

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

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02\_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

# EXHAUST GAS EMISSION STUDY

3 runs on a  
Kiln controller  
Venturi scrubber  
PM-10, PM-100  
SO<sub>2</sub>, SO<sub>3</sub>, ~~NO<sub>x</sub>~~ NO GOOD  
3 runs at the Fuller cooler  
stack (PM-10, PM-100)

AP-42 Section	11.17
Reference	13
Report Sect.	4 3
Reference	10

Gives feed and product rates.

$\frac{\text{Feed}}{\text{prod}} = 2.51$  (includes coal)

$\frac{\text{stone}}{\text{prod}} = 2.19$

J.E. BAKER COMPANY  
Millersville, Ohio

## INTRODUCTION

The J.E. Baker Company retained George D. Clayton & Associates to evaluate the emissions from the Fuller cooler stack on the No. 2 kiln and the scrubber exhaust stack on the No. 1 kiln at its operations in Millersville, Ohio. The study included the measurement of particulate emission rates, exhaust gas composition, temperature and flowrates. Additionally, sulfur oxides emission rates were measured on the scrubber outlet.

Messrs. Robert J. Brumer and Jonathan B. Schoch of Clayton & Associates conducted the study on May 21-23, 1974. Messrs. Peter Hess of the Ohio EPA, Anthony Maccari of Air Pollution Industries, Inc. and Lewis H. Dorward of the J.E. Baker Company also observed the testing.

## DESCRIPTION OF PROCESS

Dolomite stone from the adjacent quarry is screened, washed, dried and conveyed to hoppers where it is stored prior to feeding to either of the two rotary kilns. Stone and coal are fed to the No. 1 kiln to form dolomitic lime, while stone, coal, and flux are fed to the No. 2 kiln to form dead-burned dolomite. As the stone slowly tumbles down the kiln, hot exhaust gases from the combustion of the coal travel counter-currently to it. The calcium and magnesium carbonates decompose in the kiln to form calcium and magnesium oxides and carbon dioxide. Entrained dust, combustion gases and by-product carbon dioxide from the No. 1 kiln are discharged to the wet scrubber.

The scrubber is a venturi type manufactured by Air Pollution Industries, Inc. which sprays approximately 2,200 gallons of water per minute and operates at a pressure drop of approximately 13.5 inches of water across the venturi throat. The cleaned gas is then exhausted to the stack, while the dirty scrubber water is sent to a settling pond located in the quarry. This water is then recycled.

At the lower end of the No. 2 rotary kiln, the hot dead-burned dolomite leaves the kiln and falls onto a grid. A centrifugal fan forces air up through the grid cooling the dolomite to temperatures at which it can be conveyed. After passing through the grid, the cooling air either enters the kiln, where it is used as combustion air, or is exhausted through the cooler stack.

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June 27, 1974

for better environment

See NEDS data

~~SECRET~~

Mr. Edwin E. Childs, Jr.  
THE J.E. BAKER COMPANY  
P.O. Box 1189  
York, Pennsylvania 17405

STACK TEST

Dear Mr. Childs:

Presented herewith is our report of the exhaust gas emission study of the No. 1 Kiln scrubber exhaust stack and the No. 2 Kiln cooler stack at your Millersville, Ohio plant.

scrubber exhaust on high cooler stack

In summary we found that average emissions of 52.9 and 12.2 pounds of filterable particulate matter per hour were discharged from the scrubber exhaust stack and cooler stack, respectively.

The study shows that the particulate emissions from these sources are above the allowable limits of the State of Ohio Air Pollution Code which will become effective July 1, 1975.

A comparison of the present emissions with that regulation suggests that further adjustments of the scrubber are necessary to reduce the emission rate by another 27.8 percent (average). A control device capable of reducing the cooler stack emission rate by at least 80 percent is also necessary in order to bring the particulate emissions from that stack into compliance with the future Ohio limitation.

It has been a pleasure to assist you with this study, and we trust these results will be useful.

Very truly yours,

J. E. Mutchler

John E. Mutchler, P.E.  
Vice-President, Engineering

$\frac{12.2 \text{ lb/hr}}{9.8 \text{ ton/hr}} \rightarrow 1.2 \text{ lb/ton product}$ , from cooler on #2 kiln

$\frac{52.9 \text{ lb/hr}}{17.5 \text{ ton product/hr}} = 3 \text{ lb/ton product}$ , from venturi scrubber on #1 kiln

JEM/kb

Enclosure

## SAMPLING PROCEDURES

The principles of sampling followed those outlined by the U.S. Environmental Protection Agency. Exhaust gas velocity and flowrate measurements were made with an S-type Pitot tube and inclined manometer. Temperatures were measured with an iron-constantan thermocouple in conjunction with a potentiometer.

### Particulate

The sampling train consisted of a stainless steel sampling nozzle; stainless steel heated probe; heated stainless steel filter holder containing a preweighed 110mm type A glass fiber filter; two Greenburg-Smith impingers, each initially containing 100 ml of distilled water; an empty modified impinger; a modified impinger containing approximately 200 grams of silica gel; a leakless vacuum pump; a dry gas test meter; and a flowrate indicating orifice. Polyvinyl chloride tubing was used to connect the components of the sampling train in series. The sampling train is shown schematically in Figure 1.

The Pitot tube was attached to the sampling probe and velocity pressures were read throughout the test as the probe was moved from one sampling point to another. Adjustments to isokinetic rates were effected throughout each test.

At the end of each test, condensate volumes were measured and four sample fractions were created:

1. distilled water rinsings of the nozzle and probe;
2. glass fiber filter;
3. contents and rinsings of the impingers and connecting tubing;
4. silica gel impinger contents.

In the laboratory, Fractions 1 and 3 were transferred to tared beakers and their contents evaporated at 105°C. Upon reaching constant weight, the beakers and residues were reweighed on an analytical balance having a sensitivity of 0.1 milligram. Fraction 2, the filter fraction, was dried to constant weight at 105°C and reweighed on the analytical balance to determine the weight gain. Fraction 4, the silica gel fraction, was allowed to come to room temperature and reweighed to the nearest gram.

Results were calculated as filterable and total particulate. The filterable emission was considered as the weight gains obtained from Fractions 1 and 2, while the total particulate emission was considered as those weight gains obtained from Fractions 1, 2, and 3.

Sulfur Oxides (Shell Method)

The sampling train consisted of a stainless steel nozzle; heated stainless steel probe; heated stainless steel filter holder packed with glass wool; a Greenburg-Smith impinger initially containing 100 ml of 80 percent isopropyl alcohol; a Gelman filter holder containing a 47mm type A glass fiber filter; two Greenburg-Smith impingers, each initially containing 100 ml of three percent hydrogen peroxide; a modified impinger containing 200 grams of silica gel; a leakless vacuum pump; a dry gas test meter; and a flowrate indicating orifice. Polyvinyl chloride tubing was used to connect the various parts of the sampling train in series. The sulfur oxides sampling train is shown in Figure 2.

Each of the sulfur oxides tests was run anisokinetically for one-half hour at the centerline of the stack. Each test was followed by a 15-minute purge to remove entrained SO<sub>2</sub> from the isopropyl alcohol impinger contents. Upon completion of the test, two sample fractions were created:

1. contents and rinsings of the isopropyl impinger and the filter;
2. contents and rinsings of the two hydrogen peroxide impingers.

In the laboratory, an aliquot portion of the isopropyl alcohol sample solution was transferred to an Erlenmeyer flask. Two to four drops of thorin indicator were added, and the solution was titrated with a standard barium perchlorate solution to the point endpoint. The results were reported as sulfur trioxide. An aliquot portion of the hydrogen peroxide sample solution was transferred to an Erlenmeyer flask. Isopropyl alcohol was added to make an 80 percent isopropyl solution, and two to four drops of thorin indicator were added. The solution was then titrated with standard barium perchlorate solution to the pink endpoint. The results were reported as sulfur dioxide.

Orsat

An integrated gas sample was collected during each particulate test on the No. 1 kiln scrubber outlet. The sampling train consisted of a stainless steel probe, a condensate trap, a leakless diaphragm pump, and a Tedlar plastic gas collection bag. The components of the sampling train were connected by polyvinyl chloride tubing. At the job site, the sampled gas was analyzed for CO<sub>2</sub>, O<sub>2</sub> and CO by absorption according to the standard Orsat method. The integrated gas sampling train is shown in Figure 3.

- 4 -

## PRESENTATION OF RESULTS

Table I summarizes the process data for the two kilns. This information is presented in both "test period average" and "24-hour average" form.

Table II summarizes the particulate emissions measured from the cooler and scrubber stacks. Filterable particulate concentrations from the cooler stack on the No. 2 kiln ranged from 0.076 to 0.127 grain of particulate dry standard cubic foot of exhaust gas. Total particulate concentrations were found to be only slightly higher, ranging from 0.080 to 0.130 grain of particulate per dry standard cubic foot of exhaust gas. Filterable particulate emission rates varied from 9.7 to 16.1 <sup>Ave 12.2 lb/hr</sup> pounds of particulate per hour, while total particulate emission rates ranged from 10.1 to 16.5 pounds of particulate per hour. Exhaust gas flowrates used to calculate these emission rates were calculated based on the traverse taken during each test. <sup>→ 1.2 lb/ton of product</sup>

Filterable particulate concentrations measured from the scrubber exhaust stack on the No. 1 kiln ranged from 0.101 to 0.127 grain of particulate per dry standard cubic foot of exhaust gas. Total particulate concentrations ranged from 0.118 to 0.138 grain of particulate per dry standard cubic foot of exhaust gas. Filterable particulate emission rates ranged from 46.3 to 61.5 pounds of particulate per hour. Total particulate emissions ranged from 58.7 to 66.7 pounds of particulate per hour.

Table III contains the results of the sulfur oxides emission tests conducted on the scrubber outlet. Sulfur dioxide concentrations ranged from 11.3 to 29.7 parts per million (by volume) of sulfur dioxide. Sulfur dioxide emission rates varied from 6.6 to 17.4 pounds per hour.

Sulfur trioxide concentrations ranged from 3.5 to 4.4 parts per million (by volume) of sulfur trioxide, while emission rates ranged from 2.6 to 3.2 pounds of sulfur trioxide per hour.

Table IV contains the results of the orsat analysis of the integrated gas sampling conducted during each particulate test on the scrubber stack. Carbon dioxide concentrations (dry basis) ranged from 16.7 to 17.2 percent. Oxygen concentrations ranged from 9.8 to 10.0 percent (dry basis). Carbon monoxide was less than 0.1 percent (dry basis). Nitrogen calculated by difference ranged from 73.0 to 73.3 percent. Each water concentration was calculated from its particulate test condensate volume and these values ranged from 22.7 to 28.4 percent.

## DISCUSSION OF RESULTS

Ohio EPA Regulation EP-11-11 which restricts emissions of particulate matter from industrial processes states that all persons located within air quality control regions classified as Priority

I or III regions (Millersville, Ohio is in the Sandusky Air Quality Region - #180, classified Priority III), shall attain or exceed, no later than July 1, 1975, that degree of emission reduction specified by Curve P-1 of Figure II or by Table I whichever is the more restrictive.

Table I of the regulation, based on the process weight rate, is found to be more restrictive in the case of the No. 1 kiln scrubber. The maximum allowable emission rate has been calculated to be 41.4 pounds of particulate per hour. The average emission rate was measured to be 52.9 pounds of particulate per hour, which exceeds this regulation by approximately 27.8 percent.

The average cooler stack emission rate was measured to be 12.2 pounds of particulate per hour. This is well within the allowable emission rate allowed by Table I which is 18.92 pounds of particulate per hour, however, this is an uncontrolled source of emission. According to Figure II this uncontrolled emission must be reduced by 80 percent.

Both sources were found to be in compliance with respect to visible emissions. The Ohio EPA Regulation EP-11-07 requires the discharge into the atmosphere from any source of emission to be a shade or density equal to or less than that designated as No. 1 on the Ringelmann Chart or 20 percent opacity.

The cooler stack emissions were observed to have no opacity, while the scrubber stack emissions were observed to have an opacity reading of 10 to 15 percent after the dissipation of the steam plume.

The sulfur dioxide emissions from the No. 2 kiln scrubber exhaust stack were also found to be in compliance with the Ohio Regulation EP-11-12, which restricts the in-stack concentrations of sulfur dioxide from existing processes to 2000 parts per million (ppm by volume) of sulfur dioxide and from new processes to 500 ppm. The measured average in-stack sulfur dioxide concentration from the scrubber exhaust stack was 18.0 ppm of sulfur dioxide which is well within the Ohio limitation.

This report has been prepared by:

Jonathan B. Schoch  
Jonathan B. Schoch  
Environmental Control Engineer

SUMMARY OF PROCESS DATA

J. E. BAKER COMPANY  
Millersville, Ohio

May 21-23, 1974

Operation and Product	1974 Date	Source and Test Number	Time Period	Averages					
				Kiln Speed turns/hr	Coal Feedrate tons/hr	Stone Feedrate tons/hr	Flux Feedrate tons/hr	Product Rate tons/hr	Natural Gas Feedrate ft <sup>3</sup> /hr
Kiln No. 2 Dead-burned Dolomite	5/21	Cooler Stack P-1, 2, 3	12:00-19:00	38.75	3.125	17.9	0.645	9.8	Not Used
Kiln No. 2 Dead-burned Dolomite	5/21	Cooler Stack P-1, 2, 3	24 Hours	38.7	3.10	19.44	0.68	9.72	Not Used
Kiln No. 1 Dolomitic Lime	5/22	Scrubber Stack P-1 S0x-1, 2, 3	12:00-20:00	71.1	4.49	30.9	Not Used	13.3	Not Available
Kiln No. 1 Dolomitic Lime	5/22	Scrubber Stack P-1 S0x-1, 2, 3	24 Hours	72	4.42	30.0	Not Used	12.93	6995
Kiln No. 1 Dolomitic Lime	5/23	Scrubber Stack P-2, 3	08:00-15:00	73.1	4.25	30.9	Not Used	13.29	Not Available
Kiln No. 1 Dolomitic Lime	5/23	Scrubber Stack P-2, 3	24 Hours	Not Available	4.30	30.62	Not Used	13.17	7050

Plant J.E. Baker Company, Millersville, Ohio Stack Fuller Cooler Stack - Kilm No. 2

Material Sampled	Test Number	1974 Date	Sampling Period	Stack Temp of F	Stack Flowrate SCFM Dry	Concentration gr/SCFD	Emission Rate lbs/hr	Opacity %	Process Weight Rate tons/hr
Filterable Particulate	1	5/21	13:00-14:00	116	14,800	0.086	10.9	0	9.8
Filterable Particulate	2	5/21	15:20-16:20	115	14,800	0.076	9.7	0	9.8
Filterable Particulate	3	5/21	16:42-17:42	115	14,800	0.127	16.1	0	9.8
Average				115	14,800	0.096	12.2	0	9.8
Total Particulate	1	5/21	13:00-14:00	116	14,800	0.088	11.1	0	9.8
Total Particulate	2	5/21	15:20-16:20	115	14,800	0.080	10.1	0	9.8
Total Particulate	3	5/21	16:42-17:42	115	14,800	0.130	16.5	0	9.8
Average				115	14,800	0.099	12.6	0	9.8

Ver:  Job Vic JEL En

Plant J.E. Baker Company, Millersville, Ohio

Stack Scrubber Exhaust Stack - Kila No. 1

Material Sampled	Test Number	1974 Date	Sampling Period	Stack Temp °F	Stack Flowrate SCFM Dry	Concentration gr/SCFD	Emission Rate lbs/hr	Opacity %	Process Weight Rate tons/hr
Filterable Particulate	1	5/22	13:16-15:31	151	58,700	0.101	51.0	10-15	35.39
Filterable Particulate	2	5/23	09:17-11:32	150	53,000	0.102	46.3	10-15	35.15
Filterable Particulate	3	5/23	12:16-14:31	150	56,300	0.127	61.5	10-15	35.15
Average				150	56,000	0.110	52.9	10-15	35.23
Total Particulate	1	5/22	13:16-15:31	151	58,700	0.118	59.3	10-15	35.39
Total Particulate	2	5/23	09:17-11:32	150	53,000	0.129	58.7	10-15	35.15
Total Particulate	3	5/23	12:16-14:31	150	56,300	0.138	66.7	10-15	35.15
Average				150	56,000	0.128	61.6	10-15	35.23

~17.5 Tons/hr

TABLE III

SUMMARY OF SULFUR OXIDE EMISSIONS  
 Scrubber Exhaust Stack - Kiln No. 1

J.E. BAKER COMPANY  
 Millersville, Ohio

May 22, 1974

Material Sampled	Sampling Period	Stack Temperature °F	Stack Gas Flowrate SCFM Dry	Concentration ppm	Emission Rate lbs/hr
Sulfur Dioxide	17:15 - 17:45	153	58,700	29.7	17.4
Sulfur Dioxide	18:05- 18:35	152	58,700	13.1	7.6
Sulfur Dioxide	18:55- 19:25	150	58,700	11.3	6.6
Average		152	58,700	18.0	10.5
Sulfur Trioxide	17:15- 17:45	153	58,700	4.4	3.2
Sulfur Trioxide	18:05- 18:35	152	58,700	3.5	2.6
Sulfur Trioxide	18:55- 19:25	150	58,700	3.7	2.7
Average		152	58,700	3.9	2.8

TABLE IV

SUMMARY OF GASEOUS COMPOSITION

Scrubber Exhaust Stack - Kiln No. 1

J.E. BAKER COMPANY  
Millersville, Ohio

May 22-23, 1974

Test	% CO <sub>2</sub> Dry	% O <sub>2</sub> Dry	% CO Dry	% N <sub>2</sub> and Inerts Dry	% H <sub>2</sub> O
Particulate 1	17.0	10.0	<0.1	73.0	28.4
Particulate 2	16.7	10.0	<0.1	73.3	22.7
Particulate 3	17.2	9.8	<0.1	73.0	23.1
Average	17.0	9.9	<0.1	73.1	24.7

Emission Test Report  
Review Checklist

Reviewer: Lee Alter  
Review Date: 6/29/92

A. Background Information

1. Facility name: DOW CHEMICAL -- Plant B  
Location: Freeport, TX
2. Source category: Lime
3. Test date: April 30 - May 3 1974
4. Test sponsor: EPA
5. Testing contractor: Environmental Sciences and Engineering
6. Purpose of test: develop performance standards for new and modified sources
7. Pollutants measured  
 PM-10     CO     SO<sub>2</sub>     NO<sub>x</sub>    VOC    Pb     CO<sub>2</sub>  
Others (list): Opacity

8. Process overview: On an attached page provide a block diagram of the unit operations and associated air pollution control systems at the facility. Identify process tested with letters from the beginning of the alphabet (A, B, C, etc.) and APC systems with letters from end of alphabet (V, W, X, etc.). Also identify test locations with Arabic numerals (1,2,3, ...). Using the ID symbols from that sketch complete the table below that identifies processes or unit operations tested.

Test ID	Process	Process ID	Emissions tested		APCD (controlled emissions only)
			Uncontrolled	Controlled	
1	Calcination	A		✓	ESP
2	Calcination	A		✓	ESP

KILN 1  
(not run during test)

KILN 2 (A)

KILN 3 (A)

NORTH  
ESP ①

TO ATMOSPHERE

ESP ②  
SOUTH

TO ATMOSPHERE

2. For each process tested list feedstock materials and products. Indicate if activity factors are for feed (F) rate or product (P) rate.

Process ID	Feedstock materials	Products	Basis for activity factor	F/P
A	Crushed limestone	calcined lime		F
	<del>Crushed limestone</del>	<del>calcined lime</del>		<del>F</del>

Basis for data: \_\_\_\_\_  
(Indicate page/table Nos. in test report)

3. For each process or operation tested and each test run note process capacity and operating rate during test.

Process ID	Capacity	Units	Test run	Process rate	Units
A	750	tons/day	1	20.3	tons/hr
			2	20.0	tons/hr
			3	20.2	tons/hr
			4		
			1		
			2		
			3		
			4		
			1		
			2		
			3		
			4		

Basis for data: Table 2.1 (p.4) and p. 10



DRAFT/WP  
d3006-4/971130  
03/30/92 7

2. If a method used was not a reference or conditional method, provide a narrative discussion including any data manipulation needed to make results correspond to reference or conditional method results.

3. Describe any deviations identified above.



4. Tabulate emission factors

Process	Pollutant	Units	Average emission factor	
			Uncontrolled	Controlled
A-1	Filt. PM	lb/ton fed	0.094	→ ✓
	Total PM	lb/ton fed	0.138	→ ✓
	CO	lb/ton fed	0.475	→ ✓
	CO <sub>2</sub>	lb/ton fed	—	✓
	SO <sub>2</sub>	lb/ton fed	0	→ ✓
A-2	Filt. PM	lb/ton fed	0.078	→ ✓
	Total PM	lb/ton fed	0.253	→ ✓
	CO	lb/ton fed	0.267	→ ✓
	CO <sub>2</sub>	lb/ton fed	—	→ ✓
	NO <sub>x</sub>	lb/ton fed	1.82	→ ✓

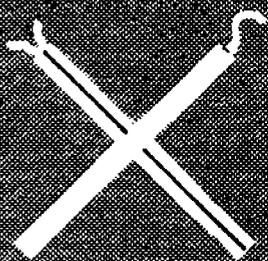
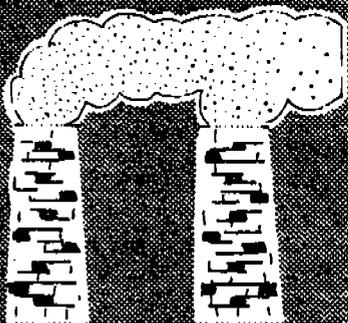
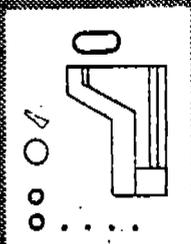
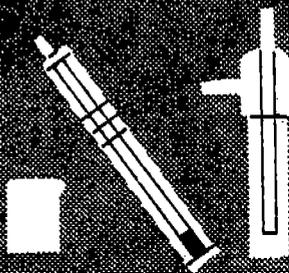
Data Rating  
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# AIR POLLUTION EMISSION TEST

DOW CHEMICAL

Freeport, Texas



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
Office of Air and Waste Management  
Office of Air Quality Planning and Standards  
Emission Measurement Branch  
Research Triangle Park, North Carolina

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
Office of Air Quality Planning and Standards  
Research Triangle Park, North Carolina 27711

SUBJECT: Source Test Report

DATE: July 29, 1975

FROM: Thomas M. Bibb, Emission Measurement Branch  
Emission Standards and Engineering Division (MD-13)

TO: See Below

The enclosed final source test report is submitted for your information. Any questions regarding the test should be directed to the Project Officer (area code 919-688-8583). Additional copies of this report are available from the Air Pollution Technical Information Center, Research Triangle Park, North Carolina 27711.

Industry: Lime Kiln

Process:

Company: Dow Chemical

Location: Freeport, Texas

Project Report Number: 74-LIM-6

Project Officer: Terry Harrison

Addressees:

John Nader

James Southerland

Test Project Engineer

Director, Air & Water Programs Division, Region IV

(copy enclosed for State Agency)

APTIC

A STUDY OF GASEOUS AND PARTICULATE  
EMISSIONS FROM LIME KILNS AT  
DOW CHEMICAL CORPORATION  
PLANT B  
FREEPORT, TEXAS

May, 1974

PREPARED AND SUBMITTED BY:

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.  
POST OFFICE BOX 13454  
GAINESVILLE, FLORIDA 32604  
PN 73 011 042

PREPARED FOR:

U.S. ENVIRONMENTAL PROTECTION AGENCY  
EMISSIONS MEASUREMENT BRANCH  
RESEARCH TRIANGLE PARK, NORTH CAROLINA

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## 1.0 INTRODUCTION

A part of the Environmental Protection Agency's ongoing work in pollution abatement is concerned with setting performance standards for new and substantially modified stationary sources. One source under consideration at present is rotary kilns used to calcine lime. Dow Chemical Corporation operates a large chemical complex in Freeport, Texas which uses slaked lime in recovering magnesium from seawater and various other operations.

There are three rotary kilns used to calcine dolomite ( $\text{CaCO}_3 \cdot \text{MgCO}_3$ ). The plant is capable of operating one, two or all three kilns simultaneously. The kilns are serviced by electrostatic precipitators (ESP's) for the control of particulate emissions. The gas stream from the operating kilns is combined prior to the ESP's and then split and ducted through two ESP's and vented to the atmosphere through two stacks, one for each ESP.

During the week of April 29, 1974, Environmental Science and Engineering, Inc. (ESE) conducted three series of tests on the two outlet stacks under contract for the EPA. During the testing period two of the kilns were operating simultaneously. Each stack was monitored for particulate matter, using EPA method 5; opacity, using a modified version of EPA method 9;  $\text{CO}_2$  and  $\text{O}_2$ , using a modified version of EPA method 3; and  $\text{CO}$ , using EPA method 10. In addition,  $\text{SO}_2$  concentrations were measured on the north stack using EPA method 6 and  $\text{NO}_x$  concentrations were measured on the south stack using EPA method 7.

Another provision of the tests was to conduct comparison tests for particulate matter at a single location in the stack using an in-stack filter and an EPA-5 train. No valid comparison data were obtained due to equipment difficulties.

## 2.0 SUMMARY AND DISCUSSION OF RESULTS

2.1 Particulate matter, Orsat, CO, SO<sub>2</sub>, NO<sub>x</sub> and opacity data are summarized in Tables 2.1 - 2.3.

The total average particulate emission rate was 4.9 kg/hr. (10.8 lbs/hr.) for the two stacks combined. However, this value is probably somewhat high as the first test on the north stack indicated 5.7 kg/hr. (12.6 lbs/hr.) alone. The average for runs 2 and 3 was 3.6 kg/hr. (7.9 lbs/hr.) for the two stacks combined, which is substantially lower. It is not known why the first run on the north stack indicated such a high emission rate. Some error may have been introduced because the person manipulating the probe misunderstood where the probe markings were to be located; instead of locating the marking at the outside of the pipe nipple, he positioned it at the inside stack wall on the first run only. This means that each point sampled was displaced from the equal area center by approximately 4 inches. It seems unlikely that this would introduce a very large error, however, it is possible that the probe tip came so close to the far stack wall that it contaminated the sample with particulate off the stack wall.

Laboratory analysis of the particulate samples showed a large amount of variability in the weight fraction caught in the various parts of the sampling train (probe, filter, etc.). The average for all of the runs was as follows: Probe - 20.5%, Filter - 32%, Back Half Water - 29.5%, Back Half Acetone - 18%. This means that only 53% of the total catch was caught in the probe and filter (front half), the remaining portion being in the impingers.





Table 2.3 Gas Data Summary

Run	Location	Flow SCMMD	Orsat Data		CO ppMD	PPMD NO <sub>x</sub>	PPM SO <sub>2</sub>	Visible Opacity			
			% CO <sub>2</sub>	% O <sub>2</sub>				1	2	3	4
1	North	1392	8.7	12.2	63	0	0	0	0	0	0
	South	1355	10.0	11.1	20	129	0	0	0	0	0
2	North	1300	9.7	11.3	27	0	0	0	0	0	<5(1)
	South	1216	10.4	9.7	34	96	0	0	0	0	0
3	North	1312	8.1	10.8	<del>850</del>	0	0	0	0	0	<5(1)
	South	1294	10.0	9.8	260	96	0	0	0	0	<5(1)

(1) Several readings of 5 and 10.

(2) Several readings of 5

After the first run, the Orsat was found to be in error when checked against ambient air. Since it rained all day Wednesday, time was spent calibrating a portable gas chromatograph to measure CO<sub>2</sub> and O<sub>2</sub>. When the integrated gas samples from the first day's testing were analyzed Wednesday afternoon, it appeared that the results were in error, i.e., the percent CO<sub>2</sub> seemed low and the percent O<sub>2</sub> high. However, when comparable results were obtained from test 2 on Thursday, it seemed to indicate that there was possibly a leak, either in the integrated sampler or in the duct work.

To find out where the leak was, a direct sample was taken from the stacks on Thursday evening; the results were the same as those obtained from the bag sample. On close examination it was discovered that ambient air was drawn into the system prior to the ESP's. The major places where this occurred were at the kiln bearing seals and the openings (approximately 20 x 40 inches) where the feed rock is dropped from conveyor belts into the kiln. These locations are on the negative side of the fan and, hence, draw ambient air into the system.

The concentration of CO as measured by NDIR<sup>1</sup> from injections taken from the integrated bag samples varied more than one would expect since the gases in the ductwork should have been thoroughly mixed. The average concentration for all six runs was 109 ppm<sup>2</sup>. However, analysis of the gases from the last day's runs indicated 250 and 260 ppm as compared to 63 and 20, 27 and 34 ppm from the first two days.

<sup>1</sup> Non-dispersive infrared

<sup>2</sup> Parts per million dry gas volume

Concentrations of NO<sub>x</sub> were 129, 96, and 96 ppmd for the three runs. Each run consisted of four grab samples, the results of which are included in Appendix A.

At no time was any SO<sub>2</sub> present in detectable amounts. This was expected since the kilns were fired with natural gas and the processed dolomite probably contained little, if any, sulfur inclusions.

Visible opacity was in general 0% with a few exceptions. One observer (No. 4) indicated quite a few as less than 5% on the second and third tests.

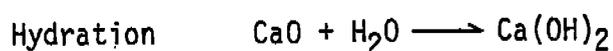
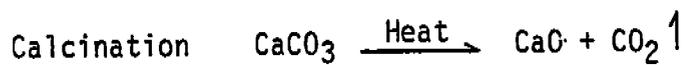
## 2.2 COMPARATIVE TESTING

Difficulties were experienced in getting a good comparative sample. No valid comparative data were obtained due to equipment malfunctions. EPA supplied some of the equipment to avoid potential problems in interfacing the special probe assembly with other parts of the sampling train. The difficulties were caused primarily by a leak in the EPA's meter box. Once this was fixed it was found that the meter was still malfunctioning. Finally, the meter stopped working during the second comparative test. Since the meter was not operating properly, it would be meaningless to calculate a grain loading based on the indicated gas volume. However, a copy of the comparative data can be found in the appendices.

### 3.0 PROCESS DESCRIPTION AND OPERATION

Limestone consists primarily of calcium carbonate or combinations of calcium and magnesium carbonate with varying amounts of impurities. Lime is a calcined or burned form of limestone, commonly divided into two basic products--quicklime and hydrated lime. Calcination expels carbon dioxide from the raw limestone, leaving calcium oxide (quicklime). With the addition of water (slaking), calcium hydroxide (hydrated lime) is formed.

In standard chemical notation, the reactions are:



The basic processes in production are: 1) quarrying the limestone raw material, 2) preparing the limestone for kilns by crushing and sizing, 3) calcining the limestone, and 4) optionally processing the quicklime further by additional crushing and sizing and then hydration. The majority of lime is produced in rotary kilns which can be fired by coal, oil, or gas. Rotary kilns have the advantages of high production per man-hour and a uniform product, but require higher capital investment and have higher unit fuel costs than most vertical kilns.

The Dow Chemical plant has three rotary lime kilns operating on Texas dolomitic limestone. The product quicklime is slaked to the hydrate (milk of lime) and used to precipitate magnesium hydroxide from seawater. Most of the purified magnesium hydroxide is reacted with hydrogen chloride to make magnesium chloride which is converted to magnesium metal in electrolytic cells.

There are three straight bore kilns, each 9 feet 6 inches by 265 feet, with a design capacity of 250 tons per day each. They "very seldom" run all three kilns, usually two are on line. The dolomite feed stone is brought into the plant sized one half to three quarters inch or three quartersto one and one half inches top size. There is no stone preheater. The kilns are fired with natural gas and the product quicklime is cooled to 200-300°F with satellite coolers. There is no quicklime storage, as all the product is fed into three rotating drum slakers where the milk of lime is produced.

The three kilns are provided with an electrostatic precipitator manufactured by the Western Precipitation Division of the Joy Manufacturing Company. The exit gas from the three kilns is cooled to 500°F by water sprays and enters a common plenum. From this plenum the gas is distributed to the two chambers of the precipitator by manually operated guillotine dampers. Each chamber has three fields, thirty-five gas passages, and a plate area of 35,280 square feet. From data which Dow supplied, it can be calculated (if only two kilns are in operation) that the design velocity is 2.0 feet per second and the design residence time is 10.5 seconds. Following the precipitators, the stack gases are vented to the atmosphere through 80 foot high stacks, one servicing each precipitator. The complete layout is illustrated in Figures 3.1 and 3.2.

The dust collected from the precipitators is presently wasted. In the future this dust may be granulated and returned to the kiln.

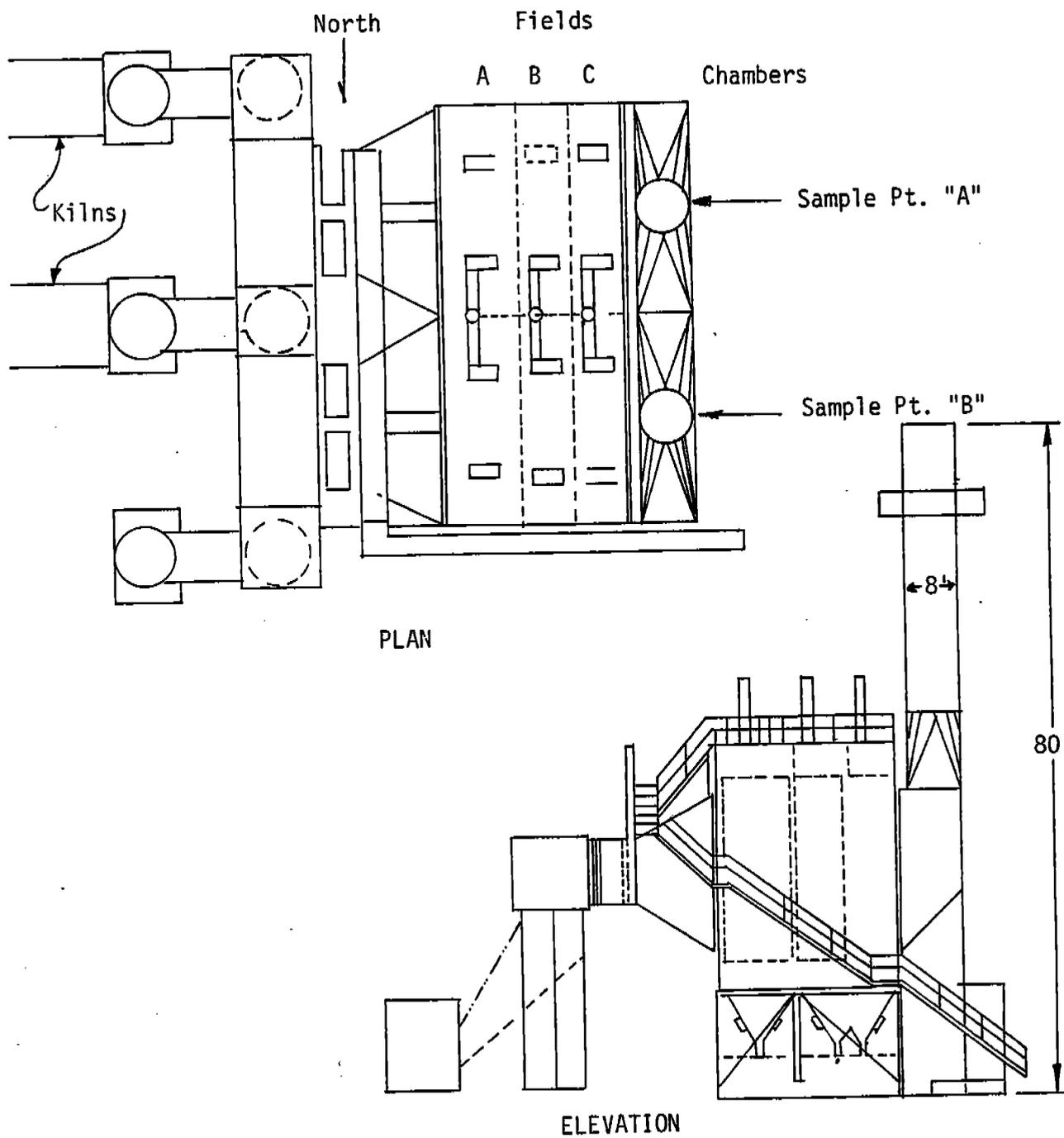


Figure 3.1. Precipitator Plan and Elevation.

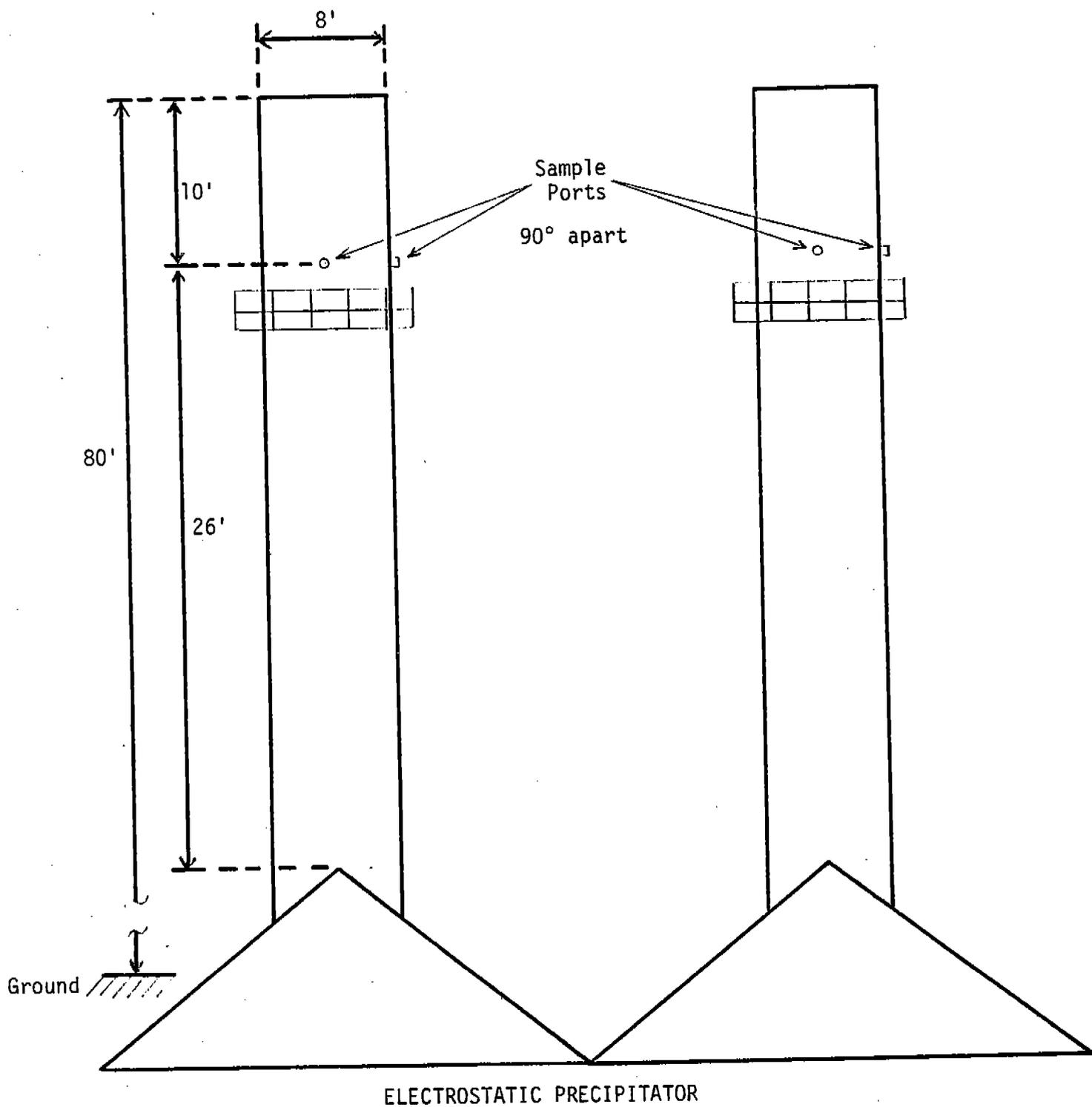


Figure 3.2 Stack Elevations

Each chamber of the precipitator has nineteen rappers, and there is one for each distribution plate. The rappers operate in sequence, one complete cycle requiring about twenty minutes.

The operation of the kilns and the electrostatic precipitator was monitored during the tests; process data are summarized in Table 3.1.

It appears that the kilns operated normally throughout the test. On May 1 there was heavy rain all day and no sampling was possible. During the 3 to 11 shift on that day, the A field in the south precipitator chamber began arcing badly and was therefore removed from service and grounded. Plant personnel thought that rain may have leaked into the insulator on the top of the precipitators. On the morning of May 2, the south A field was put back on line and, although there was still some arcing, it was not serious enough to significantly affect the efficiency of the precipitator.

On May 3, the south A field was arcing and the voltage on the field was down from 275 V (on May 2) to 250-255 V. The south A field was therefore removed from service and grounded before testing began. The south chamber, during the last day of testing, was therefore operating with 57% of its normal plate area. Even with this reduced collecting surface, there were no significant visible emissions.

Table 3.1 Summary of Operating Variables.

Test No. and (Date)	1 (4/30)	2 (5/2)	3 (5/3)
Kiln No.	2	2	3
Stone Feed Rate (tons/hr)	19.4	19.0	21.0
Ray O Tube Temp. (°F)	2174-2192	2156-2210	2174-2210
Slip Ring Temp. (°F)	1472-1490	1436-1460	1400-1436
Feed End Temp. (°F)	1156-1166	1184-1202	1220-1229
Fan Temp. ("F)	500	500-518	527-536
	21.2	18.9	21.7
	2192-2246	2156-2210	2156-2210
	1418-1436	1400-1436	1454-1490
	1256	1184-1202	1184-1202
	536	500-518	518-536
<u>Electrostatic Precipitator Data</u>			
A Field			
Primary Current (amps)	136-140	135-137	135-137*
Primary Voltage (volts)	260-275	250-283	290-300*
B Field			
Primary Current (amps)	185	183-184	182-185
Primary Voltage (volts)	230	232-235	235-240
C Field			
Primary Current (amps)	152-155	151-153	151-153
Primary Voltage (volts)	205-210	200-204	202-205

\*The south A field was grounded and not operating during the test.

#### 4.0 LOCATION OF SAMPLING POINTS

As the sampling ports were located only 26 feet downstream from the precipitator exit and 10 feet from the top of the stack, it was necessary to sample 22 points on each of two diameters through two ports 90° apart in each stack (total of 44 points in each). These points were selected according to method 1 of the Federal Register which locates each point at the center of equal area zones. The exact location of these points is included in Appendix B. As mentioned previously, for the first run on the north stack, each point was inadvertently shifted 4 inches too far into the stack. Due to the length of probe in the stack, the strain on the union of probe and heated box prevented several points near the far wall of both stacks from being sampled.

#### 5.0 SAMPLING AND ANALYTICAL PROCEDURES

##### 5.1 PARTICULATE SAMPLING

Particulate samples were obtained using the standard EPA method 5 train without a cyclone, following the procedures specified in the December 21, 1971 Federal Register. In addition, the impinger contents were obtained and analyzed according to the appropriate procedures specified in the proposed Method 5 in the August 17, 1971 Federal Register; except that, the organic extraction was not performed.

Prior to the first run, a preliminary moisture run was made in order to obtain a moisture fraction for setting the nomograph. Subsequently, for purposes of setting the nomograph, the moisture fraction was assumed to be 18-19 percent as found from the first particulate runs.

Gas temperatures were measured before and during each test with bimetallic dial thermometers accurate to  $\pm 5^{\circ}\text{F}$ . These measurements were made at a single point in the stack instead of at each sampling point. There appeared to be very little temperature gradient across the stack, making a one point temperature sample sufficient.

In addition, before each run except the third run, a preliminary velocity traverse was made on one diameter of each stack for the purpose of balancing the flow rates. If necessary, damper adjustments were made under the direction of the EPA project engineer.

At the end of each run, the particulate sampling trains were moved to a nearby room for clean-up. The samples obtained were transferred to acid-washed glass storage containers with Teflon<sup>R</sup> seals for subsequent laboratory analysis. A description of the analysis procedures is included in Appendix C.

## 5.2 SO<sub>2</sub> SAMPLING METHODS

Since it was requested by the EPA project officer that SO<sub>2</sub> sampling extend the full period during which particulate samples were obtained, it was necessary to add a dry impinger between the isopropanol bubbler and first peroxide impinger to trap any diluted isopropanol carryover to prevent sample contamination. This was the only deviation from method 6, as specified in the December 21, 1971 Federal Register.

## 5.3 NO<sub>x</sub> SAMPLING METHODS

Four NO<sub>x</sub> grab samples were taken, following Method 7 as specified in the December 21, 1971 Federal Register, during each particulate run on the

south stack; the arithmetic mean of these four samples is reported as the result for that run. These samples were approximately equally spaced in time during the run in order to obtain a representative average.

#### 5.4 INTEGRATED BAG SAMPLES

An integrated bag sample was obtained from each stack during the period of the particulate runs, following Method 3 as specified in the December 21, 1971 Federal Register.

At the end of each run the bag's contents were analyzed by NDIR for CO, and for CO<sub>2</sub> and O<sub>2</sub> by gas chromatography utilizing a thermal detector. A copy of the analytical procedures is included in Appendix C along with the calibration procedure for the GC and sample calculations showing corrections for CO<sub>2</sub> in the CO concentrations, according to Method 10 as specified in the March 8, 1974 Federal Register.

#### 5.5 VISUAL SMOKE OBSERVATIONS

During the first particulate tests, two visual observers were assigned to read each stack. Due to manpower requirements, this number was reduced to three observers on the second particulate test and two observers on the third. Since the opacity did not differ much from 0 at any time, it was possible to have the observers double up and read both stacks simultaneously for the last two tests. The observers followed the guidelines set forth in Method 9, as specified in the December 21, 1971 Federal Register.

#### 5.6 COMPARATIVE TESTING

Two probes were attached to a common pitot tube which allowed isokinetic sampling at approximately the same point in the stack. The in-stack

filter train differed from the method 5 train in that an additional in-stack filter holder was placed directly behind the nozzle. The remainder of the sampling equipment remained unchanged. Equipment difficulties prevented obtaining valid results.

APPENDIX A

CALCULATED EMISSIONS DATA

## EXPLANATION OF E.E.I. SOURCE SAMPLING CALCULATION SHEET

- PB - Barometric pressure, inches Hg  
 PS - Stack pressure, inches Hg  
 AS - Stack area, sq. ft.  
 AS' - Effective area of positive stack gas flow, sq. feet  
 NP1S - Number of traverse points where the pitot velocity head was greater than zero  
 TS - Stack temperature, °R  
 TH - Meter temperature, °R  
 H - Average square root of velocity head,  $\sqrt{\text{inches H}_2\text{O}}$   
 $\Delta H$  - Average meter orifice pressure differential, inches H<sub>2</sub>O  
 AN - Sampling nozzle area, square feet  
 CP - S-type pitot tube correction factor  
 VM - Recorded meter volume sample, cubic feet (meter conditions)  
 VC - Condensate and silica gel increase in impingers, milliliters  
 P<sub>0</sub> - Pressure at the dry test meter orifice,  $\left(\frac{PB + \Delta H}{13.6}\right)$  inches Hg  
 STP- Standard conditions, dry, 70°F, 29.92 inches Hg

- - - - -
- VWV- Conversion of condensate in milliliters to water vapor in cubic feet (STP)  
 VSJPD- Volume sampled, cubic feet (STP)  
 VT- Total water vapor volume and dry gas volume sampled, cubic feet (STP)  
 W- Moisture fraction of stack gas  
 FDA- Dry gas fraction  
   - Assumed moisture from preliminary check  
 MD- Molecular weight of stack gas, lbs/lb-mole (dry conditions)  
 MS- Molecular weight of stack gas, lbs/lb-mole (stack conditions)  
 GS- Specific gravity of stack gas, referred to air  
 EA- Excess air, %  
 $\sqrt{H \times TS}$  - Average square root of velocity head times stack temperature  
 U- Stack gas velocity, feet per minute  
 QS- Stack gas flow rate, cubic feet per minute (stack conditions)  
 QD- Stack gas flow rate, cubic feet per minute (dry conditions)  
 QSTPD- Stack gas flow rate, cubic feet per minute (STP)  
 PISO- Percent isokinetic volume sampled (method described in Federal Register)  
 ESTP- Pollutant concentration, grains per std. cubic feet  
 E12- Pollutant concentration, grains per std. cubic feet (Corrected to 12% CO<sub>2</sub>)  
 E50- Pollutant concentration, grains per std. cubic feet (Corrected to 50% EA)  
 EM- Pollutant emission rate, lbs. per hour



#### NOZZLE CALIBRATIONS

During the last day of testing (May 3) the nozzles used for sampling were calibrated for internal diameters. This was done as instructed by the EPA Project Officer by measuring three diameters (I.D.) on each of the nozzles used and averaging to determine the mean diameter; these measurements were made with calipers accurate to 0.001 inch. The 1/4 inch nozzle used during the first test North stack had mean diameter of 0.240 inch. The two-3/8 inch nozzles used for the remainder of the tests were nearly identical having a mean I.D. of 0.366 inch each.

SOURCE EMISSION TEST DATA

TEST NUMBER -  
 PLANT NAME -  
 SOURCE TESTED -  
 TYPE OF PLANT -  
 CONTROL EQUIPMENT-  
 POLLUTANT SAMPLED-

	NORTH	SOUTH
1) RUN NUMBER	1	1
2) DATE	4/30/74	4/30/74
3) TIME BEGAN	16:20	16:20
4) TIME END	18:49	18:58
5) T - NET TIME OF TEST, MINUTES	120	126
6) PB - BAROMETRIC PRESSURE, IN HG	30.28	30.28
7) PS - STACK PRESSURE, IN HG	30.28	30.28
8) ΔH - GAS MTR ORIFICE PRESS DROP, '' H2O	0.44	2.07
9) TH - GAS METER AVG TEMP, DEG F	93.6	89.3
10) VC - TOTAL H2O COLLECTED, ML	207.4	434.9
11) VVW - VOL H2O VAPOR COLL., CU FT, STP	9.83	20.61
12) VM - VOL DRY GAS SAMPLED, CU FT, MTR COND	44.729	101.514
13) VSTPD - VOL DRY GAS SAMPLED, CU FT, STP	43.386	99.62
14) W(PCT) - STACK GAS MOISTURE, PCT VOL	18.5	17.1
15) TS - AVG STACK GAS TEMPERATURE, DEG F	372.5	449.3
16) CO2 - STACK GAS CO2, PCT VOL	10	8.7
17) O2 - STACK GAS O2, '' ''	11.1	12.2
18) CO - STACK GAS CO, '' ''	0	0
19) N2 - STACK GAS N2, '' ''	78.9	79.1
20) FA - STACK GAS EXCESS AIR, PCT VOL	112.	138.
21) MD - STACK GAS MOLECULAR WEIGHT, DRY	30.04	29.88
22) MS - STACK GAS MOLECULAR WGHT, STK COND	27.82	27.84
23) GS - STACK GAS SPECIFIC GRAV, REF AIR	0.96	0.96
24) H - AVG SQUARE ROOT VEL HEAD, '' H2O	0.44	0.441
25) AVG SQUARE ROOT (STK TEMP × VEL HEAD)	12.7	13.291
26) CP - PITOT TUBE CORRECTION FACTOR	0.83	0.83
27) U - STACK GAS VELOCITY, FT/MIN	1861.1	1946.9
28) AS - STACK AREA, SQUARE FEET	50.27	50.27
29) AS' - EFFECTIVE STACK AREA, SQ FEET	50.27	50.27
30) QS - STK GAS FLOW RT, CU FT/MIN, STK CND	93559	97870
31) QSTPD - STK GAS FLOW RATE, CU FT/MIN, STP	49144	47834
32) DN - SAMPLING NOZZLE DIAMETER, IN	0.24	0.366
33) AN - SAMPLING NOZZLE AREA, SQ FT	0.00031	0.00073
34) PCT ISO-ISOKINETIC SAMPLING, PERCENT	127.7	119.3

\*\*\*S. T. P. ↔ DRY, 70 DEGREES F, 29.92 INCHES MERCURY\*\*\*  
**environmental science and engineering, inc.**

SOURCE EMISSION TEST DATA

TEST NUMBER -  
 PLANT NAME -  
 SOURCE TESTED -  
 TYPE OF PLANT -  
 CONTROL EQUIPMENT -  
 POLLUTANT SAMPLED -

	NORTH	SOUTH
1) RUN NUMBER	2	2
2) DATE	5/2/74	5/2/74
3) TIME BEGAN	11:43	11:47
4) TIME END	16:00	16:05
5) T - NET TIME OF TEST, MINUTES	200	200
6) PB - BAROMETRIC PRESSURE, IN HG	30.2	30.2
7) PS - STACK PRESSURE, IN HG	30.2	30.2
8) LH - GAS MTR ORIFICE PRESS DROP, '' H2O	1.69	1.45
9) TM - GAS METER AVG TEMP, DEG F	104.7	89
10) VC - TOTAL H2O COLLECTED, ML	591.9	604.6
11) VVW - VOL H2O VAPOR COLL., CU FT, STP	28.06	28.66
12) VM - VOL DRY GAS SAMPLED, CU FT, MTR COND	138.054	134.629
13) VSTPD - VOL DRY GAS SAMPLED, CU FT, STP	131.334	131.658
14) W(PCT) - STACK GAS MOISTURE, PCT VOL	17.6	17.9
15) TS - AVG STACK GAS TEMPERATURE, DEG F	361.1	411.5
16) CO2 - STACK GAS CO2, PCT VOL	9.7	10.4
17) O2 - STACK GAS O2, '' ''	11.3	9.7
18) CO - STACK GAS CO, '' ''	0	0
19) N2 - STACK GAS N2, '' ''	79	79.9
20) EA - STACK GAS EXCESS AIR, PCT VOL	116.	84.
21) MD - STACK GAS MOLECULAR WEIGHT, DRY	30	30.05
22) MS - STACK GAS MOLECULAR WGT, STK COND	27.89	27.9
23) GS - STACK GAS SPECIFIC GRAV, REF AIR	0.96	0.96
24) H - AVG SQUARE ROOT VEL HEAD, '' H2O	0.405	0.392
25) AVG SQUARE ROOT (STK TEMP x VEL HEAD)	11.608	11.565
26) CP - PITOT TUBE CORRECTION FACTOR	0.83	0.83
27) U - STACK GAS VELOCITY, FT/MIN	1701.2	1694.6
28) AS - STACK AREA, SQUARE FEET	50.27	50.27
29) AS' - EFFECTIVE STACK AREA, SQ FEET	50.27	50.27
30) QS - STK GAS FLOW RT, CU FT/MIN, STK CND	85521	85190
31) QSTPD - STK GAS FLOW RATE, CU FT/MIN, STP	45911	42945
32) DN - SAMPLING NOZZLE DIAMETER, IN	0.366	0.366
33) AN - SAMPLING NOZZLE AREA, SQ FT	0.00073	0.00073
34) PCT ISO-ISOKINETIC SAMPLING, PERCENT	103.2	110.5

SOURCE EMISSION TEST DATA

TEST NUMBER -  
 PLANT NAME -  
 SOURCE TESTED -  
 TYPE OF PLANT -  
 CONTROL EQUIPMENT -  
 POLLUTANT SAMPLED -

	NORTH	SOUTH
1) RUN NUMBER	3	3
2) DATE	5/31/74	5/31/74
3) TIME BEGAN	9:35	9:35
4) TIME END	13:20	13:00
5) T - NET TIME OF TEST, MINUTES	200	195
6) PB - BAROMETRIC PRESSURE, IN HG	30	30
7) PS - STACK PRESSURE, IN HG	30	30
8) ΔH - GAS MTR ORIFICE PRESS DROP, '' H2O	1.73	1.64
9) TH - GAS METER AVG TEMP, DEG F	98.5	84.4
10) VC - TOTAL H2O COLLECTED, ML	625.6	658.2
11) VVV - VOL H2O VAPOR COLL., CU FT, STP	29.65	31.2
12) VM - VOL DRY GAS SAMPLED, CU FT, MTR COND	139.929	138.906
13) VSTPD - VOL DRY GAS SAMPLED, CU FT, STP	133.715	136.149
14) W(PCT) - STACK GAS MOISTURE, PCT VOL	18.2	18.6
15) TS - AVG STACK GAS TEMPERATURE, DEG F	365.9	405.8
16) CO2 - STACK GAS CO2, PCT VOL	8.1	10
17) O2 - STACK GAS O2, '' ''	10.8	9.8
18) CO - STACK GAS CO, '' ''	0	0
19) N2 - STACK GAS N2, '' ''	81.1	80.2
20) FA - STACK GAS EXCESS AIR, PCT VOL	100.	85
21) MD - STACK GAS MOLECULAR WEIGHT, DRY	29.73	29.99
22) MS - STACK GAS MOLECULAR WGT, STK COND	27.6	27.76
23) GS - STACK GAS SPECIFIC GRAV, REF AIR	0.95	0.96
24) H - AVG SQUARE ROOT VEL HEAD, '' H2O	0.412	0.42
25) AVG SQUARE ROOT (STK TEMP x VEL HEAD)	11.830	12.349
26) CP - PITOT TUBE CORRECTION FACTOR	0.83	0.83
27) U - STACK GAS VELOCITY, FT/MIN	1749.5	1820.2
28) AS - STACK AREA, SQUARE FEET	50.27	50.27
29) AS' - EFFECTIVE STACK AREA, SQ FEET	50.27	50.27
30) QS - STK GAS FLOW RT, CU FT/MIN, STK CND	87951	91500
31) QSTPD - STK GAS FLOW RATE, CU FT/MIN, STP	46318	45693
32) DN - SAMPLING NOZZLE DIAMETER, IN	0.366	0.366
33) AN - SAMPLING NOZZLE AREA, SQ FT	0.00073	0.00073
34) PCT ISO-ISOKINETIC SAMPLING, PERCENT	104.1	110.3

\*\*\*S. T. P. ↔ DRY 70 DEGREES F, 29.92 INCHES MERCURY\*\*\*  
**environmental science and engineering, inc.**

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.  
ANALYTICAL SERVICES  
WASTEWATER TREATMENT

PLANT- DOW CHEMICAL  
 STACK- LINE KILN OUTLET - NORTH STACK  
 WEATHER CONDITIONS-

DATE- 4/30/74  
 RUN 1 FROM 16:20-18:49

AS'- 50.27 SQ. FEET    TS- 832.5 DEGREES R    TM- 553.6 DEGREES R    PS- 30.28 IN HG  
 ΔH- 0.44 IN H2O    AN- 0.000314 SQ FT    CP- 0.83    VM- 44.729 CF    H- 0.44 IN H2O  
 VC- 207.4 ML  
 TOTAL TIME- 120 MIN    NPTS- 40    ORSAT: CO2-10.00    O2-11.10    CO- 0    N2-78.9

1) 9.831	SCF
2) 43.386	SCFD
3) 53.217	SCF
4) 0.185	
5) 0.815	
6) 0.14	
7) 30.04	
8) 27.82	
9) 0.96	
10) 112.	
11) 12.7	
12) 1861.1	PPM
13) 93559	ACFM
14) 76276	CFM
15) 49144	SCFM
16) 127.7	

POLLUTANT CONCENTRATIONS, AT J. T. P.  
 MG/SCM (MG/CM HPR) = (35.31) × (HG) ÷ (VSTPP)  
 GR/SCM (J.T.P.) = (.0154) × (HG) ÷ (VSTPP)  
 POLLUTANT CONCENTRATIONS, AT STACK CONDITIONS  
 MG/ACH (MG/CM HPR) = (625.3) × (HG) × (PS) × (PDA) ÷ (VSTPP) × (TC)  
 GR/ACH (STE COND) = (.273) × (HG) × (PS) × (PDA) ÷ (VSTPP) × (TC)  
 POLLUTANT EMISSION RATE, POUNDS/FOUR  
 LBS/HR = (1.323E-4) × (HG) × (QSTPP) ÷ (VSTPP)

MG	GR/SCM	GR/ACH	MG/SCM	MG/ACH	LBS/HR	
FH	18.19	0.0067	0.0035	15.38	8.08	2.83
FILTER	27.18	0.0099	0.0052	22.63	11.88	4.17
BHW	17.4	0.0062	0.0032	14.16	7.44	2.61
BHA	20.1	0.0071	0.0038	16.36	8.59	3.01
TOTALS	84.2	0.0299	0.0157	68.53	35.99	12.62

COMMENTS : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 TEST CONDUCTED BY : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.**  
**SOURCE SAMPLING CALCULATIONS**  
**POLLUTANT EMISSIONS**

DATE- 4/30/74

PLANT- DOW CHEMICAL  
 STACK- SOUTH LIME KILN OUTLET

RUN 1 FROM 16:20-18:58

WEATHER CONDITIONS-

PB- 30.28 IN HG

PS- 30.28 IN HG

AS'- 50.27 SQ. FEET

TS- 909.3 DEGREES R

TM- 549.3 DEGREES R

H- 0.441 IN H2O

WH- 2.07 IN H2O

AN- 0.000731 SQ FT

CP- 0.83

VM- 101.514 CF

VC- 434.9 ML

TOTAL TIME- 126 MIN

NPTS- 42

ORSAT: CO2- 8.70

O2- 12.20

CO-

0 N2- 79.10

1

VWV = (0.00731) x (VC)	1) 20.614	SCF
VSTPD = ( (530) x (VW) x (PB + (AH ÷ 13.6)) ) ÷ ( 29.92 x TM )	2) 99.62	SCFD
VT = (VWV) + (VSTPD)	3) 120.234	SCF
W = (VWV) ÷ (VT)	4) 0.171	
FDA = (1.0 - W)	5) 0.829	
ASSUMED MOISTURE FRACTION	6) 0.14	
MD = (.44 x CO2) + (.32 x O2) + (.28 x (CO + N2))	7) 29.88	
MS = (MD x FDA) + (18 x W)	8) 27.84	
CS = (MS) ÷ (28.99)	9) 0.96	
CA = (100) x (O2 - 0.5 x CO) ÷ ( (0.266 x N2) - (O2 - 0.5 x CO) )	10) 138.	%
AVG(√(P x TS)) = (1 ÷ N) x SUM(√(P x TS))	11) 13.291	
U = ( 174 x CP x (√(29.92 ÷ PS x GS)) x AVG(√(P x TS)) )	12) 1946.9	FEET
US = (U) x (AS')	13) 97870	ACFM
QD = (CS) x (FDA)	14) 81090	CFM
QSTPD = (QD) x ( 530 ÷ TS ) x ( PS ÷ 29.92 )	15) 47834	SCFD
QISO = ( (0.00267 x VC x TS) + (P x TS x VM ÷ TM) ) ÷ ( TIME x U x PS x AN )	16) 119.3	%

**POLLUTANT CONCENTRATIONS, AT S. T. P.**

MG/SCM (MG/CU MTR) = (35.31) x (HG) ÷ (VSTPD)

GR/SCF (S.T.P.) = (.0154) x (HG) ÷ (VSTPD)

**POLLUTANT CONCENTRATIONS, AT STACK CONDITIONS**

MG/ACM (MG/CU MTR) = ( 625.3 ) x (HG) x (PS) x (FDA) ÷ ( (VSTPD) x (TS) )

GR/ACF (STK COND) = ( 0.273 ) x (HG) x (PS) x (FDA) ÷ ( (VSTPD) x (TS) )

**POLLUTANT EMISSION RATE, POUNDS/POUR**

LBS/HR = ( (1.323E-4) x (HG) x (QSTPD) ) ÷ ( VSTPD )

	MG	GR/SCF	GR/ACF	MG/SCM	MG/ACM	LBS/HR
H	9.9	0.0015	0.0007	3.51	1.71	0.63
ALTER	29.6	0.0046	0.0022	10.49	5.13	1.88
W	18.6	0.0029	0.0014	6.59	3.22	1.18
HA	5.8	0.0009	0.0004	2.06	1.00	0.37
TOTALS	63.9	0.0099	0.0047	22.65	11.07	4.06

COMMENTS : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

TEST CONDUCTED BY : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.  
AIR QUALITY MODELING CALCULATIONS  
POLLUTANT EMISSIONS

DATE- 5/2/74

PLANT- DOW CHEMICAL  
 STACK- LIME KILN OUTLET - NORTH STACK

RUN 2 FROM 11:43-16:00

WEATHER CONDITIONS-

PB- 30.2 IN HG

PS- 30.2 IN HG

S'- 50.27 SQ. FEET

TS- 821.1 DEGREES R

TM- 564.7 DEGREES R

H- 0.405 IN H2O

H- 1.69 IN H2O

AN- 0.000731 SQ FT

CP- 0.83

VM- 138.054 CF

VC- 591.9 ML

TOTAL TIME- 200 MIN

PPTS- 40

ORSAT: CO2- 9.70

O2- 11.30

CO-

0

N2- 79

- 1)  $VWV = (0.0474) \times (VC)$  SCF
- 2)  $VSTPD = ((530) \times (VW) \times (PB + (AH \div 13.6))) \div (29.92 \times TM)$  SCFD
- 3)  $VT = (VWV) + (VSTPD)$  SCF
- 4)  $W = (VWV) \div (VT)$
- 5)  $FPA = (1.0 - W)$
- 6) ASSUMED MOISTURE FRACTION
- 7)  $MS = (.44 \times CO_2) + (.32 \times O_2) + (.28 \times (CO + N_2))$
- 8)  $MD = (MS \times FPA) + (18 \times W)$
- 9)  $GS = (MS) \div (28.99)$
- 10)  $FPA = (100) \times (O_2 - 0.5 \times CO) \div ((0.266 \times N_2) - (O_2 - 0.5 \times CO))$
- 11)  $AVG(\sqrt{(H \times TS)}) = (1 \div H) \times SUM(\sqrt{(T \times TS)})$
- 12)  $U = (.174 \times CP \times (\sqrt{(29.92 \div PS \times GS)}) \times AVG(\sqrt{(T \times TS)})$  FPM
- 13)  $QD = (U) \times (AS')$  ACFM
- 14)  $QD = (QD) \times (FPA)$  CFM
- 15)  $QSTPD = (QD) \times (530 \div TS) \times (PS \div 29.92)$  SCFM
- 16)  $QISO = ((0.00287 \times VC \times PS) + (PO \times TS \times VM \div TM)) \div (TIME \times U \times PS \times AN)$
- POLLUTANT CONCENTRATIONS, AT S. P. P.
- $MG/SCM (MG/CU MTR) = (35.31) \times (MG) \div (VSTPD)$
- $GR/SCF (S.P.P.) = (.0154) \times (MG) \div (VSTPD)$
- POLLUTANT CONCENTRATIONS, AT STACK CONDITIONS
- $MG/ACH (MG/CU MTR) = ((625.3) \times (MG) \times (PS) \times (FPA)) \div ((VSTPD) \times (TS))$
- $GR/ACF (STK COND) = ((0.273) \times (MG) \times (PS) \times (FPA)) \div ((VSTPD) \times (TS))$
- POLLUTANT EMISSION RATE, POUNDS/ HOUR
- $LBS/HR = ((1.323E^{-4}) \times (MG) \times (QSTPD)) \div (VSTPD)$

	MG	GR/SCF	GR/ACF	MG/SCM	MG/ACFM	LBS/HR
PH	14.6	0.0017	0.0009	3.93	2.11	0.68
FILTER	16.0	0.0019	0.0010	4.30	2.31	0.74
HW	10.6	0.0012	0.0007	2.85	1.53	0.49
HA	8.2	0.0010	0.0005	2.20	1.18	0.38
TOTALS	49.4	0.0058	0.0031	13.28	7.13	2.28

COMMENTS : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

TEST CONDUCTED BY : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.**  
**SOURCE SAMPLING CALCULATIONS**  
**PARTICULATE EMISSIONS**

PLANT- DOW CHEMICAL  
 STACK- SOUTH LIME KILN OUTLET  
 WEATHER CONDITIONS-

DATE- 5/2/74  
 RUN 2 FROM 11:47-16:05

AS'- 50.27 SQ. FEET TS- 871.5 DEGREES R TM- 549 DEGREES R H- 0.392 IN H2O  
 AH- 1.45 IN H2O AN- 0.000731 SQ FT CP- 0.83 VM- 134.629 CF VC- 604.6 ML  
 TOTAL TIME- 200 MIN NPTS- 40 ORSAT: CO2-10.40 O2- 9.70 CO- 0 N2-79.90

- 1)  $VW = (0.0475) \times (VC)$  28.658 SCF
- 2)  $VSTPD = ((530) \times (VW) \times (PS + (AH \div 13.6))) \div (29.92 \times TM)$  131.658 SCFD
- 3)  $VT = (VW) + (VSTPD)$  160.316 SCF
- 4)  $W = (VW) \div (VT)$  0.179
- 5)  $FDA = (1.0 - W)$  0.821
- 6)  $AS' = (AS' \times W)$  0.19
- 7)  $MS = (.44 \times CO_2) + (.32 \times O_2) + (.28 \times (CO + N_2))$  30.05
- 8)  $MS = (MS \times FDA) + (18 \times W)$  27.9
- 9)  $GS = (MS) \div (28.99)$  0.96
- 10)  $QA = (100) \times (O_2 - 0.5 \times CO) \div ((0.266 \times N_2) - (O_2 - 0.5 \times CO))$  84
- 11)  $AVG(\sqrt{(H \times TS)}) = (1 \div H) \times SUM(\sqrt{(H \times TS)})$  11.565
- 12)  $U = (174 \times CP \times (\sqrt{(29.92 \times PS \times GS)}) \times AVG(\sqrt{(H \times TS)}))$  1694.6 FPM
- 13)  $QS = (U) \times (AS')$  851.90 ACFM
- 14)  $QD = (QS) \times (FDA)$  699.61 CFM
- 15)  $QSTPD = (QD) \times (530 \div TS) \times (PS \div 29.92)$  429.45 SCFD
- 16)  $PISO = ((0.00267 \times VC \times TS) + (PO \times TS \times VM \div TM)) \div (TIME \times U \times PS \times AN)$  110.5

**POLLUTANT CONCENTRATIONS, AT S. T. P.**

MG/SCM (MG/CU MTR) =  $(35.31) \times (MG) \div (VSTPD)$   
 GR/SCF (S.T.P.) =  $(.0154) \times (MG) \div (VSTPD)$

**POLLUTANT CONCENTRATIONS, AT STACK CONDITIONS**

MG/ACH (MG/CU MTR) =  $((625.3) \times (MG) \times (PS) \times (FDA)) \div ((VSTPD) \times (TS))$   
 GR/ACF (STK COND) =  $((0.273) \times (MG) \times (PS) \times (FDA)) \div ((VSTPD) \times (TS))$

**POLLUTANT EMISSION RATE, POUNDS/HOUR**

LBS/HR =  $((1.323E^{-4}) \times (MG) \times (QSTPD)) \div (VSTPD)$

	MG	GR/SCF	GR/ACF	MG/SCM	MG/ACM	LBS/HR
WATER	7.8	0.0009	0.0005	2.09	1.05	0.34
WATER	14.1	0.0016	0.0008	3.78	1.91	0.61
WATER	78.6	0.0092	0.0046	21.08	10.62	3.39
WATER	25.9	0.0030	0.0015	6.95	3.50	1.12
TOTALS	126.4	0.0147	0.0074	33.90	17.08	5.45

COMMENTS : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

TEST CONDUCTED BY : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.**  
**SOURCE HANDLING CALCULATIONS**  
**POLLUTANT EMISSIONS**

DATE- 5/3/74

RUN 3 FROM 9:35-13:20

PLANT- DOW CHEMICAL  
 TACK- LINE KILN OUTLET + NORTH STACK

WEATHER CONDITIONS-

PB- 30 IN HG

PS- 30 IN HG

SA- 50.27 SQ. FEET

TS- 825.9 DEGREES R

TM- 558.5 DEGREES R

H- 0.412 IN H2O

AN- 1.73 IN H2O

AN- 0.000731 SQ FT

CP- 0.83

VM- 139.929 CF

VC- 625.6 ML

TOTAL TIME- 200 MIN

NPTS- 40

ORSAT: CO2- 8.10

O2-10.80

CO-

0

N2-81.10

$VWV = (0.0474) \times (FC)$	1) 29.653	SCF
$VSTPD = ( (530) \times (VM) \times (PB + (\Delta H \div 13.6)) ) \div ( 29.92 \times TM )$	2) 133.715	SCFD
$VT = (VWV) + (VSTPD)$	3) 163.368	SCF
$W = (VWV) \div (VT)$	4) 0.182	
$FDA = (1.0 - W)$	5) 0.818	
<b>ASSUMED MOLECULAR FRACTION</b>	6) 0.18	
$MD = (.44 \times CO_2) + (.32 \times O_2) + (.28 \times (CO + N_2))$	7) 29.73	
$MS = (MD \times FDA) + (18 \times W)$	8) 27.6	
$GS = (MS) \div (28.99)$	9) 0.95	
$FDA = (100) \times (O_2 - 0.5 \times CO) \div ( (0.266 \times H_2) - (O_2 - 0.5 \times CO) )$	10) 100	%
$AVG(\sqrt{(H \times TS)}) = (1 \div H) \times SUM(\sqrt{(H \times TS)})$	11) 11.836	
$U = ( 174 \times CP \times (\sqrt{(29.92 \div PS \times GS)}) \times AVG(\sqrt{(H \times TS)}) )$	12) 1749.6	PPH
$QS = (U) \times (AS')$	13) 87951	ACFM
$QD = (QS) \times (FDA)$	14) 71987	CFM
$QSTPD = (QD) \times ( 530 \div TS ) \times ( PS \div 29.92 )$	15) 46318	SCFD
$PISO = ( (0.00267 \times VC \times TS) + (PO \times TS \times VM \div TM) ) \div ( TIME \times U \times PS \times AN )$	16) 104.1	%

**POLLUTANT CONCENTRATIONS, AT S. T. P.**

MG/SCM (MG/CU HTR) =  $(35.31) \times (MG) \div (VSTPD)$

GR/SCF (S.T.P.) =  $(.0154) \times (MG) \div (VSTPD)$

**POLLUTANT CONCENTRATIONS, AT STACK CONDITIONS**

MG/ACH (MG/CU HTR) =  $( 625.3 ) \times (MG) \times (PS) \times (FDA) \div ( (VSTPD) \times (TS) )$

GR/ACF (STK COND) =  $( 0.273 ) \times (MG) \times (PS) \times (FDA) \div ( (VSTPD) \times (TS) )$

**POLLUTANT EMISSION RATE, POUNDS/HOUR**

LBS/HR =  $( (1.323E^{-4}) \times (MG) \times (QSTPD) ) \div ( VSTPD )$

	MG	GR/SCF	GR/ACF	MG/SCM	MG/ACH	LBS/HR
H	27.5	0.0032	0.0017	7.26	3.82	1.26
FILTER	23.7	0.0027	0.0014	6.26	3.29	1.09
W	15.4	0.0018	0.0009	4.07	2.14	0.71
A	4.6	0.0005	0.0003	1.21	0.64	0.21
TOTALS	71.2	0.0082	0.0043	18.80	9.90	3.26

COMMENTS : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

TEST CONDUCTED BY : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.**  
**SOURCE AIR QUALITY CALCULATIONS**  
**PARTICULATE EMISSIONS**

DATE- 5/3/74

RUN 3 FROM 9:35-13:00

PLANT- DOW CHEMICAL  
 STACK- SOUTH LIME KILN  
 WEATHER CONDITIONS-

PB- 30 IN HG

PS- 30 IN HG

AS'- 50.27 SQ. FEET TS- 865.8 DEGREES R TM- 544.4 DEGREES R H- 0.42 IN H2O  
 W- 1.64 IN H2O AN- 0.000731 SQ FT CP- 0.83 VM- 138.906 CF VC- 658.2 ML  
 TOTAL TIME- 195 MIN NPTS- 39 ORSAT: CO2-10.00 O2- 9.80 CO- 0 N2-80.20

V<sub>VDV</sub> = (0.6875) × (VC)  
 V<sub>STPD</sub> = (530) × (V<sub>VDV</sub>) × (PB + (ΔP ÷ 13.6)) ÷ (29.92 × TM)  
 V<sub>VT</sub> = (V<sub>VDV</sub>) + (V<sub>STPD</sub>)  
 W = (V<sub>VDV</sub>) ÷ (V<sub>VT</sub>)  
 FDA = (1.0 - W)  
 ASSUMED MOISTURE FRACTION  
 MD = (.44 × CO<sub>2</sub>) + (.32 × O<sub>2</sub>) + (.28 × (CO + N<sub>2</sub>))  
 MS = (MD × FDA) + (18 × W)  
 GS = (MS) ÷ (28.99)  
 PA = (100) × (O<sub>2</sub> - 0.5 × CO) ÷ (0.266 × N<sub>2</sub>) - (O<sub>2</sub> - 0.5 × CO)  
 AVG(√(R × TS)) = (1 + W) × SUM(√(W × TS))  
 U = (174 × CP × (√(29.92 + PS × GS)) × AVG(√(W × TS))  
 QS = (U) × (AS')  
 QD = (QS) × (FDA)  
 QSTPD = (QD) × (530 ÷ TS) × (PS ÷ 29.92)  
 PISO = ((0.00267 × VC × TS) + (P × TS × VM ÷ TM)) ÷ (TIME × U × PS × AN)  
 POLLUTANT CONCENTRATIONS, AT S. T. P.  
 MG/SCM (MG/CU MTR) = (35.31) × (MG) ÷ (V<sub>STPD</sub>)  
 GR/SCF (S.T.P.) = (.0154) × (MG) ÷ (V<sub>STPD</sub>)  
 POLLUTANT CONCENTRATIONS, AT STACK CONDITIONS  
 MG/ACH (MG/CU MTR) = ((625.3) × (MG) × (PS) × (FDA)) ÷ ((V<sub>STPD</sub>) × (TS))  
 GR/ACF (STACK COND) = ((0.273) × (MG) × (PS) × (FDA)) ÷ ((V<sub>STPD</sub>) × (TS))  
 POLLUTANT EMISSION RATE, POUNDS/HOUR  
 LBS/HR = ((1.323E<sup>-4</sup>) × (MG) × (QSTPD)) ÷ (V<sub>STPD</sub>)

- 1) 31.199 SCF
- 2) 136.149 SCFD
- 3) 167.347 SCF
- 4) 0.186
- 5) 0.814
- 6) 0.18
- 7) 29.99
- 8) 27.76
- 9) 0.96
- 10) 85
- 11) 12.349
- 12) 1820.2 FPM
- 13) 91500 ACFM
- 14) 74441 CFM
- 15) 45693 SCFD
- 16) 110.3

	MG	GR/SCF	GR/ACF	MG/SCM	MG/ACH	LBS/HR
H	11.4	0.0013	0.0006	2.96	1.48	0.51
FILTER	38.1	0.0043	0.0022	9.88	4.93	1.69
W	23.4	0.0026	0.0013	6.07	3.03	1.04
HA	33.8	0.0038	0.0019	8.77	4.38	1.50
TOTALS	106.7	0.0120	0.0060	27.67	13.81	4.74

COMMENTS : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

TEST CONDUCTED BY : \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**NOX SOURCE EMISSION TEST DATA**

TEST NUMBER - 1  
 PLANT NAME - DOW FREEPORT  
 SOURCE TESTED - SOUTH LIME KILN  
 TYPE OF PLANT -  
 CONTROL EQUIPMENT - ESP  
 POLLUTANT SAMPLED - NO<sub>x</sub>

	1	2	3
1) RUN NUMBER	1	2	3
2) DATE	4/30/74	4/30/74	4/30/74
3) TIME	4:45 PM	5:15	5:50
4) FLASK NUMBER	73-284B	73-511-B	73-511-I
5) VF - FLASK AND VALVE VOLUME, ML	1920	1868	1952
6) VA - ABSORBING SOLUTION VOLUME, ML	25	25	25
7) PB - BAROMETRIC PRESSURE, IN HG	30.28	30.28	30.28
8) PS - STACK PRESSURE, IN HG	30.28	30.28	30.28
9) PI - INITIAL FLASK VACUUM, IN HG	27.7	27.7	27.7
10) PF - FINAL " " " "	0.3	1.5	2.1
11) TI - INITIAL FLASK TEMPERATURE, DEG F	95	95	95
12) TF - FINAL " " " "	76	76	76
13) VSTPD - VOL OF GAS SAMPLED, ML, S.T.P.	1721.7	1602.6	1638.1
14) TS - STACK GAS TEMPERATURE, DEG F	449	449	449
15) PCT W - STACK GAS MOISTURE, PCT VOL	11.1	17.1	17.1
16) QSTPD - STK GAS FLOW RTE, CU FT/MIN, STP			
17) MNO2 - MASS OF NO2 IN SAMPLE, GM x 1.0E6	89	454	256
18) MILLIGRAMS NO2/CU METER, STP	218.4	283.4	156.3
19) LBS NO2 /CU FT, STP	1.35 x 10 <sup>-5</sup>	1.75 x 10 <sup>-5</sup>	0.97 x 10 <sup>-5</sup>
20) PARTS PER MILLION OF NO2, STP	113.8	147.7	81.4
21) LBS NO2/HOUR			
22) BTU'S PER HOUR INPUT			
23) LBS NO2/MILLION BTU			

$$VSTPD = (17.71) \times (VF-VA) \times [((PB-PF) \div TF) - ((PB-PI) \div TI)]$$

$$MG \text{ NO}_2/\text{CU MTR} = (35.31) \times (MNO2) \div (VSTPD)$$

$$\text{LBS NO}_2/\text{CU FT} = (6.2E^{-5}) \times (MNO2) \div (VSTPD)$$

$$P. P. M. = (8.406E6) \times (\text{LBS NO}_2/\text{CU FT})$$

$$\text{LBS NO}_2/\text{ HOUR} = (60) \times (QSTPD) \times (\text{LBS NO}_2/\text{CU FT})$$

$$\text{LBS NO}_2/\text{MILLION BTU} = (\text{LBS NO}_2/\text{HR}) \div (\text{MILLION BTU /HR, INPUT})$$

\*\*\*S. T. P. ↔ DRY, 70 DEGREES F, 29.92 INCHES MERCURY\*\*\*

## NOX SOURCE EMISSION TEST DATA

TEST NUMBER - 1  
 PLANT NAME - OOW FREEPORT  
 SOURCE TESTED - SO. LINE KILN  
 TYPE OF PLANT -  
 CONTROL EQUIPMENT - ESP  
 POLLUTANT SAMPLED - NOx

AVG.

1) RUN NUMBER	4	
2) DATE	4/30/74	
3) TIME	6:40 pm	
4) FLASK NUMBER	2	
5) VF - FLASK AND VALVE VOLUME, ML	1935	
6) VA - ABSORBING SOLUTION VOLUME, ML	25	
7) PB - BAROMETRIC PRESSURE, IN HG	30.28	
8) PS - STACK PRESSURE, IN HG	30.28	
9) PI - INITIAL FLASK VACUUM, IN HG	27.8	
10) PF - FINAL " " " "	1.85	
11) TI - INITIAL FLASK TEMPERATURE, DEG F	95	
12) TF - FINAL " " " "	76	
13) VSTPD - VOL OF GAS SAMPLED, ML, S.T.P.	1640.6	
14) TE - STACK GAS TEMPERATURE, DEG F	449	
15) PCE W - STACK GAS MOISTURE, PCT VOL		
16) QSTPD - STK GAS FLOW RATE, CU FT/MIN, STP		
17) MNO2 - MASS OF NO2 IN SAMPLE, GR * 1.0E6	548	<del>248</del>
18) MILLIGRAMS NO2/CU METER, STP	334.0	248
19) LBS NO2 /CU FT , STP	$2.07 \times 10^{-5}$	$1.54 \times 10^{-5}$
20) PARTS PER MILLION OF NO2, STP	174.1	129.2
21) LBS NO2/HOUR		
22) BTU'S PER HOUR INPUT		
23) LBS NO2/MILLION BTU		

$$VSTPD = (17.71) \times (VF - VA) \times [((PB - PF) \div TF) - ((PB - PI) \div TI)]$$

$$MG \text{ NO}_2 / \text{CU MTR} = (35.31) \times (MNO_2) \div (VSTPD)$$

$$LBS \text{ NO}_2 / \text{CU FT} = (6.2E^{-5}) \times (MNO_2) \div (VSTPD)$$

$$P. P. M. = (8.406E6) \times (LBS \text{ NO}_2 / \text{CU FT})$$

$$LBS \text{ NO}_2 / \text{ HOUR} = (60) \times (QSTPD) \times (LBS \text{ NO}_2 / \text{CU FT})$$

$$LBS \text{ NO}_2 / \text{MILLION BTU} = (LBS \text{ NO}_2 / \text{HR}) \div (\text{MILLION BTU / HR} \cdot \text{INPUT})$$

\*\*\*S. T. P. ← DRY, 70 DEGREES F, 29.92 INCHES MERCURY\*\*\*

**NOX SOURCE EMISSION TEST DATA**

TEST NUMBER - 2  
 PLANT NAME - DOW FREEPORT  
 SOURCE TESTED - LIME KILN  
 TYPE OF PLANT -  
 CONTROL EQUIPMENT- ESP  
 POLLUTANT SAMPLED- NO<sub>x</sub>

1) RUN NUMBER	1	2	3
2) DATE	5-2-74	5-2-74	5-2-74
3) TIME	1200	1300	1430
4) FLASK NUMBER	6	3	2
5) VF - FLASK AND VALVE VOLUME, ML	1920	1868	1935
6) VA - ABSORBING SOLUTION VOLUME, ML	25	25	25
7) PB - BAROMETRIC PRESSURE, IN HG	30.2	30.2	30.2
8) PS - STACK PRESSURE, IN HG	30.2	30.2	30.2
9) PI - INITIAL FLASK VACUUM, IN HG	25.5	27.9	27.8
10) PF - FINAL " " " "	2.15	1.60	2.20
11) TI - INITIAL FLASK TEMPERATURE, DEG F	90	80	85
12) TF - FINAL " " " "	74	74	74
13) VSTPD - VOL OF GAS SAMPLED, ML, S.T.P.	1748.5416	1494.9	1623.6
14) TG - STACK GAS TEMPERATURE, DEG F	406		
15) PCT H - STACK GAS MOISTURE, PCT VOL			
16) QSTPD - STK GAS FLOW RTE, CU FT/MIN, STP			
17) MNO2 - MASS OF NO2 IN SAMPLE, GM x 1.0E6	280	334	271
18) MILLIGRAMS NO2/CU METER, STP	189.6	223.4	166.9
19) LBS NO2 /CU FT , STP	1.17 x 10 <sup>-5</sup>	1.39 x 10 <sup>-5</sup>	1.03 x 10 <sup>-5</sup>
20) PARTS PER MILLION OF NO2, STP	98.9	116.4	87.0
21) LBS NO2/HOUR			
22) BTU'S PER HOUR INPUT			
23) LBS NO2/MILLION BTU			

$$VSTPD = (17.71) \times (VF-VA) \times [((PB-PT) \div TF) - ((PB-PI) \div TI)]$$

$$MG \text{ NO}_2/CU \text{ MTR} = (35.31) \times (MNO2) \div (VSTPD)$$

$$LBS \text{ NO}_2/CU \text{ FT} = (6.2E^{-5}) \times (MNO2) \div (VSTPD)$$

$$P. P. M. = (8.406E6) \times (LBS \text{ NO}_2/CU \text{ FT})$$

$$LBS \text{ NO}_2/ \text{ HOUR} = (60) \times (QSTPD) \times (LBS \text{ NO}_2/CU \text{ FT})$$

$$LBS \text{ NO}_2/MILLION \text{ BTU} = (LBS \text{ NO}_2/HR) \div (MILLION \text{ BTU /HR} , \text{ INPUT})$$

\*\*\*S. T. P. ↔ DRY, 70 DEGREES F, 29.92 INCHES MERCURY\*\*\*

**NO<sub>2</sub> SOURCE EMISSION TEST DATA**

TEST NUMBER - 2  
 PLANT NAME - DOW FREEPORT  
 SOURCE TESTED - KILN OUTLET  
 TYPE OF PLANT -  
 CONTROL EQUIPMENT- ESP  
 POLLUTANT SAMPLED- NO<sub>x</sub>

TEST # 2

1) RUN NUMBER	R-4	AVG
2) DATE	5-2-74	
3) TIME	1530	
4) FLASK NUMBER	7	
5) VF - FLASK AND VALVE VOLUME, ML	1952	
6) VA - ABSORBING SOLUTION VOLUME, ML	25	
7) PB - BAROMETRIC PRESSURE, IN HG	30.2	
8) PS - STACK PRESSURE, IN HG	30.2	
9) PI - INITIAL FLASK VACUUM, IN HG	278	
10) PF - FINAL " " " "	215	
11) TI - INITIAL FLASK TEMPERATURE, DEG F	70	
12) TF - FINAL " " " "	74	
13) VSTPD - VOL OF GAS SAMPLED, ML, S.T.P.	1641.5	
14) TE - STACK GAS TEMPERATURE, DEG F		
15) PCT W - STACK GAS MOISTURE, PCT VOL		
16) QSTPD - STK GAS FLOW RATE, CU FT/MIN, STP		
17) MNO <sub>2</sub> - MASS OF NO <sub>2</sub> IN SAMPLE, GR x 1.0E6	265	
18) MILLIGRAMS NO <sub>2</sub> /CU METER, STP	155.3	
19) LBS NO <sub>2</sub> /CU FT, STP	0.97 x 10 <sup>-5</sup>	
20) PARTS PER MILLION OF NO <sub>2</sub> , STP	81.6	96
21) LBS NO <sub>2</sub> /HOUR		
22) BTU'S PER HOUR INPUT		
23) LBS NO <sub>2</sub> /MILLION BTU		

$$VSTPD = (17.71) \times (VF - VA) \times [((PB - PF) \div TF) - ((PS - PI) \div TI)]$$

$$MG \text{ NO}_2 / \text{CU MTR} = (35.31) \times (MNO_2) \div (VSTPD)$$

$$LBS \text{ NO}_2 / \text{CU FT} = (6.2E^{-5}) \times (MNO_2) \div (VSTPD)$$

$$P. P. M. = (8.406E6) \times (LBS \text{ NO}_2 / \text{CU FT})$$

$$LBS \text{ NO}_2 / \text{HOUR} = (60) \times (QSTPD) \times (LBS \text{ NO}_2 / \text{CU FT})$$

$$LBS \text{ NO}_2 / \text{MILLION BTU} = (LBS \text{ NO}_2 / \text{HR}) \div (\text{MILLION BTU / HR, INPUT})$$

\*\*\*S. T. P. ← DRY, 70 DEGREES F, 29.92 INCHES MERCURY\*\*\*

## NOX SOURCE EMISSION TEST DATA

TEST NUMBER - 3  
 PLANT NAME - DOW FREEPORT  
 SOURCE TESTED - LIME KILN OUTLET  
 TYPE OF PLANT -  
 CONTROL EQUIPMENT- ESP  
 POLLUTANT SAMPLED- NO<sub>x</sub>

	1	2	3
1) RUN NUMBER	1	2	3
2) DATE	5-3-74	5-3-74	5-3-74
3) TIME	0955	1040	1145
4) FLASK NUMBER	2	3	6
5) VF - FLASK AND VALVE VOLUME, ML	1935	1868	1920
6) VA - ABSORBING SOLUTION VOLUME, ML	25	25	25
7) PB - BAROMETRIC PRESSURE, IN HG	30.2	30.2	30.2
8) PS - STACK PRESSURE, IN HG	30.2	30.2	30.2
9) PI - INITIAL FLASK VACUUM, IN HG	28.0	28.0	28.0
10) PF - FINAL " " " "	1.7	1.1	1.75
11) TI - INITIAL FLASK TEMPERATURE, DEG F	80	88	90
12) TF - FINAL " " " "	72	72	72
13) VSTPD - VOL OF GAS SAMPLED, ML, S.T.P.	1677.8	1654.8	1661.2
14) TE - STACK GAS TEMPERATURE, DEG F			
15) PCE W - STACK GAS MOISTURE, PCT VOL			
16) QSTPD - STK GAS FLOW RATE, CU FT/MIN, STP			
17) MNO2 - MASS OF NO2 IN SAMPLE, GR x 1.0E6	264	260	333
18) MILLIGRAMS NO2/CU METER, STP	157.4	157.2	200.5
19) LBS NO2 /CU FT, STP	0.98 x 10 <sup>-5</sup>	0.97 x 10 <sup>-5</sup>	1.24 x 10 <sup>-5</sup>
20) PARTS PER MILLION OF NO2, STP	82.1	81.9	104.5
21) LBS NO2/HOUR			
22) BTU'S PER HOUR INPUT			
23) LBS NO2/MILLION BTU			

$$VSTPD = (17.71) \times (VF-VA) \times [((PB-PT) \div TF) - ((PB-PI) \div TI)]$$

$$MG \text{ NO}_2/\text{CU MTR} = (35.31) \times (MNO2) \div (VSTPD)$$

$$LBS \text{ NO}_2/\text{CU FT} = (6.2E^{-5}) \times (MNO2) \div (VSTPD)$$

$$P. P. M. = (8.406E6) \times (LBS \text{ NO}_2/\text{CU FT})$$

$$LBS \text{ NO}_2/\text{ HOUR} = (60) \times (QSTPD) \times (LBS \text{ NO}_2/\text{CU FT})$$

$$LBS \text{ NO}_2/\text{MILLION BTU} = (LBS \text{ NO}_2/\text{HR}) \div (\text{MILLION BTU /HR, INPUT})$$

\*\*\*S. T. P. ↔ DRY, 70 DEGREES F, 29.92 INCHES MERCURY\*\*\*

**NOX SOURCE EMISSION TEST DATA**

TEST NUMBER -  
 PLANT NAME -  
 SOURCE TESTED -  
 TYPE OF PLANT -  
 CONTROL EQUIPMENT -  
 POLLUTANT SAMPLED -

AVG.

1) RUN NUMBER	4		
2) DATE	5-3-74		
3) TIME	1235		
4) FLASK NUMBER	7		
5) VF - FLASK AND VALVE VOLUME, ML	1952		
6) VA - ABSORBING SOLUTION VOLUME, ML	25		
7) PB - BAROMETRIC PRESSURE, IN HG	30.2		
8) PS - STACK PRESSURE, IN HG	30.2		
9) PI - INITIAL FLASK VACUUM, IN HG	26.7		
10) PF - FINAL " " " "	2.2		
11) TI - INITIAL FLASK TEMPERATURE, DEG F	84		
12) TF - FINAL " " " "	72		
13) VSTPD - VOL OF GAS SAMPLED, ML, S.T.P.	1576.7		
14) TS - STACK GAS TEMPERATURE, DEG F			
15) PCT W - STACK GAS MOISTURE, PCT VOL			
16) QSTPD - STK GAS FLOW RTE, CU FT/MIN, STP			
17) MNO2 - MASS OF NO2 IN SAMPLE, GR x 1.0E6	231		
18) MILLIGRAMS NO2/CU METER, STP	146.5		
19) LBS NO2 /CU FT, STP	6.91 x 10 <sup>-5</sup>		
20) PARTS PER MILLION OF NO2, STP	115.2		
21) LBS NO2/HOUR			
22) BTU'S PER HOUR INPUT			
23) LBS NO2/MILLION BTU			

$$VSTPD = (17.71) \times (VF-VA) \times [((PB-PT) \div TF) - ((PB-PI) \div TI)]$$

$$MG \text{ NO}_2/\text{CU MTR} = (35.31) \times (MNO2) \div (VSTPD)$$

$$LBS \text{ NO}_2/\text{CU FT} = (6.2E^{-5}) \times (MNO2) \div (VSTPD)$$

$$P. P. M. = (8.406E6) \times (LBS \text{ NO}_2/\text{CU FT})$$

$$LBS \text{ NO}_2/\text{ HOUR} = (60) \times (QSTPD) \times (LBS \text{ NO}_2/\text{CU FT})$$

$$LBS \text{ NO}_2/\text{MILLION BTU} = (LBS \text{ NO}_2/\text{HR}) \div (\text{MILLION BTU /HR, INPUT})$$

\*\*\*S. T. P. ↔ DRY, 70 DEGREES F, 29.92 INCHES MERCURY\*\*\*

TABLE \_\_\_\_\_  
SULFUR DIOXIDE  
EMISSION DATA

PLANT DOW CHEMICAL, FREEPORT TEXAS  
STACK N. LIME KILN

Run No.	1	2	3
Date	4/30/74	5/2/74	5/3/74
Time of Sample	1625-1855	1150-1525	0945-1308
Barometric Pressure, "HG	30.28	30.20	30.0
Stack pressure, "HG	30.28	30.20	30.0
Final Meter Reading, FT <sup>3</sup>	963,179	972,400	981,565
Initial Meter Reading, FT <sup>3</sup>	960,000	965,300	975,500
Average Meter Temp. °F	92.4	91 <del>7</del>	89 <del>6</del>
Average Stack Temp. °F	374	361	367
Gas Volume Sampled, FT <sup>3</sup> , VSTPD *			
SO <sub>2</sub> Conc., LB/FT <sup>3</sup> (CSO)			
SO <sub>2</sub> Conc., P.P.M. (PPM)			

\* VSTPD = Dry, 29.92 "HG, 70°F

$$VSTPD = VM \left( \frac{P_{bar}}{P_{std}} \right) \left( \frac{T_{std}}{T_M} \right)$$

$$CSO = (7.05 \times 10^{-5} \times \frac{LB-L}{g-ml}) \frac{(VT-VTB)(N)(V_{soln})}{VA}$$

VMSTD

$$PPM = CSO \times 6041500$$

SOURCE EMISSION TEST DATA

Single Point Comparative Tests

TEST NUMBER -  
 PLANT NAME -  
 SOURCE TESTED -  
 TYPE OF PLANT -  
 CONTROL EQUIPMENT -  
 POLLUTANT SAMPLED -

	In Stack Filter Train	EPA 5 Train
1) RUN NUMBER	1	1
2) DATE	5/2/74	5/02/74
3) TIME BEGAN	12:20	12:20
4) TIME END	15:20	15:20
5) T - NET TIME OF TEST, MINUTES	180	180
6) PB - BAROMETRIC PRESSURE, IN HG	30.2	30.2
7) PS - STACK PRESSURE, IN HG	30.2	30.2
8) ΔH - GAS MTR ORIFICE PRESS DROP, ''H2O	1.48	1.48
9) TH - GAS METER AVG TEMP, DEG F	100.4	92.7
10) VC - TOTAL H2O COLLECTED, ML	273.5	619.2
11) VVV - VOL H2O VAPOR COLL., CU FT, STP	12.96	29.35
12) VM - VOL DRY GAS SAMPLED, CU FT, MTR COND	72.001	120.427
13) VSTPD - VOL DRY GAS SAMPLED, CU FT, STP	68.982	116.976
14) W(PCT) - STACK GAS MOISTURE, PCT VOL	15.8	20.1
15) TS - AVG STACK GAS TEMPERATURE, DEG F	400	400
16) CO2 - STACK GAS CO2, PCT VOL	10.4	10.4
17) O2 - STACK GAS O2, '' ''	9.7	9.7
18) CO - STACK GAS CO, '' ''	0	0
19) N2 - STACK GAS N2, '' ''	79.9	79.9
20) FA - STACK GAS EXCESS AIR, PCT VOL	84.	84.
21) MD - STACK GAS MOLECULAR WEIGHT, DRY	30.05	30.05
22) MS - STACK GAS MOLECULAR WGT, STK COND	28.15	27.63
23) GS - STACK GAS SPECIFIC GRAV, REF AIR	0.97	0.95
24) H - AVG SQUARE ROOT VEL HEAD, '' H2O	0.384	0.383
25) AVG SQUARE ROOT (STK TEMP x VEL HEAD)	11.261	11.228
26) CP - PITOT TUBE CORRECTION FACTOR	0.83	0.83
27) U - STACK GAS VELOCITY, FT/MIN	1642.8	1653.2
28) AS - STACK AREA, SQUARE FEET	50.27	50.27
29) AS' - EFFECTIVE STACK AREA, SQ FEET	50.27	50.27
30) QS - STK GAS FLOW RT, CU FT/MIN, STK CND	82585	83105
31) QSTPD - STK GAS FLOW RATE, CU FT/MIN, STP	43244	41326
32) DN - SAMPLING NOZZLE DIAMETER, IN	0.375	0.375
33) AN - SAMPLING NOZZLE AREA, SQ FT	0.00077	0.00077
34) PCT ISO-ISOKINETIC SAMPLING, PERCENT	58.1	103

\*\*\*S. T. P. ↔ DRY, 70 DEGREES F, 29.92 INCHES MERCURY\*\*\*  
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SOURCE EMISSION TEST DATA  
SINGLE POINT COMPARISON TEST

TEST NUMBER -  
PLANT NAME -  
SOURCE TESTED -  
TYPE OF PLANT -  
CONTROL EQUIPMENT-  
POLLUTANT SAMPLED-

	EPA 5 TRAIN	IN-STACK FILTER TRAIN
1) RUN NUMBER	2	2
2) DATE	5/3/74	5/3/74
3) TIME BEGAN	10:00	10:00
4) TIME END	13:45	13:45
5) T - NET TIME OF TEST, MINUTES	160	160
6) PB - BAROMETRIC PRESSURE, IN HG	30	30
7) PS - STACK PRESSURE, IN HG	30	30
8) ΔH - GAS MTR ORIFICE PRESS DROP, '' H2O	1.63	1.41
9) TH - GAS METER AVG TEMP, DEG F	96	89.2
10) VC - TOTAL H2O COLLECTED, ML	95.4	547.3
11) VV - VOL H2O VAPOR COLL., CU FT, STP	4.52	25.94
12) VM - VOL DRY GAS SAMPLED, CU FT, MTR COND	39.975	95.125
13) VSTPD - VOL DRY GAS SAMPLED, CU FT, STP	38.362	92.363
14) W(PCT) - STACK GAS MOISTURE, PCT VOL	10.5	21.9
15) TS - AVG STACK GAS TEMPERATURE, DEG F	410	410
16) CO2 - STACK GAS CO2, PCT VOL	10	10
17) O2 - STACK GAS O2, '' ''	9.8	9.8
18) CO - STACK GAS CO, '' ''	0	0
19) N2 - STACK GAS N2, '' ''	80.2	80.2
20) FA - STACK GAS EXCESS AIR, PCT VOL	85	85
21) MD - STACK GAS MOLECULAR WEIGHT, DRY	29.99	29.99
22) MS - STACK GAS MOLECULAR WGT, STK COND	28.73	27.36
23) GS - STACK GAS SPECIFIC GRAV, REF AIR	0.99	0.94
24) H - AVG SQUARE ROOT VEL HEAD, '' H2O	0.398	0.398
25) AVG SQUARE ROOT (STK TEMP x VEL HEAD)	11.744	11.744
26) CP - PITOT TUBE CORRECTION FACTOR	0.83	0.83
27) U - STACK GAS VELOCITY, FT/MIN	1701.5	1743.4
28) AS - STACK AREA, SQUARE FEET	50.27	50.27
29) AS' - EFFECTIVE STACK AREA, SQ FEET	50.27	50.27
30) QS - STK GAS FLOW RT, CU FT/MIN, STK CND	85533	87641
31) QSTPD - STK GAS FLOW RATE, CU FT/MIN, STP	46737	41794
32) DN - SAMPLING NOZZLE DIAMETER, IN	0.375	0.375
33) AN - SAMPLING NOZZLE AREA, SQ FT	0.00077	0.00077
34) PCT ISO-ISOKINETIC SAMPLING, PERCENT	33.6	90.5

\*\*\*S, T, P, ↔ DRY, 70 DEGREES F, 29.92 INCHES MERCURY\*\*\*  
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