
These are the source test reports for AP 42 section 11.17 Lime Manufacturing.
They are referenced in the database as a group, Lime Manufacturing source tests.

Commonwealth of Pennsylvania
Environmental Resources
July 24, 1991

Subject: Source Test Review

To: Data File
Bellefonte Lime Company
Spring Township, Centre County

From: William Schneider WS
Air Pollution Control Engineer
Division of Technical Services and Monitoring
Bureau of Air Quality Control

Through: Chief, Source Testing and Monitoring Section LBP

Bellefonte Lime Company operates the No. 5 rotary limestone kiln with a rated production capacity of approximately 19.5 tons per hour. Heat is supplied to the kiln through the combustion of pulverized bituminous coal in a burner located at the discharge end. Effluent from the feed end of the kiln is drawn through a Chemico S-F Venturi wet scrubber to a cyclonic separator. An induced draft fan draws material from the exit of the separator to a 60.5-inch stack approximately 60-feet above grade.

BCM Engineers, Inc. conducted three Method 5 particulate compliance tests of the exhaust stack on May 1-2, 1991, using "B" stone.

Run No. 1 may not be representative. A problem with the stone feed counter during the first 24 minutes of a 72 minute test may have led to an undercounting of the stone feed rate. The counter problem involved double measurement of the stone feed. To obtain an approximate stone feed rate for the first third of the test, Bellefonte Lime divided the elapsed stone counter reading by two. BCM speculates that a portion of the individual meter counts were single counts. An investigation of this sampling train operating data for all three runs shows that the meter box pump vacuum increased more during the first 24 minutes of Run No. 1 than during the first 24 minutes of Run Nos. 2 and 3. This seems to indicate that a higher particulate emission rate occurred during the first portion of Run No. 1. Therefore it is possible that a portion of the individual meter counts were actually single counts. This possible undercounting of the stone feed rate may have led to a lower than actual allowable particulate emission calculation and to a larger than maximum operating rate.

The second and third runs were acceptable to the Department.

The following data was extracted from the test report:

Run No.	Actual Particulate Emissions (lb/hr)	Allowable Particulate Emissions (lb/hr)
1	25.85	23.85*
2	23.45	23.51
3	23.37	23.82

*may be low

Run No.	Coal Feed Rate (ton/hr)	Store Feed Rate (ton/hr)	Lime Production Rate (ton/hr)
1	5.37	34.88*	18.31*
2	6.20	33.68	17.68
3	6.73	34.75	18.24
Rated Capacity	6.1	37.5	19.5

*may be low

cc: Mr. Brian J. Hammer - Hawk Run District
Permit File No. 14-309-033A
EPA/RSL
Reading File - Source Testing
Krishnan Ramamurthy - A & C

WS:taw

REPORT

TO

BELLEFONTE LIME COMPANY
BELLEFONTE, PENNSYLVANIA

FOR

COMPLIANCE PARTICULATE EMISSION DETERMINATION OF THE KILN NO. 5 SCRUBBER OUTLET STACK

MAY 1991

BCM PROJECT NO. 00-6066-10

PREPARED BY

STEVEN H. BROCK
ENGINEER

AND

ASHOK K. SONI, P.E.
VICE PRESIDENT

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BCM

Engineers, Planners, Scientists and Laboratory Services
One Plymouth Meeting • Plymouth Meeting, PA 19462 • Phone: (215) 825-3800

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1.0 INTRODUCTION

Bellefonte Lime Company (Bellefonte Lime) operates a lime kiln, designated as Kiln No. 5, at its facility in Bellefonte, Pennsylvania. Particulate emissions from the kiln are routed to a wet scrubber for control. BCM Engineers Inc. (BCM) was retained to determine the compliance status of the outlet stack with respect to the Pennsylvania Department of Environmental Resources (PADER) particulate emission regulations.

Three particulate test runs were performed at the outlet stack while processing "B" stone. The lime production rates during Run Nos. 1, 2, and 3 were 18.31, 17.68, and 18.24 tons per hour respectively.

The actual and allowable particulate emission rates determined from the three test runs are shown below:

Run No.	Actual Particulate Emissions (lb/hr)	Allowable Particulate Emissions (lb/hr)
1	25.85	23.85*
2	23.45	23.51
3	23.37	23.82
Average of Run Nos. 1, 2, & 3	24.22	23.73
Average of Run Nos. 2 & 3	23.41	23.67

* May be low due to the mechanical problems encountered with the stone feed counter.

Several mechanical problems were encountered with the stone feed counter during Run No. 1 which may have led to an under measurement of the lime production emission rate and therefore, a lower calculated allowable particulate emission rate. Therefore, Run No. 1 compliance emission determination is in question.

Test results show that the particulate emissions for Run Nos. 2 and 3 are below the allowable emission rates.

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TABLES

2.0 SCOPE AND OBJECTIVES

The scope of the project was outlined in BCM Proposal No. 12-8053-00 dated March 13, 1991. The objective of the sampling program was to determine the following parameters:

- Gas flow - acfm and scfm
- Gas temperature - °F
- Moisture - percent by volume
- Combustion gas analysis - percent by volume CO_2, O_2, and N_2 (by difference)
- Particulate emissions - grains/dscf and lb/hr

3.0 PROCEDURES

3.1 FIELD WORK

Field testing was conducted on May 1 and 2, 1991. The sampling team consisted of the following BCM personnel:

Philip C. Burg - Project Manager
Steven Brock - Engineer

Mr. John Bisch of Bellefonte Lime acted as liaison between BCM and Bellefonte Lime and ensured process operating conditions were suitable for testing.

Emission testing was conducted according to procedures as outlined in U.S. Environmental Protection Agency (EPA) Reference Methods 1 through 5 found in the Federal Register, Volume 42, Number 160. The testing procedures also met the PADER requirements as outlined in the Agency's Bureau of Air Quality Control, "Source Testing Manual." Descriptions of these methodologies can be found in Appendix A of this report.

3.2 ANALYTICAL METHODS

All samples generated during the sampling program were analyzed by Air Quality Services Inc., located in Pittsburgh, Pennsylvania. An outline of the analytical methodologies is contained in Appendix B. Laboratory data are also presented in Appendix B.

3.3 CALCULATIONS

A personal computer, programmed to accept input data in accordance with EPA calculation procedures, was used to perform all calculations. The reduced data appear on the computer input and output sheets which are presented in Appendix B. Appendix B also lists the equations used to determine the test results.

3.4 EQUIPMENT CALIBRATION

In accordance with accepted procedures published by the EPA, all gas velocity measuring equipment, gas volume metering equipment, and temperature measuring equipment had been calibrated within 60 days of the test program. Appendix C contains calibration data.

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4.0 TEST RESULTS

4.1 GAS FLOW RATE DATA

All gas flow rate data obtained during the three particulate test runs can be found in Table 1.

4.2 PARTICULATE EMISSION RESULTS

Particulate emission results of the three test runs are contained in Table 2. The allowable particulate emission rate, as calculated for each test run, is also contained in Table 2.

4.3 PRODUCTION DATA

Production data as determined for each of the three test runs is contained in Table 3.

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TABLE 1

GAS FLOW RATE DATA

Run No.	Gas Temperature (°F)	Moisture Content* (%)	Gas Velocity (ft/min)	Gas Flow Rate (acfm)	Gas Flow Rate (dscfm)
1	158	31.0	4,327	84,962	48,421
2	154	28.1	4,172	81,911	48,521
3	154	27.9	4,149	81,463	49,044
Avg.	155	29.0	4,216	82,779	48,662

* All moisture contents represent saturation values

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TABLE 2

PARTICULATE EMISSION RESULTS

Run No.	Gas Flow (dscfm)	Actual Particulate Emissions (gr/dscf)	Actual Particulate Emissions (lb/hr)	Allowable Particulate Emissions (lb/hr)
1	48,421	0.0623	25.85	23.85
2	48,521	0.0564	23.45	23.51
3	49,044	0.0556	23.37	23.82
Ave.	48,662	0.0581	24.22	23.73

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TABLE 3

PRODUCTION DATA

Run No.	Coal Feed Rate (ton/hr)	Stone Feed Rate (ton/hr)	Lime Production Rate (ton/hr)
1	5.37	34.88	18.31
2	6.20	33.68	17.68
3	6.73	34.75	18.24
Ave.	6.10	34.44	18.08

Notes: 1) Run No. 1 coal feed rate represents the average of the three feed rates determined at 0900, 1000, and 1100 hours
2) Stone type "B" was feed for all three runs

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5.0 DISCUSSION OF RESULTS

Test results, as contained in Table 2, show that the particulate emissions exceed the allowable emission rate for Run No. 1 by 8.4 percent. Difficulties, however, were encountered with the stone feed counter during one third of Run No. 1, which may have led to an under measurement of the lime production rate and, therefore, a lower calculated allowable particulate emission rate. Run No. 1 compliance emission determinations, therefore, are in question.

The stone feed counter problem was not noticed until sampling had continued for 24 minutes. At that time, the test was stopped and the problem was corrected. The remaining two thirds, or 48 minutes, of the test was then conducted. The actual stone feed rate for one-third of the test run, therefore, is in question. The counter problem involved double measurement of the stone feed. To obtain an approximate stone feed rate for the first third of the test, Bellefonte Lime divided the elapsed stone counter reading by two. It is possible, however, that a portion of the individual meter counts were actually single counts. Therefore, the stone feed rate may have been under measured and could not have been overmeasured.

Investigation of the sampling train operating data for all three runs (as contained on the field data sheets) shows that the meter box pump vacuum increased more during the first 24 minutes of Run No. 1 than during the first 24 minutes of Run Nos. 2 and 3. This seems to indicate that a higher particulate emission rate occurred during the first portion of Run No. 1. Since no problem with the scrubber was noted, it appear's that the apparent higher emission rate during this portion of Run No. 1 was due to a higher stone feed rate.

Test results show that particulate emissions for Run Nos. 2 and 3 are below the allowable emission rates by 0.26 percent and 1.9 percent, respectively.

APPENDIX A

FIELD SAMPLING PROGRAM

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APPENDIX A

FIELD SAMPLING PROGRAM

1.0 SAMPLING PROCEDURES

1.1 Test Station and Traverse Location

The internal diameter of the scrubber outlet stack was 60 inches. Two test ports were located in the same cross sectional plan 90 degree apart. The nearest downstream flow disturbance was located 44 feet, or 8.8 duct diameters, from the testing ports. The nearest upstream flow disturbance was the stack outlet and it was located 10 feet, or 2 duct diameters, from the testing ports. A total of 12 traverse points (6 per port) were utilized for the testing program.

1.2 Gas Flow and Temperature Determinations

The gas flow rate and temperature profiles were measured by conducting a simultaneous velocity and temperature traverse. Gas velocity heads were measured with a "S"-type pitot tube, which was connected to an inclined manometer. A Chromel-Alumel thermocouple connected to a potentiometer was used to determine the gas temperature.

1.3 Moisture Content

Moisture sampling was conducted employing the principles presented in EPA Method 4 and concurrently with particulate sampling. The parameters evaluated to determine the gas stream's moisture content were: sample gas volume, sample gas temperature, sample gas pressure, impinger moisture gain, and silica gel moisture gain. Some minor modifications were made to the Method 4 train to allow for concurrent sampling of particulate and moisture content. These modifications did not deviate from sampling principles.

Modifications, such as the substitution of a glass fiber filter for Pyrex wool as a filtering medium and the substitution of a calibrated orifice for a rotameter as a flow metering device, were incorporated.

1.4 Particulate Sampling

The sampling procedures and sampling equipment used were those outlined in Method 5 of the Federal Register, Volume 42, No. 160, August 18, 1977. This methodology also complied with PADER testing regulations.

The size of the nozzle required to maintain isokinetic sampling was calculated from the results of a previously completed velocity and temperature traverse. The sampling train used a glass-lined stainless steel probe, heated to 250°F by an internal heating element. A nozzle of the calculated size was attached to the end of the probe, which was inserted into the stack. A "S"-type pitot tube and a Chromel-Alumel thermocouple were clamped to the probe and were used to monitor the velocity head and temperature at the traverse points during the sampling period. Sampled gas passed through the nozzle and the probe to a glass fiber filter for the removal of the suspended particulates. The filter was housed in a heated chamber with the temperature maintained at 248°F ±25°F. From the filter, the stack gas passed to the impinger train. The first two impingers each contained 150 milliliters (ml) of deionized (DI) water. The third impinger contained no reagents and was a knockout impinger. The fourth impinger contained approximately 200 grams of coarse silica gel, which collected any moisture and/or vapors that had not been captured in the preceding impingers.

The second impinger was a 500-ml Greenburg-Smith impinger, while the first, third, and fourth impingers were 500-ml impingers of the Greenburg-Smith design, modified by replacing the tip with a 1/2-inch inside diameter (ID) glass tube. The impinger train was immersed in an ice bath for the entire test period so that the exiting gas temperature would not exceed 68°F.

From the impinger train, the gas was conducted through an umbilical cord to the control console (an Andersen Universal Stack Sampler), which contained the following pieces of equipment (listed in the order in which sampled gas pass through them): a main valve, a bypass valve for flow adjustment, an airtight vacuum pump, a dry gas meter, and a calibrated orifice. The orifice was equipped with pressure taps which were connected across the inclined manometer used to ensure that isokinetic conditions were maintained. A schematic diagram of the sampling train appears at the end of this appendix.

The sampling train was checked for leaks before and after each sample run. The inlet of the nozzle was plugged and the pump vacuum was held at the highest vacuum attained during that period of testing. In all cases the leakage rate was minimal and did not exceed the maximum allowable leakage rate of 0.02 cubic feed per minute (cfm).

Upon completion of a test, the soiled glass fiber filter was removed from its filter holder and placed in a petri dish, which was subsequently sealed. The probe and nozzle were washed internally, first with DI water and then with acetone. The particulate matter remaining in the probe was removed with a nylon brush attached to a polyethylene line. The front half of the glass filter holder was also rinsed with distilled water and acetone. The washings obtained were added to those collected from the nozzle and the probe. All distilled water and acetone washings were stored in separate sealed polyethylene sample bottles.

The silica gel used in the fourth impinger was removed, placed in its sample bottle, and a final weight was obtained. The contents of the first, second, and third impingers were combined, measured volumetrically, and placed in sealed sample bottles. The impingers were finally rinsed with acetone and the washings placed in separate bottles.

All test program samples, as well as blanks of the distilled water and acetone used during the testing, were submitted to Air Quality Services Inc. for analysis.

1.5 Molecular Weight Determination

An Orsat gas analyzer was used to determine the molecular weight of the exhaust gas at the scrubber outlet. The following parameters were measured in order to calculate molecular weight: volume percent carbon dioxide (CO_2) and volume percent oxygen (O_2). Volume percent nitrogen (N_2) was determined by difference.

2.0 FIELD DATA SHEETS

The flue gas velocity head, flue gas temperature, inlet and outlet dry gas meter temperatures, orifice pressure differential, sample volume, sampling time, pump vacuum, filter temperature, and the impinger train outlet gas temperature were recorded during the sampling program. The field data sheets generated during the program follow.

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APPENDIX B

LABORATORY ANALYSIS AND DATA REDUCTION

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APPENDIX B

LABORATORY ANALYSIS AND DATA REDUCTION

1.0 ANALYTICAL METHODS

All samples generated during the test program were analyzed by Air Quality Services Inc., located in Pittsburgh, Pennsylvania. The following discussions describe the analytical methods employed.

1.1 Particulate Samples

Prior to their use in the field, all glass fiber filters used in the sampling program had been tare-weighed following heating to 900°F and a 24-hour desiccation period. Upon their return to the laboratory, the filters were desiccated and reweighed. The weight difference was the amount of sample collected.

Nozzle, probe, and filter holder distilled water and acetone washings were evaporated to dryness in separate tared beakers. The residue was desiccated, and the beakers were reweighed to a constant weight. The weight difference was the amount of particulate matter collected at those locations in the sampling train. Impinger solutions, as well as front-half water washes prior to evaporation, were filtered through a 0.22-micron filter to determine the insoluble back-half particulate.

The impinger solution filtrate and the acetone wash of the impingers were dried separately to determine the soluble back-half particulate catch. In accordance with PADER test requirements, this portion of the particulate catch is reported but not included in the particulate loading calculations.

Acetone and distilled water blanks were evaporated to dryness in tared beakers and were desiccated and reweighed. Any residue that remained was a contaminant in the reagent and was considered a blank weight used as a correction factor in subsequent calculations. The laboratory results of the particulate sampling program are listed in Tables B-1 and B-2.

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2.0 EQUATIONS FOR THE CALCULATIONS OF TEST RESULTS

The equations following Tables B-1 and B-2 were programmed into a personal computer to facilitate the calculation of the test program results. The equations were prescribed in EPA Methods 2, 3, 4, and 5 of 40 CFR 60, Appendix 1, Reference Test Methods, and were used to calculate the results of particulate, flow temperature, and static pressure testing.

3.0 PARTICULATE TEST RESULTS

The complete results of the computer analyses of the data generated from the particulate test program are presented on the computer printout following the equations.

4.0 BCM COMPUTATION SHEETS

The calculations of the lime production rates and the allowable particulate emission rates are contained on the BCM computation sheets, which follow the computer printout.

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TABLE B-1

FRONT-HALF AND INSOLUBLE BACK-HALF
PARTICULATE RESULTS (mg)

	Run No. 1	Run No. 2	Run No. 3
Filter	229.97	195.75	196.20
Front-half acetone wash	0.26	0.63	0.25
Front-half water wash (insoluble)	2.58	0.94	1.31
Front-half water wash (soluble)	2.22	1.27	1.64
Insoluble back-half	5.28	2.36	3.33
Total particulate catch	240.31	200.95	202.73

TABLE B-2

SOLUBLE BACK HALF
PARTICULATE LABORATORY RESULTS (mg)

Run No.	Soluble Back Half (impinger filtrate)	Acetone Wash	Total
1	12.56	0.14	12.70
2	3.31	0.44	3.75
3	0.0086	0.44	0.449

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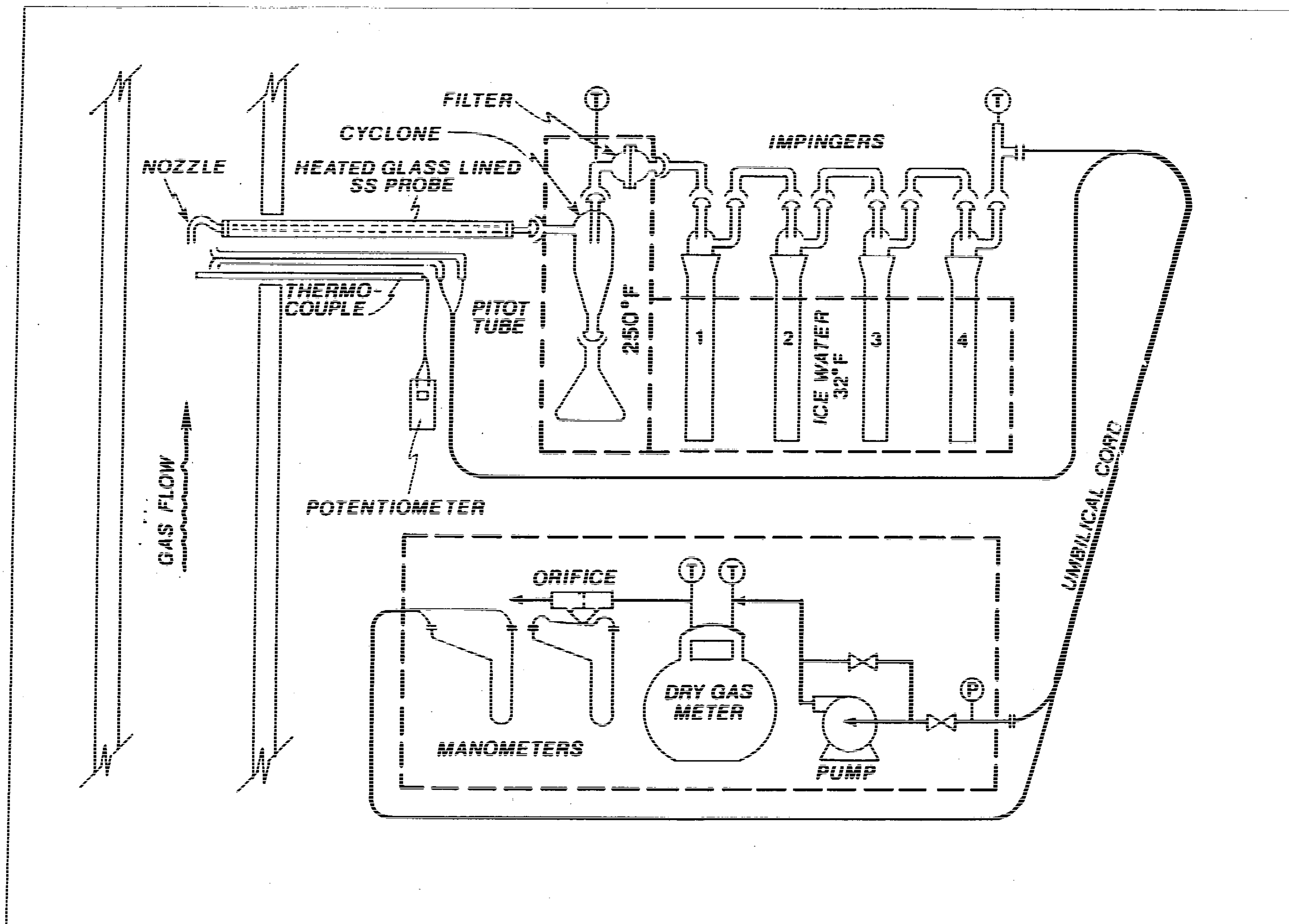
FILTER
CYCLONE
NOZZLE
HEATED GLASS LINED
SS PROBE
IMPINGERS
T
T
250°F
1
2
3
4
ICE WATER
32°F
THERMO-
COUPLE
PITOT
TUBE
GAS FLOW
POTENTIOMETER
UMBILICAL CORD
ORIFICE
T
T
DRY GAS
METER
P
MANOMETERS
PUMP

EPA METHOD 5

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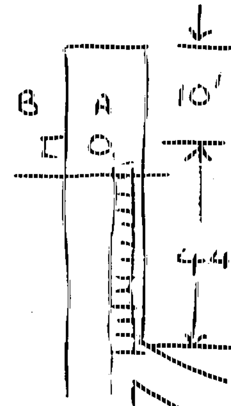
TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT Bellefonte Lime
DATE 3/8/89
SAMPLING LOCATION Scrubber Outlet
INSIDE OF FAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE A)
INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE B)
STACK I.D., (DISTANCE A - DISTANCE B)
NEAREST UPSTREAM DISTURBANCE
NEAREST DOWNSTREAM DISTURBANCE
CALCULATOR



SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	4.4	60"	2.6	5	2.6
2	14.6	↓	8.8	↓	13.8
3	29.6		17.8		22.8
4	70.4		42.4		47.2
5	85.4		51.2		56.2
6	95.6		57.4		62.4

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PLANT: Bellefonte Lime
DATE: 5/1/91
SAMPLING LOCATION: Scrubber Outlet
SAMPLE TYPE: PA Particulate
RUN NUMBER: one   OPERATOR: PCB/ SB
BAROMETRIC PRESSURE: 29.00   STATIC PRESSURE: -.76
FILTER NUMBER(S):
GEL NUMBER(S): 26.5 g Pickup
THIMBLE NUMBER: PLATE NUMBER:
H_2O PICKUP (ml): 6.03 ml Pickup

ORSAT:
CO_2: 19.8
O_2: 6.2
CO:

PYROMETER NUMBER:
THERMOCOUPLE NUMBER:
PROBE NUMBER: TYPE:
NOZZLE NUMBER: I.D. .247
METER BOX NUMBER: 420 / ΔH@ 1.87
PITOT NUMBER: C_p .84
SAMPLE BOX NUMBER(S):
ASSUMED MOISTURE (%): 32
ASSUMED METER TEMPERATURE: 100°   Ts = 160
C FACTOR: .60   REFERENCE Δp: .98

READ AND RECORD ALL DATA EVERY 6 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH, in. H_2O) DESIRED	ORIFICE PRESSURE DIFFERENTIAL ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	DRY GAS METER TEMPERATURE OUTLET ($T_{m_{out}}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	00	0855	426.852									
A-1	06	0901	431.5	.90	1.8	1.8	161	76	73	6	230	50
2	12	0907	436.5	1.2	2.5	2.5	160	94	72	8	259	50
3	18	0913	440.1	1.2	2.5	2.5	159	104	75	10	270	50
4	24	0919	447.247	1.3	2.7	2.7	166	109	77	11	260	52
			Stop test, pitot problem									
	24	0949	447.247									
5	30	0955	452.7	1.4	2.9	2.9	158	88	81	14	260	52
6	36	1001	458.210	1.3	2.7	2.7	164	105	82	15	258	54
			Stop test, change ports									
			leak check good									
	36	1027	459.128									
B-6	38	1029	460.828	1.4	2.9	2.9	160	86	82	18	260	56
			Stop test, change meter boxes									
1	38	1057	390.956									
6	42	1103	394.7	1.4	2.9	2.9	158	92	64	14	242	56
5	48	1109	400.2	1.5	3.1	3.1	154	106	69	17	257	56
4	54	1115	405.6	1.4	2.9	2.9	153	114	75	18	274	58
3	60	1121	411.0	1.4	2.9	2.9	155	119	85	19	238	60
2	66	1125	416.5	1.3	2.7	2.7	155	121	87	19	247	60
1	72	1128	421.980	1.2	2.5	2.5	155	123	90	20	244	62
				leak check @ 21" Hg = .017 cfm								

$\sqrt{\Delta P}$ = 1.233

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PLANT Bellefonte Lime
DATE 5/1/91
SAMPLING LOCATION Scrubber Outlet
SAMPLE TYPE PA Particulate
RUN NUMBER Two OPERATOR PCB/SB
BAROMETRIC PRESSURE 28.76 STATIC PRESSURE -.75
FILTER NUMBER(S)
GEL NUMBER(S) 20.5 g Pickup
THIMBLE NUMBER PLATE NUMBER
H_2O PICKUP (ml) 57.5 ml pick up

ORSAT:
CO_2 19.6
O_2 6.8
CO

PYROMETER NUMBER
THERMOCOUPLE NUMBER
PROBE NUMBER TYPE
NOZZLE NUMBER I.D. .247
METER BOX NUMBER A-1 ΔH@
PITOT NUMBER C_p
SAMPLE BOX NUMBER(S)
ASSUMED MOISTURE (%)
ASSUMED METER TEMPERATURE
C FACTOR .60 REFERENCE Δp .92

READ AND RECORD ALL DATA EVERY 6 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min	CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O DESIRED	ACTUAL	STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE INLET ($T_{m_{in}}$), °F	OUTLET ($T_{m_{out}}$), °F	PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
	00	1358	422.442					93	86	.7	235	54
B-1	08	1408	424.3	.85 .90	1.8	1.8	157	104	87	4	263	54
1	06	1414	427.1	1.0	2.1	2.1	157	114	87	5	245	56
2	12	1420	432.1	1.2	2.5	2.5	156	122	90	6	238	58
3	18	1426	437.4	1.3	2.7	2.7	154	131	95	8	231	58
4	24	1432	442.9	1.4	2.9	2.9	153	133	97	9	238	60
5	30	1438	448.4	1.4	2.9	2.9	154	135	100	9	230	62
6	36	1444	453.765	1.3	2.7	2.7	151					
			stop test change ports									
			leak check good									
	36	1455	454.183					106	97	8	247	54
A-1	42	1501	458.7	.85	1.75	1.75	154	117	96	10	237	54
2	48	1507	463.5	1.1	2.2	2.2	155	125	97	12	237	58
3	54	1513	468.7	1.2	2.5	2.5	155	129	98	13	241	58
4	60	1519	474.1	1.3	2.7	2.7	155	133	100	15	241	58
5	66	1525	480.0	1.4	2.9	2.9	154	133	102	17	249	58
6	72	1531	485.010	1.2	2.5	2.5	154					
			Leak check @	19 "Hg	=		.008 cfm					

EQUATIONS FOR PARTICULATE, MOISTURE, AND FLOW CALCULATIONS

(BASED ON STANDARD CONDITIONS OF 68°F AND 29.92"Hg)

1. $V_{w(std)} = 0.0471\ V_{wc}$

2. $V_{m(std)} = 17.64\ V_m \dfrac{P_{bar} + .07355\ \Delta H}{T_m + 460} \gamma$

3. $B_{wo} = \dfrac{V_{w(std)}}{V_{m(std)} + V_{w(std)}}$

4. $M_d = 0.44(\%CO_2) + 0.28(\%CO) + 0.32(\%O_2) + 0.28(\%N_2)$

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

6. $EA = \dfrac{(\%O_2) - 0.5(\%CO)}{0.264(\%N_2) - (\%O_2) + 0.5(\%CO)}\ 100$

7. $V_s = (85.49)(60)(C_p)\sqrt{\Delta P}\sqrt{\dfrac{T_s + 460}{(P_s)(M_s)}}$

8. $Q_s = \dfrac{(V_s)(A_s)}{144}$

9. $Q_{s(std)} = Q_s(1 - B_{wo})\ 17.64 \dfrac{P_s}{T_s + 460}$

10. $C'_s = 0.0154 \dfrac{W_t}{V_{m(std)}}$

11. $C'_w = 0.0154 \dfrac{W_t}{V_{m(std)} + V_{w(std)}}$

12. $C'_c = \dfrac{12\ C'_s}{\%CO_2}$

13. $C'_a = W_w \dfrac{(T_s + 460)(29.92)}{(528)(P_s)}$

14. $E = 0.00857\ Q_{s(std)}\ C'_s$

15. $A_n = \dfrac{(\pi)(D_n)^2}{(144)(4)}$

16. $I = \dfrac{(60)(1.667)(T_s + 460)(0.00267\ V_{wc} + V_{m(std)}/17.64)}{(\Theta)(V_s)(P_s)(A_n)}$

V_s = Stack velocity, ft/min

V_{wc} = Volume of liquid collected in impingers and silica gel, ml

$V_{w(std)}$ = Volume of liquid collected, ft^3

W_t = Total weight of particulates collected, mg

θ = Duration of test, min.

LEGEND

A_n	=	Area of nozzle, ft^2
A_s	=	Area of stack, in^2
B_{wo}	=	Moisture content of gas stream, dimensionless
C_p	=	Pitot correction factor, dimensionless
C'_a	=	Particulate concentration (stack conditions), gr/ft^3
C'_c	=	Particulate concentration at 12% CO_2 (dry), gr/dscf
C'_s	=	Particulate concentration (dry), gr/dscf
C'_w	=	Particulate concentration (wet), gr/scf
D_n	=	Diameter of nozzle, in.
E	=	Particulate emission rate, lb/hr
EA	=	Excess air, percent
ΔH	=	Orifice pressure drop, in. H_2O
I	=	Isokinetic ratio, percent
M_d	=	Dry molecular weight of stack gas, lb/lb-mole
M_s	=	Molecular weight of stack gas, lb/lb-mole
P_{bar}	=	Barometric pressure, in. Hg
P_s	=	Stack pressure (absolute), in. Hg
$\overline{\sqrt{\Delta P}}$	=	Average of square roots of pitot pressure differential, in. H_2O
Q_s	=	Stack gas flow, acfm
$Q_{s(std)}$	=	Stack gas flow, scfm
T_m	=	Average dry gas meter temperarure, ^oF
T_s	=	Average stack temperature, ^oF
V_m	=	Dry sample volume (meter conditions), ft^3
$V_{m(std)}$	=	Dry sample volume (standard conditions), ft^3

Particulates testing
Results Summary

BCM Project #	00-6066-10
Plant	Bellefonte Lime
Date	5/1/91
Location	Scrubber Out
Run Number	1
Operator	PCB

rometric Pressure:	29.00 " Hg	ORSAT:			Duct Diameter	60.00	inches
Static Pressure:	-0.76 " H2O				Duct Width	----	inches
ick Pressure:	28.94 " Hg				Duct Length	----	inches
		CO2 =	19.8	%	Duct Area	19.63	sq.ft.
		O2 =	6.2	%	Pitot Factor	0.840	
					Meter Box Factor	0.992	
ater Pickup	629.50 ml	CO =	0	%			
					Nozzle In. Diam.	0.247	inches
Start Time	08:55	N2 =	74	%	Nozzle Area	3.33E-04	sq.ft.
ration	72.00 Min				Isokinetic Ratio	104.055	

erage Stack Temp	158.3	deg F
verage Gas Meter Temp	91.1	deg F
Avg Square Root of Pitot Press	1.134	inches water
ifice Pressure Drop	2.675	inches water
Meter Dry Sample Volume	64.082	DACF
Dry Sample Volume, Corrected, Std Conditions	59.406	DSCF
y Molecular Weight of Stack Gas	31.416	lb/lb-mole
Molecular Weight of Stack Gas	27.260	lb/lb-mole
ack Gas Velocity	4,327.09	ft/min
ack Gas Flow Rate	84,962.12	ACFM
Stack Gas Flow Rate, dry, Std. Conditions	48,420.94	DSCFM
ack Gas Flow Rate, Std. Conditions	70,154.95	SCFM
Volume of Moisture Collected	29.649	SCF
Moisture Content	31.0	% - (Moisture content represents saturated value)
ass of Particulate Collected	240.31	mg
Conc. of Part., Std. Condition	0.0623	gr/dscf
Mass Emission Rate of Particulate	25.85	lb/hr

OMMENTS:

Particulates testing
Results Summary

BCM Project #	00-6066-10
Plant	Bellefonte Lime
Date	5/1/91
Location	Scrubber Out
Run Number	2
Operator	PCB

[illegible]ometric [illegible]ressure:	28.76 " Hg	ORSAT:			Duct Diameter	60.00	inches
Static Pressure:	-0.75 " H2O				Duct Width	----	inches
[illegible]ck [illegible]ressure:	28.70 " Hg				Duct Length	----	inches
		CO2 =	19.6	%	Duct Area	19.63	sq.ft.
		O2 =	6.8	%	Pitot Factor	0.840	
[illegible]ter Pickup	585.50 ml				Meter Box Factor	0.985	
		CO =	0	%	Nozzle In. Diam.	0.247	inches
Start Time	13:58	N2 =	73.6	%	Nozzle Area	3.33E-04	sq.ft.
[illegible]ration	72.00 Min.				Isokinetic Ratio	100.167	

[illegible]erage Stack Temp	154.3	deg F
[illegible]erage Gas Meter Temp	109.3	deg F
Avg Square Root of Pitot Press	1.100	inches water
[illegible]ifice Pressure Drop	2.517	inches water
Meter Dry Sample Volume	62.15	DACF
Dry Sample Volume, Corrected, Std Conditions	54.910	DSCF
[illegible]y Molecular Weight of Stack Gas	31.408	lb/lb-mole
Molecular Weight of Stack Gas	27.638	lb/lb-mole
[illegible]ck Gas Velocity	4,171.70	ft/min
[illegible]ack Gas Flow Rate	81,911.15	ACFM
Stack Gas Flow Rate, dry, Std. Conditions	48,520.75	DSCFM
[illegible]ck Gas Flow Rate, Std. Conditions	67,502.43	SCFM
Volume of Moisture Collected	27.577	SCF
Moisture Content	28.1	% - (Moisture content represents saturated value)
[illegible]ss of Particulate Collected	200.95	mg
Conc. of Part., Std. Condition	0.0564	gr/dscf
[illegible]ss Emission Rate of Particulate	23.45	lb/hr

[illegible]MMENTS:

Particulates testing
Results Summary

BCM Project #	00-6066-10
Plant	Bellefonte Lime
Date	5/2/91
Location	Scrubber Out
Run Number	3
Operator	PCB

Barometric Pressure:	29.12	" Hg	ORSAT:			Duct Diameter	60.00	inches
Static Pressure:	-0.8	" H2O				Duct Width	----	inches
						Duct Length	----	inches
Stack Pressure:	29.06	" Hg	CO2 =	18.8	%	Duct Area	19.63	sq.ft.
			O2 =	7	%	Pitot Factor	0.840	
						Meter Box Factor	0.985	
Water Pickup	598.0	ml	CO =	0	%			
						Nozzle In. Diam.	0.247	inches
Start Time	10:15		N2 =	74.2	%	Nozzle Area	3.33E-04	sq.ft.
Duration	72.00	Min				Isokinetic Ratio	101.585	

Average Stack Temp	153.9	deg F
Average Gas Meter Temp	83.4	deg F
Avg Square Root of Pitot Press	1.100	inches water
Orifice Pressure Drop	2.508	inches water
Meter Dry Sample Volume	59.902	DACF
Dry Sample Volume, Corrected, Std Conditions	56.132	DSCF
Dry Molecular Weight of Stack Gas	31.288	lb/lb-mole
Molecular Weight of Stack Gas	27.581	lb/lb-mole
Stack Gas Velocity	4,148.89	ft/min
Stack Gas Flow Rate	81,463.19	ACFM
Stack Gas Flow Rate, dry, Std. Conditions	49,043.50	DSCFM
Stack Gas Flow Rate, Std. Conditions	68,021.50	SCFM
Volume of Moisture Collected	28.166	SCF
Moisture Content	27.9	% - (Moisture content represents saturated value)
Mass of Particulate Collected	202.73	mg
Conc. of Part., Std. Condition	0.0556	gr/dscf
Mass Emission Rate of Particulate	23.37	lb/hr

COMMENTS:

BCM

COMPUTATION SHEET

Sheet Number 1 Of 2
Date 5/17/91
Job Number 6066-10
Computed by SMB Checked by

Name of Client Bellefonte Lime Compliance 5/1-5/2 1991
Project Lime Kiln No. 5 Scrubber Outlet
Description Production Rate Calculation

$$\text{STONE FEED RATE (TONS/HR)} = \left(\frac{\text{DIFFERENCE IN COUNTER READING} \times 127 \frac{lb}{count}}{2000\ lb/ton}\right)\left(\frac{60\ min/hr}{\text{ELAPSED TIME (MIN)}}\right)$$

$$\text{COAL FEED RATE (TONS/HR)} = \left(\frac{\text{DIFFERENCE IN COUNTER READING} \times 652 \frac{lb}{count}}{2000\ lb/ton}\right)\left(\frac{60\ min/hr}{\text{ELAPSED TIME (MIN)}}\right)$$

RUN No.	DIFFERENCE IN STONE COUNTER READING	DIFFERENCE IN COAL COUNTER READING	ELAPSED TIME (MIN)	STONE FEED RATE (TON/HR)	COAL FEED RATE (TON/HR)
1 Run A	322	—	30	40.89	—
Run B	914	325	105	33.17	6.05
TOTAL (TWA)*	1236	—	135	34.88	
2	822	295	93	33.68	6.20
3	912	344	100	34.75	6.73

$$\text{LIME PRODUCTION RATE (TONS/HR)} = \left(\text{STONE FEED RATE (TON/HR)}\right)\left(0.525\right)$$

Run No.	STONE FEED RATE (TON/HR)	LIME PRODUCTION RATE (TON/HR)	LIME PRODUCTION RATE (TON/DAY)
1 Run A	40.89	21.47	515.3
Run B	33.17	17.41	417.8
TOTAL (TWA)	34.88	18.31	439.44
2	33.68	17.68	424.3
3	34.75	18.24	437.9
		18.08 ave	

* Note (TWA) means Time Weighted Average.

BCM

COMPUTATION SHEET

Name of Client: Bethlehem Lime (?)
Project: Lime Kiln No. 5 Test [illegible] 1991
Description: Allowable Emission Rate Calculation

Sheet Number 2 Of 2
Date 5/1?/91
Job Number
Computed by [illegible] Checked by

As per PA DER Air Pollution Regulations 123.13(2)

$$A = 0.76E^{0.42}$$

where: A = allowable particulate emission rate, lb/hr
E = emission index = F x W, lb/hr
F = process factor for lime calcining = 200 lb/ton (1)
W = production rate of lime, tons/hr

Run No.	Production Rate (W) (tons/hr)	Allowable Emission Rate (A) (lb/hr)
1 Run A	21.47	25.50
Run B	17.41	23.36
TOTAL (TWA)	18.31	23.85
2	17.68	23.51
3	18.24	23.82
		23.73

(1) From 123.13 (?) Table

APPENDIX C

EQUIPMENT CALIBRATION

1.0 DRY GAS METER AND ORIFICE METER

The dry gas meter and orific were calibrated using a wet test meter. Gases were moved through the dry gas meter at orifice pressure differentials (ΔH's) of 0.5, 1.0, and 2.0 inches of water. With the information obtained, γ, the ratio of accuracy of wet test meter to dry test meter; and $\Delta H_@$, the orifice pressure differential that gives 0.75 cfm of air at 68°F and 29.92 inches of mercury, were calculated. The γ has a tolerance of 1.00 ±0.01 and the $\Delta H_@$ has a tolerance of 1.84 +0.26 -0.24. The γ and $\Delta H_@$ are determined as follows:

$$\gamma = \frac{V_w P_b \ (t_d + 460)}{V_d [P_b + .07353(\Delta H)](t_w + 460)}$$

$$\Delta H_@ = \frac{0.0317 \ (\Delta H)}{P_b \ (t_d + 460)} \left(\frac{(T_w + 460) \ \theta}{V_w} \right)^2$$

Where:

- ΔH = Orifice pressure differential, in H_2O
- P_b = Barometric pressure, in Hg
- t_d = Average temperature of dry gas meter, °F
- t_w = Average temperature of wet test meter, °F
- θ = Duration of test, min.
- V_d = Dry gas meter volume, ft^3
- V_w = Wet test meter volume, ft^3

BCM

METER BOX CALIBRATION SHEET

Date 4-29-91 Box No. 420 Inspector Joel S.

Pump Rebuilt, Re-oiled Oil OK Wick OK Pump Serial No. —

Manometers OK Knobs OK Oil OK Tubing New connects

Quick Connects OK Vacuum Gage OK Valves OK

Dry Gas Meter Rockwell Volume 395.8 ft³ Serial No. Small Type

Thermometers 71 In 71 °F Out 71 °F Ambient 71 °F

Amphenol ✓ Lights ✓ Switches ✓ Variac ✓

Leak Check - Max. Vacuum 30 in. Hg Leak Rate .001 CFM

Remarks Barom. 29.67

Man. Orifice	CF_w	CF_d	T_w	IT_d	OT_d	T_d	Time θ
0.5	5.002	5.208	69.5	104.6	84	94.3	[illegible] / 12.3
1.0	5.073	5.241	69.5	104.2	79.2	91.7	3:53 / 8.88
2.0	10.005	10.554	69.5	115.1	87.3	101.2	12:36 / 12.6

Tolerances: $1.6 \le \Delta H_@ \le 2.1$

$\Delta H_@ =$	$\frac{(0.0317)(\Delta H)}{(P_b)(OT_d+460)}\left[\frac{(T_w+460)(\theta)}{(CF_w)}\right]^2$	$\gamma =$	$\frac{(CF_w)(P_b)(T_d+460)}{(CF_d)(P_b+\Delta H/13.6)(T_w+460)}$
1.61	$\frac{(0.0317)(0.5)}{(29.67)(84+460)}\left[\frac{(69.5+460)(12.3)}{(5.002)}\right]^2$ (.01585; 544; 529.5; 1302.05)	1.004	$\frac{(5.002)(29.67)(94.3+460)}{(5.208)(29.67+0.0368)(69.5+460)}$ (554.3; 29.7068; 529.5)
1.70	$\frac{(0.0317)(1.0)}{(29.67)(79.2+460)}\left[\frac{(69.5+460)(8.88)}{(5.073)}\right]^2$ (539.2; 529.5; 926.86)	1.006	$\frac{(5.073)(29.67)(91.7+460)}{(5.241)(29.67+0.0737)(69.5+460)}$ (551.7; 29.7437; 529.5)
1.74	$\frac{(0.0317)(2.0)}{(29.67)(87.3+460)}\left[\frac{(69.5+460)(12.6)}{(10.005)}\right]^2$ (.0634; 547.3; 529.5; 666.84)	1.000	$\frac{(10.005)(29.67)(101.2+460)}{(10.554)(29.67+0.147)(69.5+460)}$ (561.2; 29.817; 529.5)

1.003 AVE ±2% = (.983 ≤ Y ≤ 1.023)

BCM

METER BOX CALIBRATION SHEET

Date 4-29-91 Box No. A-1 Inspector Joel S

Pump Checked Oil OK Wick OK Pump Serial No. —

Manometers GOOD Knobs OK Oil OK Tubing OK

Quick Connects GOOD Vacuum Gage OK Valves OK

Dry Gas Meter Rockwell Volume 363.6 ft³ Serial No. —

Thermometers ✓ In 70 °F Out 71 °F Ambient 71 °F

Amphenol OK Lights OK Switches OK Variac OK

Leak Check - Max. Vacuum 26.5 in. Hg Leak Rate .001 CFM

Remarks Barom. = 29.67.

Man. Orifice	CF_w	CF_d	T_w	IT_d	OT_d	T_d	Time θ
0.5	5.000	5.265	70	99.8	78.5	89.2	12:46 / 12.97
1.0	5.005	5.220	70	98.6	73	85.8	9:07 / 9.12
2.0	10.004	10.690	69.5	114.5	84	99.3	13:22 / 13.4

Tolerances: $1.6 \le \Delta H_@ \le 2.1$

$\Delta H_@ =$	$\frac{(0.0317)(\Delta H)}{(P_b)(OT_d+460)}\left[\frac{(T_w+460)(\theta)}{(CF_w)}\right]^2$	$\gamma =$	$\frac{(CF_w)(P_b)(T_d+460)}{(CF_d)(P_b+\Delta H/13.6)(T_w+460)}$
1.82	$\frac{(0.0317)(0.5)}{(29.67)(78.5+460)}\left[\frac{(70+460)(12.97)}{(5.000)}\right]^2$ (538.5; 530; 1353.62)	.983	$\frac{(5.000)(29.67)(89.2+460)}{(5.265)(29.67+0.0368)(70+460)}$ (549.2; 29.7068; 530)
1.87	$\frac{(0.0317)(1.0)}{(29.67)(73+460)}\left[\frac{(70+460)(9.12)}{(5.005)}\right]^2$ (533; 530; 965.72)	.985	$\frac{(5.005)(29.67)(85.8+460)}{(5.220)(29.67+0.0737)(70+460)}$ (545.8; 29.7437; 530)
1.98	$\frac{(0.0317)(2.0)}{(29.67)(84+460)}\left[\frac{(69.5+460)(13.4)}{(10.004)}\right]^2$ (544; 529.5; 709.25)	.984	$\frac{(10.004)(29.67)(99.3+460)}{(10.690)(29.67+0.147)(69.5+460)}$ (559.3; 29.817; 529.5)

.984 AVE ±2% = (.964 ≤ Y ≤ 1.004)