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Title: Particulate and Nitrogen Oxide Emission Measurements from Lime Kilns

Peltier, T. L. and H. D. Toy, EPA Contract No. 68-02-1404, Task No. 17

Monsanto Research Corporation

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PARTICULATE AND NITROGEN OXIDES EMISSION MEASUREMENTS FROM LIME KILNS

Plant Tested

The National Lime and Stone Company
Carey, Ohio

October 6, 7, 8 and 9, 1975

Prepared for

Environmental Protection Agency
National Air Data Branch
Research Triangle Park
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Contract No. 68-02-1404, Task No. 17

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SECTION I

INTRODUCTION

The main purpose of the sampling program at The National Lime and Stone Company was to measure the uncontrolled particulate and nitrogen dioxide emissions from calcimatic lime kiln operations and from these data determine emission factors. The study was initiated as part of the data acquisition program of the National Air Data Branch of the Environmental Protection Agency.

The field sampling program was under the direction of Thomas F. Lahre, Task Project Officer, National Air Data Branch of the Environmental Protection Agency. The sampling was performed by Monsanto Research Corporation with William R. Feairheller as Project Leader and Thomas L. Peltier as Task Leader.

This report represents data collected and emission factors determined on the preheaters and coolers associated with the No. 1 and 2 calcimatic kilns at The National Lime and Stone Company during the sampling program of October 6, 7, 8 and 9, 1975. The particulate data for the preheater and cooler outlets of the #1 kiln and the preheater outlet of the #2 kiln were determined by actual sampling. Particulate emission factors for the #2 cooler were determined by weighing the amount of dust collected in the baghouse controlling the system. NO_x emissions were sampled at the preheater duct on kiln #1.

SECTION II

SUMMARY OF RESULTS

Particulate emission data from the #1 preheater duct (which exhausts the #1 preheater and 95% of the #1 cooler emissions) appear in Tables 1 (metric units) and 2 (English units). Filterable particulate emissions (probe and filter catch) averaged 49.768 Kg/hr (109.718 lb/hr) with an average concentration of 2.5999 g/Nm^3 (1.1359 gr/dscf). Total particulate emissions averaged 50.210 Kg/hr (110.693 lb/hr) at an average concentration of 2.6230 g/Nm^3 (1.1460 gr/dscf).

Particulate emission data from the #2 preheater duct (which exhausts the #2 preheater and about 5% of the #1 cooler emissions) are listed in Tables 3 (metric units) and 4 (English units). Filterable particulate averaged an emission rate of 446.428 Kg/hr (984.188 lb/hr) and an average concentration of 10.1309 g/Nm^3 (4.4262 gr/dscf). Average total particulate emissions were 447.776 Kg/hr (987.161 lb/hr) and an average concentration of 10.1616 g/Nm^3 (4.4395 gr/dscf).

Tables 5 and 6 show particulate emissions data from the #1 cooler duct in metric and English units, respectively. These results show average filterable particulate emissions as 16.482 Kg/hr (36.440 lb/hr) with an average concentration of 3.2298 g/Nm^3 (1.4111 gr/dscf). Total particulate emissions averaged 16.585 Kg/hr (36.561 lb/hr) at an average concentration of 3.2407 g/Nm^3 (1.4159 gr/dscf).

Table 1. SUMMARY OF PARTICULATE RESULTS FOR #1 PREHEATER DUCT
(METRIC UNITS)

Run Number	1	2	Average
Date	10/8/75	10/8/75	
Method Type	EPA-5	EPA-5	
Volume of gas sampled Nm^3[a]	0.79	0.74	0.765
Percent moisture by volume	8.48	6.47	7.48
Average stack temperature - °C	198	181	189.5
Stack volumetric flow rate - Nm^3/min	322	317	320
Stack volumetric flow rate - Am^3/min	578	535	557
Percent isokinetic	107.9	102.3	105.1
Duration of run - minutes	64	64	64
Particulates - probe, cyclone and filter catch			
mg	1831.30	2137.20	1984.25
g/Nm^3	2.3066	2.8931	2.5999
Kg/hr	44.599	54.936	49.768
Particulates - total catch			
mg	1851.70	2152.30	2002.00
g/Nm^3	2.3323	2.9136	2.6230
Kg/hr	45.096	55.324	50.210
Percent impinger catch	1.1	0.7	0.9

[a]Normal cubic meters @ 20°C, 760 mm Hg

Table 2. SUMMARY OF PARTICULATE RESULTS FOR #1 PREHEATER DUCT
(ENGLISH UNITS)

Run Number	1	2	Average
Date	10/8/75	10/8/75	
Method Type	EPA-5	EPA-5	
Volume of gas sampled - dscf[a]	27.99	26.04	27.02
Percent moisture by volume	8.48	6.47	7.48
Average stack temperature - °F	388	357	372
Stack volumetric flow rate - dscfm[b]	11385	11181	11283
Stack volumetric flow rate - acfm[c]	20403	18884	19644
Percent isokinetic	107.9	102.2	105.1
Duration of run - minutes	64	64	64
Particulates - probe, cyclone and filter catch			
mg	1831.30	2137.20	1984.25
grains/dscf	1.0077	1.2640	1.1359
lb/hr	98.323	121.112	109.718
Particulates - total catch			
mg	1851.70	2152.30	2002.00
grains/dscf	1.0190	1.2729	1.1460
lb/hr	99.418	121.967	110.693
Percent impinger catch	1.1	0.7	0.9

[a]Dry standard cubic feet @ 68°F, 29.92 in. Hg

[b]Dry standard cubic feet per minute @ 68°F, 29.92 in. Hg

[c]Actual cubic feet per minute - stack conditions

Table 3. SUMMARY OF PARTICULATE RESULTS FOR #2 PREHEATER DUCT
(METRIC UNITS)

Run Number	1	2	Average
Date	10/7/75	10/7/75	
Method Type	EPA-5	EPA-5	
Volume of gas sampled Nm^3[a]	0.75	0.74	0.745
Percent moisture by volume	6.91	7.40	7.16
Average stack temperature - °C	247	235	241
Stack volumetric flow rate - Nm^3/min	721.0	751.0	736.0
Stack volumetric flow rate - Am^3/min	1450.0	1483.0	1466.5
Percent isokinetic	104.1	98.7	101.4
Duration of run - minutes	60.4	60	60.2
Particulates - probe, cyclone, and filter catch			
mg	8155.10	6919.80	7537.45
g/Nm^3	10.8683	9.3935	10.1309
Kg/hr	469.748	423.107	446.428
Particulates - total catch			
mg	8181.0	6939.50	7560.25
g/Nm^3	10.9029	9.4203	10.1616
Kg/hr	471.240	424.312	447.7760
Percent impinger catch	0.32	0.28	0.30

[a]Normal cubic meters @ 20.0°C, 760 mm Hg

Table 4. SUMMARY OF PARTICULATE RESULTS FOR #2 PREHEATER DUCT
(ENGLISH UNITS)

Run Number	1	2	Average
Date	10/7/75	10/7/75	
Method Type	EPA-5	EPA-5	
Volume of gas sampled - dscf[a]	26.45	25.97	26.21
Percent moisture by volume	6.91	7.40	7.16
Average stack temperature - °F	477	454	466
Stack volumetric flow rate - dscfm[b]	25449	26521	25985
Stack volumetric flow rate - acfm[c]	51198	52376	51787
Percent isokinetic	104.1	98.7	101.4
Duration of run - minutes	60.4	60	60.2
Particulates - probe, cyclone and filter catch			
mg	8155.10	6919.80	7537.45
grains/dscf	4.7483	4.1040	4.4262
lb/hr	1035.600	932.776	984.188
Particulates - total catch			
mg	8181.00	6939.50	7560.25
grains/dscf	4.7634	4.1156	4.4395
lb/hr	1038.889	935.432	987.161
Percent impinger catch	0.32	0.28	0.30

[a] Dry standard cubic feet @ 68°F, 29.92 in. Hg

[b] Dry standard cubic feet per minute @ 68°F, 29.92 in. Hg

[c] Actual cubic feet per minute - stack conditions

Table 5. SUMMARY OF PARTICULATE RESULTS FOR #1 COOLER DUCT
(METRIC UNITS)

Run Number	1	2	Average
Date	10/9/75	10/9/75	
Method Type	EPA-5	EPA-5	
Volume of gas sampled Nm^3[a]	1.34	1.27	1.305
Percent moisture by volume	1.13	1.12	1.125
Average stack temperature - °C	146.0	140.0	143.0
Stack volumetric flow rate - Nm^3/min	88.0	84.0	86.0
Stack volumetric flow rate - Am^3/min	130.0	122.0	126.0
Percent isokinetic	102.0	101.3	101.65
Duration of run - minutes	64	64	64
Particulates - probe, cyclone and filter catch			
mg	2893.50	5491.50	4192.50
g/Nm^3	2.1495	4.3101	3.2298
Kg/hr	11.331	21.634	16.482
Particulates - total catch			
mg	2899.50	5513.50	4206.50
g/Nm^3	2.1540	4.3274	3.2407
Kg/hr	11.387	21.782	16.585
Percent impinger catch	0.21	0.40	0.305

[a] Normal cubic meters @ 20.0°C, 760 mm Hg

Table 6. SUMMARY OF PARTICULATE RESULTS FOR #1 COOLER DUCT
(ENGLISH UNITS)

Run Number	1	2	Average
Date	10/9/75	10/9/75	
Method Type	EPA-5	EPA-5	
Volume of gas sampled - dscf[a]	47.45	44.91	46.18
Percent moisture by volume	1.13	1.12	1.125
Average stack temperature - °F	294	284	289
Stack volumetric flow rate - dscfm[b]	3113	2964	3038
Stack volumetric flow rate - acfm[c]	4599	4320	4459.5
Percent isokinetic	102.0	101.3	101.65
Duration of run - minutes	64	64	64
Particulates - probe, cyclone and filter catch			
mg	2893.50	5491.50	4192.50
grains/dscf	0.9391	1.8830	1.4111
lb/hr	25.051	47.828	36.440
Particulates - total catch			
mg	2899.50	5513.50	4206.50
grains/dscf	0.9411	1.8906	1.4159
lb/hr	25.103	48.019	36.561
Percent impinger catch	0.21	0.40	0.305

[a]Dry standard cubic feet @ 68°F, 29.92 in. Hg

[b]Dry standard cubic feet per minute @ 68°F, 29.92 in. Hg

[c]Actual cubic feet per minute - stack conditions

The #2 cooler duct could not be sampled, therefore, an emission rate was determined by weighing the amount of dust collected in the baghouse tube on the #2 cooler duct. In 190 minutes, 2660 lbs. of dust was collected giving an emission rate of 381.024 Kg/hr (840 lbs/hr) for the #2 cooler duct, assuming virtually 100% baghouse collection efficiency.

Table 7 shows the values for emission rates and emission factors from the #1 preheater, #2 preheater, #1 cooler, and #2 cooler corrected to represent the entire emissions from each separate unit. As will be explained in detail in Section III, this correction was necessary due to the irregular flow pattern through the exhaust system which could not be changed by plant personnel to allow for separate sampling of each duct.

There is a significant difference between the emission rates of the #1 and #2 preheaters. This is due to the operational differences between the two kilns. Kiln #1 has a much lower feed and production rate than kiln #2.

The large difference in the emissions from the #1 and #2 coolers (besides feed and production differences between the two kilns) is due to the fact that the #2 cooler uses direct cooling which exhausts all of the emissions and the #1 cooler uses direct and indirect cooling thereby decreasing the amount of emissions exhausted. This process is explained further in Section III.

Sampling for oxides of nitrogen was done on the #1 preheater duct. Five samples were taken and the results listed in Table 8. These data show an average concentration of 10.3 ppm by volume and an average emission rate of 0.2273 Kg/hr (0.5011 lb/hr).

Table 7. EMISSION FACTORS

	Corrected Emission Rate*		Emission Factor			
	Kg/hr	lb/hr	Kg/mTon feed	lb/Ton feed	Kg/mTon product	lb/Ton product
#1 preheater						
Run 1	28.511	62.857	2.99	5.99	5.75	11.5
Run 2	38.739	85.406	4.07	8.13	7.81	15.6
#2 preheater						
Run 1	470.411	1037.061	22.5	45.0	43.2	86.4
Run 2	423.483	933.604	20.2	40.5	38.9	77.8
#1 cooler						
Run 1	11.956	26.358	1.29	2.57	2.47	4.95
Run 2	22.871	50.420	2.46	4.92	4.73	9.46
#2 cooler						
	381.024	840	18.2	36.4	33.9	67.9

*See Appendix A, Table A-4

Table 8. SUMMARY OF NO_x RESULTS

Date	Run No.	Time	ppm[a]	grams/Nm³[b]	lb/DSCF[c] x 10^{-5}	Kg/hr[d]	lb/hr[d]	Kg/mTon Feed	lb/Ton Feed	Kg/mTon Product	lb/Ton Product
10/8/75	1	1110	14.283	0.0271	0.1690	0.5189	1.1440	0.0544	0.1090	0.1046	0.2091
10/8/75	2	1113	6.405	0.0121	0.0758	0.2327	0.5130	0.0244	0.0489	0.0469	0.0938
10/8/75	3	1115	12.633	0.0239	0.1495	0.4590	1.0120	0.0482	0.0964	0.0925	0.1850
10/8/75	4	1117	13.011	0.0247	0.1539	0.4727	1.0428	0.0496	0.0993	0.0953	0.1906
10/8/75	5	1119	5.391	0.0102	0.0638	0.1959	0.4318	0.0206	0.0411	0.0395	0.0789

[a] Parts per million, by volume

[b] Normal cubic meters @ 20°C, 760 mm Hg

[c] Dry standard cubic feet @ 68°F, 29.92 in. Hg

[d] Based on volumetric flow rate averaged from Method 5 runs (DSCFM)

. NO_x EF

SI RANGE: 0.0395 - 0.1046 kg/Mg

AVG: 0.0758 kg/Mg

ENG RANGE: 0.0789 - 0.2091 lb/ton

AVG: 0.1515 lb/ton

SECTION III

PROCESS DESCRIPTION

Lime is produced from limestone at National Lime and Stone by using 2 calcimatic (rotary hearth) kilns and 7 shaft kilns. Hydrated lime is produced by using a Schaffer hydrator.

The calcimatic kilns are fired with natural gas and operate 24 hours/day, 7 days/week. The #1 kiln produces 200 T/day and the #2 kiln produces 250 T/day of pebble lime. A baghouse collector controls the emissions from both the preheater and the cooler of the #1 kiln. The #2 kiln emissions are controlled with a baghouse on the cooler outlet and a venturi scrubber on the preheater outlet.

The preheaters are devices which use the thermal energy of the kiln exhaust to heat the limestone ($CaCO_3$) before it enters the kiln. The cooler is a piece of equipment which cools the lime (CaO) after it emerges from the kiln. The heat energy removed from the lime heats the air used to cool it, which in turn is used as preheated combustion air. The purpose of both devices is to increase the overall thermal efficiency of the kiln operation.

Figure 1 shows a schematic of the preheater, kiln and cooler combinations. The limestone is fed by conveyor into the preheater, which is a stone hopper. Exhaust air from the kiln is passed over the limestone countercurrent. The limestone

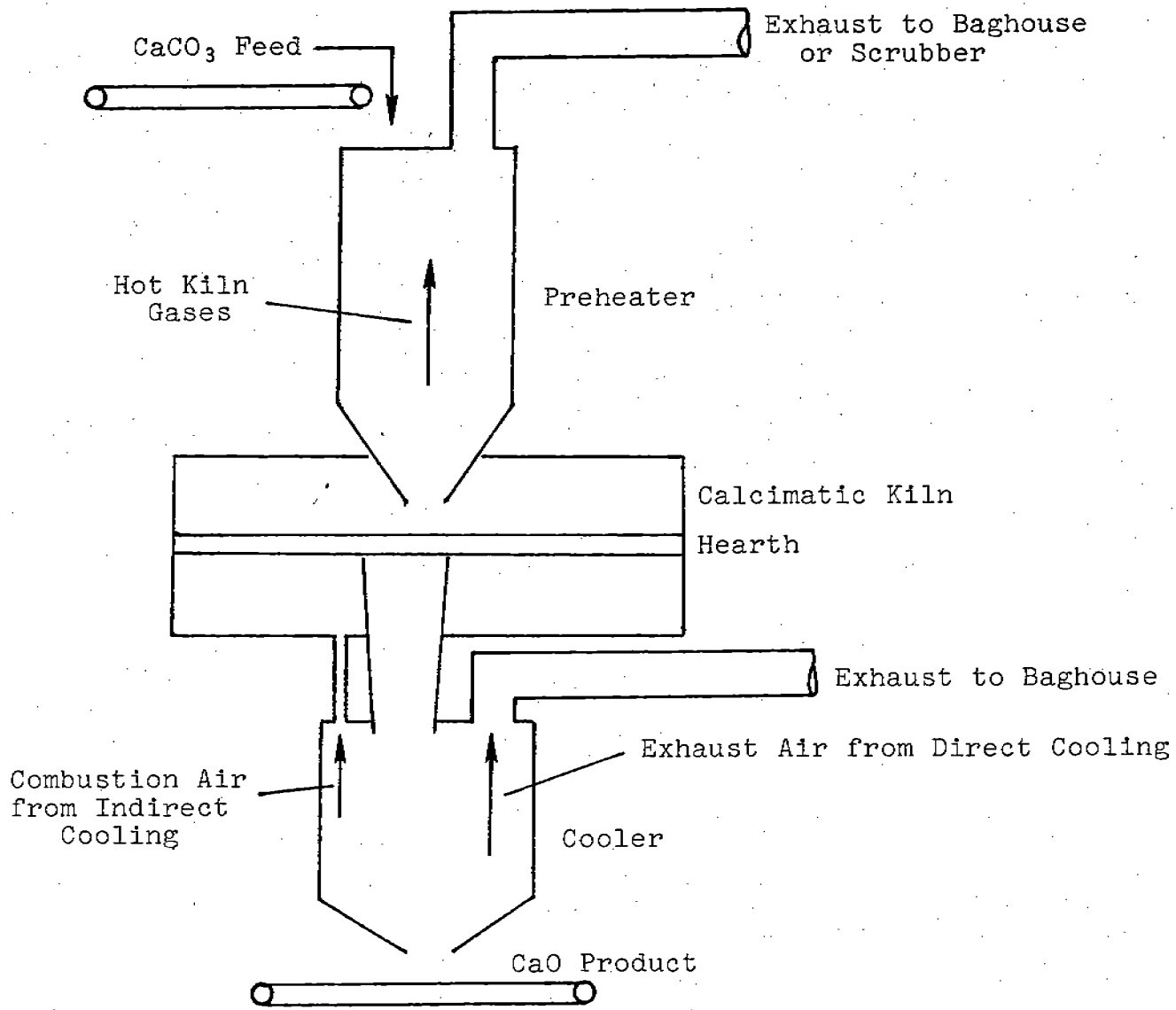


Figure 1. Schematic of Preheater, Kiln and Cooler Combinations

is then fed onto the hearth of the calcimatic by chutes at a fixed heighth with a gate type device that pulls out limestone as the hearth rotates.

The product is scraped off the hearth and down a chute into the cooler, which is a holding bin. The lime is cooled directly and indirectly. Direct cooling involves passing ambient air countercurrent through the lime. This air is then exhausted to the baghouse. Indirect cooling is done by using cooling tubes. Ambient air is passed through the tubes and a heat exchange takes place when the lime is passed by the tubes. The air in the tubes is subsequently heated and used as combustion air in the kiln. The cooled lime is then fed onto a conveyor for packaging and shipping.

The operations of preheater, kiln and cooler combinations for kilns #1 and #2 are the same except that direct cooling is used exclusively in the #2 cooler and the #2 kiln has a higher feed and production rate than #1 kiln.

The 7 shaft kilns each produce in excess of 100 T/day of lime on an operating schedule of 24 hr/day, 5 day/week. The kilns were not being used during testing because of low lime demand. One of the kilns has a primary cyclone and a venturi scrubber on the outlet, while the other 3 have a primary cyclone on the outlet.

The shaft kilns are fired with natural gas when it is available. Producer gas with a heating value of 120 Btu/ft^3 is also used for fuel. Four tons of lime are produced for every ton of coal (0.5% sulfur) burned to make producer gas.

The Schaffer hydrator converts quicklime to hydrated lime at a rate of 15 T/hr. Spray nozzles in the exhaust stack

suppress the dust and add water to the exothermic reaction to form a product of the reaction containing only 0.5% moisture. The two Raymond mills that grind the hydrated lime have their exhaust controlled with a baghouse collector. The hydrating system operates on a seasonal cycle with Fall and Spring being the busy seasons. An 8 hr/day, 5 day/wk work schedule is followed.

The sampling program undertaken at The National Lime and Stone Company was the result of discussions with the EPA, MRC, and plant personnel at The National Lime and Stone Company. It was originally determined to test the two calcimatic kilns and one of the shaft kilns before control equipment to obtain uncontrolled emission rates. The shaft kiln stack to be sampled was torn down prior to the sampling program so that control equipment could be installed on the other shaft kiln stacks. The control equipment did not enable testing for uncontrolled emissions so the shaft kilns were not tested.

The limestone feed data and the lime production data for the test period are given in Tables 9 and 10 in both metric and English units.

The cooler exhaust can be directed either into the #1 preheater or the #2 preheater by the use of a damper, as shown in Figure 2. According to plant personnel, the damper is set so that the exhaust stream in the #1 preheater duct is made up of emissions from the #1 preheater plus 95% of the emissions from the #1 cooler. The exhaust in the #2 preheater duct includes emissions from the #2 preheater plus about 5% of the emissions from the #1 cooler. This is done to allow lime emissions into the #2 preheater duct to neutralize the corrosive effect of the high CO_2 and CO content of the duct.

Table 9. SUMMARY OF LIMESTONE FEED DATA

	10/7/75		10/8/75		10/9/75	
	mTon (Ton)	mTon/hr (Ton/hr)	mTon (Ton)	mTon/hr (Ton/hr)	mTon (Ton)	mTon/hr (Ton/hr)
Calcimatic #1						
Shift #1[a]	78 (86)	9.75 (10.75)	76 (84)	9.53 (10.5)	74 (82)	9.30 (10.25)
Shift #2[b]	75 (83)	9.41 (10.375)	75 (83)	9.41 (10.375)		
Shift #3[c]	77 (85)	9.64 (10.625)	76 (84)	9.53 (10.5)		
Calcimatic #2						
Shift #1	167.32 (184.44)	20.92 (23.06)	170.82 (188.29)	21.36 (23.54)	172.56 (190.21)	21.57 (23.78)
Shift #2	172.56 (190.21)	21.57 (23.78)	167.32 (184.44)	20.92 (23.06)		
Shift #3	174.30 (192.13)	21.79 (24.02)	169.07 (186.37)	21.14 (23.30)		

[a]Shift #1 8:00 a.m. - 4:00 p.m.

[b]Shift #2 4:00 p.m. - 12 midnight

[c]Shift #3 12 midnight - 8:00 a.m.

Table 10. SUMMARY OF LIME PRODUCTION DATA

	10/7/75			10/8/75		10/9/75	
	mTon (Ton)	mTon/hr (Ton/hr)		mTon (Ton)	mTon/hr (Ton/hr)	mTon (Ton)	mTon/hr (Ton/hr)
Calcimatic #1							
Shift #1[a]	40.61 (44.76)	5.08 (5.60)	1.92	39.66 (43.72)	4.96 (5.47)	38.72 (42.68)	4.84 (5.33)
Shift #2[b]	39.19 (43.20)	4.90 (5.40)	1.92	39.19 (43.20)	4.90 (5.40)		
Shift #3[c]	40.13 (44.24)	5.02 (5.53)	1.92	39.66 (43.72)	4.96 (5.47)		
Calcimatic #2							
Shift #1	87 (96)	10.9 (12)	1.92	89 (98)	11.11 (12.25)	90 (99)	11.23 (12.375)
Shift #2	90 (99)	11.23 (12.375)	1.92	87 (96)	11.23 (12.375)		
Shift #3	91 (100)	11.3 (12.5)	1.92	88 (97)	11.00 (12.125)		

[a]Shift #1 8:00 a.m. - 4:00 p.m.

[b]Shift #2 4:00 p.m. - 12 midnight

[c]Shift #3 12 midnight - 8:00 a.m.

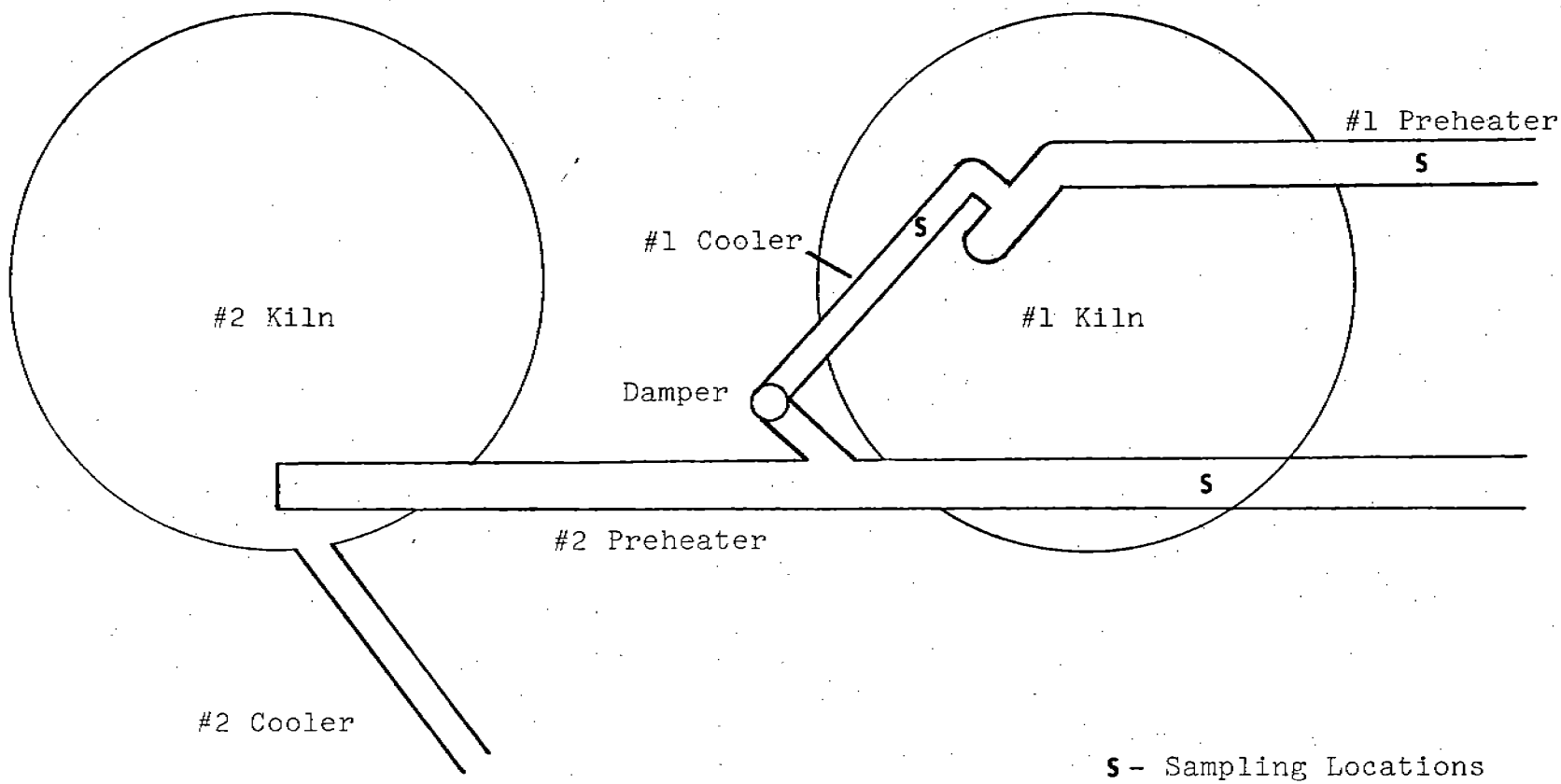


Figure 2. Exhaust system (top view)

Originally, it was planned to divert the #1 cooler flow to allow for sampling each preheater duct without emissions from the #1 cooler, but according to plant personnel at the time of the testing this was impossible.

Figure 3 is a schematic showing the relative position of the kilns, preheaters, and coolers and the paths of material, exhaust, and air flow through the system.

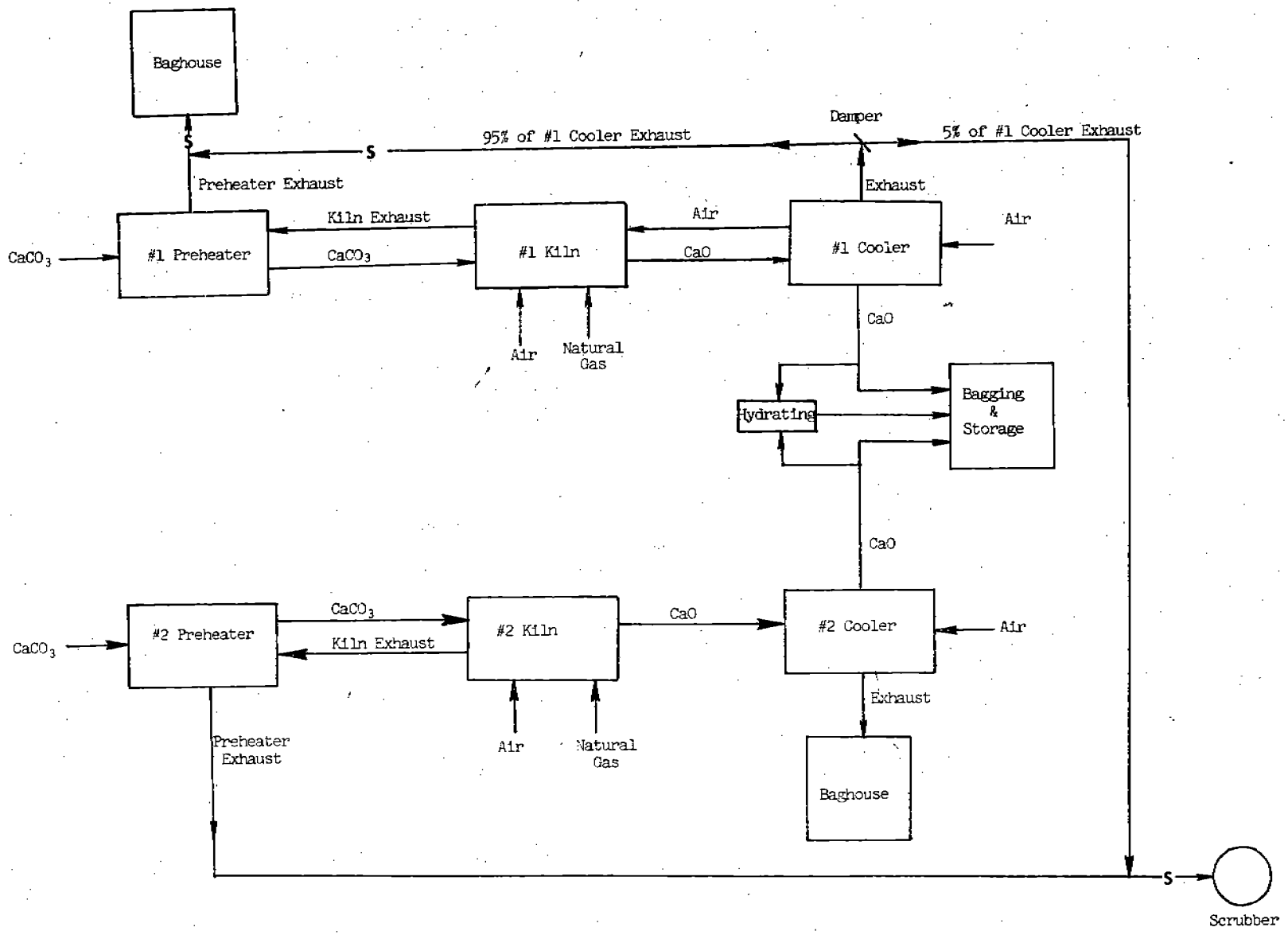


Figure 3. Schematic of Exhaust System

SECTION IV

LOCATION OF SAMPLING POINTS

Figure 2 shows the locations at which the ducts were sampled.

The #1 preheater duct was sampled using ports installed at 45° to the perpendicular as shown in Figure 4. The sampling location was 7 diameters downstream from the nearest disturbance, so a 16 point traverse was used and is illustrated in Figure 5.

The #2 preheater duct is a rectangular duct and is shown in Figure 6. Sampling ports were located on top of the duct and traverse points were located as shown in Figure 7.

The #1 cooler duct, as shown in Figure 8, was sampled at the point prior to where it connects to the #1 preheater duct so that at this location 95% of the emissions from the #1 cooler were sampled. Ports were installed at 45° angles to the perpendicular. An 8 point traverse was used, as shown in Figure 9, because the location met the minimum traverse point requirements and had a diameter of less than 24" (16").

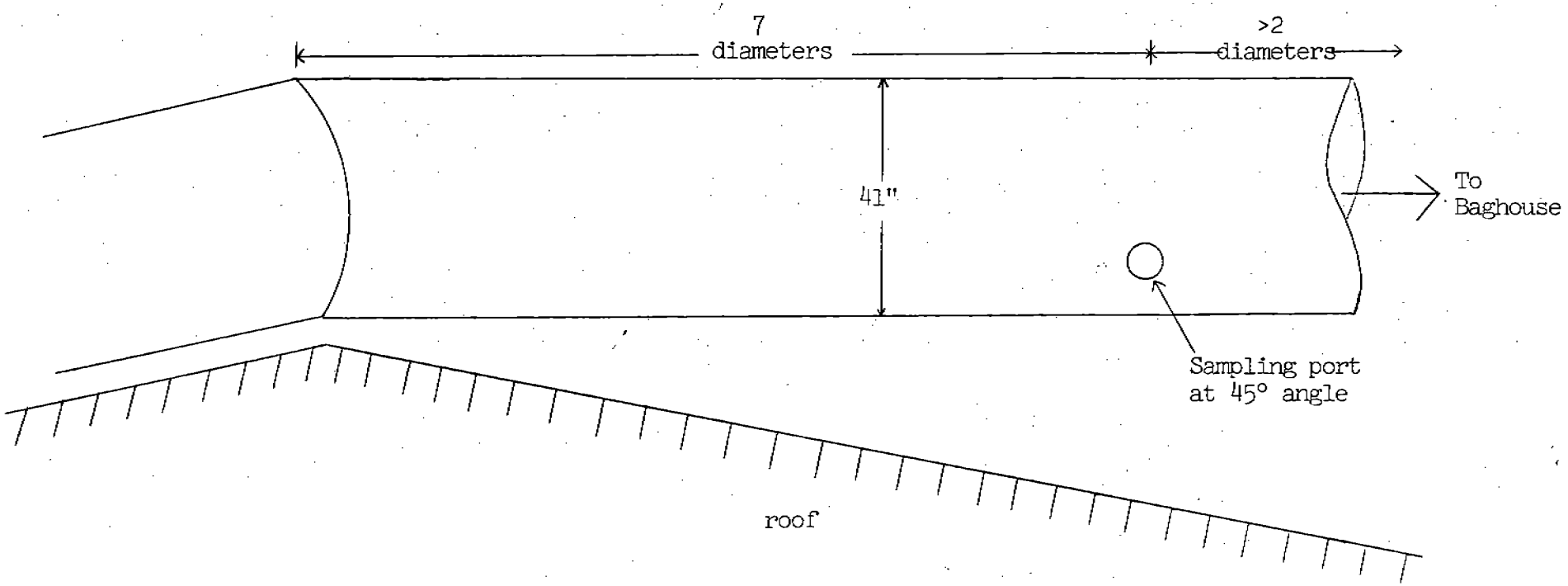
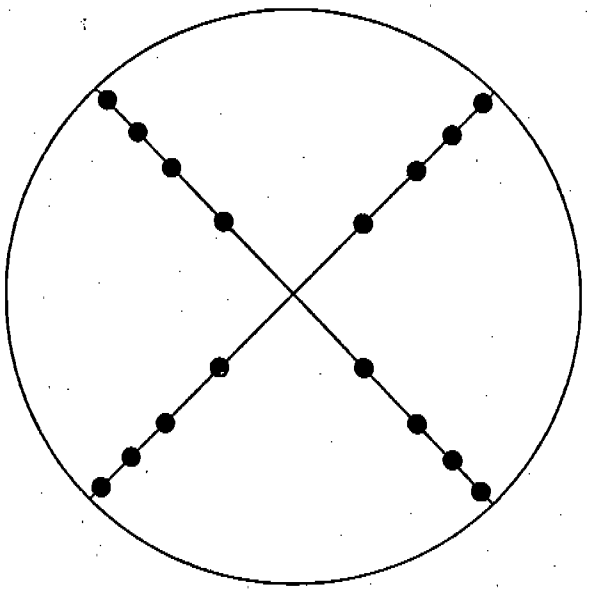


Figure 4. #1 preheater sampling location



16 point traverse

41" I.D.

Figure 5. Traverse point locations for #1 preheater

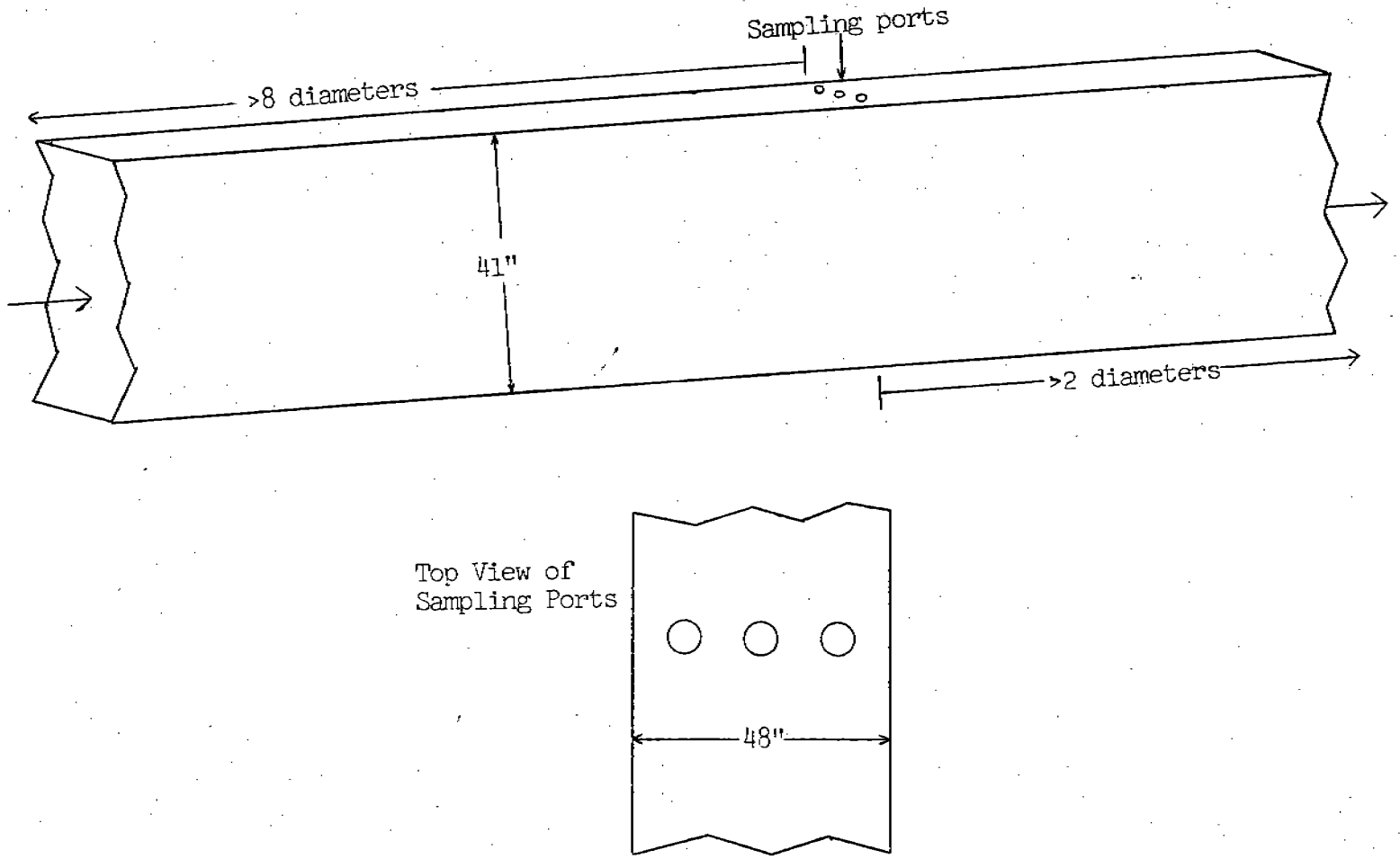


Figure 6. #2 preheater sampling locations

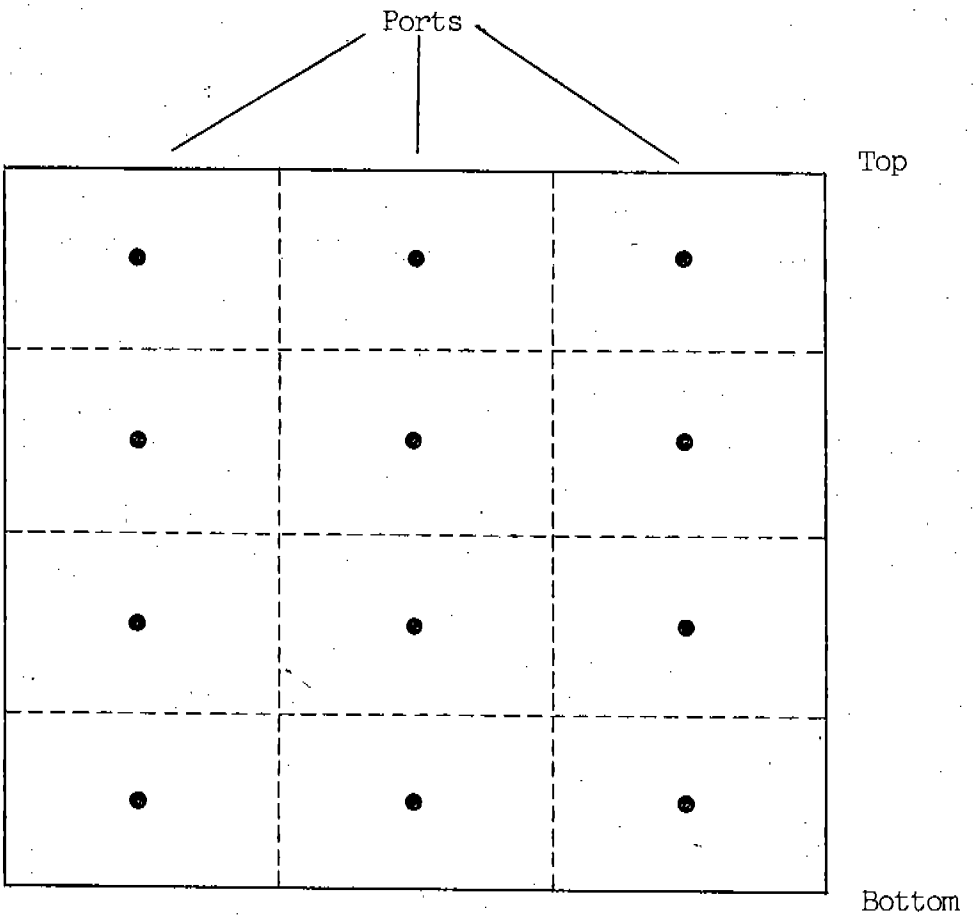


Figure 7. Traverse point locations for #2 preheater

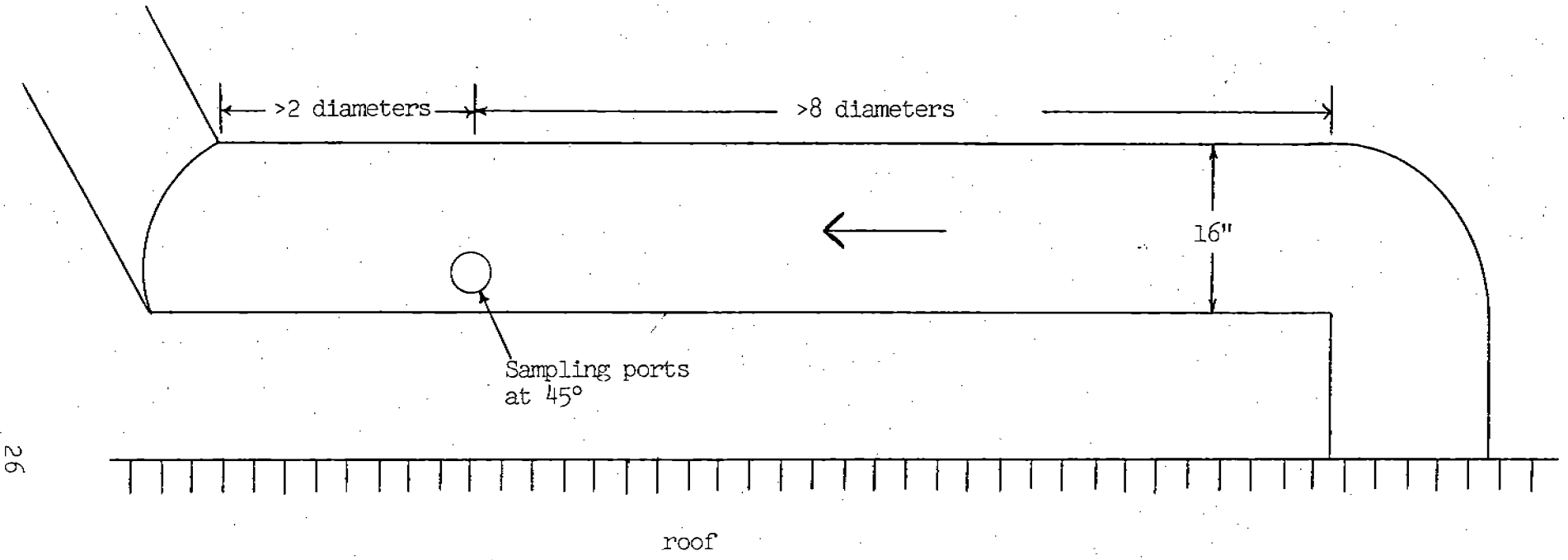
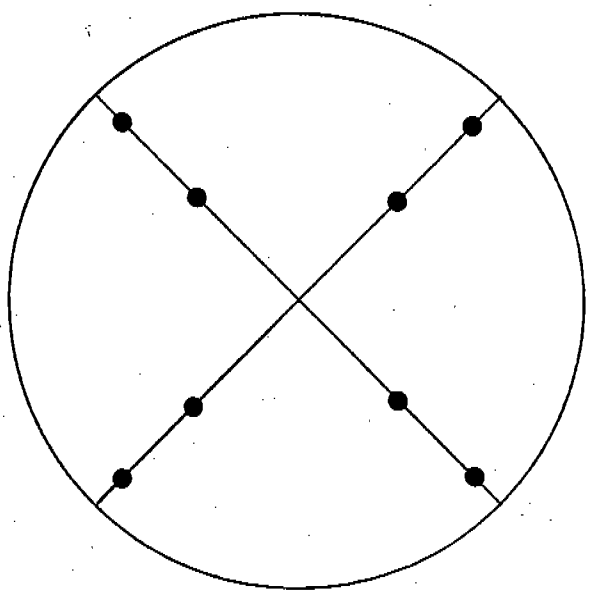


Figure 8. #1 cooler sampling location



8 point traverse

16" I.D.

Figure 9. Traverse point locations for #1 cooler

SECTION V

SAMPLING AND ANALYTICAL PROCEDURES

Uncontrolled particulate emissions from the #1 preheater, #2 preheater, and #1 cooler were tested at The National Lime and Stone Company. Samples for nitrogen oxide were taken in the #1 preheater duct.

Sampling procedures were designated by EPA. Analyses of collected samples were performed by Monsanto. Appendix E presents detailed sampling and analytical procedures.

Velocity and Gas Temperature

Gas velocities were measured with a calibrated type S pitot tube and inclined manometer. Velocities were measured at each sampling point across the stack diameter to determine an average value according to procedures described in the Federal Register, Vol. 36, No. 247, December 23, 1971, Method 2. Temperatures were measured with a Type K (Chromel-Alumel) thermocouple connected to a digital thermometer.

Molecular Weight

An integrated sample of the stack gases was collected during each particulate test by pumping the gas into a Tedlar plastic

bag at the rate of approximately 0.033 cfm. This bag sample was then analyzed with an Orsat analyzer for CO_2, O_2, and CO as described in the above mentioned Federal Register, Method 3.

Particulates

Concentrations of particulate matter in the #1 preheater were measured by Method 5 as described in the above Federal Register. A rigid train consisting of a heated glass-lined probe, a cyclone, a 3-inch diameter glass-fiber filter, and a series of Greenburg-Smith impingers was used for particulate sampling. Two runs of 64 minutes each were performed on the #1 preheater.

Concentrations of particulate matter in the #2 preheater and #1 cooler were measured by Method 5 as described in the above mentioned Federal Register with one exception. The sampling locations at both ducts required the use of a flexible probe line between the glass lined stainless steel probe and the cyclone inlet. The flexible probe was heated and the temperature was monitored and entered on the Method 5 data sheets. The heat was controlled by a variac.

Two runs were performed on each of the #2 preheater and #1 cooler. The runs for the #2 preheater were 60 minutes each and the duration of the runs on the #1 cooler was 64 minutes apiece.

Samples from the Method 5 sampling trains were recovered as outlined in the above mentioned Federal Register. After removal of the filter, all sample exposed surfaces were washed with distilled water or reagent grade acetone as specified. All sample bottles for liquid samples were obtained from

Wheaton Scientific, Catalogue No. 219630. Prior to use, each of these bottles was acid-soaked with 1:1 HNO_3 for one day, rinsed with distilled water, and soaked with distilled water for one day. The particulate sample was recovered by rinsing the nozzle, probe, flexible probe (where used), cyclone, cyclone flask, and front half of the filter holder twice with acetone into a glass container. The inside walls of the probe and flexible probe were brushed while rinsing. The back half of the filter holder, impingers, and connecting tubes were rinsed twice with distilled water and the washings placed in a glass container with the impinger contents. These components were then double-rinsed with acetone into another glass container. The filter was placed in a separate container. Blank samples of water and acetone were also taken.

Analytical procedures for the front half Method 5 samples follow the Federal Register guidelines. Back half Method 5 samples were analyzed according to the procedure outlined in Specifications for Incinerator Testing at Federal Facilities.[1] Both weights were included in the total mass of particulate. Sample weights from the Method 5 samplers are reported in Appendix A as "front half" (probe washings and filter collection weights) and "total" (front half plus water, chloroform-ether extract and impinger acetone washing weights).

NO_x

Nitrogen oxides were collected in evacuated 2-liter flasks containing 25 ml of a dilute sulfuric acid/hydrogen peroxide

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[1] Specifications for Incinerator Testing at Federal Facilities U. S. Dept. of Health, Education and Welfare, National Center for Air Pollution Control, Durham, N.C., October 1967.

absorbing solution. The sampling and analytical procedure was described in Method 7 of the Federal Register. Five nitrogen oxide samples were collected in the #1 preheater duct. Each sample was collected using a stainless steel probe. Each flask was evacuated and vacuum tested for one minute, and the initial flask temperature, pressure, and barometric pressure recorded. The sampling probe was inserted into the stack and heated, and the sample flask connected. The 3-way stopcock was turned to the "purge" position and stack gas drawn through the system with a vacuum pump to check for condensation in the probe line. The 3-way stopcock was then turned to the sample position for 15 to 30 seconds. The flask valve was then closed and disconnected from the probe. The contents were shaken for at least 5 minutes.

The flasks were allowed to set for at least 16 hours. They were then shaken for at least 2 minutes, the final pressure, temperature, and barometric pressure were taken, and the sample was transferred to a storage bottle.

The samples were analyzed using the phenoldisulfonic acid, colorimetric analysis described in the above mentioned Federal Register. Table B-1 gives the calculated amounts of nitrogen oxides given as NO_2 in both parts per million and mass per unit volume. Mass per unit time figures were calculated using the average volumetric flow rate from the Method 5 runs on the duct.

APPENDIX A

COMPLETE PARTICULATE RESULTS

Table A-1. COMPLETE PARTICULATE RESULTS (METRIC)

15 JAN 1976

NATIONAL LIME AND STONE COMPANY - 6912-17
PARTICULATE SAMPLING

ABBR	DESCRIPTION (20 DEG C)	UNITS	1-1	1-2	2-1	2-2	3-1	3-2
TT	DURATION OF RUN	MINUTES	60.4	60.0	64.0	64.0	64.0	64.0
PB	BAROMETRIC PRESSURE	CM HG	75.01	75.01	74.80	74.85	74.65	74.65
DELH	AVG ORIFICE PRESS DROP	CM H2O	1.882	2.004	1.821	1.551	5.150	4.420
VM	VOL DRY GAS(METER CON)	DCM	0.767	0.772	0.802	0.756	1.342	1.276
TM	AVG GAS METER TEMP	DEG C	23.8	31.2	19.5	23.2	15.9	17.0
VMSTD	VOL DRY GAS (STD COND)	DNCM	0.75	0.74	0.79	0.74	1.34	1.27
VW	TOTAL H2O COLLECTED	ML	41.4	43.8	54.7	38.0	11.4	10.7
VWG	VOL H2O VAPOR(STD CON)	NCM	0.056	0.059	0.073	0.051	0.015	0.014
PCNTM	PERCNT MOISTURE BY VOL		6.91	7.40	8.48	6.47	1.13	1.12
MD	MOLE FRACTION DRY GAS		0.931	0.926	0.915	0.935	0.989	0.989
CO2	PERCENT CO2		12.6	12.6	9.6	9.6	0.2	0.2
O2	PERCENT O2		12.3	12.3	13.3	13.3	20.2	20.2
N2	PERCENT N2		75.0	75.0	77.1	77.1	79.6	79.6
MWD	MOL WT OF DRY GAS		30.5	30.5	30.1	30.1	28.8	28.8
MW	MOL WT OF STACK GAS		29.6	29.6	29.0	29.3	28.7	28.7
DELP	AVG STACK VELOCITY HEAD	CM H2O	1.854	1.979	0.738	0.660	1.756	1.543
CP	PITOT COEFFICIENT		0.809	0.809	0.807	0.807	0.823	0.823
TS	STACK TEMPERATURE	DEG C	247.	235.	198.	181.	146.	140.
PM	STACK PRESSURE(STATIC)	CM H2O	-44.91	-44.91	-9.14	-9.14	-8.15	-8.15
PS	STACK PRESSURE (ABS)	CM HG	71.70	71.70	74.13	74.18	74.05	74.05
VS	AVG STACK GAS VELOCITY	MPM	1140.	1166.	678.	628.	1004.	943.
DS	STACK DIAMETER	CM	127.25	127.25	104.14	104.14	40.64	40.64
AS	STACK AREA	SQ CM	12719.2	12719.2	8518.3	8518.3	1297.3	1297.3
QS	STACK FLOW RT(DRY STD)	DNCMPM	721.	751.	322.	317.	88.	84.
QA	STACK FLOW RT(ACTUAL)	ACMPM	1450.	1483.	578.	535.	130.	122.
DN	PROBE TIP DIAMETER	CM	0.518	0.518	0.622	0.622	0.622	0.622
PCTI	PERCENT ISOKINETIC		104.1	98.7	107.9	102.2	102.0	101.3
MF	PARTICULATE (FRONT)	MG	8155.10	6919.80	1831.30	2137.20	2893.50	5491.50
MT	PARTICULATE (TOTAL)	MG	8181.00	6939.50	1851.70	2152.30	2899.50	5513.50
CAN	PARTICULATE (FRONT)	G/DNCM	10.8683	9.3935	2.3066	2.8931	2.1495	4.3101
CAO	PARTICULATE (TOTAL)	G/DNCM	10.9029	9.4203	2.3323	2.9136	2.1540	4.3274
CAT	PARTICULATE (FRONT)	G/ACM	5.3826	4.7391	1.2824	1.7066	1.4495	2.9462
CAU	PARTICULATE (TOTAL)	G/ACM	5.3997	4.7526	1.2966	1.7187	1.4525	2.9580
CAW	PARTICULATE (FRONT)	KG/HR	469.748	423.107	44.599	54.936	11.363	21.695
CAX	PARTICULATE (TOTAL)	KG/HR	471.240	424.312	45.096	55.324	11.387	21.782

Table A-2. COMPLETE PARTICULATE RESULTS (ENGLISH)

15 JAN 1976

NATIONAL LIME AND STONE COMPANY - 6912-17
PARTICULATE SAMPLING

ABBR	DESCRIPTION (68 DEG F)	UNITS	1-1	1-2	2-1	2-2	3-1	3-2
TT	DURATION OF RUN	MINUTES	60.4	60.0	64.0	64.0	64.0	64.0
PB	BAROMETRIC PRESSURE	IN HG	29.53	29.53	29.45	29.47	29.39	29.39
DELH	AVG ORIFICE PRESS DROP	IN H2O	0.741	0.789	0.717	0.611	2.027	1.740
VM	VOL DRY GAS(METER CON)	DCF	27.093	27.254	28.331	26.684	47.379	45.057
TM	AVG GAS METER TEMP	DEG F	74.9	88.1	67.2	73.8	60.6	62.7
VMSTD	VOL DRY GAS (STD COND)	DSCF	26.45	25.97	27.99	26.04	47.45	44.91
VW	TOTAL H2O COLLECTED	ML	41.4	43.8	54.7	38.0	11.4	10.7
VWG	VOL H2O VAPOR(STD CON)	SCF	1.962	2.076	2.593	1.801	0.540	0.507
PCNTM	PERCNT MOISTURE BY VOL		6.91	7.40	8.48	6.47	1.13	1.12
MD	MOLE FRACTION DRY GAS		0.931	0.926	0.915	0.935	0.989	0.989
CO2	PERCENT CO2		12.6	12.6	9.6	9.6	0.2	0.2
O2	PERCENT O2		12.3	12.3	13.3	13.3	20.2	20.2
N2	PERCENT N2		75.0	75.0	77.1	77.1	79.6	79.6
MWD	MOL WT OF DRY GAS		30.5	30.5	30.1	30.1	28.8	28.8
MW	MOL WT OF STACK GAS		29.6	29.6	29.0	29.3	28.7	28.7
DELP	AVG STACK VELOCITY HEAD	IN H2O	0.730	0.779	0.291	0.260	0.691	0.607
CP	PITOT COEFFICIENT		0.809	0.809	0.807	0.807	0.823	0.823
TS	STACK TEMPERATURE	DEG F	477.	454.	388.	357.	294.	284.
PM	STACK PRESSURE(STATIC)	IN H2O	-17.68	-17.68	-3.60	-3.60	-3.21	-3.21
PS	STACK PRESSURE (ABS)	IN HG	28.23	28.23	29.19	29.21	29.15	29.15
VS	AVG STACK GAS VELOCITY	FPM	3740.	3827.	2226.	2060.	3294.	3094.
DS	STACK DIAMETER	INCHES	50.10	50.10	41.00	41.00	16.00	16.00
AS	STACK AREA	SQ IN	1971.4	1971.4	1320.3	1320.3	201.1	201.1
QS	STACK FLOW RT(DRY STD)	DSCFM	25449.	26521.	11385.	11181.	3113.	2964.
QA	STACK FLOW RT(ACTUAL)	ACFM	51198.	52376.	20403.	18884.	4599.	4320.
DN	PROBE TIP DIAMETER	INCHES	0.204	0.204	0.245	0.245	0.245	0.245
PCTI	PERCENT ISOKINETIC		104.1	98.7	107.9	102.2	102.0	101.3
MF	PARTICULATE (FRONT)	MG	8155.10	6919.80	1831.30	2137.20	2893.50	5491.50
MT	PARTICULATE (TOTAL)	MG	8181.00	6939.50	1851.70	2152.30	2899.50	5513.50
CAN	PARTICULATE (FRONT)	GR/DSCF	4.7483	4.1040	1.0077	1.2640	0.9391	1.8830
CAO	PARTICULATE (TOTAL)	GR/DSCF	4.7634	4.1156	1.0190	1.2729	0.9411	1.8906
CAT	PARTICULATE (FRONT)	GR/ACF	2.3516	2.0705	0.5603	0.7456	0.6333	1.2872
CAU	PARTICULATE (TOTAL)	GR/ACF	2.3591	2.0764	0.5665	0.7509	0.6346	1.2923
CAW	PARTICULATE (FRONT)	LB/HR	1035.600	932.776	98.323	121.112	25.051	47.828
CAX	PARTICULATE (TOTAL)	LB/HR	1038.889	935.432	99.418	121.967	25.103	48.019

Table A-3

PARTICULATE CALCULATIONS

Example: 1-1

1. Volume of dry gas sampled at standard conditions (dscf[a])

$$VMSTD = \frac{17.65 \times VM \left(PB + \frac{DELH}{13.6}\right)}{(TM + 460)}$$

$$= \frac{17.65 \times 27.093 \left(29.53 + \frac{0.741}{13.6}\right)}{(74.9 + 460)}$$

$$= 26.45 \text{ dscf}$$

2. Volume of water vapor at standard conditons (scf[b])

$$VWG = 0.0474 \times VW$$

$$= 0.0474 \times 41.4$$

$$= 1.962 \text{ scf}$$

3. Percent moisture in stack gas

$$PCNTM = \frac{100 \times VWG}{VMSTD + VWG}$$

$$= \frac{100 \times 1.962}{26.45 + 1.962}$$

$$= 6.91$$

Table A-3 (cont'd)

PARTICULATE CALCULATIONS

4. Mole fraction of dry gas

$$MD = \frac{100 - PCNTM}{100}$$

$$= \frac{100 - 6.91}{100}$$

$$= 0.931$$

5. Molecular weight of dry stack gas

$$MWD = (\%CO_2 \times 0.44) + (\%O_2 \times 0.32) + [(\%C + \%N_2) \times 0.28]$$

$$= (12.6 \times 0.44) + (12.3 \times 0.32) + [(75.0 \times 0.28)]$$

$$= 30.5$$

6. Molecular weight of wet stack gas

$$MW = MWD \times MD \times 18(1 - MD)$$

$$= 30.5 \times 0.931 \times 18(1 - 0.931)$$

$$= 29.6$$

7. Stack gas velocity at stack conditions (fpm^c)

$$VS = 4360 \times \left[\frac{\sum_{i=1}^{i=n} \sqrt{DELP \times (TS + 460)}}{n}\right] \times \left[\frac{1}{PS \times MW}\right]^{\frac{1}{2}}$$

where n = the number of data points

Table A-3 (cont'd)

PARTICULATE CALCULATIONS

$$= 4360 \times 1.6469 \times \left(\frac{1}{28.23 \times 29.6}\right)^{\frac{1}{2}}$$

$$= 3740 \text{ fpm}$$

8. Stack gas volumetric flow rate at standard conditions (dscfm[d])

$$QS = \frac{0.123 \times VS \times AS \times MD \times PS}{TS + 460}$$

$$= \frac{0.123 \times 3740 \times 1971.4 \times 30.5 \times 28.23}{477 + 460}$$

$$= 25449 \text{ dscfm}$$

9. Stack gas volumetric flow rate at stack conditions (acfm[e])

$$QA = \frac{0.05645 \times QS\ (TS + 460)}{PS + MD}$$

$$= \frac{0.05645 \times 25449\ (477 + 460)}{28.23 \times 30.5}$$

$$= 51198 \text{ acfm}$$

10. Area of nozzle (sq. ft.)

$$AN = 54.54 \times 10^{-4}\ (DN)^2$$

$$= 54.54 \times 10^{-4}\ (0.204)^2$$

$$= 2.27 \times 10^{-4} \text{ sq. ft.}$$

Table A-3 (cont'd)

PARTICULATE CALCULATIONS

14. Particulate - probe, cyclone, and filter at stack conditions (gr/acf)

$$CAT = \frac{17.65 \times CAN \times PS \times MD}{(TS + 460)}$$

$$= \frac{17.65 \times 4.7483 \times 28.23 \times 30.5}{(477 + 460)}$$

$$= 2.3516 \text{ gr/acf}$$

15. Particulate - total at stack conditions (gr/acf)

$$CAU = \frac{17.65 \times CAO \times PS \times MD}{(TS + 460)}$$

$$= \frac{17.65 \times 4.7634 \times 28.23 \times 30.5}{(477 + 460)}$$

$$= 2.3591$$

16. Particulate - probe, cyclone and filter (lb/hr)

$$CAW = 0.00857 \times CAN \times QS$$

$$= 0.00857 \times 4.7483 \times 25449$$

$$= 1035.600 \text{ lb/hr}$$

Table A-3 (cont'd)

PARTICULATE CALCULATIONS

17. Particulate - total (lb/hr)

$$CAX = 0.00857 \times CAO \times QS$$

$$= 0.00857 \times 4.7634 \times 25449$$

$$= 1038.889 \text{ lb/hr}$$

[a]Dry standard cubic feet @ 68°F, 29.92 in. Hg

[b]Standard cubic feet @ 68°F, 29.92 in. Hg

[c]Feet per minute @ stack conditions; n = number of data points

[d]Dry standard cubic feet per minute @ 68°F, 29.92 in. Hg

[e]Actual cubic feet per minute @ stack conditions

Table A-4

CORRECTED EMISSION RATE CALCULATIONS

#1 Cooler Emissions

	tested amount	actual amount (+5%)
Run 1	25.103 lb/hr	26.358 lb/hr
Run 2	48.019 lb/hr	50.420 lb/hr
avg.	36.561 lb/hr	38.389 lb/hr

eg. 25.103 lb/hr x .05 = 1.255 lb/hr
25.103 lb/hr + 1.255 lb/hr = 26.358 lb/hr

#1 Preheater Emissions

	tested amount	actual amount (-95% #1 cooler)
Run 1	99.418 lb/hr	62.857 lb/hr
Run 2	121.967 lb/hr	85.406 lb/hr

eg. 99.418 lb/hr - 36.561 lb/hr (avg. #1 cooler emissions) =
62.857 lb/hr

#2 Preheater Emissions

	tested amount	actual amount (-5% #1 cooler)
Run 1	1038.889 lb/hr	1037.061 lb/hr
Run 2	935.432 lb/hr	933.604 lb/hr

eg. 1038.889 lb/hr - 1.828 lb/hr (5% avg. tested #1 cooler
emissions) = 1037.061 lb/hr

APPENDIX B

COMPLETE NO_x RESULTS

Table B-1. COMPLETE NO_x RESULTS

NOX CALCULATION (68 DEG F)

NATIONAL LIME AND STONE
11 MARCH 1976

VSC - SAMPLE VOLUME AT STANDARD CONDITIONS (DRY BASIS),ML
MASS - MASS OF NO2 IN GAS SAMPLE,UG
PPM - PPM,NOX AS NO2
LB/DSCF - CONCENTRATION OF NOX AS NO2 (DRY BASIS),LB/DSCF

VSC	MASS	PPM	LB/DSCF	KG/HR	G/NCM	LB/HR
0.184682E+04	0.503390E+02	0.142827E+02	0.168994E-05	0.518942E+00	0.270672E-01	0.114405E+01
0.161246E+04	0.197098E+02	0.640510E+01	0.757855E-06	0.232721E+00	0.121383E-01	0.513053E+00
0.163420E+04	0.394000E+02	0.126334E+02	0.149480E-05	0.459019E+00	0.239417E-01	0.101195E+01
0.167493E+04	0.415878E+02	0.130107E+02	0.153944E-05	0.472727E+00	0.246567E-01	0.104217E+01
0.191571E+04	0.197098E+02	0.539118E+01	0.637887E-06	0.195881E+00	0.102168E-01	0.431837E+00

METHOD 7

NO_x CALCULATIONS

Plant National Lime and Stone Co.

Date 10/8/75

Test No. Sample Calculation Run #1

Volume of flask and value (ml)	= VF =	2031
Initial absolute pressure of flask (in Hg)	= PI =	1.04
Final absolute pressure of flask (in Hg)	= PF =	27.74
Initial temperature of flask (°F)	= TI =	62
Final temperature of flask (°F)	= TF =	52
Mass of NO_x as NO_2 in gas sample (µg)	= M =	50.339

Volume of sample at standard conditions, dry basis(ml) = VS

$$VS = 17.65 \times (VF-25)\left(\frac{PF}{TF+460} - \frac{PI}{TI+460}\right)$$

$$VS = 17.65 \times (2031 - 25)\left(\frac{27.74}{52+460} - \frac{1.04}{62+460}\right) = 1847.7 \text{ ml}$$

Concentration of NO_x as NO_2 (dry basis) (lbs/scf) = C

$$C = 6.2 \times 10^{-5} \times \left(\frac{M}{VS}\right)$$

$$C = 6.2 \times 10^{-5} \times \left(\frac{50.339}{1847.7}\right) = 1.6899 \times 10^{-6} \text{ lbs/scf}$$

$$ppm = \frac{24.5}{mw} \times 1.6018 \times 10^{7} \times \frac{lb}{dSCF}$$

$$ppm = \frac{24.5}{46} \times 1.6018 \times 10^{7} \times 1.6899 \times 10^{-6} = 14.4 \text{ ppm}$$

APPENDIX C

FIELD TEST DATA SHEETS

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT Natural Lime & Stone
DATE 10-8-75
SAMPLING LOCATION #1 cooler
INSIDE OF FAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE A) _____
INSIDE OF NEAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE B) 3" nipples
STACK I.D., (DISTANCE A - DISTANCE B) 16
NEAREST UPSTREAM DISTURBANCE 8
NEAREST DOWNSTREAM DISTURBANCE 2
CALCULATOR Peltier

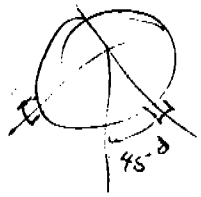
SCHEMATIC OF SAMPLING LOCATION

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	.067	16"	1 1/8	3	4 1/8
2	.250	16"	4	↓	7
3	.750	16"	12	↓	15
4	.933	16"	14 7/8	↓	17 7/8

EPA (Dur) 232
4/72

PRELIMINARY VELOCITY TRAVERSE

PLANT National Lime Co.
DATE 10/8/75
LOCATION #1 cooler
STACK I.D. 16
BAROMETRIC PRESSURE, in. Hg 29.47 25.38
STACK GAUGE PRESSURE, in. H_2O -1.95
OPERATORS T. Pettee L. Cox



SCHEMATIC OF TRAVERSE POINT LAYOUT

South

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
1	.18	289
2	.19	289
3	.19	286
4	.19	260
AVERAGE	.188	281

North

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
1	.20	283
2	.20	287
3	.20	285
4	.15	265
AVERAGE	.188	280

EPA (Dur) 233
4/72

DRY MOLECULAR WEIGHT DETERMINATION

PLANT National Lime + Stone
DATE 10-9-75
SAMPLING TIME (24-hr CLOCK) 1117 to 1147
SAMPLING LOCATION #1 cooler
SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) Integrated
ANALYTICAL METHOD Orsat
AMBIENT TEMPERATURE 55
OPERATOR Pettier

COMMENTS:

RUN / GAS	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	.2	.2					.2	44/100	.09
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)	20.4	20.2					20.2	32/100	6.46
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)								28/100	0
N_2 (NET IS 100 MINUS ACTUAL CO READING)							79.6	28/100	22.29
								TOTAL	28.84

EPA (Dur) 230
4/72

NOMOGRAPH DATA

PLANT National Lime & Stone

DATE 10/8/75

SAMPLING LOCATION #1 cooler

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.94	
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m\,avg.}$	90	
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	2.	
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	~~29.47~~	29.38
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	29.24	
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	.995	
AVERAGE STACK TEMPERATURE, °F	$T_{s\,avg.}$	280.5	
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	.188	
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	.28	
C FACTOR		1.15 →	1.08 @ .823 C_p
CALCULATED NOZZLE DIAMETER, in.		.328	.331
ACTUAL NOZZLE DIAMETER, in.		.245	
REFERENCE Δp, in. H_2O		.63	

EPA (Dur) 234
4/72

FIELD DATA

PLANT National Lime Stone
DATE 10/9/75
SAMPLING LOCATION #1 cooler
SAMPLE TYPE EPA-5
RUN NUMBER 1
OPERATOR H. Tay & Cox
AMBIENT TEMPERATURE 60
BAROMETRIC PRESSURE 29.39
STATIC PRESSURE, (P_s) ~~-1.75~~ -3.21 H_2O
FILTER NUMBER (s) 63-16

Longitude

g = .823
PROBE LENGTH AND TYPE MRC 3'
NOZZLE I.D. .245
ASSUMED MOISTURE, % 2
SAMPLE BOX NUMBER SCB-4
METER BOX NUMBER MRC-6
METER $\Delta H_@$ 1.94
C FACTOR 1.08
PROBE HEATER SETTING ~~Hi~~ Med
HEATER BOX SETTING Hi
REFERENCE Δp .63

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 4 MINUTES LEAK RATE .018 CFM @ 16 "Hg

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		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
	0	09:34	208.832										
1	0	09:34	208.832	.40	1.18	1.18	297	59	58	4.0	236	53	312
	4	09:38	211.083	.41	1.2	1.2	296	60	59	3.9	235	51	284
2	8	0942	213.385	.35	1.02	1.02	296	61	59	3.8	224	53	262
	12	0946	215.571	.65	1.9	1.9	301	62	59	4.9	234	54	260
3	16	0950	218.395	.55	1.55	1.55	295	62	59	4.4	224	54	250
	20	0954	221.139	.56	1.47	1.47	291	62	59	4.3	222	54	246
4	24	0958	223.701	.56	1.65	1.65	276	63	59	4.5	222	53	250
	28	1002	226.349	.83	2.4	2.4	293	63	59	5.5	230	54	245
5	32	1015	229.307	.98	2.9	2.9	298	59	59	6.1	226	53	248
	36	1019	232.8250	.89	2.6	2.6	297	62	59	6.0	256	50	247
6	40	1023	236.275	.86	2.51	2.51	300	63	59	5.9	261	52	286
	44	1027	239.658	.82	2.4	2.4	299	63	59	5.8	260	52	295
7	48	1031	242.957	.87	2.57	2.57	296	64	60	5.9	261	52	285
	52	1035	246.346	.86	2.51	2.51	296	63	60	6.0	259	53	289
8	56	1039	249.768	.78	2.3	2.3	293	63	60	5.8	261	53	284
	60	1043	253.069	.77	2.28	2.28	294	63	60	5.5	260	53	283
	64	1047	256.211										

ISOKINETIC CALCULATION

Plant National Lime & Stone

Run# 1, Date 10-9-75

Location #1 Cooler, Initials TLP

MOISTURE

Net volume of liquid collected in impingers and silica gel = V_L = 11.4 ml

Net volume of gas through dry gas meter at meter conditions = V_m = 47.379 cu.ft.

Barometric Pressure - absolute = BP = 29.39 in.Hg

Average absolute meter temperature (°F + 460) = T_m = 521 °R

Percent moisture = M

$$M = \frac{100}{1 + \frac{373.63\ (\ V_m\ )\ (\ BP\ )}{(\ T_m\ )\ (\ V_L\ )}}$$

$$= \frac{100}{1 + \frac{373.63\ (47.379)\ (29.39\ )}{(\ 521\ )\ (\ 11.4\ )}} = 1.1\ ^{c}\ \%$$

MOLECULAR WEIGHT

Percent O_2 by volume dry basis = O_2 = ____ %

" CO " " " " = CO = ____ %

" CO_2 " " " " = CO_2 = ____ %

N_2 = 100 - (O_2 + CO_2 + CO) = 100 - (+ +)

Percent N_2 by volume dry basis = N_2 = ____ %

Dry molecular weight = MD

MD = 0.44 (CO_2) + 0.32 (O_2) + 0.28 (N_2 + CO)

MD = 0.44 ( ) + 0.32 ( ) + 0.28 (+)

MD = 28.84

ISOKINETIC CALCULATION (Cont.d)

MOLECULAR WEIGHT (Cont.d)

Stack gas molecular weight = MS

$MS = (MD)[1 - (M \times 10^{-2})] + 18 (M \times 10^{-2})$

$MS = (28.84)[1 - (.011)] + 18 (.011) = 28.72$

VELOCITY

Pitot tube coefficient, type S = CP = .823

Average Absolute Stack Temp. (°F + 460) = T_s = 755 °R

Average of the square root of Δp = $\sqrt{\Delta p}$ = 0.822 $(in.H_2O)^{\frac{1}{2}}$

Absolute pressure of stack $\left(BP \pm \frac{p}{13.6}\right)$ = P_s = 29.15 in.Hg

Stack gas velocity = V_s

$$V_s = (85.48)(CP)\left[\sqrt{\frac{(T_s)}{(P_s)(MS)}}\right]\left[\sqrt{\Delta p}\right]$$

$$V_s = (85.48)(.823)\left[\sqrt{\frac{(755)}{(28.72)(29.15)}}\right][.822]$$

$$= 54.916 \text{ FPS}$$

ISOKINETIC PERCENT

Average pressure drop across orifice = ΔH = 2.028 in.H_2O

Total sampling time = T = 64 min.

Diameter of nozzle = d = .245 in.

Area of nozzle = A

$A = 54.54 \times 10^{-4} (d^2) = 54.54 \times 10^{-4} (.245)^2 = 3.274 \times 10^{-3}$ sq. ft.

I = percent Isokinetic

$$I = \frac{(1.667)(T_s)\left[0.00267 (V_L) + \frac{(V_m)}{(T_m)}\left(PB + \frac{(\Delta H)}{13.6}\right)\right]}{(T)(V_s)(P_s)(A)}$$

$$I = \frac{(1.667)(755)\left[0.00267 (11.4) + \frac{(47.379)}{(521)}\left(29.39 + \frac{(2.028)}{13.6}\right)\right]}{(64)(54.916)(29.15)(3.274 \times 10^{-4})}$$

$$I = 101.9 \%$$

CLEAN-UP DATA

Plant National Lime & Stone Co. Comments:
Date 12/9/75
Sampling Location No. 1 Cooler
Sample Type EPA 5
Run Number 1
Sample Box Number
Clean-up Man HT, TP, LC

IMPINGERS

	#1	#2	#3	#4	#5
Final Vol.	96 ml	104 ml	ml	ml	ml
Initial Vol.	100 ml	100 ml	ml	ml	ml
Net Vol.	-4 ml	4 ml	ml	ml	ml

Total Net Volume in Impingers _____ ml

SILICA GEL

Final Weight	211.4 g	g	g
Initial Weight	200.0 g	g	g
Net Weight	11.4 g	g	g

Total Net Weight in Silica Gel _____ g

Total Moisture 11.4 g

Filter Number(s) 63-16

MRC 7/73

FIELD DATA

Cp = .823

PLANT National Lime & Stone
DATE 10/9/15
SAMPLING LOCATION #1 Cooler
SAMPLE TYPE EPA-5
RUN NUMBER 2
OPERATOR A. Tay J. Cox
AMBIENT TEMPERATURE 60
BAROMETRIC PRESSURE 29.39
STATIC PRESSURE, (P_s) −3.2 "H_2O
FILTER NUMBER (s) 63-17

PROBE LENGTH AND TYPE 6' MRC -3'
NOZZLE I.D. .245
ASSUMED MOISTURE, % 2
SAMPLE BOX NUMBER SGB-5
METER BOX NUMBER 1224 MRC-4
METER $\Delta H_@$ 1.94
C FACTOR 1.08
PROBE HEATER SETTING ~~Heat~~ Thrl
HEATER BOX SETTING ~~Heat~~ Hgh
REFERENCE Δp .64

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 4 MINUTES LEAK RATE .016 CFM @ 15" Hg

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		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe	Flex Line
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F					
	C	1340	256.651											
1	0	1340	256.651	.44	1.26	1.26	286	61	60	6.0	255	58	297	2
	4	1344	258.962	.81	2.31	2.31	289	63	61	11.2	256	54	310	2
2	8	1348	262.124	.66	1.89	1.89	292	63	61	9.4	260	50	302	1
	12	1352	265.193	.68	1.94	1.94	292	63	61	9.1	254	44	292	1
3	16	1356	268.191	.65	1.87	1.87	290	65	61	8.5	264	78	266	1
	20	1400	271.186	.64	1.85	1.85	291	65	61	8.2	263	70	262	1
4	24	1404	274.095	.50	1.43	1.43	279	65	61	6.6	263	63	278	2
	28	1408	276.891	.49	1.4	1.4	279	65	61	6.4	266	60	276	1
5	32	1412	279.277	.69	1.99	1.99	285	62	61	8.4	308	57	249	1
	36	1424	282.215	.68	1.94	1.94	285	63	62	8.5	298	55	243	1
6	40	1428	285.174	.61	1.75	1.75	288	64	62	7.8	296	55	241	1
	44	1432	288.092	.61	1.75	1.75	289	65	62	7.6	292	55	243	1
7	48	1436	290.961	.57	1.63	1.63	288	65	62	7.2	290	55	240	1
	52	1440	293.668	.58	1.66	1.66	288	65	62	7.0	292	55	239	1
8	56	1444	296.398	.57	1.63	1.63	262	65	62	7.0	292	55	240	1
	60	1448	299.121	.54	1.54	1.54	267	65	62	6.9	293	54	241	1
	64	1452	301.710											

CLEAN-UP DATA

Plant National Lime & Stone Co. Comments:
Date 10/9/75
Sampling Location No. 1 Cooler
Sample Type EPA 5
Run Number 2
Sample Box Number
Clean-up Man HT, TW, LC

IMPINGERS

	#1	#2	#3	#4	#5
Final Vol.	6 ml	106 ml	ml	ml	ml
Initial Vol.	100 ml	100 ml	ml	ml	ml
Net Vol.	ml	6 ml	ml	ml	ml

Total Net Volume in Impingers _____ ml

SILICA GEL

Final Weight	238.7 g	g	g
Initial Weight	200.0 g	g	g
Net Weight	38.7 g	g	g

Total Net Weight in Silica Gel _____ g

Total Moisture _____ g 10.7 g → calculated using moisture from #1 Run on cooler.

Filter Number(s) 63-17

MRC 7/73

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT National Lime Co
DATE 10/6/75
SAMPLING LOCATION #1 preheater
INSIDE OF FAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE A) 1"
INSIDE OF NEAR WALL TO OUTSIDE OF NIPPLE, (DISTANCE B)
STACK I.D., (DISTANCE A - DISTANCE B) 41"
NEAREST UPSTREAM DISTURBANCE
NEAREST DOWNSTREAM DISTURBANCE
CALCULATOR

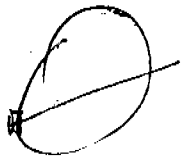
SCHEMATIC OF SAMPLING LOCATION

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	.033	41"	1 3/8"	41"	4 3/8
2	.105		4 1/4"		7 1/4
3	.194		8"		11
4	.323		13 1/4		16 1/4
5	.677		27 3/4		30 3/4
6	.806		33"		36
7	.895		36 3/4		39 3/4
8	.967		39 5/8		42 5/8

EPA (Dur) 232
4/72

PRELIMINARY VELOCITY TRAVERSE

PLANT National Lime Co.
DATE 10/6/75
LOCATION #1 preheater
STACK I.D. 41"
BAROMETRIC PRESSURE, in. Hg 29.47
STACK GAUGE PRESSURE, in. H_2O -3.6
OPERATORS H. Loy J. Coy



8 pts.
reverse-type pitot-tube
SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
1	~~.18~~ .20	~~320~~ 327
2	.19	~~310~~ 318
3	.21	~~312~~ 325
4	.24	339
5	.19	359
6	.18	363
7	.09	361
8	.14	363
AVERAGE	.18	344

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

EPA (Dur) 233
4/72

DRY MOLECULAR WEIGHT DETERMINATION

PLANT National Lime and Stone Co.
DATE 10-8-75
SAMPLING TIME (24-hr CLOCK) 1012 → 1040
SAMPLING LOCATION #1 preheater
SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) Integrated 1012 - 1040
ANALYTICAL METHOD Orsat
AMBIENT TEMPERATURE 65
OPERATOR Petters

COMMENTS:

GAS \ RUN	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	9.5	9.5	9.7	9.7			9.6	44/100	4.22
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)	22.8	13.3	23.6	13.3			13.3	32/100	4.26
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)	22.8	0	23.0	0			0	28/100	0
N_2 (NET IS 100 MINUS ACTUAL CO READING)	78.2		77				77.1	28/100	21.59
								TOTAL	30.07

EPA (Dur) 230
4/72

NOMOGRAPH DATA

PLANT National Lime Co.

DATE 10/6/75

SAMPLING LOCATION #1 preheater

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.94
AVERAGE METER TEMPERATURE (AMBIENT + 20°F), °F	$T_{m\,avg.}$	90
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	6
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	29.47
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	29.20
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	.991
AVERAGE STACK TEMPERATURE, °F	$T_{s\,avg.}$	344
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	.18
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	.21
C FACTOR		1.09
CALCULATED NOZZLE DIAMETER, in.		.340
ACTUAL NOZZLE DIAMETER, in.		.245
REFERENCE Δp, in. H_2O		.74

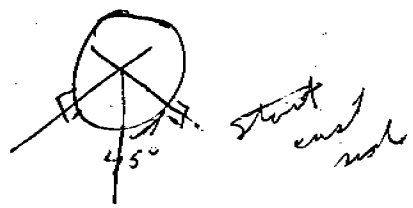
Adjusted .990

EPA (Dur) 234
4/72

FIELD DATA

PLANT National Lime Co.
DATE 10/8/75
SAMPLING LOCATION #1 preheater
SAMPLE TYPE EPA-5
RUN NUMBER 1
OPERATOR H. Toy L. Cox
AMBIENT TEMPERATURE 66°F
BAROMETRIC PRESSURE 29.45
STATIC PRESSURE, (P_s) -3.6 in H_2O
FILTER NUMBER (s)

Pitot 4B



PROBE LENGTH AND TYPE 4' MRC
NOZZLE I.D. .245
ASSUMED MOISTURE, % 6
SAMPLE BOX NUMBER #.5613-5
METER BOX NUMBER MRC-6
METER $\Delta H_@$ 1.94
C FACTOR .990 @ .31 Cp
PROBE HEATER SETTING High
HEATER BOX SETTING High
REFERENCE Δp .74

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 4 MINUTES LEAK RATE .014 CFM @ 15 "Hg

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		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe
					DESIRED	ACTUAL		INLET ($T_{m\ in}$), °F	OUTLET ($T_{m\ out}$), °F				
	C	0925	153.080										
1	C	0925	153.080	.31	.76	.76	369	59	59	2.0	228	59	201
2	4	0929	154.974	.39	.96	.96	399	63	59	2.5	253	59	171
3	8	0933	156.991	.36	.89	.89	403	65	61	2.6	268	60	193
4	12	0937	158.958	.34	.85	.85	411	67	62	2.9	283	61	237
5	16	0941	160.881	.30	.74	.74	406	69	62	2.9	293	63	256
6	20	0945	162.702	.29	.71	.71	405	71	63	3.0	305	64	271
7	24	0949	164.466	.26	.64	.64	372	71	64	3.0	313	66	276
8	28	0953	166.162	.22	.54	.54	288	70	65	3.0	313	67	245
9	32	1003	167.702	.24	.60	.60	384	67	66	3.1	294	66	245
10	36	1007	169.316	.25	.62	.62	412	69	67	3.2	303	63	234
11	40	1011	170.964	.25	.62	.62	411	70	67	3.6	314	63	242
12	44	1015	172.637	.31	.76	.76	418	72	68	4.2	313	62	270
13	48	1019	174.439	.32	.79	.79	415	73	69	4.7	319	62	271
14	52	1023	176.398	.29	.71	.71	394	73	69	4.9	323	62	270
15	56	1027	178.091	.22	.54	.54	368	74	70	4.6	326	63	268
16	60	1031	179.683	.30	.74	.74	353	74	71	5.2	328	63	262

CLEAN-UP DATA

Plant National Lime & Stone Co. Comments:
Date 10/6/75
Sampling Location No. 1 Preheater
Sample Type EPA-5
Run Number 1
Sample Box Number SGB 5
Clean-up Man H.D. Toy

IMPINGERS

	#1	#2	#3	#4	#5
Final Vol.	140 ml	104 ml	ml	ml	ml
Initial Vol.	100 ml	100 ml	ml	ml	ml
Net Vol.	40 ml	4 ml	ml	ml	ml

Total Net Volume in Impingers 44 ml

SILICA GEL

Final Weight	210.7 g	g	g
Initial Weight	200.0 g	g	g
Net Weight	10.7 g	g	g

Total Net Weight in Silica Gel 10.7 g

Total Moisture 54.7 g

Filter Number(s) 63-7 ?

MRC 7/73

ISOKINETIC CALCULATION

Run# #1, Date 10-8-75

Location #1 preheater, Initials TLP

MOISTURE

Net volume of liquid collected in impingers and silica gel = V_L = 54.7 ml

Net volume of gas through dry gas meter at meter conditions = V_m = 28.331 cu.ft.

Barometric Pressure - absolute = BP = 29.45 in.Hg

Average absolute meter temperature (°F + 460) = T_m = 527 °R

Percent moisture = M

$$M = \frac{100}{1 + \frac{373.63\ (\ V_m\ )\ (\ BP\ )}{(\ T_m\ )\ (\ V_L\ )}} + 2.5$$

$$= \frac{100}{1 + \frac{373.63\ (28.331)\ (29.45\ )}{(\ 527\ )\ (\ 54.7\ )}} + 2.5 = 8.5\ \%$$

MOLECULAR WEIGHT

Percent O_2 by volume dry basis = O_2 = ____ %

" CO " " " " = CO = ____ %

" CO_2 " " " " = CO_2 = ____ %

$N_2 = 100 - (O_2 + CO_2 + CO) = 100 - (\quad + \quad + \quad)$

Percent N_2 by volume dry basis = N_2 = ____ %

Dry molecular weight = MD

$MD = 0.44\ (\ CO_2\ ) + 0.32\ (\ O_2\ ) + 0.28\ (\ N_2 + CO\ )$

$MD = 0.44\ (\quad) + 0.32\ (\quad) + 0.28\ (\quad + \quad)$

MD = 30.07

ISOKINETIC CALCULATION (Cont.d)

MOLECULAR WEIGHT (Cont.d)

Stack gas molecular weight = MS

$MS = (MD)[1 - (M \times 10^{-2})] + 18 (M \times 10^{-2})$

$MS = (30.07)[1 - (.085)] + 18 (.085) = 29.04$

VELOCITY

Pitot tube coefficient, type S = CP = .807

Average Absolute Stack Temp. (°F + 460) = T_s = 848 °R

Average of the square root of Δp = $\sqrt{\Delta p}$ = .537 $(in.H_2O)^{\frac{1}{2}}$

Absolute pressure of stack $\left(BP \pm \frac{p}{13.6}\right)$ = P_s = 29.19 in.Hg

Stack gas velocity = V_s

$$V_s = (85.48)(CP)\left[\sqrt{\frac{(T_s)}{(P_s)(MS)}}\right]\left[\sqrt{\Delta p}\right]$$

$$V_s = (85.48)(.807)\left[\sqrt{\frac{(848)}{(29.19)(29.04)}}\right][.537]$$

$$= 37.051 \text{ FPS}$$

ISOKINETIC PERCENT

Average pressure drop across orifice = ΔH = .717 in.H_2O

Total sampling time = T = 64 min.

Diameter of nozzle = d = .245 in.

Area of nozzle = A

$A = 54.54 \times 10^{-4} (d^2) = 54.54 \times 10^{-4} (.245)^2 = 3.274 \times 10^{-4}$ sq. ft.

I = percent Isokinetic

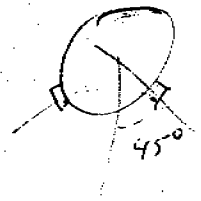
$$I = \frac{(1.667)(T_s)\left[0.00267 (V_L) + \frac{(V_m)}{(T_m)}\left(PB + \left(\frac{\Delta H}{13.6}\right)\right)\right]}{(T)(V_s)(P_s)(A)}$$

$$I = \frac{(1.667)(848)\left[0.00267 (54.7) + \frac{(28.331)}{(527)}\left(29.45 + \left(\frac{.717}{13.6}\right)\right)\right]}{(64)(37.051)(29.19)(3.274 \times 10^{-4})}$$

$$I = 108.0 \%$$

FIELD DATA

PLANT National Lime Co.
DATE 10/8/75
SAMPLING LOCATION #1 preheater
SAMPLE TYPE EPA-5
RUN NUMBER 2
OPERATOR H. Toy & Cox
AMBIENT TEMPERATURE 71
BAROMETRIC PRESSURE 29.47
STATIC PRESSURE, (P_s) -3.6" H_2O
FILTER NUMBER (s)



PROBE LENGTH AND TYPE 4' MRC.
NOZZLE I.D. .245
ASSUMED MOISTURE, % 6
SAMPLE BOX NUMBER ~~MRC~~ -4 -S-B
METER BOX NUMBER MRC -6
METER $\Delta H_@$ 1.94
C FACTOR .990 @ .81
PROBE HEATER SETTING High
HEATER BOX SETTING High
REFERENCE Δp .77

Pitot 4B

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 4 MINUTES LEAK RATE .016 CFM @ 15 Hg

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		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
		1202	181.813										
1	0	1202	181.813	.21	.49	.49	356	71	71	2.1	239	67	259
2	4	1206	183.364	.21	.49	.49	364	72	72	2.2	267	64	250
3	8	1210	184.873	.21	.49	.49	372	74	72	2.2	269	64	232
4	12	1214	186.364	.27	.63	.63	377	75	73	2.8	287	64	238
5	16	1218	188.987	.28	.66	.66	369	75	73	2.9	289	63	228
6	20	1222	189.705	.25	.59	.59	358	75	74	3.0	284	63	217
7	24	1226	191.354	.24	.57	.57	325	75	74	3.0	280	64	211
8	28	1230	193.035	.24	.57	.57	305	75	74	3.2	280	64	206
9	32	1246	194.474	.29	.68	.68	365	73	74	3.2	232	70	205
10	36	1250	196.154	.29	.68	.68	370	73	74	3.2	251	66	220
11	40	1254	197.955	.28	.66	.66	371	74	74	3.5	256	66	213
12	44	1258	199.737	.29	.68	.68	383	75	74	3.6	262	67	232
13	48	1302	201.531	.28	.66	.66	376	75	74	3.8	263	66	234
14	52	1306	203.311	.28	.66	.66	358	75	74	3.8	274	68	234
15	56	1310	205.086	.27	.63	.63	356	75	74	3.9	270	68	226
16	60	1314	206.823	.27	.63	.63	312	75	75	3.9	271	69	222
	64	1315	207.147										

Clean Probe

CLEAN-UP DATA

Plant National Lime & Stone Co. Comments:
Date 10/6/75
Sampling Location No. 1 Preheater
Sample Type EPA-5
Run Number 2
Sample Box Number 4 SGB
Clean-up Man H.D. Jay

IMPINGERS

	#1	#2	#3	#4	#5
Final Vol.	126 ml	105 ml	ml	ml	ml
Initial Vol.	100 ml	100 ml	ml	ml	ml
Net Vol.	26 ml	5 ml	ml	ml	ml

Total Net Volume in Impingers 28 ml

SILICA GEL

Final Weight	210.0 g	g	g
Initial Weight	200.0 g	g	g
Net Weight	10 g	g	g

Total Net Weight in Silica Gel 10 g

Total Moisture 38 g

Filter Number(s) 63-9

ISOKINETIC CALCULATION

Run# 2, Date 10-8-75

Location #1 gas boiler, Initials TCP

MOISTURE

Net volume of liquid collected in impingers and silica gel = V_L = 38 ml

Net volume of gas through dry gas meter at meter conditions = V_m = 26.684 cu.ft.

Barometric Pressure - absolute = BP = 29.45 in.Hg

Average absolute meter temperature (°F + 460) = T_m = 534 °R

Percent moisture = M

$$M = \frac{100}{1 + \frac{373.63\ (\ V_m\ )\ (\ BP\ )}{(\ T_m\ )\ (\ V_L\ )}} + 2.5$$

$$= \frac{100}{1 + \frac{373.63\ (26.684)\ (29.45\ )}{(\ 534\ )\ (\ 38\ )}} + 2.5 = 6.5\ \%$$

MOLECULAR WEIGHT

Percent O_2 by volume dry basis = O_2 = ____ %

" CO " " " " = CO = ____ %

" CO_2 " " " " = CO_2 = ____ %

$N_2 = 100 - (O_2 + CO_2 + CO) = 100 - (\ +\ +\ )$

Percent N_2 by volume dry basis = N_2 = ____ %

Dry molecular weight = MD

MD = 0.44 (CO_2) + 0.32 (O_2) + 0.28 (N_2 + CO)

MD = 0.44 ( ) + 0.32 ( ) + 0.28 (+)

MD = 30.07

ISOKINETIC CALCULATION (Cont.d)

MOLECULAR WEIGHT (Cont.d)

Stack gas molecular weight = MS

$MS = (MD)[1 - (M \times 10^{-2})] + 18 (M \times 10^{-2})$

$MS = (30.07)[1 - (.065)] + 18 (.065) = 29.29$

VELOCITY

Pitot tube coefficient, type S = CP = .807

Average Absolute Stack Temp. (°F + 460) = T_s = 817 °R

Average of the square root of Δp = $\sqrt{\Delta p}$ = 0.509 $(in.H_2O)^{\frac{1}{2}}$

Absolute pressure of stack $\left(BP \pm \frac{p}{13.6}\right)$ = P_s = 29.19 in.Hg

Stack gas velocity = V_s

$$V_s = (85.48)(CP)\left[\sqrt{\frac{(T_s)}{(P_s)(MS)}}\right]\left[\sqrt{\Delta p}\right]$$

$$V_s = (85.48)(.807)\left[\sqrt{\frac{(817)}{(29.29)(29.19)}}\right][.509]$$

$$= 34.323 \text{ FPS}$$

ISOKINETIC PERCENT

Average pressure drop across orifice = ΔH = .611 in.H_2O

Total sampling time = T = 64 min.

Diameter of nozzle = d = .245 in.

Area of nozzle = A

$A = 54.54 \times 10^{-4} (d^2) = 54.54 \times 10^{-4} (\quad)^2 = 3.274 \times 10^{-4}$ sq. ft.

I = percent Isokinetic

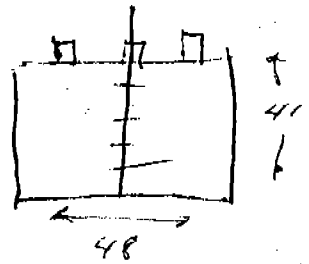
$$I = \frac{(1.667)(T_s)\left[0.00267 (V_L) + \frac{(V_m)}{(T_m)}\left(PB + \frac{(\Delta H}{13.6}\right)\right]}{(T)(V_s)(P_s)(A)}$$

$$I = \frac{(1.667)(817)\left[0.00267 (38) + \frac{(26.684)}{(534)}\left(29.45 + \frac{(.611}{13.6}\right)\right]}{(64)(34.323)(29.19)(3.274 \times 10^{-4})}$$

$$I = 102.2 \%$$

PRELIMINARY VELOCITY TRAVERSE

PLANT National Lime Co.
DATE 10/6/75
LOCATION #2 preheater
STACK I.D. 41"
BAROMETRIC PRESSURE, in. Hg 29.47
STACK GAUGE PRESSURE, in. ~~H2O~~ -1.3" Hg
OPERATORS A. Ley L. Cox



SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
1	.98	487
2	.97	481
3	.78	464
4	.68	422
AVERAGE	.85	464

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

EPA (Dur) 233
4/72

DRY MOLECULAR WEIGHT DETERMINATION

PLANT National Lime + Stone
DATE 10-7-75
SAMPLING TIME (24-hr CLOCK) 1120 - 1210
SAMPLING LOCATION #2 preheater duct
SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) Integrated
ANALYTICAL METHOD Orsat
AMBIENT TEMPERATURE 70°
OPERATOR Pettus

COMMENTS:

GAS \ RUN	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2	12.6	12.6	12.6	12.6			12.6	44/100	5.54
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)	24.8	12.2	24.9	12.3			12.25	32/100	3.92
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)	—		25.0	.1			.1	28/100	.03
N_2 (NET IS 100 MINUS ACTUAL CO READING)							75.05	28/100	21.01
								TOTAL	30.5

EPA (Dur) 230
4/72

NOMOGRAPH DATA

PLANT National Lime Co

DATE 10/6/75

SAMPLING LOCATION #1 & 2 preheaters

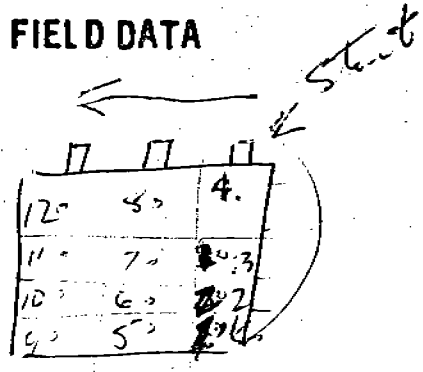
CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.94
AVERAGE METER TEMPERATURE (AMBIENT + 20°F), °F	$T_{m\,avg.}$	90
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	6
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	29.47
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	28.17
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	.956
AVERAGE STACK TEMPERATURE, °F	$T_{s\,avg.}$	464
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	.85
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	.98
C FACTOR		1.04
CALCULATED NOZZLE DIAMETER, in.		.241
ACTUAL NOZZLE DIAMETER, in.		.204
REFERENCE Δp, in. H_2O		1.8

Adj .944 @ .81 C_p

EPA (Dur) 234
4/72

FIELD DATA

PLANT National Lime Co.
DATE 10/7/75
SAMPLING LOCATION #2 pelletizer
SAMPLE TYPE EPA-5
RUN NUMBER 1
OPERATOR A. Tay J. Coy
AMBIENT TEMPERATURE 72
BAROMETRIC PRESSURE ~~30~~ 29.53
STATIC PRESSURE, (P_s) -1.3 "Hg
FILTER NUMBER (s) 63-6



PROBE LENGTH AND TYPE MRC 4'
NOZZLE I.D. .204
ASSUMED MOISTURE, % 4
SAMPLE BOX NUMBER 5613-5
METER BOX NUMBER MRC-6
METER $\Delta H_@$ 1.94
C FACTOR .994 @ .81 Cp
PROBE HEATER SETTING Hi
HEATER BOX SETTING Hi
REFERENCE Δp 1.8

Pitot tube 4 B (reversed)

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES LEAK RATE .012 CFM @ 15.8 Hg

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		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
	0	1015	96.977										186
1	0	1015	97.064	.51	.52	.52	460	72	69	4.5	265	71	189
2	5	1020	98.876	.67	.68	.68	503	72	69	5.1	268	69	232
3	10	1025	100.998	.63	.64	.64	498	74	70	5.2	289	70	235
4	15	1030	103.167	.67	.68	.68	459	75	71	6.1	265	70	207
5	20	1040	105.843	.64	.65	.65	432	75	73	5.5	296	72	201
6	25	1045	107.668	.73	.74	.74	500	76	73	6.9	311	71	248
7	30	1050	109.865	.77	.79	.79	503	78	74	8.0	303	72	255
8	35	1055	112.141	.80	.81	.81	484	79	75	8.5	290	71	223
9	40	1102	114.569	.75	.76	.76	478	78	75	8.9	281	72	230
10	45	1107	116.671	.88	.89	.89	482	79	76	9.9	277	70	253
11	50	1112	119.068	.90	.91	.91	477	80	77	10.9	271	71	251
12	55	1117	121.556	.81	.82	.82	443	80	77	11.0	284	72	
	60	1122	124.157										
	Actual time												
	60.4 min.												

Calculate to 4th cent

CLEAN-UP DATA

Plant National Lime Co. Comments:
Date 10/7/75
Sampling Location #2 precalciner
Sample Type EPA-5
Run Number 1
Sample Box Number SGB-5
Clean-up Man H. Toy

IMPINGERS

	#1	#2	#3	#4	#5
Final Vol.	130 ml	105 ml	ml	ml	ml
Initial Vol.	100 ml	100 ml	ml	ml	ml
Net Vol.	30 ml	5 ml	ml	ml	ml

Total Net Volume in Impingers 35 ml

SILICA GEL

Final Weight	206.4 g	g	g
Initial Weight	200 g	g	g
Net Weight	6.4 g	g	g

Total Net Weight in Silica Gel 6.4 g

Total Moisture 41.4 g

Filter Number(s) 63-6

MRC 7/73

ISOKINETIC CALCULATION

Run# 1, Date 10-7-75

Location #2 preheater, Initials TLD

MOISTURE

Net volume of liquid collected in impingers and silica gel = V_L = 411.4 ml

Net volume of gas through dry gas meter at meter conditions = V_m = 27.093 cu.ft.

Barometric Pressure - absolute = BP = 29.53 in.Hg

Average absolute meter temperature (°F + 460) = T_m = 535 °R

Percent moisture = M

$$M = \frac{100}{1 + \frac{373.63\ (\ V_m\ )\ (\ BP\ )}{(\ T_m\ )\ (\ V_L\ )}} + 2.5$$

$$= \frac{100}{1 + \frac{373.63\ (27.093)\ (29.53\ )}{(\ 535\ )\ (\ 411.4\ )}} + 2.5 = 6.9\ \%$$

MOLECULAR WEIGHT

Percent O_2 by volume dry basis = O_2 = ____ %

" CO " " " " = CO = ____ %

" CO_2 " " " " = CO_2 = ____ %

$N_2 = 100 - (O_2 + CO_2 + CO) = 100 - (\ \ +\ \ +\ \ )$

Percent N_2 by volume dry basis = N_2 = ____ %

Dry molecular weight = MD

$MD = 0.44\ (\ CO_2\ ) + 0.32\ (\ O_2\ ) + 0.28\ (\ N_2 + CO\ )$

$MD = 0.44\ (\ \ ) + 0.32\ (\ \ ) + 0.28\ (\ \ +\ \ )$

MD = 30.5

ISOKINETIC CALCULATION (Cont.d)

MOLECULAR WEIGHT (Cont.d)

Stack gas molecular weight = MS

$MS = (MD)[1 - (M \times 10^{-2})] + 18 (M \times 10^{-2})$

$MS = (30.5)[1 - (.069)] + 18 (.069) = 29.64$

VELOCITY

Pitot tube coefficient, type S = CP = .809

Average Absolute Stack Temp. (°F + 460) = T_s = 936 °R

Average of the square root of Δp = $\sqrt{\Delta p}$ = 0.852 $(in.H_2O)^{\frac{1}{2}}$

Absolute pressure of stack $\left(BP \pm \frac{p}{13.6}\right)$ = P_s = 28.23 in.Hg

Stack gas velocity = V_s

$$V_s = (85.48)(CP)\left[\sqrt{\frac{(T_s)}{(P_s)(MS)}}\right]\left[\sqrt{\Delta p}\right]$$

$$V_s = (85.48)(.809)\left[\sqrt{\frac{(936)}{(28.23)(29.64)}}\right][0.852]$$

$$= 62.315 \text{ FPS}$$

ISOKINETIC PERCENT

Average pressure drop across orifice = ΔH = 0.74 in.H_2O

Total sampling time = T = 60.4 min.

Diameter of nozzle = d = .204 in.

Area of nozzle = A

$A = 54.54 \times 10^{-4} (d^2) = 54.54 \times 10^{-4} (.204)^2 = 2.270 \times 10^{-4}$ sq. ft.

I = percent Isokinetic

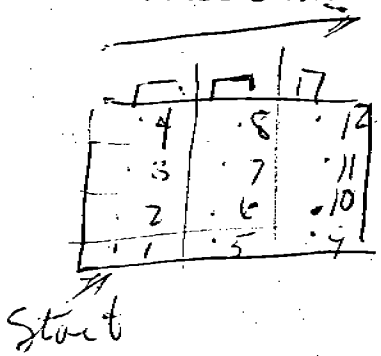
$$I = \frac{(1.667)(T_s)\left[0.00267 (V_L) + \frac{(V_m)}{(T_m)}\left(PB + \left(\frac{\Delta H}{13.6}\right)\right)\right]}{(T)(V_s)(P_s)(A)}$$

$$I = \frac{(1.667)(936)\left[0.00267 (41.4) + \frac{(27.093)}{(535)}\left(29.53 + \left(\frac{.74}{13.6}\right)\right)\right]}{(60.4)(62.315)(28.23)(2.270 \times 10^{-4})}$$

$$I = 104.1 \%$$

FIELD DATA

PLANT National Lime Co.
DATE 10/7/75
SAMPLING LOCATION #2 preheater
SAMPLE TYPE EPA-5
RUN NUMBER 2
OPERATOR A. Ley, L. Cox
AMBIENT TEMPERATURE 84
BAROMETRIC PRESSURE 29.53
STATIC PRESSURE, (P_s) -1.3" Hg
FILTER NUMBER (s) 68 6



Pitot tube 4B-R
PROBE LENGTH AND TYPE 4' MRC
NOZZLE I.D. .204
ASSUMED MOISTURE, % 6
SAMPLE BOX NUMBER 5GB-4
METER BOX NUMBER MRC-6
METER $\Delta H_@$ 1.94
C FACTOR .994
PROBE HEATER SETTING High
HEATER BOX SETTING High
REFERENCE Δp 1.8

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES LEAK RATE .01 CFM @ 15.2 Hg

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		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe	Filter
					DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F					
	0		126.618											
1	5	1440	125.618	.76	.77	.77	436	89	89	3.6	267	82	218	10
2	5	1445	127.915	.90	.91	.91	462	89	90	4.2	271	77	214	12
3	10	1450	130.337	.91	.92	.92	451	89	89	4.5	280	78	249	12
4	15	1455	132.798	.88	.89	.89	422	89	89	4.8	278	79	254	13
*	20	1500	135.109	[illegible]	[illegible]	[illegible]	[illegible]	88	88	5.41	299	78	[illegible]	[illegible]
5	20	1502	135.109	.70	.71	.71	462	88	88	5.4	299	78	233	11
6	25	1507	137.541	.68	.69	.69	472	88	88	5.7	292	78	242	10
7	30	1512	139.542	.80	.81	.81	466	88	88	6.1	309	78		6
8	35	1517	141.871	.82	.83	.83	446	88	88	6.8	303	80		10
*	40	1522	144.267	[illegible]										
9	40	1524	144.261	.63	.66	.66	452	88	87	6.2	320	81		10
10	45	1529	146.329	.75	.76	.76	472	88	87	6.7	317	82		10
11	50	1534	148.403	.83	.84	.84	479	89	87	7.9	325	79		11
12	55	1539	150.687	.67	.68	.68	434	87	86	8.0	318	79		10
	60	1544	152.872											

* Change Data

CLEAN-UP DATA

Plant National Lime Co. Comments:
Date 10/7/75
Sampling Location #2 preheater
Sample Type EPA-5
Run Number 2
Sample Box Number SGB-4
Clean-up Man H. Tay

IMPINGERS

	#1	#2	#3	#4	#5
Final Vol.	136 ml	100 ml	ml	ml	ml
Initial Vol.	100 ml	100 ml	ml	ml	ml
Net Vol.	36 ml	0 ml	ml	ml	ml

Total Net Volume in Impingers 36 ml

SILICA GEL

Final Weight	207.8 g	g	g
Initial Weight	200 g	g	g
Net Weight	7.8 g	g	g

Total Net Weight in Silica Gel [illegible] g

Total Moisture 43.8 g

Filter Number(s) 63-8

MRC 7/73

ISOKINETIC CALCULATION

Run# 2, Date 10-7-75

Location I2 preheater, Initials TCF

MOISTURE

Net volume of liquid collected in impingers and silica gel = V_L = 43.8 ml

Net volume of gas through dry gas meter at meter conditions = V_m = 27.254 cu.ft.

Barometric Pressure - absolute = BP = 29.53 in.Hg

Average absolute meter temperature (°F + 460) = T_m = 548 °R

Percent moisture = M

$$M = \frac{100}{1 + \frac{373.63\ (\ V_m\ )\ (\ BP\ )}{(\ T_m\ )\ (\ V_L\ )}} + 2.5$$

$$= \frac{100}{1 + \frac{373.63\ (27.254)\ (29.53\ )}{(\ 548\ )\ (\ 43.8\ )}} + 2.5 = 7.4\ \%$$

MOLECULAR WEIGHT

Percent O_2 by volume dry basis = O_2 = ____ %

" CO " " " " = CO = ____ %

" CO_2 " " " " = CO_2 = ____ %

$N_2 = 100 - (O_2 + CO_2 + CO) = 100 - (\quad + \quad + \quad)$

Percent N_2 by volume dry basis = N_2 = ____ %

Dry molecular weight = MD

$MD = 0.44\ (\ CO_2\ ) + 0.32\ (\ O_2\ ) + 0.28\ (\ N_2 + CO\ )$

$MD = 0.44\ (\quad) + 0.32\ (\quad) + 0.28\ (\quad + \quad)$

MD = 30.5

ISOKINETIC CALCULATION (Cont.d)

MOLECULAR WEIGHT (Cont.d)

Stack gas molecular weight = MS

$MS = (MD)[1 - (M \times 10^{-2})] + 18\,(M \times 10^{-2})$

$MS = (30.5)[1 - (.074)] + 18\,(.074) =$ 29.58

VELOCITY

Pitot tube coefficient, type S = CP = .809

Average Absolute Stack Temp. (°F + 460) = T_s = 915 °R

Average of the square root of Δp = $\sqrt{\Delta p}$ = .881 $(in.H_2O)^{\frac{1}{2}}$

Absolute pressure of stack $\left(BP \pm \frac{p}{13.6}\right)$ = P_s = 28.23 in.Hg

Stack gas velocity = V_s

$$V_s = (85.48)(CP)\left[\sqrt{\frac{(T_s)}{(P_s)(MS)}}\right]\left[\sqrt{\Delta p}\right]$$

$$V_s = (85.48)(.809)\left[\sqrt{\frac{(915)}{(28.23)(29.58)}}\right][.881]$$

= 63.774 FPS

ISOKINETIC PERCENT

Average pressure drop across orifice = ΔH = .789 $in.H_2O$

Total sampling time = T = 60 min.

Diameter of nozzle = d = .204 in.

Area of nozzle = A

$A = 54.54 \times 10^{-4}\,(d^2) = 54.54 \times 10^{-4}\,(.204)^2 =$ 2.27×10^{-4} sq. ft.

I = percent Isokinetic

$$I = \frac{(1.667)(T_s)\left[0.00267\,(V_L) + \frac{(V_m)}{(T_m)}\left(PB + \frac{(\Delta H}{13.6}\right)\right]}{(T)(V_s)(P_s)(A)}$$

$$I = \frac{(1.667)(915)\left[0.00267\,(43.8) + \frac{(27.254)}{(548)}\left(29.53 + \frac{(.789}{13.6}\right)\right]}{(60)(63.774)(28.23)(2.27 \times 10^{-4})}$$

I = 98.8 %

SOURCE SAMPLING PROCEDURE - EPA METHOD 7 - NOx

Date 10-8-75

Company National Lime and Stone

Project 6912-17

Sample Point * 1 preheater exhaust

Analyst

Sample Day	Sample Time	Sample No.	T/B Flask No.	Initial Bar. Press. in Hg	Initial Flask Vacuum in Hg	Initial Temp. °F	Clean Up Analysis Day	Clean Up Analysis Time	Final Bar. Press. in Hg	Final Flask Vacuum in Hg	Final Temp. °F	ABS @ 420	TOTAL Dil. ml	FLASK Vol.-ABS ml	NOx Conc. lb/scf	NOx Conc. ppm
10/8	1110	1	42/4	29.47	28.40	62	10/9	1030	29.39	1.65	52°					
10/8	1113	2	7	29.47	28.60	62		1032		5.70						
10/8	1115	3	12*	29.47	28.30	63		1035		5.10						
10/8	1117	4	8	29.47	28.60	64		1036		4.70						
10/8	1119	5	16**	29.47	28.10	64	↓	1040	↓	0.80	↓					

* Top also had 39 label on it tag indicated 12

** Top also said 30

NO_x COMPUTER PROGRAM INPUT DATA FOR EPA - METHOD 7 CALCULATIONS

Company National Lime & Stone

Date

Job Number 022-701.13-200.3037

Analyst

Card #1 - Input Coordinates N= 6 M= 1 K= 5

Card #2 - Standards x(µg/ml)= 0. 1. 2. 3. 4. 5.

Card #3 y(abs.)= .05 .182 .274 .418 .502 .630

Card #	4	5	6	7	8	9	10	11	12	
Flask # Top/Bottom	Absolute	Initial Barometric Pressure	Final Barometric Pressure	Initial Temperature	Final Temperature	Initial Flask Vacuum	Final Flask Vacuum	Total Dilution	Flask Volume-absorbing solution	DSCF/M NO_x Conc.
	@ 410 nm	~~mmHg~~/inHg	mmHg/inHg	~~°C~~/°F	~~°C~~/°F	~~mmHg~~/inHg	~~mmHg~~/inHg	ml	ml	~~PPM~~
12/4	~~0.032~~ 0.080	29.47	29.39	~~62~~ 62	52	28.40	1.65	250	2006	6823
7	~~0.048~~ 0.066	29.47	29.39	~~62~~ 62	52	28.60	5.70	"	2047	
12	~~0.027~~ 0.075	29.47	29.39	~~63~~ 63	52	28.30	5.10	"	2047	
8	~~0.028~~ 0.070	29.47	29.39	~~64~~ 64	52	28.60	5.70	"	2126	
16	~~0.018~~ 0.066	29.47	29.39	64	52	28.10	0.80	"	2038	

N = # (x, y) Pairs
M = 0 indicates input is in metric
= 1 indicates input is in inches

K = # of observations

APPENDIX D

ANALYTICAL DATA SHEETS

ANALYTICAL DATA

PLANT NATIONAL LIMESTONE

DATE 11/4/75

SAMPLING LOCATION #1 Cooler

SAMPLE TYPE E.P.A #5

RUN NUMBER #1

SAMPLE BOX NUMBER MRC

CLEAN-UP MEN H. Toy

ANALYST W. McDonald

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER 384-10 — 2745.2 mg

FILTER NUMBER 63-16 — CONTAINER 63-16 — 148.3 mg

FRONT HALF SUBTOTAL 2893.5 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-26 — 1.6 mg

ETHER-CHLOROFORM EXTRACTION — 0 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-12 — 4.4 mg

BACK HALF SUBTOTAL 6.0 mg

TOTAL WEIGHT 2899.5 mg

MOISTURE

IMPINGERS

FINAL VOLUME	ml
INITIAL VOLUME	ml
NET VOLUME	ml

SILICA GEL

FINAL WEIGHT	g	g	g
INITIAL WEIGHT	g	g	g
NET WEIGHT	g	g	g

TOTAL MOISTURE g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT NATIONAL LIMESTONE

DATE 11/4/75

SAMPLING LOCATION #1 Cooler

SAMPLE TYPE E.P.A #5

RUN NUMBER #2

SAMPLE BOX NUMBER M2C

CLEAN-UP MEN H. TOY

ANALYST W. McDONALD

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER 384-11 — 5387.3 mg

FILTER NUMBER 63-17 — CONTAINER 63-17 — 104.2 mg

FRONT HALF SUBTOTAL 5491.5 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-28 — 1.5 mg

ETHER-CHLOROFORM EXTRACTION 384-29 — 12.2 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-13 — 8.3 mg

BACK HALF SUBTOTAL 22.0 mg

TOTAL WEIGHT 5513.5 mg

MOISTURE

IMPINGERS

FINAL VOLUME	ml
INITIAL VOLUME	ml
NET VOLUME	ml

SILICA GEL

FINAL WEIGHT	g	g	g
INITIAL WEIGHT	g	g	g
NET WEIGHT	g	g	g

TOTAL MOISTURE g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT NATIONAL LIMESTONE

DATE 11-4-75

SAMPLING LOCATION #1 Preheater

SAMPLE TYPE E.P.A #5

RUN NUMBER #1

SAMPLE BOX NUMBER MRC

CLEAN-UP MEN H. Toy

ANALYST W. McDONALD

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER 384.2 — 1591.7 mg

FILTER NUMBER 63-7 — CONTAINER 63-7 — 239.6 mg

FRONT HALF SUBTOTAL 1831.3 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-18 — 7.2 mg

ETHER-CHLOROFORM EXTRACTION 384-19 — 5.9 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-4 — 7.3 mg

BACK HALF SUBTOTAL 20.4 mg

TOTAL WEIGHT 1851.7 mg

MOISTURE

IMPINGERS

FINAL VOLUME	ml
INITIAL VOLUME	ml
NET VOLUME	ml

SILICA GEL

FINAL WEIGHT	g	g	g
INITIAL WEIGHT	g	g	g
NET WEIGHT	g	g	g

TOTAL MOISTURE g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT National Limestone

DATE 11/4/75

SAMPLING LOCATION #1 Preheater

SAMPLE TYPE E.P.A #5

RUN NUMBER 2

SAMPLE BOX NUMBER M.R.C.

CLEAN-UP MEN H. Toy

ANALYST W. McDonald

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER 384-3 — 1969.5 mg

FILTER NUMBER 63-9 — CONTAINER 63-9 — 167.7 mg

FRONT HALF SUBTOTAL 2137.2 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-20 — 8.0 mg

ETHER-CHLOROFORM EXTRACTION 384-21 — 2.0 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-5 — 5.1 mg

BACK HALF SUBTOTAL 15.1 mg

TOTAL WEIGHT 2152.3 mg

MOISTURE

IMPINGERS

FINAL VOLUME _____ ml

INITIAL VOLUME _____ ml

NET VOLUME _____ ml

SILICA GEL

FINAL WEIGHT	_____ g	_____ g	_____ g
INITIAL WEIGHT	_____ g	_____ g	_____ g
NET WEIGHT	_____ g	_____ g	_____ g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT NATIONAL LIMESTONE

DATE 11-4-75

SAMPLING LOCATION #2 Preheater

SAMPLE TYPE E.P.A METHOD 5

RUN NUMBER #1

SAMPLE BOX NUMBER M.B.C

CLEAN-UP MEN H. Toy

ANALYST W. McDONALD

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER 384-6 — 7770.4 mg

FILTER NUMBER 63-6 — CONTAINER 63-6 — 384.7 mg

FRONT HALF SUBTOTAL 8155.1 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-22 — 5.0 mg

ETHER-CHLOROFORM EXTRACTION 384-23 — 5.7 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-8 — 15.2 mg

BACK HALF SUBTOTAL 25.9 mg

TOTAL WEIGHT 8181.0 mg

MOISTURE

IMPINGERS

FINAL VOLUME _____ ml

INITIAL VOLUME _____ ml

NET VOLUME _____ ml

SILICA GEL

FINAL WEIGHT	_____ g	_____ g	_____ g
INITIAL WEIGHT	_____ g	_____ g	_____ g
NET WEIGHT	_____ g	_____ g	_____ g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

ANALYTICAL DATA

PLANT NATIONAL LIMESTONE

DATE 11/4/75

SAMPLING LOCATION #2 Preheater

SAMPLE TYPE E.P.A #5

RUN NUMBER 2

SAMPLE BOX NUMBER MRC

CLEAN-UP MEN H. TOY

ANALYST W. McDONALD

COMMENTS:

FRONT HALF

LABORATORY RESULTS

ACETONE WASH OF NOZZLE, PROBE, CYCLONE (BYPASS), FLASK, FRONT HALF OF FILTER HOLDER — CONTAINER 384-7 — 6557.8 mg

FILTER NUMBER 63-8 — CONTAINER 63-8 — 362.0 mg

FRONT HALF SUBTOTAL 6919.8 mg

BACK HALF

IMPINGER CONTENTS AND WATER WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-24 — 4.1 mg

ETHER-CHLOROFORM EXTRACTION 384-25 — 1.8 mg

ACETONE WASH OF IMPINGERS, CONNECTORS, AND BACK HALF OF FILTER HOLDER — CONTAINER 384-9 — 13.8 mg

BACK HALF SUBTOTAL 19.7 mg

TOTAL WEIGHT 6939.5 mg

MOISTURE

IMPINGERS

FINAL VOLUME _____ ml

INITIAL VOLUME _____ ml

NET VOLUME _____ ml

SILICA GEL

FINAL WEIGHT	_____ g	_____ g	_____ g
INITIAL WEIGHT	_____ g	_____ g	_____ g
NET WEIGHT	_____ g	_____ g	_____ g

TOTAL MOISTURE _____ g

EPA (Dur) 231
4/72

NO_x COMPUTER PROGRAM INPUT DATA FOR EPA - METHOD 7 CALCULATIONS

Company National Lime & Stone Date

Job Number 022-760.13-200.3037 Analyst

Card #1 - Input Coordinates N= 6 M= 1 K= 5

Card #2 - Standards x(µg/ml)= 0. 1. 2. 3. 4. 5.

Card #3 y(abs.)= .05 .182 .274 .418 .502 .630

Card #	4	5	6	7	8	9	10	11	12	
Flask # Top/Bottom	Absolute	Initial Barometric Pressure	Final Barometric Pressure	Initial Temperature	Final Temperature	Initial Flask Vacuum	Final Flask Vacuum	Total Dilution	Flask Volume-absorbing solution	DSCF/M NO_x Conc.
	@ 410 nm	~~mmHg~~/inHg	mmHg/inHg	~~°C~~/°F	~~°C~~/°F	~~mmHg~~/inHg	~~mmHg~~/inHg	ml	ml	~~ppm~~
12/4	~~0.032~~ 0.050	29.47	29.39	~~62~~ 62	52	28.40	1.65	250	2006	6823
7	~~0.048~~ 0.066	29.47	29.39	~~62~~ 62	52	28.60	5.70	"	2047	
12	~~0.027~~ 0.075	29.47	29.39	~~63~~ 63	52	28.30	5.10	"	2047	
8	~~0.028~~ 0.076	29.47	29.39	~~64~~ 64	52	28.60	5.70	"	2126	
16	~~0.018~~ 0.066	29.47	29.39	64	52	28.10	0.50	"	2038	

N = # (x, y) Pairs
M = 0 indicates input is in metric
= 1 indicates input is in inches

K = # of observations

APPENDIX E

SAMPLING PROCEDURES

Method 5 MRC Clean Up Procedure

1. Transportation to Clean Up Area

After the run is finished the train can be removed to the clean up area. This can be done with the probe in place or it can be removed from the train and sealed at both ends. If the probe is removed, the cyclone entrance must be sealed to avoid any loss of contamination of its contents. Caution must be exercised when sealing the system for transportation so that cooling of the front half of the train will not cause water to be pulled into it from the back half.

2. Probe Clean Up

Remove any material from the outside of the probe and nozzle that may contaminate the sample by falling or being washed into the sample bottle. Remove the nozzle and rinse the inside with acetone into the front 1/2 acetone sample bottle. Brush the inside with a clean test tube brush while flushing with acetone into the sample bottle. Wash the brush with acetone into the bottle. Rinse the inside of the nozzle a final time with acetone.

Elevate one end (the nozzle end) of the probe and rinse through with acetone into the front 1/2 sample bottle while slowly rotating through 720°. Run a clean probe brush through the probe while flushing with acetone and slowly rotating the brush. When the brush is exposed on the down stream end of the probe, rinse it into the sample bottle with acetone. Do not pull the brush back through the probe. Repeat the brushing step. Rinse the probe a final time by flushing with acetone while rotating it 360°. Wash the funnel into the sample bottle. Observe the probe inside and repeat the clean up procedure if sample particles are obvious.

3. Cyclone and Filter Clean Up

Remove the cyclone and connecting glassware. Rinse the cyclone with acetone into the collection flask and pour into the front 1/2 sample bottle. Repeat until all loose material is collected. If sample material adheres to the inside surfaces, a small test tube brush can be used to free it, and it should be rinsed into the sample bottle. If a brush or spatula is used to clean the cyclone and

catch bottle, it must be cleaned into the sample bottle. All connecting glassware between the cyclone system and filter must be treated in the same manner, i.e., flushing and or brushing the sample exposed surfaces into the sample container with acetone until no sample material is visible.

The filter assemble must be disassembled in a dust free area. The filter membrane should be loosened from the silicon rubber gasket by running a knife blade or spatula between them being careful not to scrape or loosen particles of glass from the glass frit. Lift the filter, using a spatula, and place into its storage container. Carefully scrape all particles of filter material from both mating surfaces (i.e.: the silicon rubber gasket and the front-half glass holder) and place them in the storage container. Rinse and brush the front-half glass holder's sample exposed surfaces into the sample bottle with acetone. Do not wash or rinse the frit. Wash brushes, spatulas and funnels into the sample and store.

4. Back 1/2 Clean Up

Rinse the back half filter holder, connecting glass to the first impinger, and impinger "U" bends with distilled water into the back half water wash sample bottle by filling or flushing twice. Remove each of the first three impingers and pour the content into a graduated cylinder for measurement. Transfer these contents into the sample bottle. Wash each of the three impingers two times by squirting about 100 ml of distilled water into each, covering the inlet and outlet openings with clean caps or clean fingers, and shaking to cause the wash water to contact all of the inside surfaces. Pour this wash water into the sample bottle and rinse the graduated cylinder and funnel into sample bottle with distilled water. Seal the bottle and store.

Rinse the back half filter holder, the filter to impinger connectors, and the impinger "U" bends with acetone into the back half acetone wash sample bottle by filling or flushing two times. Wash each of the three impingers two times by adding about 100 ml of acetone and shaking as with the water wash. Transfer these washings to the sample bottle. Rinse the graduated cylinder used to measure the water and the funnel with acetone into the sample bottle. Cap the bottle and store.

Nitrogen Oxides Sampling Procedure

Nitrogen oxides were collected in evacuated 2-liter flasks containing 25 ml of a dilute sulfuric acid/hydrogen peroxide absorbing solution. The sampling and analytical procedure was described in Method 7 of the Federal Register. Each sample was collected using a stainless steel probe. Each flask was evacuated and vacuum tested for one minute, and the initial flask temperature, pressure, and barometric pressure recorded. The sampling probe was inserted into the stack and heated, and the sample flask connected. The 3-way stopcock was turned to the "purge" position and stack gas drawn through the system with a vacuum pump to check for condensation in the probe line. The 3-way stopcock was then turned to the sample position for 15 to 30 seconds. The flask valve was then closed and disconnected from the probe. The contents were shaken for at least 5 minutes.

The flasks were allowed to set for at least 16 hours. They were then shaken for at least 2 minutes, the final pressure, temperature, and barometric pressure were taken, and the sample was transferred to a storage bottle.

APPENDIX F

PROJECT PARTICIPANTS

Project Participants

Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Standards and Engineering Division

Thomas F. Lahre	Project Officer Emission Measurement Branch

MONSANTO RESEARCH CORPORATION

William R. Feairheller, Jr.	Research Group Leader
Thomas L. Peltier	Research Engineer, Task Leader
Harlan D. Toy	Research Engineer
Lloyd Cox	Technician (Field Sampling)
Francine A. Kulik	Research Chemist (Analysis)
Windle H. McDonald	Technician (Analysis)
Joan Hecathorn	Secretary