

# AIR POLLUTION EMISSION TEST

WOODVILLE LIME AND

(PLANT NAME)

CHEMICAL COMPANY

WOODVILLE, OHIO

(PLANT ADDRESS)



U. S. ENVIRONMENTAL PROTECTION AGENCY  
Office of Air and Water Programs  
Office of Air Quality Planning and Standards  
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EMISSION TESTING REPORT  
EPA REPORT 74-LIM-3-B  
WOODVILLE LIME AND CHEMICAL CO..  
WOODVILLE, OHIO

Contract No. 68-02-0237  
Task 26

Submitted by:

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## II. INTRODUCTION

Under the Clean Air Act of 1970, as amended, the Environmental Protection Agency is charged with the establishment of performance standards for stationary sources which may contribute significantly to air pollution. A performance standard is based on the best emission reduction systems which have been shown to be technically and economically feasible.

In order to set realistic performance standards, accurate data on pollutant emissions must be gathered from the stationary source category under consideration.

Woodville Lime and Chemical Co. in Woodville, Ohio, was designated as a possible representative well-controlled stationary source in the lime production industry and therefore was selected for an emission testing program. The process under investigation in this test series was operation of the No. 1 lime kiln at the Woodville plant, from which emissions are controlled by a cyclone in series with a Buell electrostatic precipitator.

Preliminary tests were performed during the week of May 20, 1974, to ascertain composition and velocity of the gas stream and to observe visible emissions.

The emission test program was conducted from July 8 to 10, 1974, on three test runs. Sampling was done at the kiln stack to determine concentrations of filterable and total particulate,

oxides of nitrogen, and sulfur dioxide. Determinations of moisture content and dry molecular weight were performed simultaneously. Samples of the kiln feed, kiln product, kiln fuel, and effluent dust from the ESP unit were collected for calculation of a sulfur balance. In addition, visible emissions were recorded by two certified observers during this time. Because of difficulties with process operation and above-normal production rates, further tests were scheduled for August 5, 1974. In the interim between test periods the kiln was shut down, at which time the ESP was cleaned and inspected.

### III. SUMMARY OF RESULTS

Data on particulate emissions from the lime kiln are summarized in Table 1. Emissions of filterable particulate, as measured by the probe and filter catch, averaged 9.77 pounds per hour at a concentration of 0.041 grain per DSCF. Total particulate emissions averaged 18.3 pounds per hour at a concentration of 0.077 grain per DSCF. Emissions of filterable particulate were higher in the first two tests than in the third. This can probably be attributed to discontinuity in process operations and to problems with control equipment, described in Section IV, "Process Operation". Because of these difficulties, the emissions data reported in this report are considered questionable with respect to being representative of a well-controlled lime-producing process.

Data on oxides of nitrogen emissions are summarized in Table 2. These data show an average concentration of 339 ppm by volume and an hourly emission rate of 67.7 pounds per hour of  $\text{NO}_2$ .

Data on sulfur dioxide emissions are summarized in Table 3. These data show an average concentration of 44.5 ppm by volume and an hourly emission rate of 12.0 pounds per

Table 1. SUMMARY OF PARTICULATE DATA

Run Number	<u>1</u>	<u>3</u>	<u>5</u>	<u>Avg.</u>
Date	7/8/74	7/9/74	7/10/74	
Volume of Gas Sampled, DSCF <sup>a</sup>	237.923	239.642	248.641	242.07
Average Stack Temperature, °F	621	669	674	655
Percent Moisture by Volume, %	11.3	12.1	11.4	11.6
Stack Volumetric Flow Rate, DSCFM <sup>b</sup>	27619	27390	28658	27889
Stack Volumetric Flow Rate, ACFM <sup>c</sup>	64393	67296	70330	67340
Percent Isokinetic	102.9	104.5	103.6	140
Unit Production Rate, ton/hr				
<u>Particulates</u> - probe, bypass, and filter catch				
mg	781.1	718.9	417.0	639
gr/DSCF	0.051	0.046	0.026	0.041
gr/ACF	0.022	0.019	0.011	0.017
lb/hr	12.0	10.9	6.4	9.77
lb/ton				
<u>Particulates</u> - total				
mg	1704.6	989.9	889.3	1194.6
gr/DSCF	0.111	0.064	0.055	0.077
gr/ACF	0.047	0.026	0.022	0.032
lb/hr	26.2	15.0	13.6	18.3
lb/ton				

<sup>a</sup> Dry standard cubic feet at 70°F, 29.92 in Hg.

<sup>b</sup> Dry standard cubic feet per minute at 70°F, 29.92 in. Hg.

<sup>c</sup> Actual cubic feet per minute.

Table 2. SUMMARY OF OXIDES OF NITROGEN DATA

NO <sub>x</sub> Test No.	A	B	C	D	E	F	G	H	I	J	K	L	Average
Date, 1974	7/8	7/8	7/8	7/8	7/9	7/9	7/9	7/9	7/10	7/10	7/10	7/10	
Time, 24 hour clock	1748	1848	1951	2048	915	1015	1115	1215	920	1033	1130	1230	
Flow Rate, DSCFM <sup>a</sup>	27619	27619	27619	27619	27390	27390	27390	27390	28658	28658	28658	28658	
Sample Volume, ml	1457	1521	1519	1495	1554	1549	1487	1522	1602	1938	1616	1660	
Milligrams of NO <sub>2</sub>	0.83	0.672	0.953	0.957	0.976	0.934	1.034	1.014	1.093	1.169	1.349	1.290	
NO <sub>x</sub> Concentration, ppm	299	232	329	336	330	316	364	349	358	316	438	408	339.58
NO <sub>x</sub> lb/hr	58.9	45.6	64.8	66.1	64.4	61.8	71.3	68.3	73.2	64.7	89.5	83.3	67.66
Average ppm	299				339.75				380				
lb/hr	58.85				66.45				77.67				

a) Dry standard cubic feet per minute, corrected to 70° and 29.92" Hg as obtained during particulate test runs.



Table 3. SUMMARY OF SULFUR DIOXIDE DATA

Test No.	2	4	6	Avg.
Date, 1974	7/8	7/9	7/10	
Flow rate, DSCFM <sup>a</sup>	27619	27390	28658	
Sample volume, DSCF <sup>a</sup>	166.917	165.549	166.705	
SO <sub>2</sub> in sample, grams	0.867	0.130	0.649	
SO <sub>2</sub> emissions, lb/hr	19.1	2.42	14.4	12.0
SO <sub>2</sub> concentration, ppm by volume	70.2	10.6	52.6	44.5

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a) Dry standard cubic feet at 70°F 29.92 in. Hg.

hour of sulfur dioxide.

Visual determination of the opacity of emissions from the lime kiln exit stack was performed independently by two PEDCo personnel. Data on opacity measurements are summarized in Table 4. The average opacity was less than 5 percent in all tests. A period of high emissions occurred, however, for about 1 minute in the first test, during which opacity levels exceeded 20 percent. Failure of a field in the electrostatic precipitator caused the discontinuity, with the result that the opacity values are not considered typical of those occurring with well-controlled lime-production operations.

During sample recovery on test 1, the probe glass liner tip was found to be broken. This test was therefore not representative of true emissions. Because of the higher than expected opacity and various process problems, this test series was terminated before enough measurements were obtained to provide representative results.

Table 4. SUMMARY OF VISIBLE EMISSION DATA

Run No.	<u>1</u>		<u>3</u>		<u>5</u>	
Date	7/8/74		7/9/74		7/10/74	
	Obs. 1	Obs. 2	Obs. 1	Obs. 2	Obs. 1	Obs. 2
Interval of Observations <sup>a</sup> Start	1715	1713	840	843	820	838
End	2124	2112	1245	1235	1252	1239
Duration of Observation, min <sup>b</sup>	247	228	245	233	272	212.5
Total No. of Readings <sup>c</sup>	988	912	980	932	1088	850
No. of Readings Unobservable	0	10	0	154	0	0
No. of Readings @ 0% Opacity	986	711	914	174	1061	782
5%	2	184	34	597	21	66
10%	-	7	26	7	5	1
15%	-	-	3	-	1	1
20%	-	-	3	-	-	-
25%	-	-	-	-	-	-
30%	-	-	-	-	-	-
35%	-	-	-	-	-	-
40%	-	-	-	-	-	-
45%	-	-	-	-	-	-
50%	-	-	-	-	-	-
Percent Readings Unobservable	0	0.8	0	16.5	0	0
Percent Readings @ 0% Opacity	99.8	78.0	93.3	18.7	97.5	92.0
5%	0.2	20.2	3.5	64.1	1.9	7.8
10%	-	-	2.6	0.7	0.5	0.1
15%	-	-	0.3	-	0.1	0.1
20%	-	-	0.3	-	-	-
Percent Readings Exceeding 20%	-	-	-	-	-	-

<sup>a</sup> 24-hour clock start and end times

<sup>b</sup> Excluding the time that readings were not recorded for period of observation.

<sup>c</sup> Readings recorded at 15-second intervals unless otherwise noted.

Observer 1 - R. S. Amick

Observer 2 - W. G. DeWees

#### IV. PROCESS DESCRIPTION

Limestone consisting primarily of calcium carbonate or combinations of calcium and magnesium carbonate with varying amounts of impurities is quarried at the Woodville Plant. The limestone is calcined or burned to form lime, 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, calcium hydroxide (hydrated lime) is formed.

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 followed by hydration. The majority of lime is produced in rotary kilns which can be fired by coal, oil, or gas. Rotary kilns have the advantage of producing high production per man-hour and a more uniform product. However, they do require higher capital investment and unit fuel costs than most vertical kilns.

The Woodville Lime and Chemical plant has two rotary kilns each equipped with a Buell electrostatic precipitator. The kilns are almost identical. The feed for both is a dolomitic stone, quarried on the site and fed in sizes ranging from 1 inch to 2 1/4 inches at a rate of about 700 tons per day. There is no

preheater. Normally the kiln is fueled with a mixture of 95 percent Number 6 fuel oil and 5 percent natural gas. Both kilns have two heat transfer sections, each 20 feet long. The product, about 350 tons per day, is cooled in a Neims cooler before storage. There is no product crushing, but undersize material is separated and returned to the kiln. The majority of the product is used in the steel industry, mostly in basic oxygen furnaces; none of the product is hydrated.

The electrostatic precipitator on kiln Number 1 was put in operation in July 1971. In this kiln the main process fan is located before the ESP, with a cyclone before the fan to reduce fan blade erosion. The precipitator on kiln Number 2 was put in operation in December 1973. The main process fan is after the ESP and there is no cyclone.

In both systems the inlet gas to the precipitators is cooled to about 600°F with a combination of water injection and/or tempering air. Each precipitator has 28,800 square feet of collecting surface area, which includes one cell and two fields; design gas velocity is 1.5 feet per second and treatment time, 10.0 seconds. The plant manager reported that an earlier emission test showed exit loadings of less than 0.005 grain per dry standard cubic foot.

At present the dust collected from the precipitators is disposed of in the quarry. It is expected that in the future the

dust will be granulated and used as a component of dry mix fertilizers that are blended in another part of the complex.

At the time of the initial plant inspection (February 8, 1974) the precipitators were working satisfactorily and had been very well maintained. The plant is representative of modern design; raw materials and products are typical of those in the industry.

## V. LOCATION OF SAMPLING POINTS

Figure 1 shows the sampling ports and sampling points used in the No. 1 lime kiln exit stack. The sampling ports were located in a 63.5-inch inside-diameter vertical stack, 4 feet (0.75 diameter) from the stack exit, and 12 feet (2.26 diameters) from the nearest downstream disturbance. In order to meet the sampling requirements of Methods 1 and 5 of the Federal Register, Vol. 36, No. 247, it was necessary to install a stack extension on the ESP exhaust outlet. Forty-eight traverse points (24 along each of two perpendicular diameters) were used as described in the Federal Register Method 1. Additional sampling points in the existing stack at a lower site were used for some of the gas sampling.

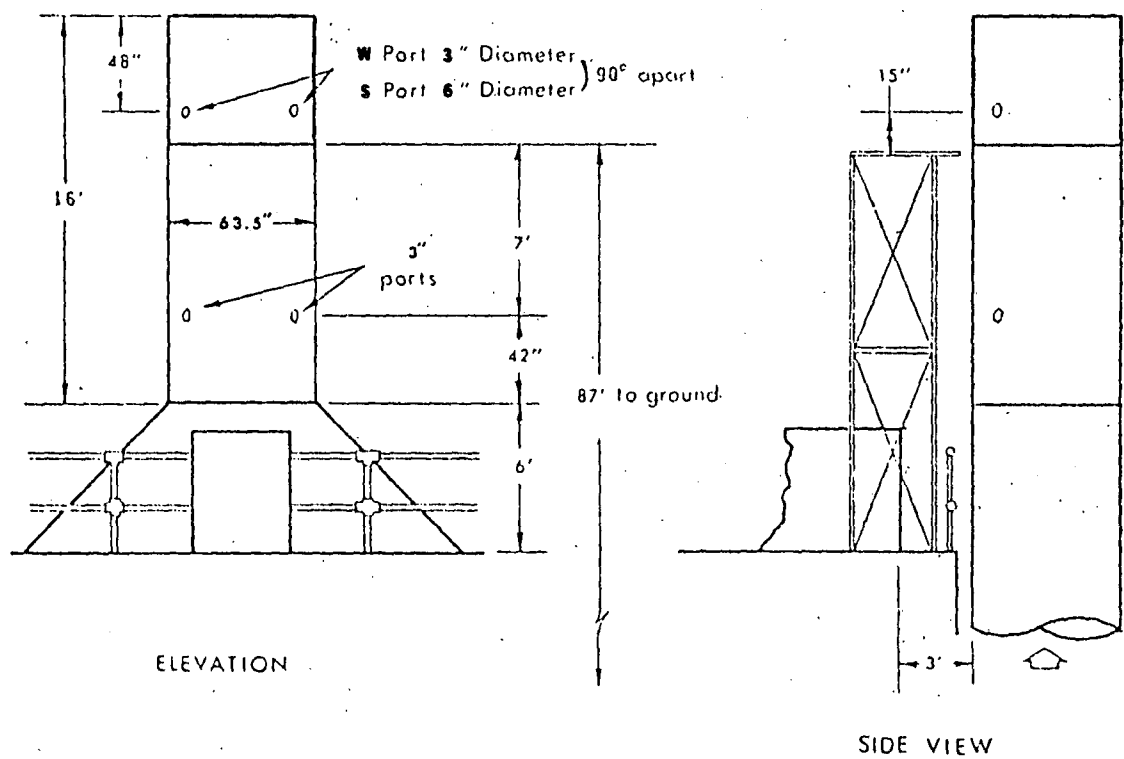
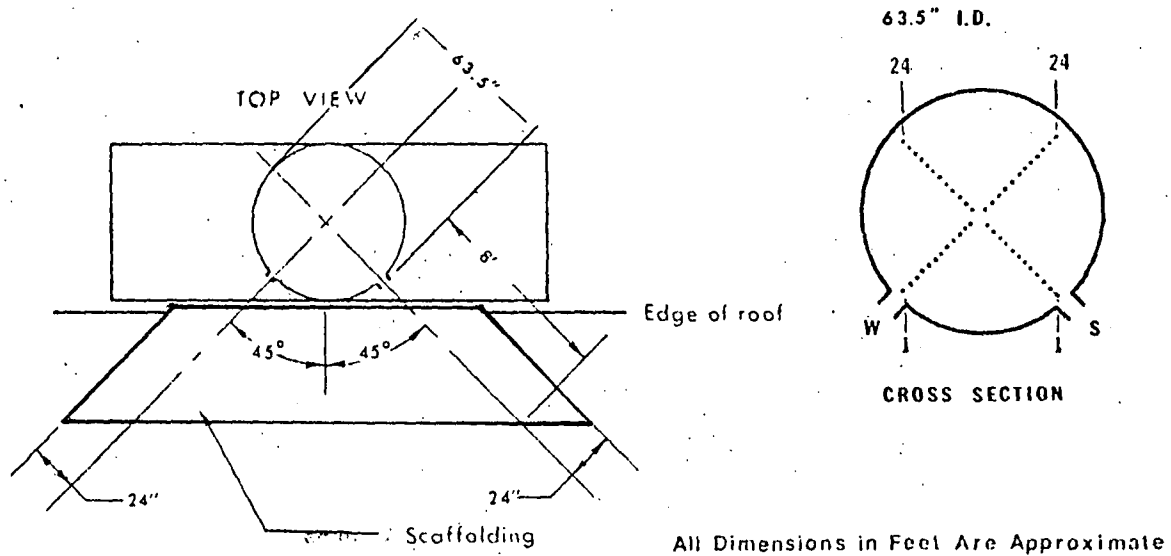


Figure 1. Test Site-No. 1 Kiln Precipitator Outlet.



## VI. PROCESS OPERATION & TEST CONDITIONS

Before the test series began, EPA engineers had decided to conduct tests at the Woodville plant only during periods in which opacity of visible emissions from the kiln stack was in the range of 0 to 5 percent. This range had been described as typical of opacities during operation of the No. 1 kiln and was judged to be typical of those occurring in a well-controlled lime-producing plant.

Although plant operations appeared to be normal and preliminary readings indicated 0 to 5 percent opacity values, several problems developed during the first day of testing, July 8, 1974. After about 3 hours of testing, PEDCo's team of opacity readers stopped the tests at 8:22 p.m. because opacity values were exceeding the 5 percent limit. Testing was resumed at 8:27 p.m. and continued until 9:13 p.m., when the "A" field of the kiln's electrostatic precipitator malfunctioned, probably because of overload. Sampling was resumed at 9:16 p.m., when the opacity values again dropped to the 0 to 5 percent range. The first test was completed at 9:29 p.m.

The second test was started on July 9 at 8:41 a.m. Opacities of visible emissions ranged between 0 and 5 percent

throughout the entire test sequence. The test was completed at 12:48 p.m., and because no problems were encountered in sampling or process operation the emissions were considered representative of those occurring normally.

After completion of the second test, plant operators performed a routine cleaning operation, shutting down a fan on the inlet to the ESP for removal of adhering dust. The fan was not re-started after cleaning, however, and opacity readings during the afternoon ranged between 10 and 15 percent. The third test, therefore, was not begun until the following day.

Testing was resumed at 8:24 a.m. on July 10. Operations appeared normal except for a heavy load in the kiln, as evidenced by the ampere meter on the kiln-drive motor. Opacity readings ranged from 0 to 5 percent. Sampling was hampered, however, by blockage in the silica gel impinger, which was replaced several times. As testing progressed, the opacity readers reported an increasing number of 5 percent readings, with occasional 'puffs' as high as 10 percent. Observations of the plume were difficult because of cloudy skies. Test No. 3 was completed at 12:55 p.m.

Operating variables for the three test runs are summarized in Table 5, and sulfur contents of the various process streams are shown in Table 6.

A fourth test, intended to provide values to replace those obtained in Test No. 1, was started at 3:00 p.m. July

Table 5. SUMMARY OF OPERATING VARIABLES

Date	7/8/74	7/9/74	7/10/74
Particulate Test No.	1	3	5
Stone Feed Rate, ton/hr <sup>a</sup>			
Oil Rate, gal/hr	322	356	375
Firing Zone Temp, °F	2620-2650	2600-2650	2590-2620
Mid Kiln, Temp, °F	1460-1465	1450-1475	1470-1520
Kiln Feed End Temp, °F	1020-1040	1000-1035	1050-1080
Before ESP Temp, °F	683-700	685-700	700-725
Stack Temp, °F	660-675	660-690	670-700

ELECTROSTATIC PRECIPITATOR DATA

"A" Field

Primary current, amps	39-50	37-46	48-61
Primary voltage, volts	250-275	250-265	250-270
Precipitator current, amps	0.20-0.30	0.19-0.23	0.20-0.32

"B" Field

Primary current, amps	41-55	50-54	53-61
Primary voltage, volts	240-260	240-250	240-250
Precipitator current, amps	0.27-0.35	0.28-0.30	0.32-0.37

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a) Obtained by multiplying indicated tonnage by (see Appendix D).

Table 6. SULFUR CONTENT OF KILN, FUEL OIL, FEED ROCK, PRODUCT AND EFFLUENT DUST.

<u>Sample</u>	<u>Date</u>	<u>Time</u>	<u>Sulfur Content % by weight</u>
#1 ESP Col. Dust	7/8/74	1830	0.9
#1 ESP Col. Dust	7/9/74	1015	1.32
#1 ESP Col. Dust	7/10/74	0800	1.28
#2 ESP Col. Dust	7/8/74	2030	0.78
#2 ESP Col. Dust	7/9/74	1255	1.16
#2 ESP Col. Dust	7/10/74	1030	1.64
#1 Stone Feed	7/8/74	1750	0.02
#1 Rock Feed	7/9/74	1100	0.07
#1 Rock Feed	7/10/74	1700	0.06
#1 Rock Feed	7/10/74	1000	0.07
#2 Stone Feed	7/8/74	2036	0.14
#2 Rock Feed	7/9/74	1230	0.04
#2 Rock Feed	7/10/74	1300	0.04
#2 Kiln Product	7/9/74	1300	0.01
#1 Lime Product	7/8/74	1720	0.07
#1 Lime Product	7/9/74	0930	0.04
#1 Lime Product	7/10/74	1000	0.02
#2 Lime Product	7/8/74	2030	0.06
#2 Lime Product	7/10/74	1230	0.07
#1 Fuel Oil	7/9/74	0930	1.75
#1 Fuel Oil	7/8/74	1900	2.26
#2 Fuel Oil	7/9/74	1230	1.7
#2 Fuel Oil	7/10/74	1230	0.875
#2 Fuel Oil	7/8/74	2030	3.22
#1 Fuel Oil	7/10/74	1100	2.26

10. Except for the heavily loaded kiln, process operations appeared normal. Because opacity readings rose to the 15 to 20 percent range, testing was stopped at 4:30 p.m. Cleanup operations later revealed that the sampling probe was broken. The values obtained in this test were therefore discarded, and further sampling was scheduled for the following day.

On the morning of July 11, however, stack opacity values were again ranging between 5 and 10 percent. Although plant personnel tried several variations in kiln operation, the high opacity readings persisted throughout the day and evening. A reading at 10:30 p.m. gave values between 20 and 25 percent.

At 6:00 a.m. on July 12, opacity readings still ranged between 5 and 10 percent. Personnel of the Woodville plant, EPA, and PEDCo agreed that the kiln should be shutdown briefly for inspection. Examination of the ESP revealed that several charge plates were covered with about 1 inch of a sticky substance, which prevented the dust particles in the effluent from receiving the positive charge and thus reduced collection efficiency. It was estimated that cleaning of the plates would require shutdown of the kiln for a week or so. A shutdown was scheduled for the week of July 15 to allow cleaning of the ESP, rebricking of certain kiln sections, and routine periodic maintenance. Further emissions testing was to be conducted shortly after resumption of kiln operation.

## VII. SAMPLING AND ANALYTICAL PROCEDURES

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

### Velocity and Gas Temperature

Gas velocities were measured with a calibrated type S pitot tube and inclined draft gage. Velocities were measured at each sampling point across the stack diameter to determine an average value according to procedures described in the Federal Register<sup>1</sup> - Method 2. Temperatures were measured with the use of a thermocouple.

### Molecular Weight

A 4-hour integrated sample of the stack gases was collected during test 1 by pumping the gas into a Tedlar plastic bag at the rate of approximately 0.005 CFM. This bag sample was then analyzed with an Orsat analyzer for CO<sub>2</sub>, O<sub>2</sub>, and CO as described in the Federal Register, Method 3.

### Particulates

Concentrations of particulate matter in stack gases were measured by Method 5 as described in Federal Register<sup>2</sup>. A rigid train consisting of a heated glass-lined probe, a 3-inch diameter

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1) Federal Register, Vol. 36, No. 247, December 23, 1971.

2) Federal Register, Vol. 36, No. 159, August 17, 1971.

glass-fiber filter, and a series of Greenburg-Smith impingers was used for particulate sampling, as shown in Figure 2.

Sampling was conducted under isokinetic conditions by monitoring stack-gas velocity with a pitot tube and adjusting the sampling rate accordingly.

The particulate sample was recovered by triple-rinsing the nozzle, probe, cyclone by-pass, and front half of the filter holder with acetone into a glass container. The back half of the filter holder, impingers, and connecting tubes were rinsed with distilled water and the washings placed in a glass container with the impinger contents. These components were then triple-rinsed with acetone into another glass container. The filter was placed in a separate container. Blank samples of water and acetone were also taken.

#### NO<sub>x</sub>

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 as described in Method 7 of the Federal Register<sup>1</sup> except that the final flask vacuum was read immediately after sampling.

#### SO<sub>2</sub>

Sulfur dioxide sampling procedures followed those described in Method 6. However, due to the low expected concentrations,

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1) Federal Register, Vol. 36, No. 247, December 23, 1971.

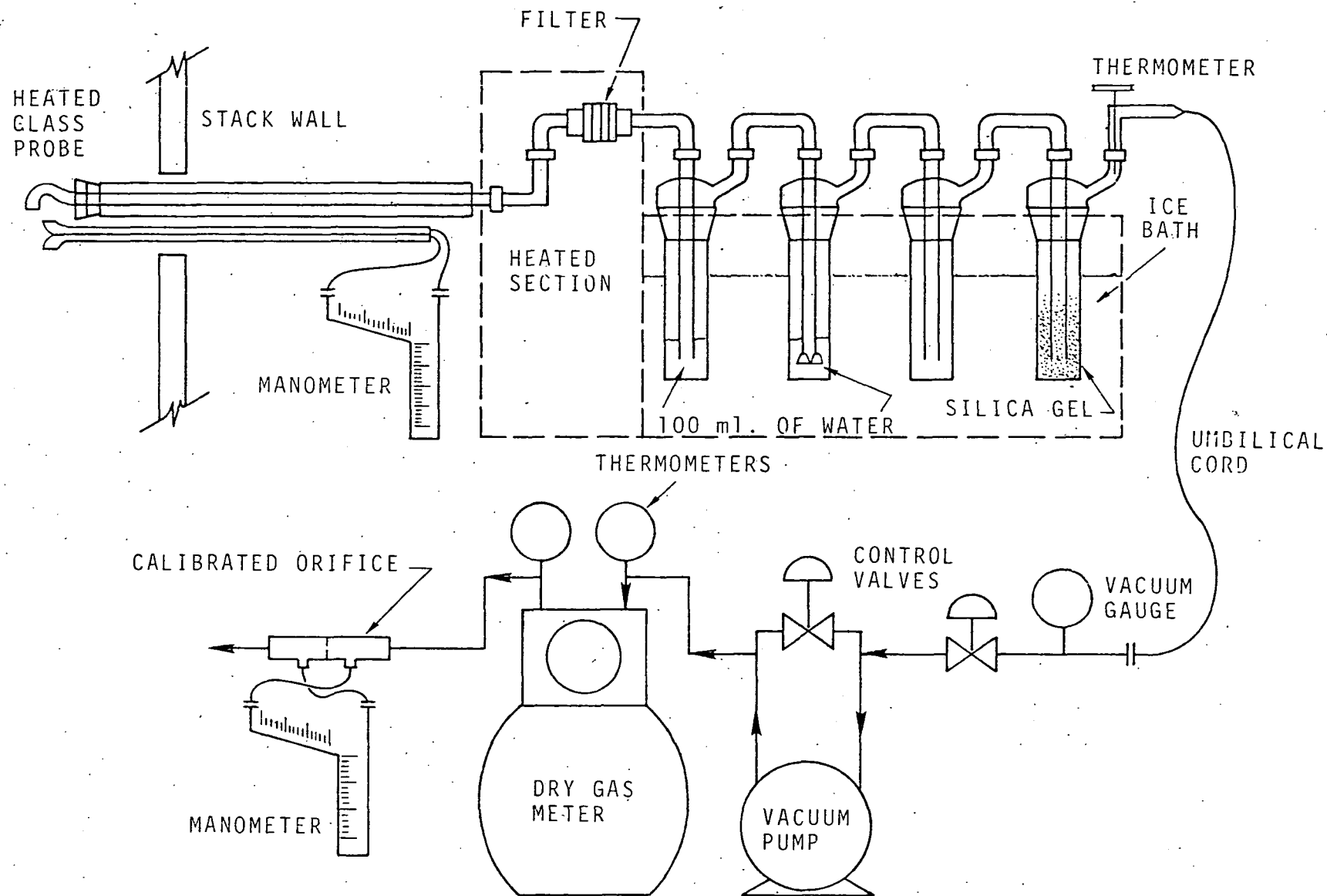


Figure 2. Particulate Sample Train



larger sampling equipment was used. Flue gas was passed through a set of Greenburg-Smith impingers at a rate of approximately 0.8 cubic foot per minute. The first impinger contained 150 ml of 80 percent isopropanol; the second and third impingers contained 100 ml each of 3 percent hydrogen peroxide/water solution. After sampling, ambient air was passed through the train for 10 to 15 minutes. The isopropanol solution was discarded, and the peroxide solution rinsed into a glass container. The hydrogen peroxide solution was titrated with barium chloride, using a Thorin indicator as described in Method 6.

#### Visible Emissions

Visible emissions were determined according to procedure in Method 9. Readings were difficult to determine at times due to trucks loading and unloading ESP dust and quarry rock in the vicinity of either the ESP unit or the observer and the light colored plume against an overcast and partly cloudy sky caused poor distinction. In addition, certain ESP rappers set up a visible emission condition (puffs) that read approximately 5 to 10 percent opacity for about 2 to 3 seconds every cycle.

#### Sulfur Analysis

Solid samples were analyzed using Standard Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime, C25-67, A.S.T.M. Standards, Part 9, Cement; Lime; Gypsum, 1972, American Society for Testing and Materials, Philadelphia, Pa.

Fuel oil samples were analyzed using Standard Method of Test for Sulfur in Petroleum Products by the Bomb Method, D 129-64, A.S.T.M. Standards, Part 17, Petroleum Products - Fuels, Solvents, Burner Fuel Oils, Lubricating Oils, Cutting Oils, Lubricating Greases, Hydraulic Fluids, 1972, American Society for Testing Materials, Philadelphia, Pa.