.25	.50	.42	.18	72	73	13.5		63		242	
H - 1	:30	445.95	.18	.42	.30	.20	73	74	15.0		63		228	
2	:36	447.47	.26	.51	.45	.21	73	74	15.5		63		249	
3	11:42	448.73	.22	.47	.37	.15	73	74	15.5		64		218	
TOTAL				11.25		6.14	1719	1762					5672	
AVERAGE				.47		.25	71	73					236	

STATIC PRESSURE = − 2.45" H_2O

CORRECTED SAMPLE VOLUME = 39.02 Ft.³ (532) Meter Volume X 1.034 Dry Meter Calibration Factor (696) = 40.34 Ft.³

RUN NO. 15

PPR. INPUT

PARTICULATE & WATER CATCH

IMPINGER NO. 57	Final Weight 894.91 Initial Weight 522.86 Increase	WATER WEIGHT GAIN	IMPINGER 1 372.05
			IMPINGER 2 3.70
IMPINGER NO. 58	Final Weight 556.24 Initial Weight Increase 552.54		IMPINGER 3 2.17
			IMPINGER 4 19.77
IMPINGER NO. 59	Final Weight 457.96 Initial Weight Increase 455.79		TOTAL 397.69
			ORSAT
IMPINGER NO. 60	Final Weight 835.43 Initial Weight Increase 815.66		CO_2 25.0
			O_2 6.8
THIMBLE ~~FILTER~~ NO. #31	Final Weight 73.0346 Initial Weight Part. Catch 47.3841		CO .01
	25.6505		N_2 68.2

SOLID WEIGHT GAIN

BEAKER NO. 18	Final Weight 143.8929 Initial Weight 143.6560 Increase .2369	25,650.5 67.9 236.9	BEAKER 1
			BEAKER 2
		126.5	BEAKER 3
BEAKER NO. 19	Final Weight 143.7369 Initial Weight 143.6104 Increase .1265	26,082	BEAKER 4
			TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
BEAKER NO. 23 PROBE WASH	Final Weight 117.6658 Initial Weight 117.7337 Increase .0679		

Moisture Content: Sample Vol. 40.34 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (532) X 28.3 L/ft.^{3} = 1137 L Dry Gas

Water Weight $\frac{397.69 \text{ gm.}}{18 \text{ gm./mol.}}$ x 24.1 $\frac{L}{mol.}$ = 532 L H_2O Vapor

Total = 1669 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{532 \text{ L}}{1669 \text{ L}}$ x 100 = 32 %

PARTICULATE FIELD DATA

Run No. 16
Location STACK
Date 5/22/77
Operator D.V.V.

Amb. Temp. °F 68°F W.B. / 76°F D.B.
Bar. Press. "Hg. 29.42"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 4'
Inp. Nos. 61 → 64
Sample Box No. STACK
f = .59

Heater Box Setting ____

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:10	661.06	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:16	662.67	.14	.37	.15	.16	71	72	2.5	108	73	204	326	
2	:22	664.43	.20	.45	.21	.18	69	70	3.0	171	72	201	325	
3	:28	666.34	.25	.50	.25	.23	68	70	3.5	178	66	233	324	
4	:34	668.35	.28	.53	.28	.24	68	71	3.5	193	69	268	323	
5	:40	670.49	.31	.55	.32	.27	67	70	4.0	196	71	258	321	
6	:46	672.64	.31	.55	.32	.28	68	71	4.0	210	71	270	320	
7	:52	674.79	.30	.55	.32	.29	69	73	4.0	185	70	282	321	
8	:58	676.95	.30	.55	.32	.28	69	73	4.0	225	74	299	324	
B - 1	10:03/09	678.36	.12	.34	.13	.12	69	72	3.0	245	74	259	317	
2	:15	679.98	.18	.42	.18	.16	69	71	3.0	214	75	347	320	
3	:21	681.87	.24	.49	.25	.21	69	71	3.5	205	73	295	321	
4	:27	683.88	.27	.52	.28	.24	69	72	3.5	203	72	272	321	
5	:33	685.94	.28	.53	.28	.26	69	72	3.5	206	70	271	321	
6	:39	688.10	.31	.55	.32	.28	69	72	4.0	214	71	275	320	
7	:45	690.28	.30	.55	.32	.28	69	72	4.0	231	71	315	321	
8	:51	692.44	.30	.55	.32	.28	69	73	4.0	245	73	402	322	
C - 1	10:57/03	693.79	.10	.31	.10	.10	70	72	3.0	229	68	357	308	
2	11:09	695.35	.17	.41	.17	.15	69	71	3.5	192	69	256	309	
3	:15	697.03	.20	.45	.21	.17	69	71	3.5	187	69	248	308	
4	:21	698.92	.25	.50	.25	.21	69	72	4.0	186	71	254	316	
5	:27	700.83	.25	.50	.25	.23	69	72	4.0	179	73	234	315	
6	:33	702.75	.26	.51	.27	.23	69	72	4.0	199	74	291	317	
7	:39	704.79	.28	.53	.28	.25	69	72	4.0	212	74	329	311	
8	11:45	706.83	.28	.53	.28	.25	70	73	4.0	266	74	408	322	
TOTAL				11.74		5.47	1655	1720					7653	
AVERAGE				.49		.23	69	72					319	

STATIC PRESSURE = − .54" H_2O

(530) Meter Volume

Dry Meter Calibration Factor (779)

CORRECTED SAMPLE VOLUME = [illegible] FT.³ [illegible] = 46.73 FT.³

RUN NO. 16

PARTICULATE & WATER CATCH

IMPINGER NO. 61	Final Weight 972.12 Initial Weight 571.74 Increase	
IMPINGER NO. 62	Final Weight 530.13 Initial Weight Increase 550.83	
IMPINGER NO. 63	Final Weight 471.84 Initial Weight Increase 448.20	
IMPINGER NO. 64	Final Weight 847.75 Initial Weight Increase 807.73	
FILTER NO. # 8	Final Weight .8728 Initial Weight Part. Catch .8440 .0288	

WATER WEIGHT GAIN

IMPINGER 1	400.38
IMPINGER 2	-20.70
IMPINGER 3	23.64
IMPINGER 4	40.02
TOTAL	443.34

ORSAT

CO_2	25.0
O_2	6.8
CO	.01
N_2	68.2

SOLID WEIGHT GAIN

BEAKER NO. 15	Final Weight 146.7769 Initial Weight Increase 146.6369 .1400	28.8 23.3 52.1	BEAKER 1 _____ BEAKER 2 _____
BEAKER NO. 17	Final Weight 142.7157 Initial Weight Increase 142.5821 .1336	140.0 133.6 375.7	BEAKER 3 _____ BEAKER 4 _____
BEAKER NO. _____	Final Weight _____ Initial Weight Increase _____		TOTAL _____
BEAKER NO. 4 PROBE WASH	Final Weight 115.5787 Initial Weight Increase 115.5554 .0233		

Moisture Content: Sample Vol. 46.73 ft.^{3} x $\frac{460 + 70 \ (530)}{460 + \text{Meter Temp.} \ (530)}$ X 28.3 L/ft.^{3} = 1322 L Dry Gas

Water Weight $\frac{443.34 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 593 L H_2O Vapor

Total = 1915 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{593 \text{ L}}{1915 \text{ L}}$ x 100 = 31 %

(BOB)

PARTICULATE FIELD DATA

Run No. 17
Location PPR. INPUT
Date 5/23/77
Operator D.V.V.

Amb. Temp. °F 69°F W.B. / 75°F D.B.
Bar. Press. "Hg. 29.53"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6MIN EACH

Probe Tip Dia., In 1/4"
Probe Length 10'
Inp. Nos. 65 → 68
Sample Box No. PPR. INPUT
F = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:01	449.09	ΔP	$\sqrt{\Delta P}$	Desired	Actual	Inlet	Outlet						
A - 1	:07	450.73	.14	.37	.23	.25	74	75	4.0		71		147	
2	:13	452.70	.23	.48	.39	.40	72	73	4.5		67		152	
3	:19	454.55	.37	.61	.65	.34	71	73	5.0		67		202	
B - 1	:25	456.39	.13	.36	.21	.33	71	74	5.5		66		178	
2	:31	458.15	.25	.50	.42	.30	70	74	6.0		66		188	
3	:37	459.98	.33	.57	.56	.32	71	74	7.0		66		199	
C - 1	:43	461.89	.12	.34	.20	.37	71	75	7.0		68		182	
2	:49	463.62	.19	.43	.32	.30	71	75	7.0		67		179	
3	9:57/03	465.44	.16	.40	.25	.32	72	74	7.5		71		183	
D - 1	10:09	467.12	.13	.36	.21	.27	72	74	8.0		72		165	
2	:15	468.68	.12	.34	.20	.23	72	74	8.5		71		172	
3	:21	470.20	.16	.40	.25	.21	72	74	9.0		72		169	
E - 1	:27	471.84	.28	.53	.47	.27	72	74	8.5		72		210	
2	:33	473.45	.33	.57	.56	.25	72	74	8.5		73		215	
3	:39	475.20	.35	.59	.62	.30	72	75	9.0		72		217	
F - 1	:45	476.86	.18	.42	.30	.25	72	75	10.5		72		203	
2	11:01/07	478.41	.16	.40	.25	.23	72	73	11.0		73		198	
3	:13	479.90	.33	.57	.56	.21	73	75	11.5		75		211	
G - 1	:19	481.60	.16	.40	.25	.27	73	75	10.0		75		179	
2	:25	483.47	.29	.54	.50	.34	73	75	11.0		76		192	
3	:31	485.33	.33	.57	.56	.34	73	76	12.0		75		205	
H - 1	:37	487.36	.23	.48	.39	.42	72	76	12.0		74		177	
2	:43	489.58	.25	.50	.42	.50	73	77	10.0		74		188	
3	:49	491.90	.28	.53	.47	.53	72	77	10.5		73		218	
TOTAL				11.26		7.55	1728	1791					4529	
AVERAGE				.47		.31	72	74					189	

STATIC PRESSURE = - 2.65" H_2O

CORRECTED SAMPLE VOLUME = (533) Meter Volume 42.81 Ft.^{3} X Dry Meter Calibration Factor 1.034 = (649) 44.26 Ft.^{3}

RUN NO. 17

PPR. INPUT

PARTICULATE & WATER CATCH

IMPINGER NO. 65	Final Weight 932.48 Initial Weight 570.60 Increase	WATER WEIGHT GAIN	IMPINGER 1	361.88
			IMPINGER 2	105.68
IMPINGER NO. 66	Final Weight 677.52 Initial Weight 571.84 Increase		IMPINGER 3	2.02
			IMPINGER 4	16.94
IMPINGER NO. 67	Final Weight 446.90 Initial Weight 444.88 Increase		TOTAL	486.52
			ORSAT	
IMPINGER NO. 68	Final Weight 838.94 Initial Weight 822.00 Increase		CO_2	26.0
			O_2	7.2
THIMBLE ~~FILTER~~ NO. # 29	Final Weight 61.9955 Initial Weight 36.1115 Part. Catch 25.8840		CO	0.01
			N_2	66.8

SOLID WEIGHT GAIN

BEAKER NO. 20	Final Weight 144.9764 Initial Weight 144.2111 Increase .7653	25,884 201.1 765.3	BEAKER 1	
			BEAKER 2	
BEAKER NO. 24	Final Weight 149.3524 Initial Weight 148.4275 Increase .9249	924.9 27,775.3	BEAKER 3	
			BEAKER 4	
			TOTAL	
BEAKER NO.	Final Weight Initial Weight Increase			
BEAKER NO. 34 PROBE WASH	Final Weight 147.7239 Initial Weight 146.5228 Increase .2011			

1 MP.

Moisture Content: Sample Vol. 44.26 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (533) X 28.3 L/ft.^{3} = 1245 L Dry Gas

Water Weight $\frac{486.52 \text{ gm.}}{18 \text{ gm. mol.}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 651 L H_2O Vapor

Total = 1896 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{651 \text{ L}}{1896 \text{ L}}$ x 100 = 34 %

(JOHN)

PARTICULATE FIELD DATA

Run No. 18
Location STACK
Date 5/23/77
Operator D.V.V.

Amb. Temp. °F 69°F W.B. 75°F D.B.
Bar. Press. "Hg. 29.53"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS (@ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 4'
Inp. Nos. 69 → 72
Sample Box No. STACK
f = .59

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:04	707.16	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:10	708.31	.08	.28	.08	.08	72	73	2.0	95	63	85	277	
2	:16	709.74	.16	.40	.16	.13	70	71	2.5	99	63	136	303	
3	:22	711.47	.20	.45	.21	.19	70	71	3.0	105	63	141	317	
4	:28	713.24	.22	.47	.23	.19	69	71	3.0	128	65	221	319	
5	:34	715.12	.25	.50	.25	.21	69	71	3.0	249	63	189	316	
6	:40	717.01	.25	.50	.25	.21	69	71	3.0	253	63	191	318	
7	:46	719.00	.28	.53	.29	.24	69	72	3.5	205	64	222	315	
8	:52	721.01	.28	.53	.29	.24	69	72	3.5	248	64	245	318	
B - 1	10:00/06	722.31	.10	.31	.10	.10	70	72	3.0	208	68	174	308	
2	:12	723.87	.18	.42	.19	.15	69	71	3.5	268	71	182	322	
3	:18	725.79	.22	.47	.23	.23	70	72	3.5	306	72	179	326	
4	:24	727.81	.28	.53	.29	.25	70	72	3.5	301	77	183	326	
5	:30	729.87	.30	.55	.32	.25	70	73	4.0	311	76	195	327	
6	:36	732.07	.31	.55	.32	.29	70	73	4.0	209	77	328	328	
7	:42	734.30	.30	.55	.32	.30	70	73	4.0	211	77	332	327	
8	:48	736.48	.31	.55	.32	.28	70	74	4.0	233	78	402	324	
C - 1	11:04/10	737.94	.13	.36	.14	.13	70	71	3.0	140	76	182	317	
2	:16	739.73	.22	.47	.23	.20	71	72	3.5	183	76	249	324	
3	:22	741.61	.26	.51	.27	.21	70	72	3.5	190	76	248	329	
4	:28	743.76	.30	.55	.32	.28	70	72	4.0	191	77	257	331	
5	:34	745.99	.32	.56	.34	.30	70	72	4.0	203	77	274	330	
6	:40	748.21	.31	.55	.32	.30	70	73	4.0	206	77	273	331	
7	:46	750.43	.32	.56	.34	.30	70	74	4.0	215	76	278	319	
8	:52	752.65	.30	.55	.32	.30	71	74	4.0	217	74	298	319	
TOTAL				11.70		5.36	1678	1732					7671	
AVERAGE				.49		.22	70	72					319	

STATIC PRESSURE = - 0.56 " H_2O CORRECTED SAMPLE VOLUME = 45.49 (531) Meter Volume Ft.^{3} X 1.021 (779) Dry Meter Calibration Factor = 46.44 Ft.^{3}

RUN NO. 18

PARTICULATE & WATER CATCH

IMPINGER NO. 69	Final Weight 975.64 Initial Weight 583.39 Increase	WATER WEIGHT GAIN	IMPINGER 1 ~~975~~ 392.25
			IMPINGER 2 72.46
IMPINGER NO. 70	Final Weight 642.25 Initial Weight Increase 569.79		IMPINGER 3 1.16
			IMPINGER 4 20.20
IMPINGER NO. 71	Final Weight 460.00 Initial Weight Increase 458.84		TOTAL 486.07
			ORSAT
IMPINGER NO. 72	Final Weight 803.83 Initial Weight Increase 283.63		CO_2 26.0
			O_2 7.2
FILTER NO. # 9	Final Weight .9736 Initial Weight Part. Catch .8575 .1161		CO 0.01
			N_2 66.8

SOLID WEIGHT GAIN

BEAKER NO. 31	Final Weight 144.3300 Initial Weight 144.2800 Increase .0500	116.1 34.4 150.5	BEAKER 1
			BEAKER 2
IMP. Calvin BEAKER NO. 32	Final Weight 145.1821 Initial Weight 145.1266 Increase .0555	55.5 34.4 240.4	BEAKER 3
			BEAKER 4
			TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
BEAKER NO. 33 PROBE WASH	Final Weight 146.1206 Initial Weight 146.0862 Increase .0344		

Moisture Content: Sample Vol. 46.44 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) / (531) X 28.3 L/ft.^{3} = 1312 L Dry Gas

Water Weight $\frac{486.07 \text{ gm.}}{18 \text{ gm./mol.}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 651 L H_2O Vapor

Total = 1963 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{651 \text{ L}}{1963 \text{ L}}$ x 100 = 33 %

(BOB)

PARTICULATE FIELD DATA

Run No. 19
Location PPR-INPUT
Date 5/24/77
Operator D.V.V.

Amb. Temp. °F 69 °F W.B / 74 °F D.B.
Bar. Press. "Hg. 29.54"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 10'
Inp. Nos. 73 → 76
Sample Box No. PPR. INPUT
$\bar{F}$ = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:19	492.25	ΔP	$\sqrt{\Delta P}$	Desired	Actual	Inlet	Outlet						
A - 1	:25	493.95	.17	.41	.27	.27	73	75	4.0		68		262	
2	:31	495.83	.28	.53	.47	.34	73	74	5.0		67		268	
3	:37	497.70	.35	.59	.62	.34	73	74	5.5		67		274	
B - 1	:43	499.51	.15	.39	.25	.31	72	75	6.0		70		245	
2	:49	501.26	.27	.52	.47	.30	72	75	6.5		72		250	
3	:55	503.00	.38	.61	.65	.30	72	75	7.5		75		262	
C - 1	10:01	504.71	.13	.36	.21	.28	72	75	8.0		76		201	
2	:07	506.30	.20	.45	.34	.23	72	75	8.5		76		215	
	10:12/18	507.99	.20	.45	.34	.27	73	75	8.0		77		236	
D - 1	:24	509.55	.14	.37	.23	.23	73	76	8.5		77		198	
2	:30	511.02	.13	.36	.21	.20	73	76	9.0		78		201	
3	:36	512.44	.15	.39	.25	.18	73	76	9.5		78		208	
E - 1	:42	513.95	.22	.47	.36	.21	74	76	11.0		78		224	
2	:48	515.39	.31	.55	.53	.20	73	76	11.0		77		230	
3	:54	516.79	.35	.59	.62	.18	74	76	11.5		78		232	
F - 1	11:00	518.21	.19	.43	.31	.18	74	75	12.0		77		202	
2	11:08/14	519.90	.20	.45	.34	.27	75	76	13.0		78		214	
3	:20	521.30	.35	.59	.62	.18	76	77	13.5		78		232	
G - 1	:26	522.78	.15	.39	.25	.20	76	77	14.0		78		231	
2	:32	523.93	.30	.55	.53	.12	77	77	14.0		79		234	
3	:38	525.25	.35	.59	.62	.16	76	77	14.0		80		238	
H - 1	:44	526.53	.14	.37	.23	.15	74	74	15.0		78		236	
2	:50	527.78	.18	.42	.30	.15	75	75	15.5		78		242	
3	:56	529.09	.15	.39	.25	.16	75	75	15.5		78		256	
TOTAL				11.22		5.42	1770	1812					5359	
AVERAGE				.47		.22	74	75					223	

STATIC PRESSURE = − 2.60" H_2O

CORRECTED SAMPLE VOLUME = (534) Meter Volume 36.84 Ft.³ X Dry Meter Calibration Factor 1.034 (683) = 38.09 Ft.³

RUN NO. 19

PPR. INPUT

PARTICULATE & WATER CATCH

IMPINGER NO. 73	Final Weight 915.89 Initial Weight 552.10 Increase	WATER WEIGHT GAIN	IMPINGER 1 363.79
			IMPINGER 2 13.57
IMPINGER NO. 74	Final Weight 579.00 Initial Weight 565.43 Increase		IMPINGER 3 1.49
			IMPINGER 4 18.47
IMPINGER NO. 75	Final Weight 442.36 Initial Weight 440.87 Increase		TOTAL 397.32
			ORSAT
IMPINGER NO. 76	Final Weight 805.54 Initial Weight 787.07 Increase		CO_2 25.0
			O_2 7.6
THIMBLE ~~FILTER~~ NO. #26	Final Weight 71.6909 Initial Weight 44.5314 Part. Catch 27.1595		CO 0.15
			N_2 68.0

SOLID WEIGHT GAIN

MP. BEAKER NO. 3	Final Weight 113.3965 Initial Weight 113.1073 Increase .2892	27,159.5 72.5 289.~ 336.1	BEAKER 1
			BEAKER 2
			BEAKER 3
Cadmium BEAKER NO. 14	Final Weight 141.6711 Initial Weight 141.3350 Increase .3361	27857.3	BEAKER 4
			TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
BEAKER NO. 30 PROBE WASH	Final Weight 142.9803 Initial Weight 142.9078 Increase .0725		

Moisture Content: Sample Vol. 38.09 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (538) X 28.3 L/ft.^{3} = 1070 L Dry Gas

Water Weight $\frac{397.32 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 532 L H_2O Vapor

Total = 1602 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{532 \text{ L}}{1602 \text{ L}}$ x 100 = 33 %

(JOHN)

PARTICULATE FIELD DATA

Run No. 20
Location STACK
Date 5/24/77
Operator D.V.V.

Amb. Temp. °F 69°F W.B. / 74°F D.B.
Bar. Press. "Hg. 29.54"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 4'
Inp. Nos. 77 → 80
Sample Box No. STACK
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:22	752.95	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:28	754.52	.14	.37	.15	.15	72	73	2.5	83	70	78	319	
2	:34	756.25	.20	.45	.21	.19	71	72	2.5	97	70	88	325	
3	:40	758.19	.26	.51	.27	.23	71	72	3.0	130	73	101	332	
4	:46	760.18	.28	.53	.28	.24	71	73	3.0	185	77	111	333	
5	:52	762.31	.31	.55	.32	.27	71	73	3.2	194	72	124	329	
6	:58	764.49	.32	.56	.34	.28	70	73	3.5	257	73	135	334	
7	10:04	766.64	.31	.55	.32	.28	71	74	3.5	178	73	140	330	
8	:10	768.80	.30	.55	.32	.28	71	75	3.5	189	73	159	331	
B - 1	10:15/21	770.01	.10	.31	.10	.09	72	74	2.5	119	74	92	320	
2	:27	771.62	.21	.46	.21	.16	72	74	3.0	141	75	125	323	
3	:33	773.46	.25	.50	.25	.21	72	75	3.2	124	75	190	332	
4	:39	775.44	.28	.53	.28	.24	73	75	3.5	136	76	201	333	
5	:45	777.47	.32	.56	.34	.26	73	76	3.5	187	77	208	336	
6	:51	779.58	.32	.56	.34	.27	72	75	3.5	248	75	215	336	
7	:57	781.68	.32	.56	.34	.27	72	76	3.8	204	75	194	332	
8	11:03	783.79	.31	.55	.32	.27	72	76	4.0	187	76	201	334	
C - 1	11:11/17	784.90	.08	.28	.08	.08	74	76	3.0	144	77	108	320	
2	:23	786.38	.16	.40	.16	.13	74	76	4.0	132	78	116	322	
3	:29	787.94	.18	.42	.18	.15	73	75	4.0	148	76	122	334	
4	:35	789.75	.23	.48	.24	.20	74	76	4.5	224	77	206	335	
5	:41	791.60	.25	.50	.25	.21	72	74	4.5	270	78	212	339	
6	:47	793.49	.27	.52	.28	.21	73	75	4.5	228	76	203	333	
7	:53	795.39	.28	.53	.28	.21	72	75	4.5	206	77	211	333	
8	:59	797.41	.27	.52	.28	.24	72	75	4.8	198	78	246	332	
TOTAL				11.75		5.12	1730	1788					7927	
AVERAGE				.49		.21	72	74					330	

STATIC PRESSURE = − 0.60" H_2O

CORRECTED SAMPLE VOLUME = 44.46 Ft.³ (533) Meter Volume X 1.021 (790) Dry Meter Calibration Factor = 45.39 Ft.³

RUN NO. 20

PARTICULATE & WATER CATCH

STACK

IMPINGER NO. 77	Final Weight 944.72 Initial Weight 545.78 Increase	WATER WEIGHT GAIN	IMPINGER 1 398.94
			IMPINGER 2 28.65
IMPINGER NO. 78	Final Weight 607.86 Initial Weight Increase 579.21		IMPINGER 3 5.11
			IMPINGER 4 30.60
IMPINGER NO. 79	Final Weight 450.52 Initial Weight Increase 445.41		TOTAL 463.30
			ORSAT
IMPINGER NO. 80	Final Weight 835.73 Initial Weight Increase 805.13		CO_2 25.0
			O_2 7.0
FILTER NO. # 10	Final Weight 1.0003 Initial Weight Part. Catch .8589 .1434		CO 0.05
			N_2 68.0

SOLID WEIGHT GAIN

MP. BEAKER NO. 6	Final Weight 117.0320 Initial Weight 116.9967 Increase .0353	143.4 27.4 170.8	BEAKER 1
			BEAKER 2
MP. BEAKER NO. 7	Final Weight 117.5420 Initial Weight 117.5058 Increase .0362	35.3 36.2 247.3	BEAKER 3
			BEAKER 4
			TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
BEAKER NO. 27 PROBE WASH	Final Weight 120.5236 Initial Weight 120.4962 Increase .0274		

Moisture Content: Sample Vol. 45.39 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (533) X 28.3 L/ft.^{3} = 1277 L Dry Gas

Water Weight $\frac{463.3 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 620 L H_2O Vapor

Total = 1897 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{620 \text{ L}}{1897 \text{ L}}$ x 100 = 32 %

(BOB)

PARTICULATE FIELD DATA

Run No. 21
Location STACK
Date 6/20/77
Operator DVV

Amb. Temp. °F 86°F(DB) 73°F(WB)
Bar. Press. "Hg. 29.26" Hg
Assumed Moist 30%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In 1/4"
Probe Length 4'
Inp. Nos. 81 → 84
Sample Box No. PART
F = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE
START OF EACH TEST
POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	10:58	805.84	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	11:04	807.56	.11	.33	.12	.17	67	68	0.5	127	65	129	300	
2	:10	809.10	.22	.47	.23	.14	68	70	0.5	181	68	142	316	
3	:16	811.08	.28	.53	.28	.24	68	70	0.5	150	69	137	316	
4	:22	813.34	.31	.55	.32	.30	68	70	0.5	188	69	163	313	
5	:28	815.55	.33	.57	.33	.30	68	71	0.5	197	66	130	314	
6	:34	817.86	.35	.59	.37	.32	69	72	0.5	178	67	240	316	
7	:40	820.24	.33	.57	.33	.33	69	72	1.0	203	69	250	316	
8	:46	822.61	.33	.57	.33	.34	69	73	1.0	219	68	258	317	
B - 1	12:03/09	824.28	.14	.37	.14	.17	70	72	0.5	159	69	172	300	
2	:15	826.25	.25	.50	.25	.24	70	72	0.5	215	71	126	305	
3	:21	828.44	.31	.55	.32	.28	71	73	0.5	248	72	116	314	
4	:27	830.70	.33	.57	.33	.30	71	73	0.5	147	76	114	312	
5	:33	832.91	.38	.61	.39	.30	72	74	0.5	183	76	127	311	
6	:39	835.40	.40	.63	.41	.37	73	76	1.0	194	77	181	313	
7	:45	837.67	.33	.57	.33	.32	73	76	0.5	146	76	246	312	
8	:51	839.92	.38	.61	.39	.30	74	78	0.5	157	77	258	313	
C - 1	13:05/11	841.45	.15	.39	.16	.14	74	75	0.5	101	75	199	291	
2	:17	843.04	.25	.50	.25	.15	73	74	0.5	93	70	137	305	
3	:23	845.31	.31	.55	.32	.32	74	75	0.5	96	74	114	310	
4	:29	847.67	.35	.59	.37	.33	75	76	0.5	104	78	116	313	
5	:35	850.01	.38	.61	.39	.34	74	76	0.5	115	78	137	311	
6	:41	852.37	.40	.63	.41	.34	73	76	0.5	117	77	238	310	
7	:47	854.71	.40	.63	.41	.34	72	75	0.5	118	78	243	310	
8	:53	857.14	.35	.59	.37	.35	73	77	0.5	117	80	250	312	
TOTAL				13.08		6.73	1708	1764					7450	
AVERAGE				0.54		0.28	71	73					310	

STATIC PRESSURE = − 0.56" H_2O CORRECTED SAMPLE VOLUME = (532) Meter Volume Ft.³ X (770) Dry Meter Calibration Factor = 52.38 Ft.³

Part.

RUN NO. 21

PARTICULATE & WATER CATCH

IMPINGER NO. 81	Final Weight 840.59 Initial Weight 548.64 Increase	WATER WEIGHT GAIN	IMPINGER 1 291.95
			IMPINGER 2 108.08
IMPINGER NO. 82	Final Weight 654.48 Initial Weight Increase 546.40		IMPINGER 3 2.41
			IMPINGER 4 16.52
IMPINGER NO. 83	Final Weight 450.47 Initial Weight Increase 448.06		TOTAL 419.00
			ORSAT
IMPINGER NO. 84	Final Weight 807.31 Initial Weight Increase 790.75		CO_2 26.5
			O_2 6.4
FILTER NO. 12	Final Weight 8564 Initial Weight Part. Catch 8534 .0030		CO 0.03
			N_2 67.1

SOLID WEIGHT GAIN

BEAKER NO. 25	Final Weight 148.6984 Initial Weight Increase 148.6300 .0684	.0030 1401 .1431	BEAKER 1
			BEAKER 2
BEAKER NO.	Final Weight Initial Weight Increase	68.4 211.5	BEAKER 3
			BEAKER 4
			TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
BEAKER NO. 28 PROBE WASH	Final Weight 140.8954 Initial Weight 140.8723 Increase .1401		

Moisture Content: Sample Vol 52.38 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530 / 532) X 28.3 L/ft.^{3} = 1477 L Dry Gas

Water Weight $\frac{419 \text{ gm.}}{18 \text{ gm. mol.}}$ x 24.1 $\frac{L}{mol.}$ = 561 L H_2O Vapor

Total = 2037 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{561 \text{ L}}{2038 \text{ L}}$ x 100 = 27.5 %

(Bo8)

PARTICULATE FIELD DATA

Run No. 23
Location STACK
Date 6/21/77
Operator DVV

Amb. Temp. °F 68°F(DB) 62°F(WB)
Bar. Press. "Hg. 29.44" Hg
Assumed Moist 30%
Test Periods 144 MIN
24 PTS @ 6MIN EACH

Probe Tip Dia., In 1/4"
Probe Length 4'
Inp. Nos. 89 → 92
Sample Box No. PART
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:36	857.44	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:42	858.94	.14	.37	.15	.14	66	67	2.0	85	59	209	297	
2	:48	860.74	.22	.47	.23	.20	67	68	2.5	163	60	132	304	
3	:54	862.69	.26	.51	.27	.23	66	68	3.0	206	60	130	316	
4	10:00	864.78	.32	.56	.33	.27	66	69	3.5	231	60	131	318	
5	:06	866.88	.33	.57	.33	.27	66	70	3.5	169	63	112	316	
6	:12	869.07	.35	.59	.37	.28	67	71	4.0	227	63	165	318	
7	:18	871.25	.36	.60	.37	.28	67	72	4.0	206	64	241	318	
8	:24	873.44	.35	.59	.37	.29	67	72	4.5	237	66	249	317	
B - 1	10:40/46	874.99	.18	.42	.18	.15	67	69	2.5	158	66	180	298	
2	:52	876.88	.26	.51	.27	.21	68	71	3.0	163	66	132	312	
3	:58	879.09	.30	.55	.32	.30	69	71	3.5	211	66	142	321	
4	11:04	881.20	.35	.59	.37	.27	69	72	3.5	235	68	149	323	
5	:10	883.25	.38	.61	.39	.25	70	73	3.5	204	78	134	321	
6	:16	885.48	.38	.61	.39	.30	70	73	4.0	229	80	187	323	
7	:22	887.71	.35	.59	.37	.30	70	74	4.0	179	72	316	323	
8	:28	889.94	.38	.61	.39	.30	70	74	4.0	217	70	322	324	
C - 1	11:42/48	891.46	.13	.36	.14	.13	68	70	2.5	189	64	187	300	
2	11:54	893.24	.23	.48	.24	.19	69	71	3.0	162	61	112	309	
3	12:00	895.35	.30	.55	.32	.27	69	71	3.5	121	64	131	322	
4	:06	897.57	.35	.59	.37	.30	69	71	4.0	155	64	132	322	
5	:12	899.78	.38	.61	.39	.30	70	72	4.0	208	66	135	323	
6	:18	902.03	.38	.61	.39	.31	70	73	4.5	248	64	177	324	
7	:24	904.26	.38	.61	.39	.30	70	74	4.5	264	89	247	321	
8	:30	906.49	.35	.59	.37	.30	71	74	4.5	238	81	246	323	
TOTAL				13.15		6.14	1641	1710					7593	
AVERAGE				0.55		0.25	68	71					316	

(529) (776)

STATIC PRESSURE = − 0.64" H_2O CORRECTED SAMPLE VOLUME = 49.05 Ft.³ (Meter Volume) X 1.021 (Dry Meter Calibration Factor) = 50.08 Ft.³

PART

RUN NO. 23

PARTICULATE & WATER CATCH

IMPINGER NO. 89	Final Weight 926.53 Initial Weight 568.44 Increase	WATER WEIGHT GAIN	IMPINGER 1 358.09
			IMPINGER 2 57.56
IMPINGER NO. 90	Final Weight 590.65 Initial Weight 533.09 Increase		IMPINGER 3 11.26
			IMPINGER 4 28.67
IMPINGER NO. 91	Final Weight 471.11 Initial Weight 459.85 Increase		TOTAL 455.58 + ~~31.34~~ ORSAT 486.92
IMPINGER NO. 92	Final Weight 843.22 Initial Weight 814.55 Increase		CO_2 27.0
			O_2 5.0
FILTER NO. 13	Final Weight 9064 Initial Weight .8478 Part. Catch .0586		CO —
			N_2 68.0

SOLID WEIGHT GAIN

BEAKER NO. ~~Orp~~ 16	Final Weight 154.2288 Initial Weight 154.1422 Increase .0866	.0586 .0459 .1045	BEAKER 1
			BEAKER 2
BEAKER NO. ~~Orp~~ 16A	Final Weight 142.2589 Initial Weight 142.2305 Increase .1150	115 .2195	BEAKER 3
			BEAKER 4
			TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
BEAKER NO. ~~Probe~~ 29 PROBE WASH	Final Weight 141.9202 Initial Weight 141.8743 Increase .0459		

Moisture Content: Sample Vol. 50.08 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) / (529) X 28.3 L/ft.^{3} = 1420 L Dry Gas

Water Weight ~~455.6~~ 486.9 gm. / 18 gm./mol. x 24.1 L/mol. = ~~610~~ 652 L H_2O Vapor

Total = ~~2030~~ 2072 L

H_2O Vol. / Total ~~610~~ 652 L / ~~2030~~ 2072 L x 100 = 31.4%

(Dob)

PARTICULATE FIELD DATA

Run No. 25
Location STACK
Date 6/22/77
Operator DVV

Amb. Temp. °F 67°F (DB & WB)
Bar. Press. "Hg. 29.35" Hg
Assumed Moist 30%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In 1/4"
Probe Length 4'
Inp. Nos. 97 → 100
Sample Box No. PART
γ = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:17	906.78	ΔP	$\sqrt{\Delta P}$	Desired	Actual	Inlet	Outlet						
A - 1	:23	908.22	.15	.39	.16	.13	70	71	1.0	151	57	256	302	
2	:29	910.01	.25	.50	.25	.20	70	72	1.0	154	53	197	306	
3	:35	912.17	.33	.57	.33	.28	69	71	2.0	215	51	160	308	
4	:41	914.49	.35	.59	.37	.32	69	71	2.5	220	51	147	308	
5	:47	916.86	.38	.61	.39	.34	69	72	2.5	292	51	145	307	
6	:53	919.17	.38	.61	.39	.33	68	72	2.5	274	52	162	308	
7	:59	921.55	.40	.63	.41	.34	69	73	3.0	151	53	214	315	
8	10:05	923.93	.38	.61	.39	.34	69	73	3.0	144	56	218	314	
B - 1	10:20/26	925.40	.16	.40	.16	.13	69	71	1.0	100	48	97	307	
2	:32	927.31	.25	.50	.25	.23	69	71	2.0	155	51	99	307	
3	:38	929.46	.31	.55	.32	.29	70	72	2.0	173	50	101	312	
4	:44	931.79	.35	.59	.37	.33	70	72	2.5	163	48	92	310	
5	:50	934.20	.40	.63	.41	.35	70	73	2.5	161	48	103	311	
6	:56	936.62	.38	.61	.39	.35	70	73	2.5	178	54	147	307	
7	11:02	939.02	.38	.61	.39	.35	70	73	2.5	205	47	211	308	
8	:08	941.26	.38	.61	.39	.30	70	74	5.5	164	47	214	309	
C - 1	11:35/41	942.73	.11	.33	.12	.13	70	71	5.0	160	50	116	299	
2	:47	944.75	.22	.47	.23	.24	70	71	2.0	158	47	123	303	
3	:53	946.65	.28	.47	.28	.22	70	71	2.0	161	47	116	308	
4	:59	948.74	.32	.56	.32	.27	70	72	2.5	168	49	117	305	
5	12:05	950.98	.32	.56	.32	.30	70	72	2.5	149	50	123	306	
6	:11	953.19	.35	.59	.37	.30	70	72	2.5	119	51	161	305	
7	:17	955.38	.36	.60	.37	.30	70	72	2.5	229	52	281	306	
8	:23	957.68	.38	.61	.39	.27	70	73	2.5	233	53	215	306	
TOTAL				13.20		6.64	1671	1728					7374	
AVERAGE				0.55		0.28	69	72					307	

STATIC PRESSURE = −0.58" H_2O

CORRECTED SAMPLE VOLUME = 50.70 (531) Ft.^{3} X 1.021 (767) = 51.76 Ft.^{3}

Meter Volume — Dry Meter Calibration Factor

PART

RUN NO. 25

PARTICULATE & WATER CATCH

IMPINGER NO. 97	Final Weight 855.75 Initial Weight 542.85 Increase	
IMPINGER NO. 98	Final Weight 629.27 Initial Weight 564.99 Increase	
IMPINGER NO. 99	Final Weight 476.85 Initial Weight 467.78 Increase	
IMPINGER NO. 100	Final Weight 835.33 Initial Weight 812.38 Increase	
FILTER NO. 14	Final Weight .9448 Initial Weight Part. Catch .8367 .1081	

WATER WEIGHT GAIN

IMPINGER 1	312.9
IMPINGER 2	64.3
IMPINGER 3	9.1
IMPINGER 4	23.0
TOTAL	409.3

ORSAT

CO_2	26.0
O_2	6.2
CO	—
N_2	67.8

SOLID WEIGHT GAIN

BEAKER NO. 14	Final Weight 141.6369 Initial Weight 141.3327 Increase .5823	.1081 .0299 .138.0	BEAKER 1
BEAKER NO. 27	Final Weight 130.6658 Initial Weight 130.4958 Increase .2781	.2781 .4161	BEAKER 2 BEAKER 3 BEAKER 4 TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
BEAKER NO. C PROBE WASH	Final Weight 117.0240 Initial Weight 116.9950 Increase .0299		

Moisture Content: Sample Vol. 51.76 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (531) X 28.3 L/ft.^{3} = 1462 L Dry Gas

Water Weight $\frac{493 \text{ gm.}}{18 \text{ gm./mol.}}$ x 24.1 $\frac{L}{mol.}$ = 548 L H_2O Vapor

Total = 2010 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{548 \text{ L}}{2010 \text{ L}}$ x 100 = 27.2 %

Interoffice Memo

LONE STAR INDUSTRIES, INC.

P. O. Box 2148, Houston, Texas 77001

Originating Office: Central Research Laboratory

Date: April 15, 1977

PERSONAL & BUSINESS CONFIDENTIAL

TO: ~~C. D. Coppinger~~

FROM: W. W. Hurst

SUBJECT: Emission Testing at Greencastle - 1977 Scope of Work

CC: C. D. Fehnel
S. S. Fritts
C. W. Moore
C. A. Buckelew
G. Thomas

Your request for work activity in the field of Emission Testing in herein acknowledged and the following program is offered for your consideration and approval.

1. Testing objective is to furnish Greencastle group, as well as, the Corporate group, source emission data generated by procedures, testing equipment, and methods acceptable to the Indiana Air Pollution Emission Control Authority.

2. Plans are to leave Houston Monday, May 2, so as to start testing later in the week (probably on Friday, May 6). We will consider this period for starting firm unless we hear from you or you hear from us that rescheduling is necessary. This time of the year, we should not experience abnormal delays due to weather problems.

3. At the stack, we plan to conduct three individual tests for both sulfur and particulate emissions with test occurring at different periods and so that the test for sulfur and for particulates will occur simultaneously. During the particulate and SOX runs by EPA Methods, we will monitor stack for SOX and NOX with our Environmetric equipment. A comparison with your Envirometric results and EPA results can be developed.

4. A precipitator efficiency evaluation will be made by simultaneously testing the precipitator input and stack for particulate emissions. We recommend this test be conducted at the normal and also excessive insufflation rates of kiln dust. Each kiln operating mode will be tested three (3) times per usual.

5. Hi-Vol test will be conducted at property lines as required and in accordance with data previously collected at property lines.

6. Additional tests over and above as outlined in (3-5) will not be made unless preliminary findings indicate erroneous final results or specific requests are made by management.

7. Testing time will consume a minimum of 17 - eight hour - shifts. To set-up, move to new location and gather equipment will require an additional 7 shifts. In the event we have breakdowns or breakdowns occur effecting the operation, more time will be required. We can count on some inclement weather causing lost time.

We plan to work one shift per day on a 2 week cycle so as to work 8 days, travel 2 and off 4. This plan necessarily means we work every other weekend which we trust will not create undue hardship from a scheduling point of view. The tour will likely consume the better part of a month and a half overall. Reporting will be within a week after we receive all results of supporting data.

8. We will need the full time help of 2 plant people. They do not need to be technical people but willing to learn and physically apt.

9. If there have been no modifications since our last tour, test ports exist with required support outriggers to handle gear. We do not need power accessible to test ports since we work via an umbilical cord connected to the Mobile Laboratory. However, we do need a source of 440 volts A.C. within 100' of Mobile Lab, as it would logically be located with respect to testing locations, so as to power our whole system. The power facility should be readily available barring system modification since our last visit.

10. As back-up data and to extend our understanding of product sulfurization and particulate abatement, we plan to collect samples for analysis and gather rate data concurrently with testing.

(a) Generally, we will need individual 2 hr. samples of coal fuel, raw mix kiln feed, clinker and discarded kiln dust along with rate data of these parameters. As in the past, we will have coal analyzed by an outside laboratory. Our testing program will provide similar information on kiln exit gases.

(b) We would like to start sampling at the time we begin testing and continue until we complete our test.

(c) Needless to say, we need the best possible rate data. Therefore, if any preliminary adjustment can be made to improve the accuracy of measuring quantities of materials involved, we should make these adjustments before starting the test. We especially need a good handle on the quantity of kiln dust discarded from system under test.

(d) Chemically, we will need a sulfur determination on each day's composites of clinker, raw mix, and dust - along with alkali. A complete analysis on each weekly composite of clinker, raw mix, and dust should suffice. A single composite of coal will be sufficient for "ultimate analysis" (Carbon, Hydrogen, Oxygen, and Sulfur).

All individual samples should be clearly marked with date and time and saved for possible re-check if final results indicate discrepancy.

(e) Rate data should be recorded on a 2 hr. basis unless the data is recorded on a chart that can be transcribed at the end of test period.

(f) Manpower needed to sample and record usage rates will be over and above the people needed for assisting with the emission gas testing.

If there are any questions and/or modifications to the program that are considered advisable and/or necessary, all concerned are asked to contact me so that we can finalize the program.

Bill

WWH/po

Interoffice Memo

LONE STAR INDUSTRIES, INC.

One Greenwich Plaza, Greenwich, Connecticut 06830

Originating Office: Greencastle Plant

Date: April 18, 1977

File: G - 8 - Q

TO: W. W. Hurst

FROM: C. D. Coppinger

SUBJECT: Emission Testing at Greencastle - 1977 Scope of Work

cc: C. D. Fehnel
S. S. Fritts
C. W. Moore
C. A. Buckelew
G. W. Thomas

In reply to your April 15th memo on the above subject, we wish to advise that the program offered looks fine to us, and we look forward to seeing you at the plant around May 6th.

Doug

CDC:dnb

G. F. Messinger

Interoffice Memo

LONE STAR INDUSTRIES, INC.

One Greenwich Plaza, Greenwich, Connecticut 06830

Originating Office: Greencastle Plant

Date: May 27, 1977 5/31

File: G - 8 - Q

PERSONAL &
BUSINESS CONFIDENTIAL

TO: C. D. Coppinger

FROM: W. W. Hurst

SUBJECT: Emission Testing at Greencastle - 1977 Scope of Work, Revision 1

cc: C. D. Fehnel
S. S. Fritts
C. W. Moore
C. A. Buckelew
G. W. Thomas

You will recall that we discussed the advisability of monitoring the stack for possible variations in both sulfur and particulate emissions, during your planned test program, using waste oil as a partial supplement for coal.

No substantial variation is anticipated; however, since we are on location and readily available for this work, it seemed the proposed monitoring would be in order as a precautionary measure.

Therefore, in addition to the approved work outlined in my letter of April 15, we will conduct three (3) tests on successive days, simultaneously measuring sulfur and particulate emissions, unless an objection to this plan is forthcoming from the Corporate Group.

All other work previously outlined will proceed according to plan.

Bill
dnb

WWH:dnb

Interoffice Memo

LONE STAR INDUSTRIES, INC.

Originating Office: C&CM Group - Technical

Date: August 9, 1977

TO: C. D. Coppinger

FROM: G. F. Messinger

SUBJECT: Sulfur and Particulate Stack Emissions Testing
Greencastle Plant

Enclosed is one (1) copy of each of Bill Hurst's reports on the Sulfur Dioxide Emission Test and the Particulate Emission Test conducted at the Greencastle Plant May 8 through June 22, 1977.

The particulate tests look very good from the standpoint of the Indiana code, which is an extremely lenient code. Compared to Federal E.P.A. codes, the results are borderline. I have attached a tabulation comparing the average results of runs 1, 3, and 5 and of runs 21, 23, and 25 against the respective codes. On an individual run basis, test runs 3, (13 - 14), (19 - 20), 21 and 25 actually exceed the E.P.A. codes.

We would suggest that the reports be treated as internal unless specifically requested by jurisdictional authorities and in this event, we would appreciate the opportunity to review the request before submission.

Please assign CTR numbers to the reports and advise for our file references.

G. F. Messinger

GFM/jml

cc: W. R. Payne, Jr.
C. D. Fehnel/M. M. Reid
C. W. Moore
W. W. Hurst

PARTICULATE EMISSION TESTS

GREENCASTLE PLANT

MAY - JUNE 1977

ITEM	PARTICULATES RUN NUMBERS 1-3-5	21-23-25
Feed Rate T/Hr.	135	138
Fuel Rate T/Hr.	18	19
Process Wt. (E.P.A.) T/Hr.	153	157
Slurry Water T/Hr.	65.3	68.6
Process Wt. (Ind.)	218.3	225.6
Allowable Emission Lbs/Hr.		
1. E.P.A. (Suggested Existing Sources)	38.7	38.8
2. E.P.A. (New Source Perf. Std.)	40.5	41.4
3. Indiana	221.6	225.3
Actual Measured Emission Lbs/Hr.	28.7	38.4

1. $E = 17.31\ P^{(0.16)}$
   P = Process Weight $>$ 30 T/Hr.

2. E = 0.3 lbs./Hr. for each T/Hr. Kiln Feed (dry).

3. $E = 15.0\ P^{(0.5)}$

Interoffice Memo

LONE STAR INDUSTRIES, INC.

One Greenwich Plaza, Greenwich, Connecticut 06830

Originating Office: Greencastle Plant

Date: August 12, 1977

File: G - 8 - Q

TO: G. F. Messinger

FROM: E. S. Anderson

SUBJECT: Sulfur & Particulate Stack Emissions Testing - Greencastle Plant

cc: C. D. Fehnel/M. M. Reid - No Enc.
C. W. Moore - "
W. W. Hurst - "
W. R. Payne, Jr. - "
C. D. Coppinger - "

Per the request included in your memo of August 9, 1977 to C. D. Coppinger, on the above subject, we have attached herewith two (2) copies of our "CTR" page, showing numbers and titles assigned the respective reports.

Also, since we had previously received and CTR'd copies of Bill Hurst's Particulate Emissions Report, we are returning the one (1) copy you sent, for whatever use you may have.

ESA:dnb
Enc.

LONE STAR CEMENT

DWG.NO	SUBJECT	MFRS.DWG	PUR.ORDER	C.
CTR-C-3010	Greencastle Presentation (Feb. 1966) Evaluation of 4 mm. Bbl. Cement Plant	Book		801
5912	New Plant - Soil Boring Report (Holes #1/18)	None		
5913	" - #5 Silo Group - Soil Boring Report (Holes #19/26)	G-R-800-L		
6223	Kiln Dept. - Stack Emission Study (Nov. 1973)	Report		
6263	" - " (Nov. 1975)	"		
6264	" - Ambient Air Sampling Survey (Dec. 1975)	"		
6301	" - Stack Emission Study (June 1977)	"		
6302	Plant Property - Layout of Water Lines for Fire			
6309	Kiln Dept. - Sulfur Dioxide Emissions Study (June 1977)	"		

Interoffice Memo

LONE STAR INDUSTRIES, INC.

Originating Office: C & CM

Date: July 11, 1977

TO: Mike Reid

FROM: Stewart S. Fritts

SUBJECT: Greencastle Plant - Particulate and Sulphur Study
W. W. Hurst Report

A preliminary review of the two reports submitted by Bill Hurst per his transmittal of July 7, 1977 to C. D. Fehnel raises some pertinent questions as follows:

1. Fuel Analysis by Pittsburg Testing Laboratory shows BTU value on an "As Received " basis - which is fine. However, I would have expected the Ash and the Moisture Content of the Sample would have been determined separately and likewise reported. I took the liberty of contacting PPL and found that they had run the Moisture and the Ash but failed to record it on the lab sheet. The values are 4.55 and 12.84 respectively. It would have appeared to me that Bill should not have accepted the PPL report without making the inquiry. All that it took was a telephone call to the Pittsburg Labs. I have inserted the proper values in the PPL Report.

2. Fuel Consumption Calculation - Molal Basis pg 13 shows the Coal Mill Feed on an "As Used" basis for each of the three sets of runs. These appear to be correctly identified. However, on pg 10 he shows the analysis for the three sets of runs on an "As Fed" amd on an "As Used" basis and then proceeds to make his calculations and material balances using the "As Fed" base. On pg 15 he attempts to differentiate between Free Water in Coal "As Used" and Free Water in Coal "As Fed" but I fail to appreciate this approach because all of the water that enters the kiln from the coal comes from the coal feeder and this would represent the total water in the coal and not just the "Free Water". This moisture varies from 11.20 % to 12.50 % while the "As Fed" moisture which is really the water in the pulverized coal as it enters the kiln burner pipe at the hood (and after it has been partially dried) varies from 5.16 % to 6.09 %. On pg . 14 he reports Distribution of Combustion and Products on the basis of "As Received", however, I believe we means the word "As Used" since he takes the analysis from pg. 13. Perhaps his calculations are entirely valid but it would seem to me he is attempting to mix "Apples and Oranges" and coming up with "Sour Grapes" and I do not believe he intends to do that. We have been through this exercise before and I thought we had it all straightened out. Apparently not.

On the other hand I could hardlyaccept a Water Material balance of 78.72 % for Runs 1-5 and 82.78 % for Runs 21-25 as being realistically close ; but 97.58 % for Runs 7-20 is excellent.

3. Summary Schematic Gas Balances pgs. 34, 35 and 36 are fine presentations but they could be developed more realistically as shown per the attached fpr pg. 34- Raw Mix should not be tied into Infiltrated Air but should be shown as an independent addition to the kiln. The attached schematic would appear to be a great deal more realistic. You will note I have circled the values that require correction to coincide with the values outlined in the work sheets pgs. 15 thru 21.

4. In his discussion, Bill appears to be rather optimistic concerning the test results in relation to the Allowable per the Indiana Regulations. While his calculations are in line I would seriously question resting on our laurels in so far as EPA is concerned. As you know EPA limits emissions from the kiln at 0.3 lbs per hour per Ton of Kiln Feed per hour with Fuel excluded as a part of the kiln feed. This means the allowable would be 40.5 lbs/hr. for Runs 1 - 5; 37.8 lbs/hr for Runs 7 - 20 and 41.4 lbs/hr. for Runs 21-25. On the basis of the results reported we do not have much margin for error. In fact Test Runs 3, (13-14),(17-18), (19-20), 21 and 25 show emission values that are in excess of the Allowable EPA Regulations.

   To date EPA has not raised the issue concerning Cement Plant Regulations in the State of Indiana mainly because the cement manufacturers have recognized their obligation and took positive steps to come to grips with the situation. However, the present Indiana Regulation is so grossly out of line I feel confident in a show down we would have very little room for bargaining power. Therefore I do not believe we should flaunt our position at Greencastle. Reporting the facts is fine but making comparisons on the basis of unrealistic Allowables is another matter.

5. In reviewing the Sulphur Study, I note Bill refers to high (1450° F and 1600° F "back-end ")temperatures. I am not too sure what is meant by "back-end" conditions, If he means the temperature of the load just below the chain system then his reading is porbably correct - but he should have identified the position of the reading in the kiln system.

6. Bill's evaluation of the SOX versus NOX relation may require further study. As I see it. NOX development is basically a function of flame temperature and as such is limited to theavailable O_2 within the combustion zone of the kiln and the amount of excess air within the combustion space will have a significant influence on the development of NOX. Similarly the sulphur in the fuel and more especially the mineralized sulphur (Iron pyrites) will influence the avilability of the O_2 to form NOX after the SOX in the combustion zone has been satisfied. In all probability organic sulphur in the fuel will readily combine with O_2 to form SO_2 and perhaps some SO_3 if there is any catalysis present - which there is in the form of water vapor as well as minor trace elements in the fuel. In the case of sulphur in the raw kiln feed we have an entirely different relationship - especially in the long wet kiln. I am not too sure we have very much conversion of sulphur to SO_2 from sulphur in the raw mix especially if the sulphur is present as iron pyrites in which case the conversion from FeS_2 passes through the H_2S phase in combination with heat and water vapor as well as residual O_2 - if any is available - and it is highly questionable whether enough would be available to sustain an oxidizing atmosphere for the conversion of the sulphur in FeS_2 to SO_2. As you know the Orsat analysis is at best a very crude approximation of the actual gaseous condition in a Portland Cement kiln ex-

haust. It does serve a limited purpose, but - under today's enlightenment and the need for better energy conservation coupled with a refinement of the combustion process - we will require more sophisticated analytical equipment to properly delineate the factors that enter the calculations.

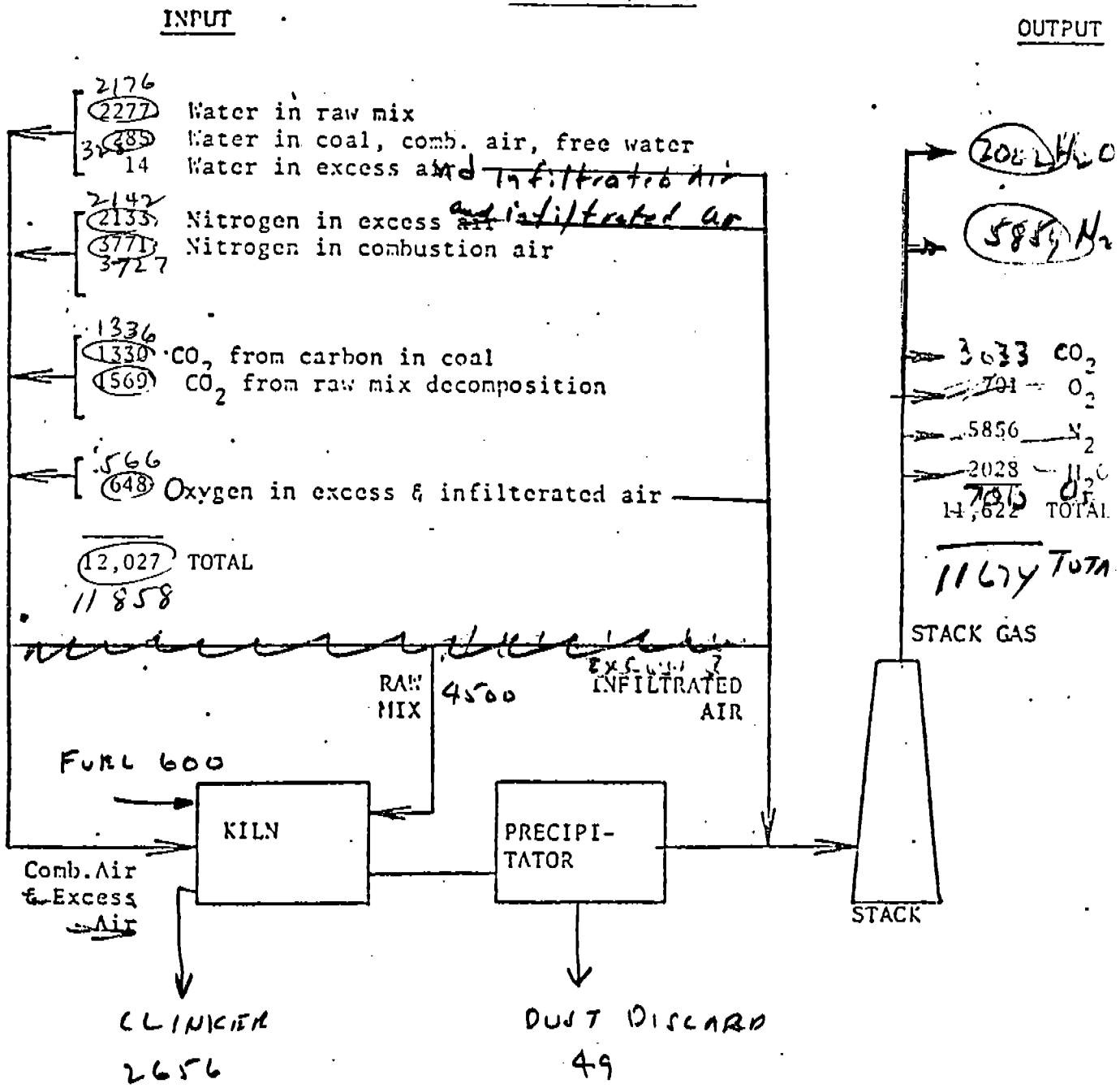
As an example, we consider the N_2 content of the exhaust gas as the difference between the CO_2 absorption by KOH solution plus the O_2 absorption by pyrogallic acid solution plus the CO absorption by the cupperous oxide solution - but we are never sure that these absorbed products are definite and singular. With the advent of the NOX and SOX syndrom our confidence level in the actual chemistry of the kiln exhaust gas is even more disturbing. We could be on the threshold of a major research program that may or may not be warranted on our part. Perhaps the PCA could get involved.

7. Bill's data relating to Orsat analysis is probably taken at the stack - although Table XI pg 12 of the sulphur report does not specifically so state . However, on pg 19 of the same report he refers to "V. Actual Kiln Exit Gas at Sampling Ports" but since the Sampling Ports are in the Stack then the Orsat Analysis should refer to Stack Sampling and not Kiln Exit Gas since the Stack Sampling is influenced by infiltration and Bill notes the infiltration in his calculations. On the other hand the amount of Excess Air shown at 34.8 percent on pg. 20 is hardly represenative because he is comparing Theoretical Moles from Combustion with Orsat analysis of the Stack Gases. Perhaps, I am not understanding his reasoning but on the face of it a 7.3 % O_2 represents a great deal more than 34.8 % Excess Air; and a rough calculation would indicate the value closer to 80 %.

Ken

RUNS 1 - 5

SUMMARY SCHEMATIC
GAS BALANCE
UNITS: Lb/Min.



3. Exit Gas Flow

$$CO_2 = \frac{18.52}{(1 - .411)}$$

$$N_2 = \frac{38.35}{(1 - .411)}$$

4. Theoretical Exit
At Std Cond. [illegible]

Volume = (338.35)(33[illegible] = [illegible] (Wet)

OR (130,903)(1 - .4[illegible] [illegible] (Dry)

V. 4 (O_2 Balance)
Actual Kiln Exit Gas = [illegible] [illegible] (Dry)

Excess Air = 118,4[illegible] [illegible] (Dry)

3 CO_2 Balance
Actual Kiln Exit Gas = 3,882
[illegible] (Dry)

Excess = (110,882 - 72[illegible]

5 Avg Excess Air = 4[illegible]

= 37,[illegible]

V-6 Kiln Excess Air [illegible]

$$O_2 = \frac{(37,453)(.2132)}{387} = 659.35 \text{ [illegible]}$$

$$N_2 = \frac{(37,453)(.7448)}{387} = 2,421.72$$

$$H_2O = \frac{(37,453)(.0420)}{387} = 14.28$$

$$\text{or } \frac{(14.28)(387)}{18} = 307 \text{ SCFM}$$

V-7 Actual Kiln Exit Gas Volume

(a) Theoretical Kiln Exit Gas (V-4) = 130,903 SCFM (w)
(b) Excess Air (V-5 and V-6) = 37,953 + 307
= 37,760 SCFM (w)

(c) Actual Kiln Exit Gas (a)+(b) = 168,663 SCFM (w)

$$\text{(1) Stack Gas} = \frac{(168663)(792)(29.92)}{(530)(29.39)}$$

= 256,585 ACFM (w)

II 3. Production of Water
(Basis of Total Water)

a) Combustion Water - 230.66 Flue
b) Free Water Combusted - 72.21
c) Combustion Air Water - [illegible]

Total 327.66

IV Theoretical Kiln Exit Gas (Portion of Water)

		H_2O (lb)
1.	a) Combustion Process	327.66
	b) Raw Mix Liberation	2176.56
		2504.22

2. Exit Gas Analysis - Wet Basis

CO_2 Mol 66.02

H_2O Mol $\frac{2504.22}{18}$ = 139.12

N_2 Mol 133.11

Total = 338.25

Hence:

$CO_2 = \frac{66.02}{338.25} = 19.52\ \%$

$H_2O = \frac{139.12}{338.25} = 41.13\ \%$

$N_2 = \frac{133.11}{338.25} = 39.35\ \%$

VII

4 [illegible]

[illegible] = [illegible]

[illegible]

VII

4 H_2O

H_2O [illegible] = [illegible]

[illegible]

[illegible]

ENVIRONMENTAL DEPT. COPY

LONE STAR INDUSTRIES, INC.

Cement & Construction Materials Group

CENTRAL RESEARCH LABORATORY

P. O. BOX 2148

HOUSTON, TEXAS 77001

CTR-G-630D

SULFUR DIOXIDE EMISSIONS TESTING

GREENCASTLE PLANT

MAY 8 - JUNE 22, 1977

Interoffice Me

LONE STAR INDUSTRIES, INC.

P. O. Box 2148, Houston, Texas 77001

Originating Office: Central Research Laboratory

Date: July 1, 1977

PERSONAL & BUSINESS CONFIDENTIAL

TO: D. C. Coppinger

FROM: W. W. Hurst

SUBJECT: Stack Sulfur Emissions at Greencastle Plant

CC: S. S. Fritts
C. D. Fehnel
C. W. Moore

Stack sulfur emission gases were tested on selected days between May 8 and June 22. Sulfur level testing included 6 runs on stack at 2 different production modes. Testing was conducted in accordance with EPA Method 8 for sulfur evaluation for stationary sources as given in Fed. Register, Vol. 35, No. 247 dated December 23, 1971 and amended June 8, 1976.

Objectives were:

(1) Determine concentration of stack sulfur emissions.

(2) Evaluate results of EPA Method 8 with Environmetric results.

Results showed:

(1) Stack total sulfur emission averated 638 lbs/hr. as SO_2; whereas, the allowable limit by the "Process Weight" formula is 728 lbs/hr. as SO_2 or 966 lbs/hr. SO_2 by the "Heat Input" formula. (See Table III)

(2) At low sulfur concentrations agreement between the Environmetric vs. EPA Method 8 was poor. At higher concentrations, agreement was reasonably good.

Respectfully submitted,

W. W. Hurst, P.E.

WWH/po

Encl.

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Table I shows the rate at which Sulfur Dioxide is emitted from the stack for every run (p.1).

Table II shows the process rates during testing period (p.2).

Table III calculates the allowable limit for Sulfur Dioxide emissions, according to Indiana Air Pollution Control Board. (p.3).

Table IV and V records Sulfur emissions that existed as Sulfur Dioxide and as Acid Mist (H_2SO_4) and/or Sulfur Trioxide for each run (p.5).

Table VI itemizes the exhaust gas characteristics (p.7).

Table VII tabulates gas flow rate data (p.8).

Table VIII gives data relative to gas collected during testing and the parameters needed to make this information meaningful. (p.9).

Table IX records coal analysis given by the local plant personnel (p.10).

Table X indicates average chemical characteristics of raw mix feed, product clinker and waste dust. (p.11).

Table XI shows gas composition, on the dry basis. (p.12).

Table XII shows meterological conditions during testing period (p.13).

Material Balance Sample Calculation for Runs 2 - 6 is presented after Table XII. The results for both parts (Runs 2 - 6 and Runs 22 - 26) were calculated by Computer Program and presented following the Sample Calculation, (pp.14-30).

Appendix:

* % Isokinetic Sample Calculation for stack run No. 2, (p.32).
* Schematic Diagrams for Material Balances, (p.36).
* Sample Traverse Plans, (p.38).
* Pittsburgh Testing Laboratory Coal Analysis, (p.40).

TABLE I

GREENCASTLE STACK EMISSIONS SURVEY

SO_2 EMISSION RATE

Run No.	Exhaust Gas Temp. °F	Exhaust Gas Press. "Hg	Exhaust Gas Volume ACFM	Exhaust Gas Volume SCFM	SO_2 Emission Rate Lbs/Hr. (Dry)	SO_2 Emission Rate ppm
2	333	29.35	232,000	152,400	384.24	254
4	331	29.41	232,800	153,300	89.27	59
6	334	29.43	223,200	146,500	84.13	58
Ave.				150,700	185.88	123.7
22	308	29.21	249,800	168,300	1083.27	649
24	316	29.39	249,900	167,600	925.95	557
26	305	29.30	248,900	168,900	1259.97	752
Ave.				168,300	1089.73	652.7
TOTAL AVERAGE				159,500	637.8	388

* ppm based on actual wet gas emitted from stack @ standard conditions.

TABLE II

GREENCASTLE EMISSION SURVEY

PROCESS RATES, CONSUMPTION AND PRODUCTION

Run No.	Date (1977)	Type of Fuel	Fuel Rate T/Hr "As Used"	Kiln Feed T/Hr	% Slurry Water	Clinker Produced T/Hr	Dust Disposed T/Hr
2	5 - 8	Coal	18.5	135	31.1	81	.146
4	5 - 9	Coal	18.0	135	33.3	79	.146
6	5 - 10	Coal	17.5	135	33.3	79	.146
Ave.			18.0	135	32.6	79.7	.146
22	6 - 20	Coal	18.75	138	33.2	88	.125
24	6 - 21	Coal	18.75	138	33.2	87	.125
26	6 - 22	Coal	19.50	138	33.3	88	.125
Ave.			19.0	138	33.2	87.7	.125

TABLE III

ALLOWABLE SULFUR DIOXIDE EMISSIONS
PER
INDIANA AIR POLLUTION CONTROL BOARD
REGULATIONS 5 & 13

In accordance with Indiana APC Board and their definition of Process Weight, we are allowed:

Coal	- 18.5	T/Hr.
Raw Mix Solids	- 136.5	T/Hr.
Raw Mix Water	- 66.9	T/Hr.
TOTAL	221.9	T/Hr.

Sulfur Dioxide Emissions:

(1) Based on Process Weight

$$Ep = 19.5\ p^{0.67}$$

where Ep = maximum allowable SO_2 emissions in lbs/Hr.

p = process weight in Ton/Hr.

$$Ep = 19.5\ (221.9)^{0.67}$$

$$= (19.5)(37.32)$$

$$= \underline{727.74}\ \text{lbs/hr. } SO_2$$

or

$$\frac{(727.74)(387)(1{,}000{,}000)}{(60)\quad(64)(159{,}500)} = \underline{457.9}\ \text{ppm } SO_2{}^*$$

(2) Based on Process Heat Input

$$Ep = 17.0\ Qm^{0.67}$$

where $Ep = Em \times Qm$

Ep = maximum allowable sulfur dioxide emissions in pounds per hour.

Em = maximum allowable sulfur dioxide emissions in pounds per million BTU Heat Input

Qm = Total Combustion equipment capacity rating, fuel heat input in million of BTU/Hr.

Table IX shows we used 18.5 T/Hr. coal @ 11,238 BTU/Lb. so that BTU Input/Hr. as millions is:

$$Qm = \frac{(18.5)(2000)(11,238)}{1,000,000} = 415.8 \text{ Btu/hr.}$$

$$Ep = 17.0\ (415.8)^{0.67}$$

$$= (17)(56.8) = \underline{965.6} \text{ lb/hr. } SO_2$$

or $$\frac{(965.6)(387)(1,000,000)}{(60)\quad(64)(159,500)} = \underline{610.1} \text{ ppm } SO_2{}^*$$

* ppm based on actual wet gas emitted from stack @ standard conditions.

TABLE IV
GREENCASTLE EMISSION STUDY
SULFUR DIOXIDE EMISSION - EPA METHOD 8
1977

(A) Normality of Std. H_2SO_4 — 0.010
(B) Mls. Std. H_2SO_4 used — 20.00
(C) Mls. Barium Perchlorate Soln. Req'd. — 20.30
(D) Normality of $Ba(ClO_4)\cdot 3H_2O$ Soln. — 0.0095
(D) = (A)(B)/(C)

Sample No.	Location	(E) Tot. Vol. Peroxide/ SO_2 Mls.	(F) Aliquot titrated Mls.	(G) Quantity Factor (E)/(F)	(H) Vol. Gas Sampled @ Std. Cond. Dry - Cu. Ft.	(I) Vol. $Ba(ClO_4)$ Soln. titrant Mls.
	Stack	350	1	350	52.27	12.10
4	"	550	1	550	51.42	1.30
6	"	655	1	655	45.72	1.25
22	"	355	1	355	49.23	29.65
24	"	390	1	390	40.34	20.60
26	"	390	1	390	52.31	36.30

Sample No.	(J) Blank Corr. -Mls.	(K) Net Titrant Mls. (I-J)	(L) Run Constant (7.05×10^{-5}) $(D)\times10^{-7}$	(M) Conc. SO_2 Lbs/Std. C.F. Dry $\frac{(L)(K)(G)}{(H)}\times10^{-6}$	(N) Conc. as Sulfur Lbs/Std. C.F. Dry $(0.5)(M)\times10^{-6}$	SO_2 Lbs/Hr. Std. Conc. Dry (M)(CFH)
2	0.05	12.05	6.70	54.06	27.03	370.20
4	"	1.25	"	8.96	4.48	60.94
6	"	1.20	"	11.52	5.76	71.80
22	"	29.60	"	143.01	71.50	1052.98
24	"	20.55	"	133.11	66.55	896.23
26	"	36.25	"	181.08	90.54	1228.08

TABLE V
GREENCASTLE EMISSION STUDY
SULFURIC ACID & SULFUR TRIOXIDE EMISSION- EPA METHOD 8
1977

(A) Normality of Std. H_2SO_4 = 0.010
(B) Mls. Std. H_2SO_4 used = 20.00
(C) Mls. Barium Perchlorate Soln. Req'd. = 20.30
(D) Normality of $Ba(ClO_4)\cdot 3H_2O$ Soln. = 0.0095

(D) = (A)(B)/(C)

Sample No.	Location	(E) Tot.Vol. Alcohol / H_2SO_4 Mls.	(F) Aliquot titrated Mls.	(G) Quantity Factor (E)/(F)	(H) Vol. Gas Sampled @ Std.Cond. Dry - Cu.ft.	(I) Vol. $Ba(ClO_4)$ Soln. titrant Mls.
2	Stack	455	1	455	52.27	0.40
4	"	425	"	425	51.42	0.80
6	"	385	"	385	45.72	0.40
22	"	430	"	430	49.23	0.75
24	"	530	"	530	40.34	0.55
26	"	610	"	610	52.31	0.65

Sample No.	(J) Blank Corr. -Mls.	(K) Net Titrant Mls. (I-J)	(L) Run Const. ($1.08X10^{-4}$) (D) X 10^{-6}	(M) Conc. H_2SO_4 Lbs/Std.C.F. Dry (L)(K)(G) / (H) X 10^{-6}	(N) Conc. as Sulfur Lbs/Std. C.F.Dry (.327)(M) X 10^{-6}	H_2SO_4 Lbs/Hr. @ Std.Cond dry (M)(CFH)
2	0.05	0.35	1.03	3.14	1.02	21.50
4	"	0.75	"	6.38	2.08	43.39
6	"	0.35	"	3.03	0.99	18.88
22	"	0.70	"	6.30	2.06	46.38
24	"	0.50	"	6.76	2.21	45.51
26	"	0.60	"	7.20	2.35	48.83

TABLE VI
GREENCASTLE EMISSION STUDY
EXHAUST GAS CHARACTERISTICS
1977

Run No.	Pitot Tube Factor	Temp. °R. T_s	% Water in Gas	Gas Density Lbs/Lb-Mole	Stack Gas Press. "Hg.	Static Gas Press. "H_2O
2	.80	793	25	28.38	29.35	-0.53
4	.80	791	26	28.11	29.41	-0.64
6	.80	794	29	28.43	29.43	-0.61
22	.80	768	27	28.57	29.21	-0.60
24	.80	776	33	27.73	29.39	-0.65
26	.80	765	33	27.65	29.30	-0.68

TABLE VII
GREENCASTLE EMISSION SURVEY
EXHAUST GAS FLOW RATE
1977

Run No.	Barometric Press."Hg.	Stack Area Sq.Ft.	ΔP "H_2O	Velocity Ft./Sec.	Volume ACFM	Volume CFH @ 29.92 & 70°F. X 10^6
2	29.39	109.5	.53	35.37	232,400	6.848
4	29.46	109.5	.53	35.44	232,800	6.801
6	29.48	109.5	.51	33.97	223,200	6.233
22	29.26	109.5	.58	38.03	249,900	7.363
24	29.44	109.5	.57	38.04	249,900	6.733
26	29.35	109.5	.57	37.89	248,900	6.782

TABLE VIII
GREENCASTLE EMISSION SURVEY
GAS SAMPLING AND TESTING PARAMETERS
1977

Run No.	Date 1977	Test Nozzle Size Sq.Ft.	Test Duration Minutes	Meter Temp. °R.	Meter Vol. Meter Cond. Cu.Ft.	Meter Vol. Std.Cond. 29.92 & 70 Cu.Ft.	Meter Press. "Hg.	Meter Press. ΔH "H_2O	% Iso-kinetic
2	5 - 8	.000341	144	528	52.99	52.27	29.41	.28	102.6
4	5 - 9	"	"	531	52.30	51.42	29.48	.28	102.1
6	5 - 10	"	"	535	46.84	45.72	29.49	.23	98.7
22	6 - 20	"	"	535	49.23	47.73	29.29	.39	87.8
26	6 - 22	"	"	532	52.31	51.16	29.38	.45	102.6
24	6 - 21	"	"	529	40.34	39.78	29.46	.25	79.5

TABLE IX

GREENCASTLE EMISSION SURVEY

PLANT COAL ANALYSIS

1977

Results were recorded based on Coal "as fed to kiln" and "as used".*

	Run 1 -6 (May 8 - 10)		Runs 7 - 20 (May 12 - 24)		Runs 21 - 26 (June 20 - 22)	
	"As Fed"	"As Used"	"As Fed"	"As Used"	"As Fed"	"As Used"
H_2O:	5.16	12.00	6.09	12.50	5.74	11.20
V.C.:	36.45	33.82	33.58	33.15	34.10	32.12
F.C.:	45.59	42.30	46.17	43.02	46.42	43.73
Ash:	12.80	11.88	12.16	11.33	13.74	12.94
S:	2.44	2.26	2.14	1.99	2.98	2.81
Btu/Lb:	12,045	11,176	12,175	11,344	11,883	11,195

* "As Fed" refers to moisture condition of coal as it was actually fed to the kiln.
"As Used" refers to moisture condition of coal as it enters Coal Mill and not as fed to kiln.

** Average Heat content of coal was 11,238 Btu/lb. as used.

TABLE X
GREENCASTLE EMISSION STUDY
CHEMICAL ANALYSIS
1977

DATE (1977)	RAW FEED TO KILN			CLINKER	DUST
	% CaO	% MgO	% SO_3	% SO_3	% SO_3
5/8 - 5/12	43.75	0.45	0.30	1.43	17.24
5/19 - 5/24	43.88	0.50	0.36	1.51	16.29
6/20 - 6/22	44.19	0.50	0.37	1.33	22.76

TABLE XI

GREENCASTLE EMISSION SURVEY
GAS ANALYSIS

Run No.	Date (1977)	Gas Composition - %		
		CO_2	O_2	N_2
2	5 - 8	22.0	8.0	70.0
4	5 - 9	21.0	7.6	71.4
6	5 - 10	26.0	6.2	67.8
22	6 - 20	26.5	6.4	67.1
24	6 - 21	27.0	5.0	68.0
26	6 - 22	26.0	6.2	67.8

TABLE XII
GREENCASTLE STACK EMISSION SURVEY
METEOROLOGICAL CONDITIONS
1977

Run No.	Relative Humidity	Ambient Temp. °F.	Barometric Pressure
2	40	72	29.39
4	53	53	29.46
6	43	59	29.48
22	54	86	29.26
24	72	68	29.44
26	100	67	29.35

MATERIAL BALANCE CALCULATIONS

(Sample Calculation for Runs 2 - 6)

I. Fuel Consumption Calculation - Molal Basis

A. Coal Analysis

See copy of letters enclosed from Pittsburgh Testing Laboratory showing ultimate analysis of average sample gathered during testing. Also, see Table IX for moisture and Sulfur level of coal "as used". Accordingly, ultimate coal analysis in states of interest, are:

% Component	Dry Basis	Coal Mill Feed "As Used" *	Coal Mill Feed "As Used" **
Carbon	69.33	60.86	61.04
Hydrogen	4.88	4.28	4.29
Nitrogen	1.72	1.51	1.52
Oxygen	8.29	7.28	7.30
Sulfur	2.33	2.26	2.81
Water	None	12.00	11.20
Ash	13.45	11.81	11.84
Total	100	100	100
Btu/lb.	12,517	11,176	11,195

* P.T.L. Analysis was corrected for moisture @ 12% and sulfur @ 2.26% and Btu/lb., for Runs 2 - 6.

** P.T.L. Analysis was corrected for moisture @ 11.2% and sulfur @ 2.81% and Btu/lb., for Runs 22 - 26.

B. Distribution of Combustables and Products

Line	Fuel Constituent	Fuel, Oxygen & Air per 100 lbs. Coal: Lbs. per 100 Lbs. Coal	Mol. Wt. Divisor	Moles Fuel Constituent	O_2 Multiplier	O_2 Moles Theo. Req'd.	"As Received" Moles/100 Lbs. Coal: CO_2 & SO_2	O_2	N_2	H_2O
1	C to CO_2	60.86	12	5.07	1	5.07	5.07	--	--	--
2	H_2 to H_2O	4.28	2	2.14	0.5	1.07	--	--	--	2.14
3	S to SO_2	2.26	32	0.07	1	0.07	0.07	--	--	--
4	O_2 (Deduct)	7.28	32	0.23	--	-0.31	--	--	--	--
5	N_2	1.51	28	0.05	--	0	--	--	0.05	--
6	Ash	11.81	--	--	--	0	--	--	--	--
7	Water	12.00	18	0.67	--	0	--	--	--	0.67
8	Cl_2	--	70	0	--	0	--	--	--	--
9	Total	100	--	8.23	--	5.90				

10	Therefore, O_2 req'd. is O_2, Line 9, -	5.90			
11	Recall, Mole ratio of N_2 to O_2 in Air is 3.76				
12	Then, N_2 with Air = (5.9)(3.76) =	22.18		22.18	
13	Air Dry (Supplied in Line 10 + 12) =	28.08			
14	H_2O in Air = (.0082*)(28.08) =	0.23			0.23
15	Air (Wet) supplied in Line 13 + 14 =	28.31			
16	Flue Gas Constituents (Lines 1-15) Total =		5.14	22.23	3.04

Total Moles Wet Flue Gas/100 Lbs. Coal (As Received) = 30.41

Total Moles Dry Flue Gas/100 Lbs. Coal (As Received) = 27.37

* Molal Humidity for Ambient Air @ 61°F., 29.44"Hg and 45% Relative Humidity.

II. Theoretical Combustion Gas Quantities - (No Excess Air)

1. The average fuel coal used by kiln during testing period from May 8 to May 10 was 18 ton/hr.

or

$$\frac{(18)(2000)}{60} = 600 \text{ lbs/min.}$$

Accordingly, 100 lbs. coal supplies fuel for -

$$\frac{100}{600} = 0.167 \text{ min. of kiln operation}$$

2. Therefore, referring to I-B:

$$CO_2 = \frac{(5.07)(44)}{0.167} = \underline{1335.81} \text{ lbs/min. produced}$$

$$H_2O = \frac{(3.04)(18)}{0.167} = \underline{327.66} \text{ lbs/min. produced}$$

$$N_2 = \frac{(22.23)(28)}{0.167} = \underline{3727.18} \text{ lbs/min. produced}$$

$$SO_2 = \frac{(0.07)(64)}{0.167} = \underline{26.83} \text{ lbs/min. produced}$$

3. Breakdown of Water Source

(a) Combustion Water:

$$\frac{(2.14)(18)}{(.167)} = 230.66 \text{ lb/min. produced}$$

(b) Free Water in Coal "As Used":

$$\frac{(0.67)(18)}{(.167)} = 72.21 \text{ lb/min.}$$

(c) Free Water in Coal "As Fed to Kiln":

$$\frac{5.16 \times \frac{(100 - 12)}{(100 - 5.16)}}{12} \times 72.21 = 28.81 \text{ lb/min.}$$

Loss Water = 72.21 - 28.81 = 43.4 lb/min.

(d) Water in Combustion Air:

$$\frac{(0.23)(18)}{.167} = 24.79 \text{ lb/min.}$$

III. Liberation of CO_2 and H_2O from Raw Mix

Average raw mix feed rate during test was 135 ton/hr. or 4500 lb/min. dry solids.

Raw Mix Chemical Analysis was used to determine the available CO_2 liberated from $CaCO_3$ and $MgCO_3$:

$$(\%\ CaO) \times \frac{100}{56} = \%\ CaCO_3$$

$$= 43.75 \times \frac{100}{56} = 78.125$$

$$(\%\ MgO) \times \frac{84}{40} = \%\ MgCO_3$$

$$= 0.45 \times \frac{84}{40} = 0.945$$

From $CaCO_3$, $CO_2 = \frac{(78.125)(44)}{(100)} = 34.375$ lb.

From $MgCO_3$, $CO_2 = \frac{(0.945)(44)}{84} = 0.495$ lb.

Total CO_2 = 34.87 lb/100 lb. Raw Mix

or,

$$CO_2 = \frac{(34.87)(4500)}{100}$$

$$= \underline{1569.15} \text{ lb/min.}$$

Average % Slurry Water was 32.6, which amounts to:

$$H_2O = \frac{4500}{(1 - 0.326)} - 4500$$

$$= \underline{2176.56} \text{ lb/min.}$$

IV. Theoretical Kiln Exit Gas - (No Excess Air)

1. Total Exit Gas Quantities (per min. of kiln operation)

Source	CO_2(lb)	H_2O(lb)	N_2(lb)
(a) Combustion Process	1335.81	284.26	3727.18
(b) Raw Mix Liberation	1569.15	2176.56	--
TOTAL	2904.96	2460.82	3727.18

2. Exit Gas Analysis - Wet Basis

$$CO_2 \text{ (Mole)} = \frac{2904.96}{44} = 66.02$$

$$H_2O \text{ (Mole)} = \frac{2460.82}{18} = 136.71$$

$$N_2 \text{ (Mole)} = \frac{3727.18}{28} = 133.11$$

TOTAL 335.84 Moles/Min.

Hence:

$$CO_2 = \frac{66.02}{335.84} = 19.66\%$$

$$H_2O = \frac{136.71}{335.84} = 40.71\%$$

$$N_2 = \frac{133.11}{335.84} = 39.63\%$$

3. Exit Gas Analysis - Dry Basis

$$CO_2 = \frac{19.66}{(1 - .4071)} = 33.16\%$$

$$N_2 = \frac{39.63}{(1 - .4071)} = 66.84\%$$

4. Theoretical Exit Gas Volume

At Standard Conditions (70°F. and 29.92"Hg)

Volume = (335.84)(387) = 129,970 SCFM (Wet)

or = (129,970)(1 - .4071) = 77,059 SCFM (Dry)

V. Actual Kiln Exit Gas at Sampling Ports

1. Exhaust Gas included not only Theoretical Combustion Air and Excess Combustion Air but also Infiltrated Air at kiln exit, precipitators, etc. From here forward, the term Excess Air will be used instead of Excess and Infiltrated Air.

2. Average Orsat Analysis taken from Exhaust gas are showing along with Theoretical Gas Analysis:

ORSAT ANALYSIS (DRY)	THEO. ANALYSIS (DRY)
CO_2 - 23.0	CO_2 - 33.1
O_2 - 7.3	O_2 - 0
N_2 - 69.7	N_2 - 66.9

3. Excess Air Calculation - CO_2 Balance (Using Above Analyses)

$$(\text{Vol. Comb. Gas})(\%\ CO_2) + (\text{Vol. Excess Air})(\%\ CO_2) = (\text{Vol. Actual Gas})(\%\ CO_2)$$

Let X = Vol. Comb. Gas (Relative)
100-X = Vol. Excess Air (Relative)
100 = Vol. Actual Gas (Relative)

Then -

$$(X)(33.1) + (100 - X)(0) = (100)(23)$$

$$33.1X = 2300$$

$$X = 69.5\%\ \text{Comb. Gas}$$

$$100-X = \underline{30.5\%}\ \text{Excess Air}$$

From IV-4, Above, the Theoretical Dry Exit Gas was 77,059 SCFM, therefore, Actual Kiln Exit Gas (Dry)was:

$$\frac{77{,}059}{.695} = 110{,}876\ \text{SCFM - Dry}$$

$$\text{Excess Air} = (110{,}876 - 77{,}059)$$

$$= \underline{33{,}817}\ \text{SCFM - Dry}$$

4. Oxygen Balance (Using Above Analyses)

$$(\text{Vol. Comb. Gas})(\%\ O_2) + (\text{Vol. Excess Air})(\%\ O_2) = (\text{Vol. Actual Gas})(\%\ O_2)$$

Using the same symbol X as above,

$$(X)(0) = (100 - X)(21) = (100(7.3)$$

$$X = \frac{2100 - 730}{21}$$

$$= 65.2\% \text{ Comb Gas}$$

$$100 - X = \underline{34.8\%} \text{ Excess Air}$$

Hence,

$$\text{Actual Kiln Exit Gas} = \frac{77{,}059}{.652} = 118{,}188 \text{ SCFM - Dry}$$

$$\text{Excess Air} = (118{,}188 - 77{,}059)$$

$$= \underline{41{,}129} \text{ SCFM - Dry}$$

5. Reconciliation of Balance

The CO_2 and O_2 balances should give the same quantity of excess air for a given location. They do not agree exactly due to experimental error, but they are close enough so that an average of the balances should accurately represent the true condition.

$$\text{(Average) Excess Air} = \frac{33{,}817 + 41{,}129}{2}$$

$$= \underline{37{,}473} \text{ SCFM - Dry}$$

6. Weight of Excess Air Components

Lb/min. of kiln operation

$$O_2 = \frac{(37{,}473)(.21)(32)}{(387)} = \underline{650.69} \text{ lb/min.}$$

$$N_2 = \frac{(37{,}473)(.79)(28)}{(387)} = \underline{2141.87} \text{ lb/min.}$$

$$H_2O = \frac{(37{,}473)(.0082)(18)}{(387)} = \underline{14.29} \text{ lb/min.}$$

$$\text{or} \frac{(14.29)(387)}{18} = 307 \text{ SCFM}$$

(Recall 0.0082 was the Molal Humidity @ Testing Period)

7. Actual Kiln Exit Gas Volume:

(a) Theoretical Kiln Exit Gas (IV-4) = 129,970 SCFM (Wet)

(b) Excess Air (V-5 and V-6) = 37,473 + 307

= 37,780 SCFM (Wet)

(c) Actual Kiln Exit Gas (a) + (b) = 167,750 SCFM (Wet)

(1) Stack conditions $= \frac{(167,750)(792)(29.92)}{(530)(29.39)}$

= 255,196 ACFM (Wet)

VII. Gas Balance

(1) CO_2

CO_2 Input = 2905.0 Lb/Min. (from IV-1)

CO_2 Output = 2898.7 Lb/Min. (from VI-2-c)

Measuring Efficiency = 99.8%

(2) O_2

O_2 Input = 650.7 Lb/Min. (from V-6)

O_2 Output = 661.1 Lb/Min. (from VI-2-c)

Measuring Efficiency = 101.6%

(3) N_2

N_2 Input = 5869.0 Lb/Min. (from IV-1 and V-6)

N_2 Output = 5577.5 Lb/Min. (from VI-2-c)

Measuring Efficiency = 95.0%

(4) H_2O

H_2O Input = 2475.1 Lb/Min. (from IV-1 and V-6)

H_2O Output = 1873.4 Lb/Min. (from VI-2-c)

Measuring Efficiency = 75.7%

VIII. Sulfur Balance

1. Sulfur Input

(a) SO_2 produced by burning coal was 26.83 lb/min. (from II-2), then sulfur input from fuel coal was:

$$(26.83)\frac{(32)}{(64)} = 13.41 \text{ lb/min.}$$

(b) SO_3 content in raw mix was 0.3%. The average feed rate was 4500 lb/min. Then, sulfur added to process from raw mix was:

$$(4500)(0.003)\frac{(32)}{(80)} = 5.4 \text{ lb/min.}$$

(c) Total Sulfur Input = 18.81 lb/min.

2. Sulfur Output

(a) SO_3 content in clinker was 1.43%. The average clinker produced rate was 79.7 Ton/Hr. or 2656.7 Lb/Min. Then, sulfur removed from the process in clinker was:

$$(2656.7)(0.0143)\frac{(32)}{(80)} = 15.20 \text{ lb/min.}$$

(b) Kiln dust contained 17.24% SO_3. The average dust removed rate was 0.146 ton/hr. or 4.87 lb/min. Sulfur removed with discarded kiln dust was:

$$(4.87)(.1724)\frac{(32)}{(80)} = 0.33 \text{ lb/min.}$$

(c) Table I shows the average SO_2 emission from stack was 185.88 lb/hr. (Runs 2 - 6), then sulfur leaving stack was:

$$\frac{(185.88)}{(60)} \times \frac{(32)}{(64)} = 1.55 \text{ lb/min.}$$

(d) Total Sulfur Output = 17.08 lb/min.

3. Sulfur Measuring Efficiency = $\frac{17.08}{18.81}$

= 90.8%

MATERIAL BALANCE CALCULATIONS FOR KILN OPERATED WITH COAL AS FUEL

EMISSION TESTING AT GREENCASTLE PLANT, MAY & JUNE / 1977

RUNS 2-6 (MAY/8-MAY/10, 1977)

DATA INPUT

CARBON WEIGHT% IN COAL= 60.86
HYDROGEN WEIGHT% IN COAL= 4.28
NITROGEN WEIGHT% IN COAL= 1.51
OXYGEN WEIGHT% IN COAL= 7.28
SULFUR WEIGHT% IN COAL= 2.26
WATER WEIGHT% IN COAL= 12
WATER WEIGHT% IN COAL AS FED TO KILN = 5.16
CAO WEIGHT% IN RAW MIX = 43.75
MGO WEIGHT% IN RAW MIX = .45
H2O WEIGHT% IN RAW MIX = 32.6
SO3 WEIGHT% IN RAW MIX = .3
SO3 WEIGHT% IN CLINKER = 1.43
SO3 WEIGHT% IN DUST = 17.24
TOTAL SO2 EMISSION FROM STACK, LB/MIN = 3.1
CO2 VOL.%, ORSAT ANALYSIS = 23
OXY VOL.%, ORSAT ANALYSIS = 7.3
N2 VOL.%, ORSAT ANALYSIS = 69.7
AVE.RAW FEED, TON/HR = 135
AVE.CLINKER PRODUCED, TON/HR = 79.7
AVE.DUST REMOVED, TON/HR = .146
AVE.FUEL COAL RATE, TON/HR= 18
MOLAL HUMIDITY OF AMBIENT AIR = 8.20000000E-03
AVE.VOL.OF STACK GAS (WET), ACFM = 229 500
AVE.VOL.% OF H2O IN STACK GAS = 26.7
AVE.TEMP.OF STACK GAS, DEG.R = 792
AVE.PRES.OF STACK GAS, IN.HG.= 29.39

RESULTS

BASIS 100 LB FUEL COAL (AS USED)

THEORETICAL AIR REQUIRED :
DRY AIR = 66174.69 SCFM
WET AIR = 66717.32 SCFM

EXCESS AIR CALCULATED :
BASED ON CO2 BALANCE, DRY = 33226.78 SCFM
BASED ON OXY BALANCE, DRY = 41551.93 SCFM
AVERAGE, DRY = 37389.36 SCFM
AVERAGE, WET = 37695.95 SCFM

CARBON DIOXIDE BALANCE :

CO2 FROM COMBUSTION PROCESS	=	1338.92 LB/MIN
CO2 LIBERATED FROM RAW MIX	=	1569.15 LB/MIN
TOTAL INPUT	=	2908.07 LB/MIN
CO2 MEASURED FROM STACK	=	2891.64 LB/MIN
TOTAL OUTPUT	=	2891.64 LB/MIN
MEASURING EFFICIENCY (O/I)	=	99.43 %

OXYGEN BALANCE :

O2 IN EXCESS AIR	=	649.24 LB/MIN
TOTAL INPUT	=	649.24 LB/MIN
O2 MEASURED FROM STACK	=	667.47 LB/MIN
TOTAL OUTPUT	=	667.47 LB/MIN
MEAS. EFFICIENCY (O/I)	=	102.80 %

NITROGEN BALANCE :

N2 IN COMBUSTION AIR	=	3791.44 LB/MIN
N2 IN EXCESS AIR	=	2137.08 LB/MIN
TOTAL INPUT	=	5928.53 LB/MIN
N2 MEASURED FROM STACK	=	5576.41 LB/MIN
TOTAL OUTPUT	=	5576.41 LB/MIN
MEAS. EFFICIENCY (O/I)	=	94.06 %

WATER BALANCE :

H2O FROM COMBUSTION PROCESS	=	231.12 LB/MIN
H2O IN COMBUSTION AIR	=	25.23 LB/MIN
H2O IN EXCESS AIR	=	14.26 LB/MIN
H2O IN SLURRY	=	2176.55 LB/MIN
H2O IN FUEL COAL	=	28.72 LB/MIN
TOTAL INPUT	=	2475.90 LB/MIN
H2O MEASURED FROM STACK	=	1873.45 LB/MIN
TOTAL OUTPUT	=	1873.45 LB/MIN
MEASURING EFFICIENCY (O/I)	=	75.66 %

SULFUR BALANCE :

SULFUR IN FUEL COAL	=	13.56 LB/MIN
SULFUR IN RAW MIX	=	5.40 LB/MIN
TOTAL INPUT	=	18.96 LB/MIN
SULFUR IN CLINKER	=	15.19 LB/MIN
SULFUR IN WASTE DUST	=	0.33 LB/MIN
SULFUR EMITTED FROM STACK	=	1.55 LB/MIN
TOTAL OUTPUT	=	17.08 LB/MIN
MEASURING EFFICIENCY (O/I)	=	90.09 %

TOTAL THEO.VOL.OF KILN EXIT GAS (WET) = 169532.68 SCFM
TOTAL MEAS.VOL.OF KILN EXIT GAS (WET) = 150859.05 SCFM
TOTAL GAS MEAS. EFFICIENCY = 88.98 %

MATERIAL BALANCE CALCULATIONS FOR KILN OPERATED WITH COAL AS FUEL

EMISSION TESTING AT GREENCASTLE PLANT, MAY & JUNE / 1977

RUNS 22-26 (JUNE/20-JUNE/22, 1977)

DATA INPUT

CARBON WEIGHT% IN COAL= 61.04
HYDROGEN WEIGHT% IN COAL= 4.2 9
NITROGEN WEIGHT% IN COAL= 1.52
OXYGEN WEIGHT% IN COAL= 7.3
SULFUR WEIGHT% IN COAL= 2.81
WATER WEIGHT% IN COAL= 11.2
WATER WEIGHT% IN COAL AS FED TO KILN = 5.74
CAO WEIGHT% IN RAW MIX = 44.19
MGO WEIGHT% IN RAW MIX = .5
H2O WEIGHT% IN RAW MIX = 33.2
SO3 WEIGHT% IN RAW MIX = .37
SO3 WEIGHT% IN CLINKER = 1.33
SO3 WEIGHT% IN DUST = 22.76
TOTAL SO2 EMISSION FROM STACK, LB/MIN = 18.16
CO2 VOL.%, ORSAT ANALYSIS = 26.5
OXY VOL.%, ORSAT ANALYSIS = 5.9
N2 VOL.%, ORSAT ANALYSIS = 67.6
AVE.RAW FEED, TON/HR = 138
AVE.CLINKER PRODUCED, TON/HR = 87.7
AVE.DUST REMOVED, TON/HR = .125
AVE.FUEL COAL RATE, TON/HR= 19
MOLAL HUMIDITY OF AMBIENT AIR = 2.08 0000E-02
AVE.VOL.OF STACK GAS (WET), ACFM = 249600
AVE.VOL.% OF H2O IN STACK GAS = 31
AVE.TEMP.OF STACK GAS, DEG.R = 770
AVE.PRES.OF STACK GAS, IN.HG.= 29.3

RESULTS

BASIS 100 LB FUEL COAL (AS USED)

THEORETICAL AIR REQUIRED :
DRY AIR = 70248.62 SCFM
WET AIR = 71709.79 SCFM

EXCESS AIR CALCULATED :
BASED ON CO2 BALANCE, DRY = 18529.61 SCFM
BASED ON OXY BALANCE, DRY = 32183.17 SCFM
AVERAGE, DRY = 25356.39 SCFM
AVERAGE, WET = 25883.80 SCFM

CARBON DIOXIDE BALANCE :

CO2 FROM COMBUSTION PROCESS	=	1417.48 LB/MIN
CO2 LIBERATED FROM RAW MIX	=	1622.45 LB/MIN
TOTAL INPUT	=	3039.93 LB/MIN
CO2 MEASURED FROM STACK	=	3497.61 LB/MIN
TOTAL OUTPUT	=	3497.61 LB/MIN
MEASURING EFFICIENCY (O/I)	=	115.05 %

OXYGEN BALANCE :

O2 IN EXCESS AIR	=	440.29 LB/MIN
TOTAL INPUT	=	440.29 LB/MIN
O2 MEASURED FROM STACK	=	566.33 LB/MIN
TOTAL OUTPUT	=	566.33 LB/MIN
MEAS. EFFICIENCY (O/I)	=	128.62 %

NITROGEN BALANCE :

N2 IN COMBUSTION AIR	=	4024.87 LB/MIN
N2 IN EXCESS AIR	=	1449.31 LB/MIN
TOTAL INPUT	=	5474.18 LB/MIN
N2 MEASURED FROM STACK	=	5677.78 LB/MIN
TOTAL OUTPUT	=	5677.78 LB/MIN
MEAS. EFFICIENCY (O/I)	=	103.71 %

WATER BALANCE :

H2O FROM COMBUSTION PROCESS	=	244.53 LB/MIN
H2O IN COMBUSTION AIR	=	67.96 LB/MIN
H2O IN EXCESS AIR	=	24.53 LB/MIN
H2O IN SLURRY	=	2286.22 LB/MIN
H2O IN FUEL COAL	=	34.24 LB/MIN
TOTAL INPUT	=	2657.49 LB/MIN
H2O MEASURED FROM STACK	=	2425.82 LB/MIN
TOTAL OUTPUT	=	2425.82 LB/MIN
MEASURING EFFICIENCY (O/I)	=	91.28 %

SULFUR BALANCE :

SULFUR IN FUEL COAL	=	17.79 LB/MIN
SULFUR IN RAW MIX	=	6.80 LB/MIN
TOTAL INPUT	=	24.60 LB/MIN
SULFUR IN CLINKER	=	15.55 LB/MIN
SULFUR IN WASTE DUST	=	0.37 LB/MIN
SULFUR EMITTED FROM STACK	=	9.08 LB/MIN
TOTAL OUTPUT	=	25.01 LB/MIN

MEASURING EFFICIENCY (O/I)= 101.65 %

TOTAL THEO.VOL.OF KILN EXIT GAS (WET) = 165648.43 SCFM
TOTAL MEAS.VOL.OF KILN EXIT GAS (WET) = 168242.51 SCFM
TOTAL GAS MEAS. EFFICIENCY = 101.56 %

DISCUSSION OF RESULTS

(1) Sulfur Stack Emissions

Note the SO_2 emission data in Table I shows the first 3 runs emitted Sulfur at the average rate of 186 lbs/hr. as SO_2; whereas, the second 3 runs averaged emissions of 1090 lbs/hr. SO_2.

Rate data in Table II shows the low sulfur emission runs were made at approx. 90% kiln capacity; whereas, the high sulfur runs were made at 100% kiln capacity. Table IX shows sulfur in coal at 2.26% for low SO_2 emission runs and 2.81% for high emission runs which one might anticipate. Table X shows .30% SO_3 in raw mix for low sulfur runs and .37% SO_3 in raw mix for high sulfur emissions which also might be expected. The surprise comes when one notes the sulfur in clinker (1.43%) formed from low sulfur fuel and raw mix, was higher than the sulfur in clinker (1.33%) formed from high sulfur fuel and raw mix. Note also, the 80% capacity kiln operation occurred with 2.9% excess oxygen and a backend temperature of 1450° F. while the 100% capacity operation had 1.9% excess oxygen and 1600°F. backend temperature. Does this mean that by operating a "hot kiln" one can actually burn sulfur out of the clinker and emit it as SO_2 or; conversely, absorb sulfur in clinker by operating a relatively "cool kiln" and minimize SO_2 emissions?

In any event, it seems clear that the Greencastle operation can be very close to the limit of allowable sulfur emissions, if not occasionally exceeding limits, when the kiln sees a combination of high sulfur coal with high sulfur raw mix and at the same time pushing the kiln for top production.

(2) SOX and NOX Evaluation

During the periods of high sulfur emissions which at times exceeded 1000 ppm according to the Envirometric charts, the NOX seemed to be depressed. That is to s[illegible], we continue to see the SOX and NOX usually move in opposite directions bu[illegible] not always. We hazard the speculation that the SOX vs. NOX configuration is based on the fact that sulfur has a

greater affinity for oxygen than nitrogen at elevated temperatures. Accordingly, with no sulfur free for oxidation, the nitrogen forms NOX with available oxygen with NOX levels depending on heat and quantity of excess oxygen. As free sulfur developes, with heat and available oxygen remaining constant, the sulfur preferentially combines with available oxygen leaving less for NOX production so that NOX concentrations drop. If, at the same time sulfur becomes available, heat remains the same and oxygen increases then the NOX will not drop but remain the same or possibly increase. Increasing NOX and SOX simultaneously is rare because it is difficult to supply the oxygen without decreasing the heat and this is the reason one seldom sees increasing SOX and NOX simultaneously.

In the complete absence of sulfur, one can set a NOX level as a reliable standard. This is the case at Greencastle. That is to say, it might be ascertained that a NOX level of 1000 ppm gives an ideally hot kiln with, let us say, the desired amount of excess oxygen at 2%. Now, if the oxygen increases with heat remaining essentially the same, the NOX will increase or, possibly, the excess oxygen remains unchanged and the heat increases the NOX will also go up.

The monitoring aspect of NOX level is, in fact, based on keeping the excess oxygen constant which is relatively easy, and if the NOX level falls the kiln is cooling or the reverse. All this is well and good, but now we are running into increased frequency of significant sulfur in fuel and/or raw mix. When sulfur available for oxidation occurs, it has the same effect on NOX standard as a cooling action in the kiln. Therefore, when monitoring NOX levels, how does one know whether the drop in NOX level is caused by sudden availability of sulfur or a cooling kiln as a combination of both? The results are the same with respect to depressing the NOX trend.

Conceivably, with both SOX and NOX capability, one might quantatively reason that for every 1% of SOX registered this would automatically lower the NOX "X" percent and any deviation beyond this correction meant the kiln, in fact, was cooling or heating as the case may be.

The point is that NOX control is excellent where there is no major sulfur involvement but with sulfur involvement it would seem important to investigate its influence on NOX to get reliable data. At this stage of development, I would say NOX control isn't for everybody.

A P P E N D I X

SAMPLE CALCULATION FOR STACK RUN 2

NOMENCLATURE

A_n	-	Cross-sectional area of sample nozzle, sq. ft.
A	-	Cross-sectional area of stack, $ft.^3$
B_{wo}	-	Proportion by volume of water vapor in the gas stream, dimensionless
C_p	-	Pitot tube coefficient, dimensionless
$C_{p\ std.}$	-	Pitot tube coef. of standard type tube @ .99
$C_{p\ test}$	-	Pitot tube coefficient of type "S" pitot tube
$c's$	-	Concentration of particulate matter in stack gas, gr./s.c.f. dry basis
c_s	-	Concentration of particulate matter in stack gas, lb/s.c.f.
D_s	-	Inside diameter of stack at sample port, Ft.
E	-	Particulate emission rate
ΔH	-	Average pressure drop across the orifice meter, inches H_2O
I	-	Percent of Iso Kinetic sampling. Test acceptable between 90% - I - 110%
K_p	-	$85.48 \frac{ft.}{sec.} \frac{lbs.}{lb\text{-}mole\ ^\circ R}$
M_d	-	Dry molecular weight of stack gas
M_{H_2O}	-	Molecular weight of water, 18 lb/lb-mole
M_s	-	Molecular weight of stack gas (wet basis) lbs/lb-mole $M_d\ (1-B_{wo}) + 18\ B_{wo}$
M_n	-	Total amount of particule matter collected, mg.
P_{bar}	-	Barometric pressure at the orifice meter, inches Hg.
$P_{std.}$	-	Absolute pressure at standard conditions, 29.92 inches Hg.
P_s	-	Absolute stack gas pressure, inches Hg.

$\Delta P_{std.}$	-	Velocity head measured by standard type pitot tube
ΔP_{test}	-	Velocity head measured by type "S" pitot tube
$\sqrt{\Delta p}_{ave.}$	-	Ave. velocity head of stack gas, inches H_2O
Q_s	-	Volumetric flow rate, dry basis, standard conditions, $ft.^3/hr.$
R	-	Ideal gas constant
°R	-	Degrees of temperature, Rankin (F+460)
ρH_2O	-	Density of water, 1 gm./ml.
$(T_s)_{ave}$	-	Average absolute stack gas temperature, °R
$T_{std.}$	-	Absolute temperature at standard conditions, 530°R
T_m	-	Average dry gas meter temperature, °R
θ	-	Total sampling time, min.
$V_{m\ std.}$	-	Volume of gas sample through the dry gas meter (standard conditions), cu. ft.
$V_{s\ (ave)}$	-	Stack gas velocity, feet per second (f.p.s.)
V_m	-	Volume of gas sample through the dry gas meter (meter conditions) cu. ft.
V_{ic}	-	Total volume of liquid collected in impingers and silica gel
17.71	-	°R per inch. Hg @ std. cond. of 530 & 29.92
24.1	-	Liters water per gram-mole
28.3	-	Liters dry air per cu. ft.
1.667	-	100/60 min/sec
13.6	-	Specific gravity of mercury
2.205×10^{-6}	-	mg/lb.
0.0154	-	Grains per mg.
32	-	Molecular weight of oxygen

1. Pitot Tube Calibration

Using "S" type, Tube "b" 4' length calibrated Feb. 1, 1977.

$$Cp\ test = Cp\ std. \sqrt{\frac{P_{std}}{P_{std}}}$$

Forward

$$Cp\ test = (.99) \sqrt{\frac{.58}{.88}}$$

$$Cp = .80$$

Reverse

$$Cp\ test = (.99) \sqrt{\frac{.56}{.87}}$$

$$= .79$$

$$Cp\ ave. = .80$$

2. Velocity of Stack Gas

$$V_{s\ ave.} = K_p\ C_p \sqrt{\Delta P\ ave} \sqrt{\frac{T_{s\ ave.}}{P_s\ M_s}}$$

$$V_{s\ ave.} = (85.48)(.80)(.53) \sqrt{\frac{793}{(20.35)(28.38)}}$$

$$V_{s\ ave.} = 35.37 \text{ ft/sec}$$

3. Volume of Gas (Actual) from Stack

$$Volume = (V_{s\ ave.})\ (A)\ (60)$$

$$Volume = (35.37)(109.5)(60) = 232{,}381 \text{ ACFM}$$

4. Volume Dry Gas @ Standard Conditions

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

$$Q_s = 3600\ (1-.25)(35.37)(109.5) \frac{(530)(29.35)}{(793)(29.92)}$$

$$Q_s = 6.85 \times 10^6 \text{ SCFH}$$

5. Sample Gas Volume @ Standard Conditions

$$V_m \text{ std.} = 17.71\ V_m \left(\frac{P_{bar} + \Delta H/13.6}{Tm} \right)$$

$$V_m \text{ std.} = (17.71)(52.99) \left(\frac{29.39 + \frac{.28}{13.6}}{528} \right)$$

$$V_m \text{ std.} = 52.27 \text{ cu.ft.}$$

6. Percent of Isokinetic - EPA Method

$$I = \frac{(1.667\ Ts) \left[(.00267)\ (Vic) + \left(\frac{Vm}{Tm}\ (P\ bar + \frac{\Delta H}{13.6}) \right) \right]}{(\theta)\ (Vs)\ (Ps)\ (A_n)}$$

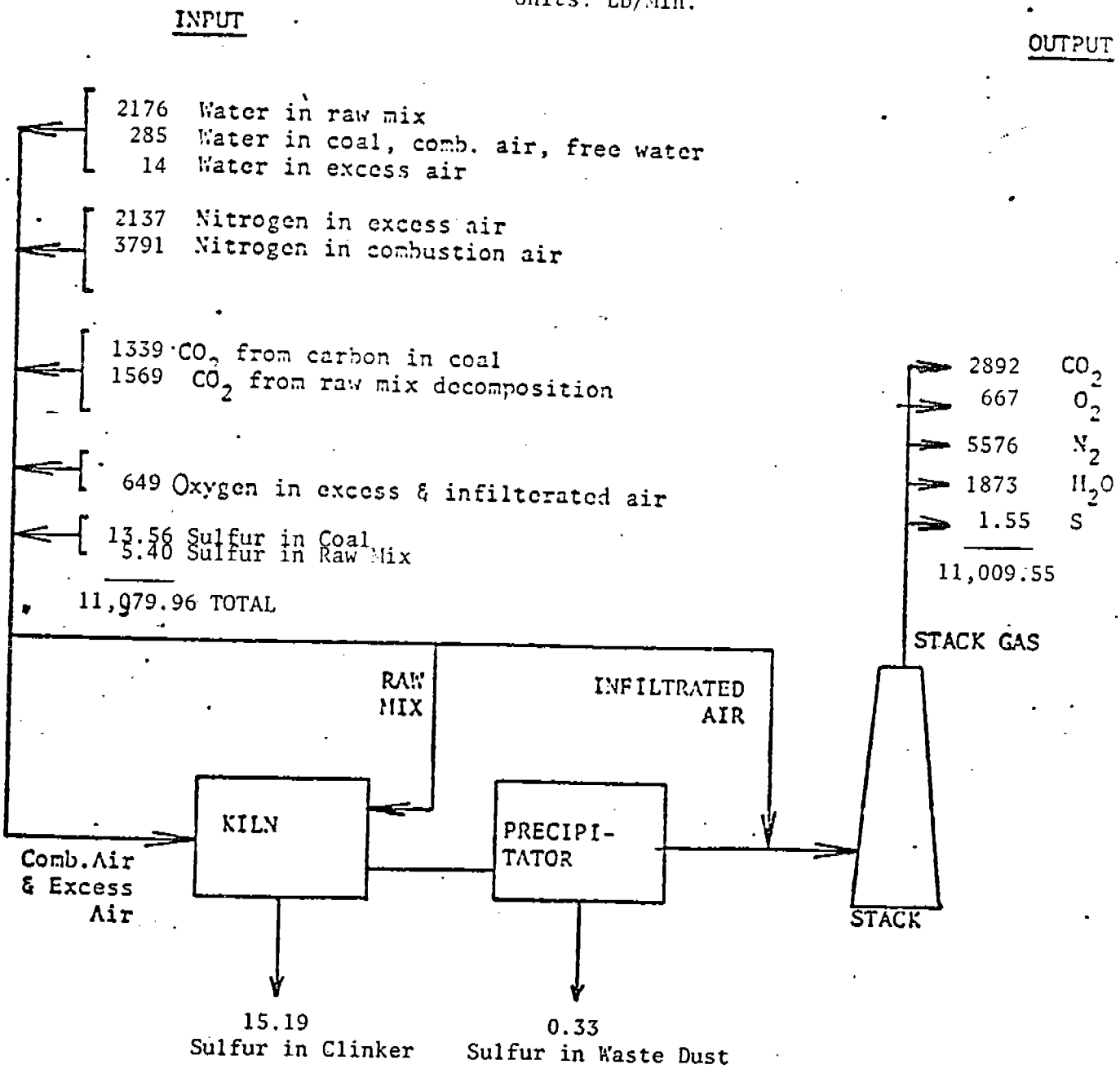
$$I = \frac{(1.667)(793)(1.004 + 2.951)}{(144)(35.37)(29.35)(.000341)}$$

$$I = 102.6$$

% Isokinetic for all runs (from Run No. 2 to Run No. 26) were calculated using the same method as above, and are presented in Table VIII.

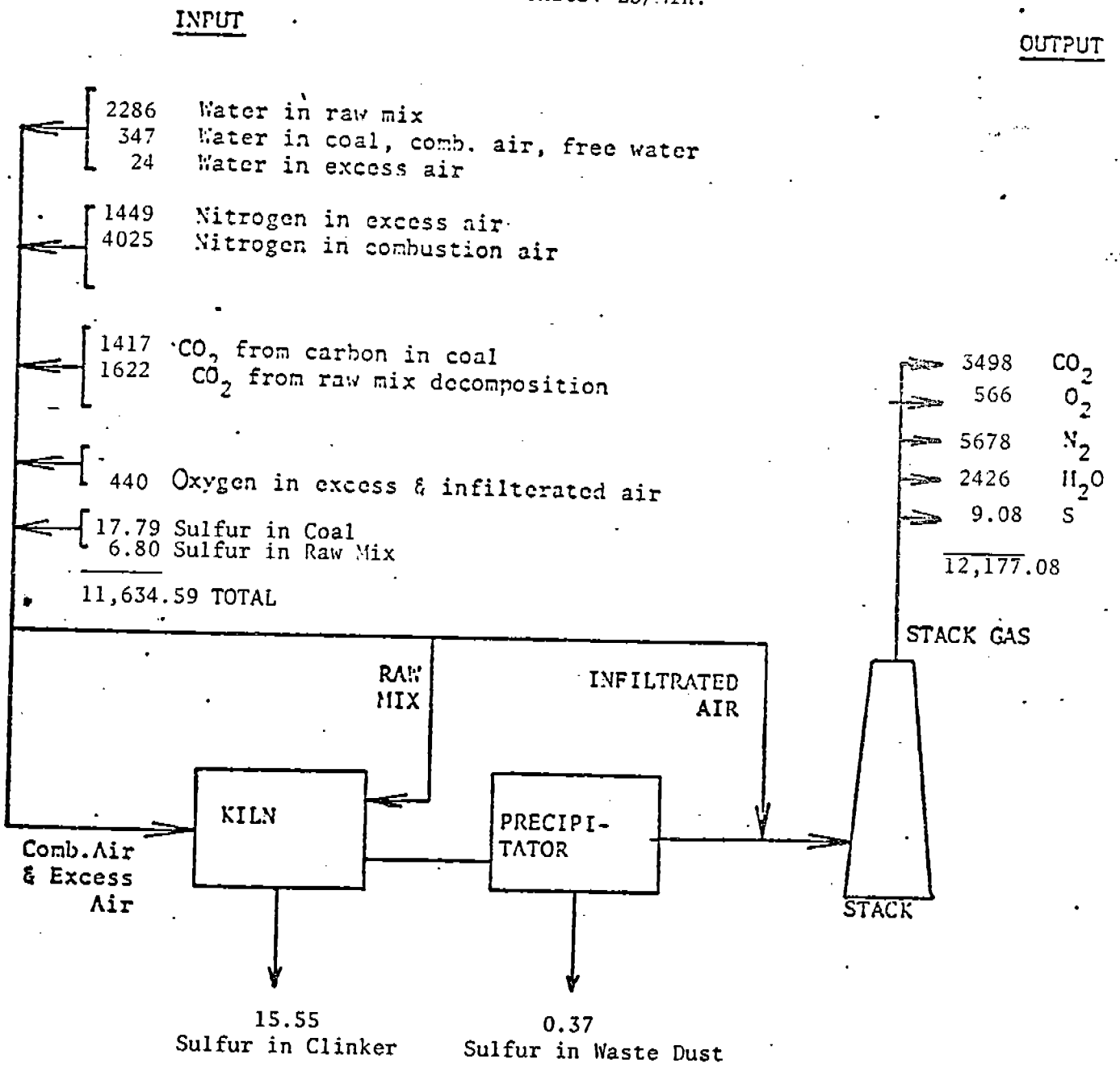
RUNS 2-6

SUMMARY SCHEMATIC
GAS BALANCE
Units: Lb/Min.



RUNS 22- 26

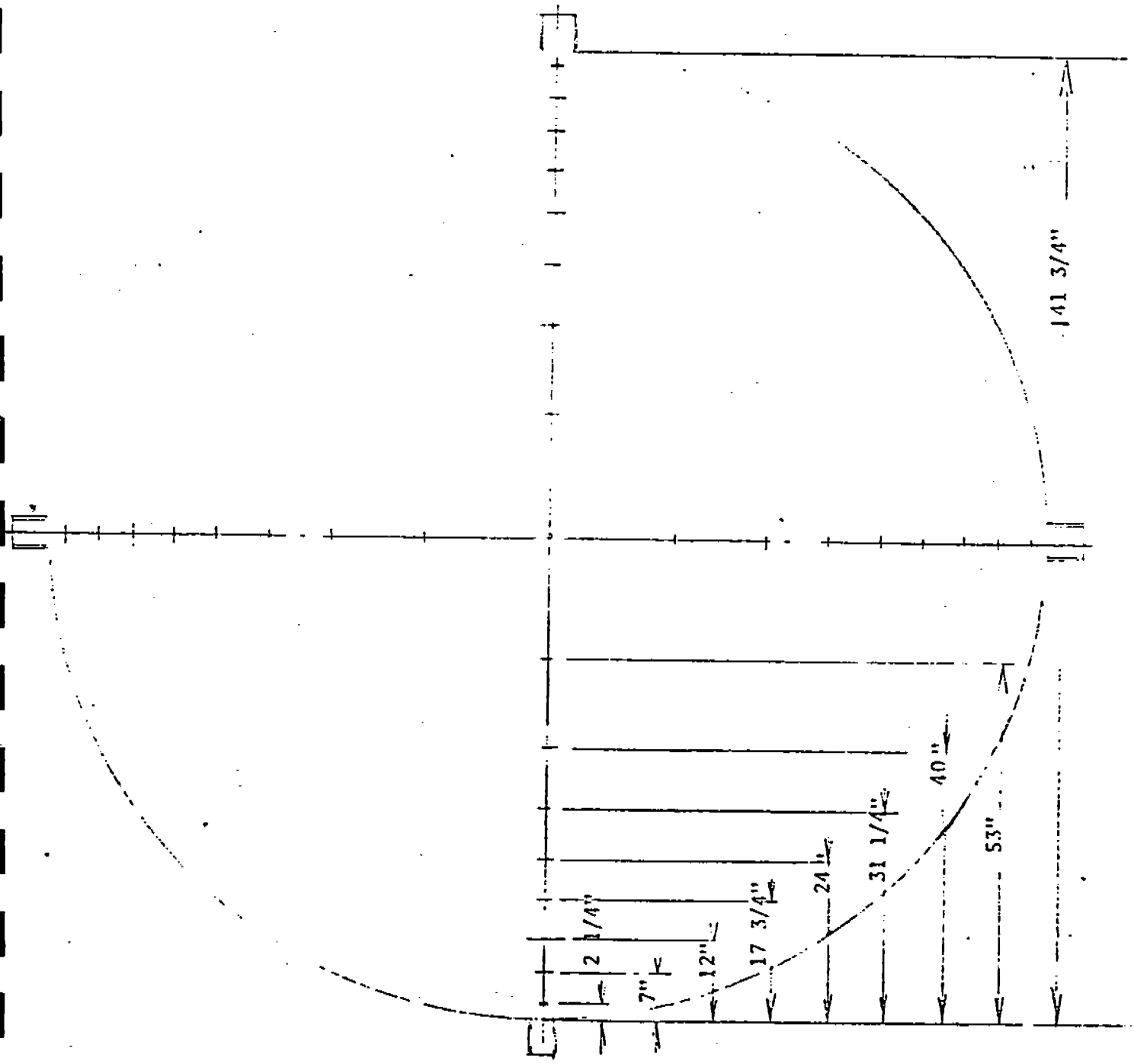
SUMMARY SCHEMATIC
GAS BALANCE
Units: Lb/Min.



GREENCASTLE EMISSION SURVEY

KILN STACK

VELOCITY, PARTICULATE & SULFUR SAMPLING TRAVERSE

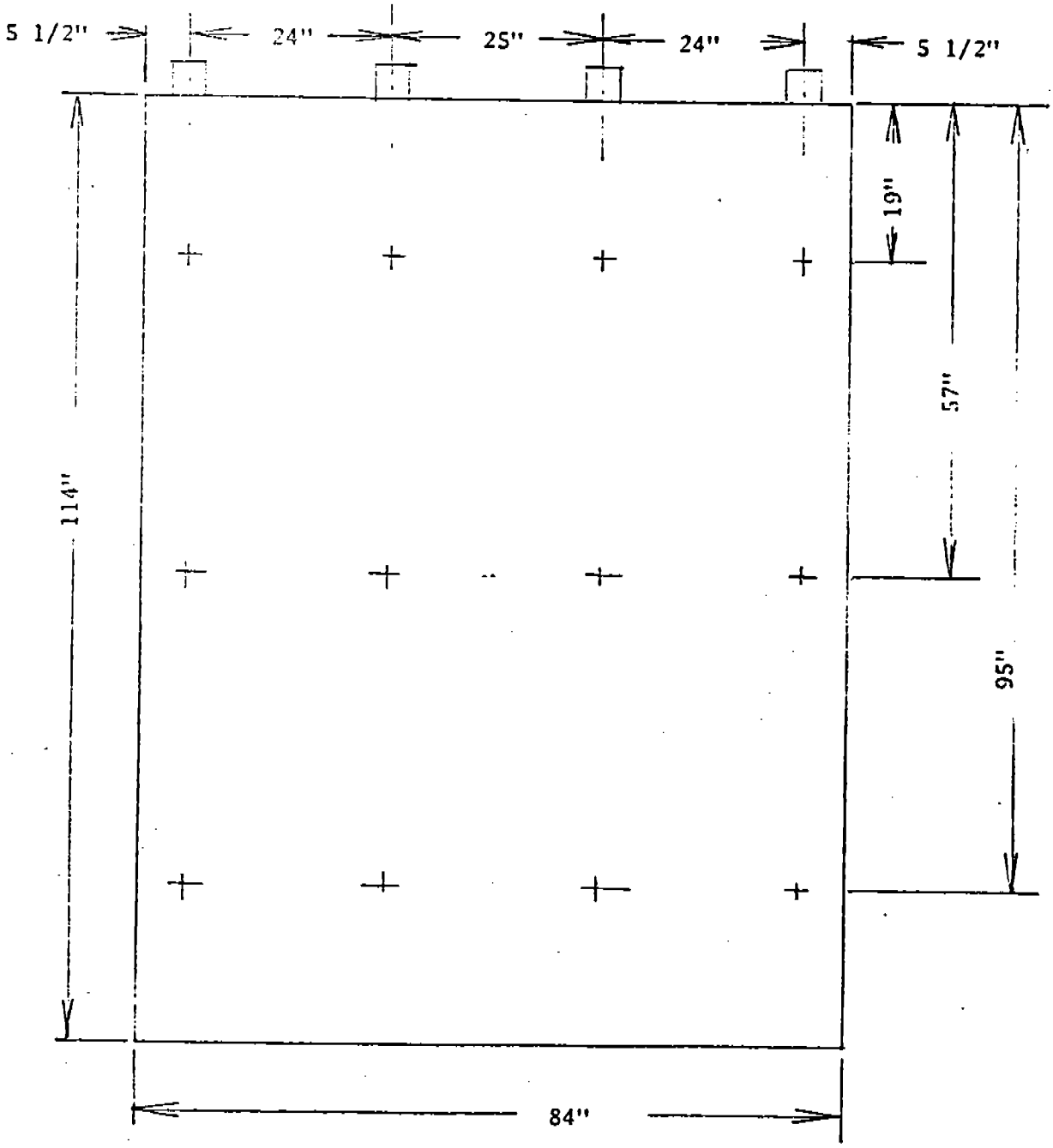


PLAN VIEW

* SAMPLING LOCATIONS

CROSS SECTIONAL AREA 10.5 Sq.Ft.

GREENCASTLE PRECIPITATOR
WEST SIDE ENTRANCE DUCT
SOUTH HALF
VELOCITY & SAMPLING TRAVERSE



PLAN VIEW

SAMPLE POINT LOCATION
CROSS SECTIONAL AREA 66.5 Sq.Ft.

FORM 407 REV. 40

PITTSBURGH TESTING LABORATORY

ESTABLISHED 1881
850 POPLAR STREET, PITTSBURGH, PA. 15220

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PITTSBURGH, PA. 15

AREA CODE 412 TELEPHONE 922-4000

LABORATORY No. 776358

CLIENT'S No.

ORDER No. PG-6218

REPORT

June 24, 1977

Analysis of: COAL

Marked: "Green Castle - Coal sample - May 77"

Submitted by: Lone Star Industries, Inc.

Reported to: Lone Star Industries, Inc.
P. O. Box 2148
Houston, Texas 77001

	As Received	Dry Basis
Carbon	-	69.33%
Hydrogen	-	4.88%
Oxygen	-	8.29%
Nitrogen	-	1.72%
Sulfur	-	2.33%
Ash	12.84 %	13.45%
Moisture	4.55 %	None
BTU Per Pound	11,947	12,517

PITTSBURGH TESTING LABORATORY

Robert J. King
Manager, Chemical Department

3 - Client
Attn: Clyde W. Moore

pd

SO_x (B.o.B)

~~PARTICULATE~~ FIELD DATA

57°F W.B.

Run No. 2
Location STACK
Date 5/8/77
Operator D.V.V.

Amb. Temp. °F 72°F D.B.
Bar. Press. "Hg. 29.39"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 4'
Inp. Nos. 5 → 8
Sample Box No. SO_x
f = .69

Heater Box Setting ____

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:53	309.18	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A -1	:59	310.83	.12	.34	.14	.16	65	67	3.0	202	71	303	309	
2	10:05	312.73	.23	.48	.24	.21	65	67	3.5	244	71	265	325	
3	:11	314.82	.28	.53	.28	.27	65	68	4.0	264	69	256	339	
4	:17	317.03	.30	.55	.32	.30	66	69	4.0	204	65	245	338	
5	:23	319.38	.35	.59	.37	.33	66	70	4.5	227	63	218	336	
6	:29	321.85	.37	.61	.39	.37	66	70	5.0	248	65	321	336	
7	:35	324.29	.35	.59	.37	.35	66	71	5.0	251	68	396	346	
8	:41	326.83	.35	.59	.37	.39	66	71	5.5	225	67	413	334	
B -1	11:03/09	328.38	.12	.34	.14	.15	67	68	3.0	140	62	124	320	
2	:15	330.23	.19	.43	.20	.21	67	69	3.5	234	64	189	323	
3	:21	332.18	.24	.50	.25	.23	67	69	4.0	209	64	210	331	
4	:27	334.25	.27	.52	.28	.25	68	71	4.0	153	64	220	333	
5	:33	336.43	.28	.53	.28	.28	68	71	5.0	227	65	241	336	
6	:39	338.79	.31	.55	.32	.33	68	72	5.0	205	66	258	340	
7	:45	341.04	.33	.57	.33	.30	68	72	5.5	189	67	321	345	
8	:51	343.49	.33	.57	.33	.37	68	72	5.5	144	67	401	338	
C -1	12:27/23	345.20	.17	.41	.17	.17	67	69	3.5	121	71	185	294	
2	:39	346.97	.31	.55	.32	.19	68	69	5.0	209	71	266	328	
3	:45	349.21	.30	.55	.32	.30	68	70	6.0	227	69	278	335	
4	:51	351.73	.35	.59	.37	.39	69	71	7.0	241	72	249	336	
5	:57	354.10	.37	.61	.39	.33	69	72	7.0	205	71	324	341	
6	13:03	356.51	.38	.61	.39	.35	68	72	7.5	187	72	385	345	
7	:09	358.83	.35	.59	.32	.32	69	72	8.0	141	73	378	339	
8	:15	361.08	.35	.59	.32	.30	69	73	8.5	214	73	345	338	
TOTAL				12.79		6.85	1613	1685					7990	
AVERAGE				0.53		.28	67	70					333	

STATIC PRESSURE = — .53

CORRECTED SAMPLE VOLUME = (528) Meter Volume 51.90 Ft.³ X Dry Meter Calibration Factor 1.021 = (793) 52.99 Ft.³

SOx

RUN NO. 2

~~PARTICULATE~~ & WATER CATCH

IMPINGER NO. 5	Final Weight 875.23 Initial Weight 603.72 Increase	WATER WEIGHT GAIN	IMPINGER 1 271.51
			IMPINGER 2 87.98
IMPINGER NO. 6	Final Weight 679.36 Initial Weight 591.38 Increase		IMPINGER 3 14.09
			IMPINGER 4 2.26
IMPINGER NO. 7	Final Weight 580.33 Initial Weight 566.24 Increase		TOTAL 375.84
			ORSAT
IMPINGER NO. 8	Final Weight 882.24 Initial Weight 879.98 Increase		CO_2 22.0
			O_2 8.0
FILTER NO.	Final Weight Initial Weight Part. Catch		CO —
			N_2 70.0

SOLID WEIGHT GAIN

BEAKER NO.	Final Weight Initial Weight Increase		BEAKER 1
			BEAKER 2
BEAKER NO.	Final Weight Initial Weight Increase		BEAKER 3
			BEAKER 4
			TOTAL
BEAKER NO.	Final Weight Initial Weight Increase		
BEAKER NO. PROBE WASH	Final Weight Initial Weight Increase		

Moisture Content: Sample Vol. 52.99 ft.^{3} x $\frac{(530)\ 460 + 70}{460 + \text{Meter Temp.}\ (528)}$ X 28.3 L/ft.^{3} = 1505 L Dry Gas

Water Weight $\frac{375.84 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 503 L H_2O Vapor

Total = 2008 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{503 \text{ L}}{2008 \text{ L}}$ x 100 = 25 %

(49B)

SOx ~~PARTICULATE~~ FIELD DATA

Run No. 4
Location STACK
Date 5/9/77
Operator D.V.V.

Amb. Temp. °F 45°F W.B. 53°F D.B.
Bar. Press. "Hg. 29.46"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In 1/4"
Probe Length 4'
Inp. Nos. 13 → 16
Sample Box No. SOx
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:23	361.37	ΔP	$\sqrt{\Delta P}$	Desired	Actual	Inlet	Outlet						
A - 1	:29	363.07	.16	.40	.16	.17	60	62	3.0	169	33	160	331	
2	:35	364.93	.25	.50	.25	.21	60	64	3.5	212	34	188	332	
3	:41	367.04	.31	.55	.32	.27	61	67	6.5	249	35	198	335	
4	:47	369.19	.36	.60	.37	.28	61	69	8.0	187	35	220	334	
5	:53	371.55	.36	.60	.37	.33	63	70	9.0	212	38	256	337	
6	:59	373.90	.38	.61	.39	.34	63	70	10.0	248	41	318	333	
7	10:05	376.18	.36	.60	.37	.32	64	71	11.0	185	45	385	337	
8	:11	378.44	.36	.60	.37	.30	66	72	12.0	99	55	405	335	
B - 1	10:32/38	380.12	.11	.33	.12	.17	68	72	6.0	113	38	189	308	
2	:44	381.85	.18	.42	.18	.19	67	73	10.0	240	42	203	324	
3	:50	383.84	.25	.50	.25	.24	68	73	11.0	195	43	253	332	
4	:56	386.03	.31	.55	.32	.28	70	75	11.5	163	45	302	333	
5	11:02	388.25	.31	.55	.32	.30	71	78	12.0	214	45	345	332	
6	:08	390.48	.33	.57	.33	.30	71	78	13.0	243	48	301	338	
7	:14	392.59	.31	.55	.32	.27	71	78	14.0	198	49	240	335	
8	:20	394.62	.31	.55	.32	.26	72	79	14.5	213	52	251	336	
C - 1	11:35/41	396.01	.15	.39	.16	.12	71	78	13.5	115	50	152	324	
2	:47	397.68	.22	.47	.23	.17	72	79	15.0	168	51	174	329	
3	:53	400.52	.31	.55	.32	.50	72	79	14.5	214	51	185	331	
4	:59	403.19	.33	.57	.33	.43	73	79	8.0	259	53	243	332	
5	12:05	405.57	.35	.59	.37	.33	74	80	7.5	219	59	268	331	
6	:11	408.07	.35	.59	.37	.37	74	80	8.0	198	61	303	333	
7	:17	410.30	.34	.58	.35	.30	75	81	9.0	152	63	310	332	
8	:23	412.60	.33	.57	.33	.32	76	81	9.5	168	66	322	332	
TOTAL				12.79		6.77	1643	1788					7956	
AVERAGE				.53		0.28	68	74					331	

STATIC PRESSURE = -.64 " H_2O

CORRECTED SAMPLE VOLUME = (531) Meter Volume 51.23 Ft.³ X Dry Meter Calibration Factor (791) 1.021 = 52.30 Ft.³

RUN NO. 4

PARTICULATE & WATER CATCH

Sao

IMPINGER NO. 13	Final Weight 823.34 Initial Weight 627.64 Increase	WATER WEIGHT GAIN	IMPINGER 1 195.7
			IMPINGER 2 27.71
IMPINGER NO. 14	Final Weight 741.35 Initial Weight 713.64 Increase		IMPINGER 3 43.54
			IMPINGER 4 130.39
IMPINGER NO. 15	Final Weight 744.08 Initial Weight 700.54 Increase		TOTAL 397.34
			ORSAT
IMPINGER NO. 16	Final Weight 915.31 Initial Weight 784.92 Increase		CO_2 21.0
			O_2 7.6
FILTER NO. _____	Final Weight _____ Initial Weight Part. Catch _____		CO —
			N_2 71.4

SOLID WEIGHT GAIN

BEAKER NO. _____	Final Weight _____ Initial Weight Increase _____		BEAKER 1 _____
			BEAKER 2 _____
BEAKER NO. _____	Final Weight _____ Initial Weight Increase _____		BEAKER 3 _____
			BEAKER 4 _____
			TOTAL _____
BEAKER NO. _____	Final Weight _____ Initial Weight Increase _____		
BEAKER NO. _____ PROBE WASH	Final Weight _____ Initial Weight Increase _____		

Moisture Content: Sample Vol. 52.30 ft.^{3} x $\frac{(530)\ 460 + 70}{460 + \text{Meter Temp.}\ (531)}$ X 28.3 L/ft.^{3} = 1477 L Dry Gas

Water Weight $\frac{397.34 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 532 L H_2O Vapor

Total = 2009 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{532 \text{ L}}{2009 \text{ L}}$ x 100 = 26 %

SOx

~~PARTICULATE~~ FIELD DATA

Run No. 6
Location STACK
Date 5/10/77
Operator D.V.V

Amb. Temp. °F 48 °F W.B. 59 °F D.B.
Bar. Press. "Hg. 29.48"
Assumed Moist 25%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 41
Inp. Nos. 21 → 24
Sample Box No. SOx
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:14	412.89	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A-1	:20	414.74	.13	.36	.14	.21	62	68	4.5	146	45	131	314	
2	:26	416.47	.19	.43	.20	.19	62	69	4.0	151	41	127	326	
3	:32	418.38	.26	.51	.27	.23	66	70	4.5	185	45	125	334	
4	:38	420.44	.30	.55	.32	.25	67	72	6.0	173	44	115	338	
5	:44	422.65	.36	.60	.37	.30	70	75	7.5	284	46	135	339	
6	:50	424.86	.35	.59	.37	.30	70	76	8.5	225	50	185	340	
7	:56	427.01	.35	.59	.37	.29	71	76	8.5	188	52	301	339	
8	10:02	429.13	.33	.57	.33	.27	71	78	9.0	158	55	330	339	
B-1	10:12/18	430.62	.11	.33	.12	.14	72	77	7.5	150	48	136	322	
2	:24	432.24	.18	.42	.18	.18	73	80	8.0	282	50	113	325	
3	:30	434.08	.22	.47	.23	.20	75	80	10.0	235	51	120	335	
4	:36	436.09	.28	.53	.28	.24	76	81	10.0	180	52	125	336	
5	:42	438.26	.30	.55	.32	.28	76	81	10.0	141	55	144	338	
6	:48	440.47	.32	.56	.33	.30	76	82	10.0	185	59	191	339	
7	:54	442.58	.30	.55	.32	.27	77	82	10.0	281	56	242	339	
8	11:00	444.68	.30	.55	.32	.27	78	83	10.5	240	58	256	337	
C-1	11:15/21	445.93	.14	.37	.15	.15	78	81	10.0	190	50	105	325	
2	:27	447.65	.23	.48	.24	.17	75	79	12.5	275	61	113	331	
3	:33	449.51	.23	.48	.24	.21	78	81	14.0	231	62	122	338	
4	:39	451.42	.30	.55	.32	.23	77	80	14.5	179	65	125	338	
5	:45	453.34	.33	.57	.33	.23	78	81	14.5	145	59	132	340	
6	:51	455.23	.35	.59	.37	.21	78	81	15.0	182	58	188	338	
7	:57	457.04	.30	.55	.32	.20	78	82	15.0	155	62	245	341	
8	12:03	458.77	.33	.57	.33	.19	79	83	15.0	150	61	252	339	
TOTAL				12.32		5.51	1763	1878					8030	
AVERAGE				.51		.23	73	78					334	

STATIC PRESSURE = -0.61

CORRECTED SAMPLE VOLUME = (535) Meter Volume 45.88 Ft.^{3} X Dry Meter Calibration Factor 1.021 = (794) 46.84 Ft.^{3}

RUN NO. 6 Sac

PARTICULATE & WATER CATCH

IMPINGER NO. 21	Final Weight 782.33 Initial Weight 636.63 Increase	WATER WEIGHT GAIN	IMPINGER 1 145.70
			IMPINGER 2 89.77
IMPINGER NO. 22	Final Weight 785.51 Initial Weight Increase 695.24		IMPINGER 3 88.27
			IMPINGER 4 80.93
IMPINGER NO. 23	Final Weight 771.56 Initial Weight Increase 683.29		TOTAL 404.67
			ORSAT
IMPINGER NO. 24	Final Weight 922.14 Initial Weight Increase 841.21		CO_2 26.0
			O_2 6.2
FILTER NO. _____	Final Weight _____ Initial Weight Part. Catch _____		CO —
			N_2 67.8

SOLID WEIGHT GAIN

BEAKER NO. _____	Final Weight _____ Initial Weight Increase _____	BEAKER 1 _____
		BEAKER 2 _____
BEAKER NO. _____	Final Weight _____ Initial Weight Increase _____	BEAKER 3 _____
		BEAKER 4 _____
		TOTAL _____
BEAKER NO. _____	Final Weight _____ Initial Weight Increase _____	
BEAKER NO. _____ PROBE WASH	Final Weight _____ Initial Weight Increase _____	

Moisture Content: Sample Vol. 46.84 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (535) X 28.3 L/ft.^{3} = 1313 L Dry Gas

Water Weight $\frac{404.67 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 542 L H_2O Vapor

Total = 1855 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{542 \text{ L}}{1855 \text{ L}}$ x 100 = 29 %

SOx (SHIRLEY)

~~PARTICULATE~~ FIELD DATA

Run No. 22
Location STACK
Date 6/20/77
Operator DVV

Amb. Temp. °F 86°F(DB) 73°F(WB)
Bar. Press. "Hg. 29.26"Hg
Assumed Moist 30%
Test Periods 144 MIN

Probe Tip Dia., In 1/4"
Probe Length 4'
Inp. Nos. 85 → 88
Sample Box No. SOx
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	11:01	529.31	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:07	531.00	.20	.45	.34	.27	69	71	3.0	77	67	808	303	
2	:13	532.72	.28	.53	.47	.27	69	71	3.5	79	68	104	311	
3	:19	534.86	.38	.61	.65	.44	69	71	4.0	79	67	102	312	
4	:25	537.10	.38	.61	.65	.50	69	72	5.0	83	66	124	312	
5	:31	539.28	.40	.63	.68	.47	69	73	5.5	83	66	213	312	
6	:37	541.49	.40	.63	.68	.50	69	74	6.5	83	66	287	311	
7	:43	543.63	.40	.63	.68	.44	69	75	7.0	83	69	284	310	
8	:49	545.78	.40	.63	.68	.47	70	75	7.0	88	74	251	311	
B - 1	12:06/12	547.55	.20	.45	.34	.30	72	74	4.0	79	67	104	301	
2	:18	549.60	.28	.53	.48	.42	71	74	5.0	79	68	99	304	
3	:24	552.00	.32	.56	.56	.60	71	75	6.0	81	69	100	309	
4	:30	554.08	.38	.61	.65	.42	72	76	6.0	84	70	115	309	
5	:36	556.39	.40	.63	.68	.53	72	77	7.0	86	71	175	308	
6	:42	558.56	.40	.63	.68	.47	73	78	7.5	88	73	223	310	
7	:48	560.61	.40	.63	.68	.42	74	79	8.0	92	80	252	309	
8	:54	562.64	.40	.63	.68	.42	76	80	8.5	96	78	265	312	
C - 1	13:08/14	563.74	.15	.39	.25	.11	77	78	9.5	93	74	118	300	
2	:20	565.39	.23	.48	.39	.25	75	77	12.5	98	74	105	302	
3	:26	567.21	.32	.56	.56	.31	78	81	13.5	171	75	198	312	
4	:32	569.08	.35	.59	.62	.34	76	79	14.0	98	75	125	308	
5	:38	570.04	.40	.63	.68	.37	77	81	14.5	94	76	174	308	
6	:44	572.98	.40	.63	.68	.37	76	81	14.5	104	78	245	305	
7	:50	574.95	.40	.63	.68	.40	76	81	15.0	100	78	245	306	
8	:56	576.92	.40	.63	.68	.40	77	83	15.0	100	78	265	307	
TOTAL				13.93		9.49	1746	1836					7392	
AVERAGE				0.58		0.39	73	76					308	

(535) (768)

STATIC PRESSURE = − 0.60" H_2O

CORRECTED SAMPLE VOLUME = 47.61 Ft.³ (Meter Volume) X 1.034 (Dry Meter Calibration Factor) = 49.23 Ft.³

SO_x

RUN NO. 22

PARTICULATE & WATER CATCH

IMPINGER NO. 85	Final Weight 812.48 Initial Weight 602.00 Increase	WATER WEIGHT GAIN	IMPINGER 1 210.48
			IMPINGER 2 151.15
IMPINGER NO. 86	Final Weight 740.13 Initial Weight 588.98 Increase		IMPINGER 3 -42.58
			IMPINGER 4 72.73
IMPINGER NO. 87	Final Weight 535.86 Initial Weight 578.44 Increase		TOTAL 391.78
			ORSAT
IMPINGER NO. 88	Final Weight 886.52 Initial Weight 813.83 Increase		CO_2 26.5
			O_2 6.4
FILTER NO.	Final Weight Initial Weight Part. Catch		CO 0.03
			N_2 67.1

SOLID WEIGHT GAIN

BEAKER NO.	Final Weight Initial Weight Increase	BEAKER 1
		BEAKER 2
BEAKER NO.	Final Weight Initial Weight Increase	BEAKER 3
		BEAKER 4
		TOTAL
BEAKER NO.	Final Weight Initial Weight Increase	
BEAKER NO. PROBE WASH	Final Weight Initial Weight Increase	

Moisture Content: Sample Vol. 49.23 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (535) X 28.3 L/ft.^{3} = 1380 L Dry Gas

Water Weight $\frac{391.78 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 524 L H_2O Vapor

Total = 1904 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{524 \text{ L}}{1904 \text{ L}}$ x 100 = 27.5%

SO$_x$ (STEVE)

~~PARTICULATE~~ FIELD DATA

Run No. 24
Location STACK
Date 6/21/77
Operator DVV

Amb. Temp. °F 68°F (DB) 62°F (WB)
Bar. Press. "Hg. 29.44" Hg
Assumed Moist 30%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 4'
Inp. Nos. 93 → 96
Sample Box No. SOx
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O		Orifice ΔH In. H_2O		Dry Gas Temp. °F		Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:39	577.73	ΔP	√ΔP	Desired	Actual	Inlet	Outlet						
A - 1	:45	579.36	.20	.45	.34	.25	65	68	3.0	60	62	206	303	
2	:51	581.21	.31	.55	.53	.34	67	68	4.0	114	67	118	312	
3	:57	583.18	.38	.61	.65	.40	65	68	5.0	183	67	121	321	
4	10:03	585.06	.40	.63	.68	.34	65	69	6.5	204	68	140	322	
5	:09	586.91	.38	.61	.65	.34	65	70	7.0	230	68	201	323	
6	:15	588.72	.40	.63	.68	.32	66	71	7.5	161	67	296	314	
7	:21	590.50	.40	.63	.68	.30	66	72	8.0	170	67	314	320	
8	:27	592.30	.40	.63	.68	.32	67	74	11.5	166	68	284	321	
B - 1	10:43/49	593.57	.20	.45	.34	.15	67	71	9.5	98	68	148	305	
2	:55	595.13	.28	.53	.47	.23	69	71	12.5	138	68	108	315	
3	11:01	596.73	.34	.58	.60	.23	69	72	13.0	139	68	126	323	
4	:07	598.34	.38	.61	.65	.25	69	73	13.0	91	68	102	325	
5	:13	599.70	.40	.63	.68	.16	70	73	13.0	102	74	97	318	
6	:19	601.20	.40	.63	.68	.21	70	73	13.0	114	74	109	322	
7	:25	602.66	.38	.61	.65	.20	70	73	13.0	182	75	113	324	
8	:31	604.12	.38	.61	.65	.20	70	73	13.0	225	76	116	326	
C - 1	11:45/51	605.35	.18	.42	.30	.14	70	71	11.0	89	60	105	301	
2	:57	606.87	.24	.49	.42	.21	69	71	13.5	110	61	115	307	
3	12:03	608.49	.28	.53	.47	.25	69	72	14.0	92	62	108	311	
4	:09	610.15	.34	.58	.60	.25	69	72	14.0	103	61	109	313	
5	:15	611.74	.34	.58	.60	.23	70	73	14.0	152	62	161	313	
6	:21	613.40	.38	.61	.65	.25	70	73	14.5	233	64	188	316	
7	:27	615.08	.38	.61	.65	.27	70	74	14.5	158	65	192	316	
8	:33	616.75	.38	.61	.65	.27	70	74	14.5	133	67	181	316	
TOTAL				13.82		6.11	1637	1719					7587	
AVERAGE				0.57		0.25	68	71					316	

STATIC PRESSURE = −0.65" H_2O CORRECTED SAMPLE VOLUME = (529) Meter Volume 39.02 Ft.^{3} X Dry Meter Calibration Factor (776) 1.034 = 40.34 Ft.^{3}

RUN NO. 24 SO_x

PARTICULATE & WATER CATCH

IMPINGER NO. 93	Final Weight 789.88 Initial Weight 576.95 Increase	WATER WEIGHT GAIN	IMPINGER 1 212.93
			IMPINGER 2 113.40
IMPINGER NO. 94	Final Weight 701.78 Initial Weight 588.38 Increase		IMPINGER 3 14.00
			IMPINGER 4 81.64
IMPINGER NO. 95	Final Weight 594.46 Initial Weight 580.46 Increase		TOTAL 421.97
			ORSAT
IMPINGER NO. 96	Final Weight 880.17 Initial Weight 798.53 Increase		CO_2 27.0
			O_2 5.0
FILTER NO.	Final Weight Initial Weight Part. Catch		CO —
			N_2 68.0

SOLID WEIGHT GAIN

BEAKER NO.	Final Weight Initial Weight Increase	BEAKER 1
		BEAKER 2
BEAKER NO.	Final Weight Initial Weight Increase	BEAKER 3
		BEAKER 4
		TOTAL
BEAKER NO.	Final Weight Initial Weight Increase	
BEAKER NO. PROBE WASH	Final Weight Initial Weight Increase	

Moisture Content: Sample Vol. 40.34 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530) (529) X 28.3 L/ft.^{3} = 1144 L Dry Gas

Water Weight $\frac{421.97 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{\text{L}}{\text{mol.}}$ = 565 L H_2O Vapor

Total = 1709 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{565 \text{ L}}{1709 \text{ L}}$ x 100 = 33.0 %

(GARY)

PARTICULATE FIELD DATA

Run No. 26
Location STACK
Date 6/22/77
Operator DVV

Amb. Temp. °F 67°F (DB & WB)
Bar. Press. "Hg. 29.35" Hg
Assumed Moist 30%
Test Periods 144 MIN
24 PTS @ 6 MIN EACH

Probe Tip Dia., In. 1/4"
Probe Length 4'
Inp. Nos. 101 → 104
Sample Box No. SOx
f = .69

Heater Box Setting

FILL IN ALL BLANKS
READ & RECORD AT THE START OF EACH TEST POINT

Point	Clock Time	Dry Gas Meter C.F.	Pitot In. H_2O ΔP	Pitot In. H_2O $\sqrt{\Delta P}$	Orifice ΔH In. H_2O Desired	Orifice ΔH In. H_2O Actual	Dry Gas Temp. °F Inlet	Dry Gas Temp. °F Outlet	Vac. In. Hg Gage	Box Temp. °F	Imp. Temp. °F	Probe Temp. °F	Stack Temp. °F	Stack Press. In. H_2O
	9:20	617.10												
A - 1	:26	618.50	.15	.39	.25	.18	72	74	8.0	53	52	148	301	
2	:32	620.13	.23	.48	.39	.25	70	72	7.0	56	52	157	307	
3	:38	622.05	.28	.53	.48	.36	70	72	7.0	61	51	160	311	
4	:44	624.02	.35	.59	.52	.39	70	73	7.0	70	50	162	311	
5	:50	626.14	.35	.59	.52	.45	69	73	7.5	73	52	171	311	
6	:56	628.32	.38	.61	.65	.48	69	74	7.5	71	51	169	311	
7	10:02	630.60	.40	.63	.68	.53	69	75	6.5	72	51	175	310	
8	:08	632.88	.40	.63	.68	.53	69	76	6.5	71	53	183	310	
B - 1	10:23/29	634.49	.15	.39	.25	.25	70	73	4.0	69	50	150	301	
2	:35	636.57	.32	.56	.56	.43	70	73	5.0	74	50	158	305	
3	:41	638.87	.35	.59	.62	.53	71	74	5.0	74	50	159	306	
4	:47	641.24	.40	.63	.68	.57	70	75	5.0	74	52	162	306	
5	:53	643.54	.40	.63	.68	.53	70	75	5.5	75	53	168	306	
6	:59	645.87	.38	.61	.65	.57	70	76	5.5	78	54	244	306	
7	11:05	648.06	.40	.63	.68	.49	71	77	5.5	78	56	249	305	
8	:11	650.06	.40	.63	.68	.40	71	76	8.0	79	56	235	305	
C - 1	11:38/44	651.37	.16	.40	.25	.16	72	73	11.0	75	46	186	298	
2	:50	653.55	.32	.56	.56	.47	71	72	15.5	74	46	168	300	
3	:56	655.87	.35	.59	.62	.54	71	73	15.0	78	46	170	303	
4	12:02	658.45	.38	.61	.65	.68	71	75	15.0	82	46	182	304	
5	:08	660.78	.40	.63	.68	.56	71	76	10.0	79	47	222	303	
6	:14	663.13	.40	.63	.68	.56	71	76	9.0	79	47	281	302	
7	:20	665.49	.40	.63	.68	.56	71	77	9.0	84	47	295	302	
8	:26	667.69	.38	.61	.65	.47	71	77	9.0	89	47	283	303	
TOTAL				13.78		10.94	1690	1787					7327	
AVERAGE				0.57		0.45	70	74					305	

STATIC PRESSURE = - 0.68" H_2O

CORRECTED SAMPLE VOLUME = 50.59 Ft.³ (532) Meter Volume X 1.034 Dry Meter Calibration Factor = 52.31 Ft.³ (765)

SO_x

RUN NO. 26

PARTICULATE & WATER CATCH

IMPINGER NO. 101	Final Weight 929.94 Initial Weight 564.38 Increase	WATER WEIGHT GAIN	IMPINGER 1 365.56
			IMPINGER 2 176.05
IMPINGER NO. 102	Final Weight 740.54 Initial Weight 564.49 Increase		IMPINGER 3 −38.92
			IMPINGER 4 59.35
IMPINGER NO. 103	Final Weight 548.13 Initial Weight 587.05 Increase		TOTAL 562.04
			ORSAT
IMPINGER NO. 104	Final Weight 860.54 Initial Weight 801.19 Increase		CO_2 26.0
			O_2 6.2
FILTER NO.	Final Weight Initial Weight Part. Catch		CO —
			N_2 67.8

SOLID WEIGHT GAIN

BEAKER NO.	Final Weight Initial Weight Increase	BEAKER 1
		BEAKER 2
BEAKER NO.	Final Weight Initial Weight Increase	BEAKER 3
		BEAKER 4
		TOTAL
BEAKER NO.	Final Weight Initial Weight Increase	
BEAKER NO. PROBE WASH	Final Weight Initial Weight Increase	

Moisture Content: Sample Vol. 52.31 ft.^{3} x $\frac{460 + 70}{460 + \text{Meter Temp.}}$ (530 / 532) X 28.3 L/ft.^{3} = 1475 L Dry Gas

Water Weight $\frac{562.04 \text{ gm.}}{18 \frac{\text{gm.}}{\text{mol.}}}$ x 24.1 $\frac{L}{\text{mol.}}$ = 752 L H_2O Vapor

Total = 2227 L

$\frac{H_2O \text{ Vol.}}{\text{Total}}$ $\frac{752 \text{ L}}{2227 \text{ L}}$ x 100 = 33.7%

Interoffice Memo

LONE STAR INDUSTRIES, INC.

Originating Office: C&CM Group - Technical

Date: August 9, 1977

TO: C. D. Coppinger

FROM: G. F. Messinger

SUBJECT: Sulfur and Particulate Stack Emissions Testing
Greencastle Plant

Enclosed is one (1) copy of each of Bill Hurst's reports on the Sulfur Dioxide Emission Test and the Particulate Emission Test conducted at the Greencastle Plant May 8 through June 22, 1977.

The particulate tests look very good from the standpoint of the Indiana code, which is an extremely lenient code. Compared to Federal E.P.A. codes, the results are borderline. I have attached a tabulation comparing the average results of runs 1, 3, and 5 and of runs 21, 23, and 25 against the respective codes. On an individual run basis, test runs 3, (13 - 14), (19 - 20), 21 and 25 actually exceed the E.P.A. codes.

We would suggest that the reports be treated as internal unless specifically requested by jurisdictional authorities and in this event, we would appreciate the opportunity to review the request before submission.

Please assign CTR numbers to the reports and advise for our file references.

G. F. Messinger

G. F. Messinger

GFM/jml

cc: W. R. Payne, Jr.
C. D. Fehnel/M. M. Reid
C. W. Moore
W. W. Hurst

Interoffice Memo

LONE STAR INDUSTRIES, INC.

Originating Office: C & CM

Date: July 11, 1977

TO: Mike Reid

FROM: Stewart S. Fritts

SUBJECT: Greencastle Plant - Particulate and Sulphur Study
W. W. Hurst Report

A preliminary review of the two reports submitted by Bill Hurst per his transmittal of July 7, 1977 to C. D. Fehnel raises some pertinent questions as follows:

1. Fuel Analysis by Pittsburg Testing Laboratory shows BTU value on an "As Received " basis - which is fine. However, I would have expected the Ash and the Moisture Content of the Sample would have been determined separately and likewise reported. I took the liberty of contacting PPL and found that they had run the Moisture and the Ash but failed to record it on the lab sheet. The values are 4.55 and 12.84 respectively. It would have appeared to me that Bill should not have accepted the PPL report without making the inquiry. All that it took was a telephone call to the Pittsburg Labs. I have inserted the proper values in the PPL Report.

2. Fuel Consumption Calculation - Molal Basis pg 13 shows the Coal Mill Feed on an "As Used" basis for each of the three sets of runs. These appear to be correctly identified. However, on pg 10 he shows the analysis for the three sets of runs on an "As Fed" amd on an "As Used" basis and then proceeds to make his calculations and material balances using the "As Fed" base. On pg 15 he attempts to differentiate between Free Water in Coal "As Used" and Free Water in Coal "As Fed" but I fail to appreciate this approach because all of the water that enters the kiln from the coal comes from the coal feeder and this would represent the total water in the coal and not just the "Free Water". This moisture varies from 11.20 % to 12.50 % while the "As Fed" moisture which is really the water in the pulverized coal as it enters the kiln burner pipe at the hood (and after it has been partially dried) varies from 5.16 % to 6.09 %. On pg . 14 he reports Distribution of Combustion and Products on the basis of "As Received", however, I believe we means the word "As Used" since he takes the analysis from pg. 13. Perhaps his calculations are entirely valid but it would seem to me he is attempting to mix "Apples and Oranges" and coming up with "Sour Grapes" and I do not believe he intends to do that. We have been through this exercise before and I thought we had it all straightened out. Apparently not.

On the other hand I could hardlyaccept a Water Material balance of 78.72 % for Runs 1-5 and 82.78 % for Runs 21-25 as being realistically close ; but 97.58 % for Runs 7-20 is excellent.

3. Summary Schematic Gas Balances pgs. 34, 35 and 36 are fine presentations but they could be developed more realistically as shown per the attached fpr pg. 34- Raw Mix should not be tied into Infiltrated Air but should be shown as an independent addition to the kiln. The attached schematic would appear to be a great deal more realistic. You will note I have circled the values that require correction to coincide with the values outlined in the work sheets pgs. 15 thru 21.

4. In his discussion, Bill appears to be rather optimistic concerning the test results in relation to the Allowable per the Indiana Regulations. While his calculations are in line I would seriously question resting on our laurels in so far as EPA is concerned. As you know EPA limits emissions from the kiln at 0.3 lbs per hour per Ton of Kiln Feed per hour with Fuel excluded as a part of the kiln feed. This means the allowable would be 40.5 lbs/hr. for Runs 1 - 5; 37.8 lbs/hr for Runs 7 - 20 and 41.4 lbs/hr. for Runs 21-25. On the basis of the results reported we do not have much margin for error. In fact Test Runs 3, (13-14),(17-18), (19-20), 21 and 25 show emission values that are in excess of the Allowable EPA Regulations.

   To date EPA has not raised the issue concerning Cement Plant Regulations in the State of Indiana mainly because the cement manufacturers have recognized their obligation and took positive steps to come to grips with the situation. However, the present Indiana Regulation is so grossly out of line I feel confident in a show down we would have very little room for bargaining power. Therefore I do not believe we should flaunt our position at Greencastle. Reporting the facts is fine but making comparisons on the basis of unrealistic Allowables is another matter.

5. In reviewing the Sulphur Study, I note Bill refers to high (1450° F and 1600° F "back-end ")temperatures. I am not too sure what is meant by "back-end" conditions, If he means the temperature of the load just below the chain system then his reading is porbably correct - but he should have identified the position of the reading in the kiln system.

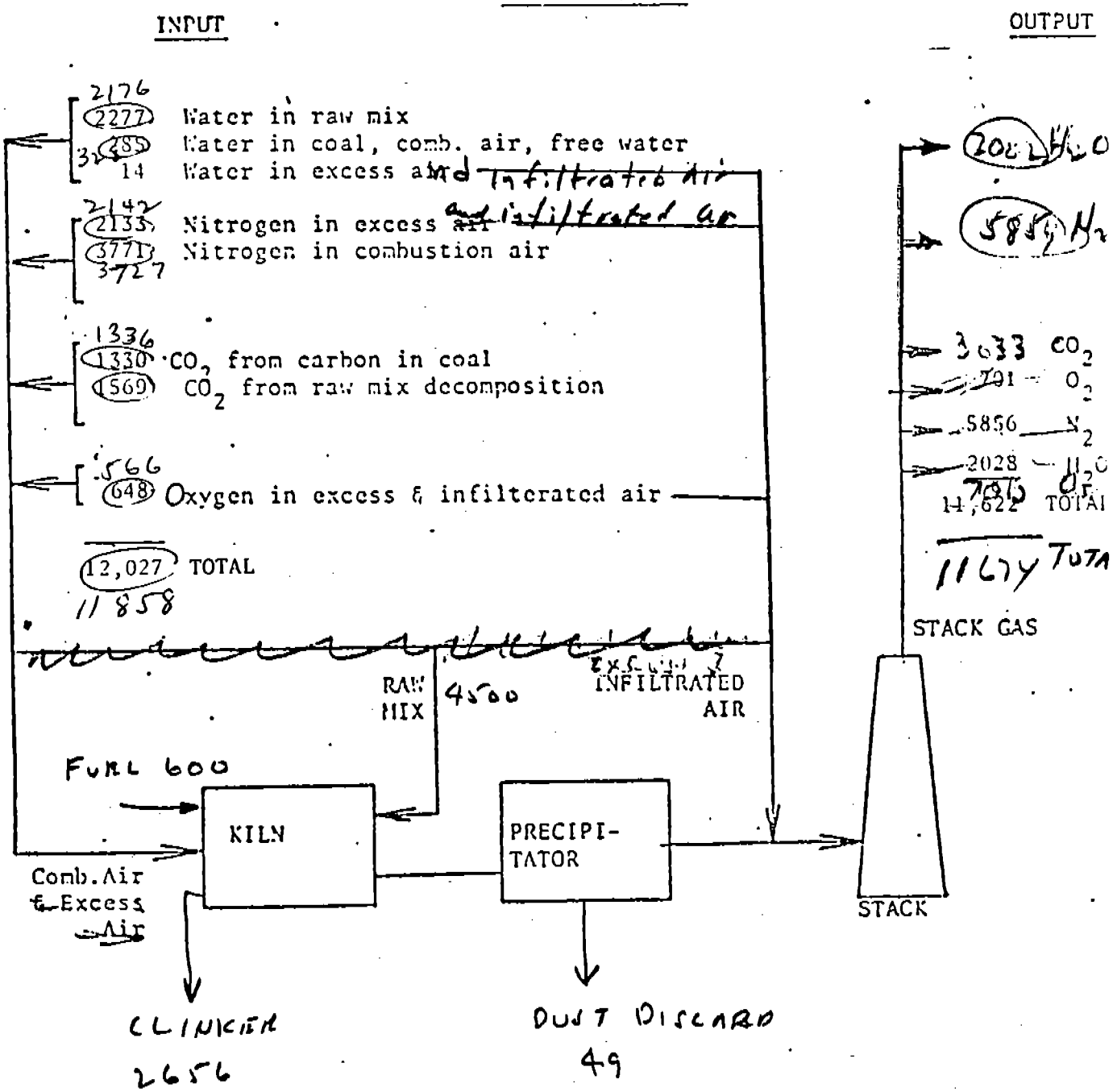
6. Bill's evaluation of the SOX versus NOX relation may require further study. As I see it. NOX development is basically a function of flame temperature and as such is limited to theavailable O_2 within the combustion zone of the kiln and the amount of excess air within the combustion space will have a significant influence on the development of NOX. Similarly the sulphur in the fuel and more especially the mineralized sulphur (Iron pyrites) will influence the avilability of the O_2 to form NOX after the SOX in the combustion zone has been satisfied. In all probability organic sulphur in the fuel will readily combine with O_2 to form SO_2 and perhaps some SO_3 if there is any catalysis present - which there is in the form of water vapor as well as minor trace elements in the fuel. In the case of sulphur in the raw kiln feed we have an entirely different relationship - especially in the long wet kiln. I am not too sure we have very much conversion of sulphur to SO_2 from sulphur in the raw mix especially if the sulphur is present as iron pyrites in which case the conversion from FeS_2 passes through the H_2S phase in combination with heat and water vapor as well as residual O_2 - if any is available - and it is highly questionable whether enough would be available to sustain an oxidizing atmosphere for the conversion of the sulphur in FeS_2 to SO_2. As you know the Orsat analysis is at best a very crude approximation of the actual gaseous condition in a Portland Cement kiln ex-

haust. It does serve a limited purpose, but - under today's enlightenment and the need for better energy conservation coupled with a refinement of the combustion process - we will require more sophisticated analytical equipment to properly delineate the factors that enter the calculations.

As an example, we consider the N_2 content of the exhaust gas as the difference between the CO_2 absorption by KOH solution plus the O_2 absorption by pyrogallic acid solution plus the CO absorption by the cupperous oxide solution - but we are never sure that these absorbed products are definite and singular. With the advent of the NOX and SOX syndrom our confidence level in the actual chemistry of the kiln exhaust gas is even more disturbing. We could be on the threshold of a major research program that may or may not be warranted on our part. Perhaps the PCA could get involved.

7. Bill's data relating to Orsat analysis is probably taken at the stack - although Table XI pg 12 of the sulphur report does not specifically so state . However, on pg 19 of the same report he refers to "V. Actual Kiln Exit Gas at Sampling Ports" but since the Sampling Ports are in the Stack then the Orsat Analysis should refer to Stack Sampling and not Kiln Exit Gas since the Stack Sampling is influenced by infiltration and Bill notes the infiltration in his calculations. On the other hand the amount of Excess Air shown at 34.8 percent on pg. 20 is hardly represenative because he is comparing Theoretical Moles from Combustion with Orsat analysis of the Stack Gases. Perhaps, I am not understanding his reasoning but on the face of it a 7.3 % O_2 represents a great deal more than 34.8 % Excess Air; and a rough calculation would indicate the value closer to 80 %.

Ken

RUNS 1 - 5

SUMMARY SCHEMATIC
GAS BALANCE
UNITS: Lb/Min.