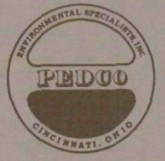
EMISSION TESTING REPORT

EPA REPORT NO. 74-KPM-15

ST. REGIS PAPER CO.
TACOMA, WASHINGTON



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ST. REGIS PAPER CO.
TACOMA, WASHINGTON

Contract No. 68-02-0237
Task 27

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II. INTRODUCTION

Under the Clean Air Act of 1970, as amended, the Environmental Protection Agency is charged with establishing 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.

St. Regis Paper Co. in Tacoma, Washington was designated as a well-controlled stationary source in the kraft pulp mill industry and was thereby selected by OAP for an emission testing program. The tests were conducted during the period of February 12 to February 19, 1974.

The specific processes under investigation in this test series were the No. 2 lime kiln and the No. 4 recovery furnace. Emissions from the lime kiln were controlled by a venturi scrubber followed by a cyclone separator demister. Emissions from the recovery furnace were controlled by an electrostatic precipitator (ESP). A schematic diagram of the simplified Kraft process and the operations sampled is shown in Figure 2.1.

Five particulate tests were conducted in the exit stack of the recovery furnace to determine filterable and total particulate

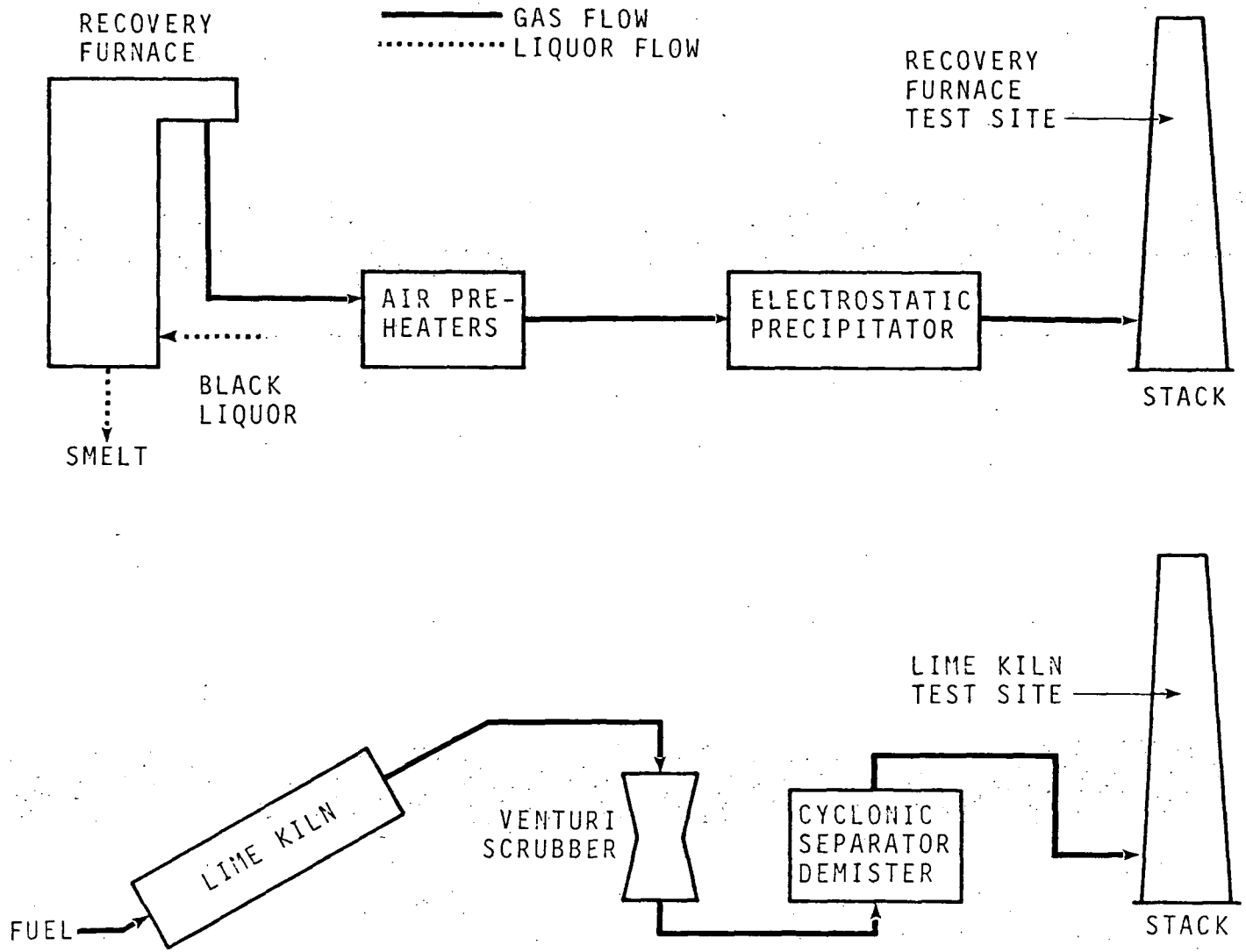

Figure 2.1. Schematic diagram of simplified Kraft process and processes sampled.

emissions. Simultaneous determination of moisture content and dry molecular weight of the flue gases were also made. It was originally intended that six runs be made; however, the sixth test was cancelled due to a malfunction in the No. 4 recovery furnace ESP. The duration of the recovery furnace tests varied from 224 minutes to 336 minutes and averaged 315 minutes. These relatively lengthy tests were necessary because the No. 4 recovery furnace ESP provided such a high particulate control efficiency that the exit gas stream was extremely clean, and a longer sampling period was required than normal in order to obtain a measurable particulate sample.

Six particulate tests were conducted on the exit stack of the lime kiln to determine filterable and total particulate emissions. Simultaneous determination of moisture content and dry molecular weight of the kiln flue gases were made.

During the period of testing the No. 4 Recovery Furnace, the crew of another contractor, (Valentine, Fisher, and Tomlinson) were conducting parallel, simultaneous particulate emission tests of the recovery furnace with both an in-stack filter sampling train and an out-of-stack heated filter sampling train. Their tests were designed to permit a comparison of the two sampling train methods. Results of this test are available in a separate EPA Report 74-KPM-14.

III. SUMMARY OF RESULTS

Recovery Furnace

A summary of particulate emission and flue gas data for the five (5) particulate tests on the No. 4 Recovery Boiler exhaust is presented in Table 3.1. The data is fairly consistent when all the tests are considered simultaneously. Although the particulate emission concentration varied from 0.00445 gr/DSCF (grains per dry standard cubic foot) (Test 1-3) to 0.01139 gr/DSCF (Test 1-5), this variation is not unexpected, when ESP efficiencies of 99+ percent and the many possible process variations are considered. The average particulate emission results for the five tests were 11.22 lb/hr and 0.0087 gr/DSCF.

Several problems were encountered during the recovery furnace testing, resulting in the abortion of three tests; however, none of the five tests shown in the summary tables were effected. Twice during testing, the No. 4 Recovery Boiler ESP malfunctioned, which necessitated a restart of the test since the resulting uncontrolled recovery furnace emissions overloaded the sampling trains before they could be shut off. The other aborted test resulted from a break in the six foot glass probe which was discovered during a leak test while changing ports. Since it was not known when the break had occurred, a new test was started.

Table 3.1 SUMMARY OF PARTICULATE EMISSION RESULTS
NO. 4 RECOVERY FURNACE

Run Number	1-1	1-2	1-3	1-4	1-5
Date	2-12-74	2-13-74	2-14-74	2-15-74	2-18-74
Volume of Gas Sampled - DSCF[a]	176.861	182.949	388.718	273.535	244.558
- (Nm^3)[b]	5.01	5.18	11.0	7.76	6.93
Average Stack Temperature - °F	338	349	361	347	345
- °C	170	177	182	175	174
Percent Moisture by Volume - %	21.5	22.8	23.1	22.1	22.9
Stack Volumetric Flow Rate - DSCFM[c]	141928	148427	159325	160461	148142
- (Nm^3/sec)[d]	67.0	70.1	75.2	75.7	69.9
Stack Volumetric Flow Rate - ACFM[e]	274310	292782	312178	299248	294630
- m^3/sec	139	149	158	152	150
Percent Isokinetic	111.0	109.8	108.7	101.2	98.6
Particulates - probe, and filter catch					
mg	30.4	37.3	61.2	39.0	43.2
gr/DSCF[f]	0.00265	0.00314	0.00242	0.0022	0.00273
(mg/Nm^3)[g]	6.06	7.18	5.54	5.03	6.25
gr/ACF	0.00137	0.00159	0.00126	0.00117	0.00137
mg/m^3	3.19	3.70	2.93	2.72	3.19
lb/hr	3.226	4.002	3.358	3.026	3.461
Kg/hr	1.46	1.82	1.52	1.37	1.57
Particulates - total					
mg	92.4	127.8	112.1	154.3	180.6
gr/DSCF	0.00806	0.01078	0.00445	0.00870	0.01139
mg/Nm^3	18.4	24.7	10.2	19.9	26.1
gr/ACF	0.00417	0.00545	0.00231	0.00466	0.00573
mg/m^3	9.71	12.7	5.38	10.9	13.3
lb/hr	9.808	13.715	6.152	11.973	14.471
Kg/hr	4.45	6.23	2.79	5.44	6.57

[a] Dry standard cubic feet at 70°F, 29.92 in. Hg.

[b] Normal cubic meters at 21.1°C, and 760 mm Hg. - dry basis

[c] Dry standard cubic feet per minute at 70°F, 29.92 in. Hg.

[d] Normal cubic meters per second at 21.1°C, and 760 mm Hg. - dry basis

[e] Actual cubic feet per minute.

[f] Grains per dry standard cubic foot.

[g] Milligrams per dry normal cubic meter.

Lime Kiln

A summary of particulate emission data from the six tests on the No. 2 Lime Kiln is presented in Table 3.2. The emission results of the first three (3) particulate tests on the lime kiln (Tests 2-1 through 2-3) were very similar, with an average grain loading of 0.1113 gr/DSCF and average emission rate of 13.41 lb/hr. The final three (3) test results were neither similar when compared with one another or with the first three tests. This probably occured because the fuel used to fire the rotary lime kiln was changed from oil to natural gas about mid-way through Test 2-4. The grain loading for Test 2-4 (0.0856 gr/DSCF) was about midway between the average grain loading for the first three tests (0.1113 gr/DSCF) and that of Test 2-5 (0.05961 gr/DSCF), which supports the possibility that the fuel switch to gas caused a decrease in particulate emissions. This rationale also is consistent with the fact that particulate emissions from oil combustion are generally higher than those from natural gas combustion. Test 2-6 yielded a grain loading of only 0.03699 gr/DSCF, but the volumetric flow rate (11,560 DSCFM) for this test was well below the average flow rate for the other five tests (13,467 DSCFM), which could account for this difference. The production rate was somewhat lower during this run. (See Chapter IV).

The average grain loading for the six kiln tests was 0.08604 gr/DSCF, while the emission rate averaged 11.2 lb/hr. There were no problems encountered with the actual testing which should influence the results.

Table 3.2 SUMMARY OF PARTICULATE EMISSION RESULTS
NO. 2 LIME KILN

Run Number	2-1	2-2	2-3	2-4	2-5	2-6
Date	2-12-74	2-13-74	2-14-74	2-14-74	2-14-74	2-14-74
Volume of Gas Sampled - DSCF[a]	59.589	57.781	54.503	56.300	58.532	48.010
- Nm^3 [b]	1.68	1.64	1.54	1.59	1.66	1.36
Average Stack Temperature - °F	151	151	151	154	156	152
- °C	66	66	66	68	69	67
Percent Moisture by Volume - %	25.2	24.3	25.5	30.6	27.0	24.5
Stack Volumetric Flow Rate - DSCFM[c]	14755	14292	13165	12832	13896	11560
- Nm^3/sec [d]	6.97	6.75	6.21	6.06	6.56	5.46
Stack Volumetric Flow Rate - ACFM[e]	22844	21714	20357	21337	22016	17643
- m^3/sec	11.6	11.0	10.3	10.8	11.2	8.96
Percent Isokinetic	101.0	101.0	103.5	109.7	105.3	103.5
Particulates - probe, bypass, and filter catch						
mg	416.8	363.7	361.5	312.3	226.1	115.1
gr/DSCF[f]	0.10794	0.09713	0.10235	0.08560	0.05961	0.03699
mg/Nm^3 [g]	247	222	234	196	136	84.6
gr/ACF	0.06962	0.06395	0.06632	0.05152	0.03762	0.02432
mg/m^3	162	149	154	120	87.6	56.6
lb/hr	13.651	11.899	11.550	9.415	7.100	3.678
kg/hr	6.18	5.39	5.23	4.26	3.21	1.66
Particulates - total						
mg	435.3	392.5	411.4	332.9	336.5	198.9
gr/DSCF	0.11273	0.10483	0.11648	0.08560	0.05961	0.03699
mg/Nm^3	258	240	266	196	136	84.6
gr/ACF	0.07271	0.06902	0.07548	0.05492	0.05599	0.04203
mg/m^3	.69	161	176	128	130	98
lb/hr	14.257	12.842	13.144	10.036	10.567	6.356
kg/hr	6.45	5.81	5.94	4.54	4.78	2.88

[a] Dry standard cubic feet at 70°F, 29.92 in. Hg.

[b] Normal cubic meters at 21.1°C, and 760 mm Hg. - dry basis

[c] Dry standard cubic feet per minute at 70°F, 29.92 in. Hg.

[d] Normal cubic meters per second at 21.1°C, and 760 mm Hg. - dry basis

[e] Actual cubic feet per minute.

[f] Grains per dry standard cubic foot.

[g] Milligrams per dry normal cubic meter.

IV. PROCESS DESCRIPTION AND OPERATION

The St. Regis Paper Company mill at Tacoma, Washington produces 1000 tons of kraft pulp per day. About 15 percent of the pulp is bleached and made into paper. The remaining pulp is made into a variety of brown paper and paperboard products. The plant has been operating since 1928.

Process Description

A. General

The process for making kraft pulp from wood is shown in Figure 4.1. In the process, wood is chipped into small pieces and then cooked in digesters (five batch and two continuous) at elevated pressure and temperature. The cooking chemicals, called white liquor, are sodium hydroxide and sodium sulfide in water solution. The white liquor chemically dissolves lignin, leaving wood cellulose (pulp) which is filtered from the spent liquor and washed. The pulp is made into paper.

The balance of the pulping process is designed to recover the cooking chemicals. Spent cooking liquor and the pulp wash water are combined for treatment to recover chemicals. The combined stream, called weak black liquor, is concentrated in steam heated multiple-effect evaporators, including a special effect called a concentrator. The strong black liquor leaving the evaporators is burned in a recovery furnace.

Combustion of the organic matter in the black liquor provides heat needed to generate process steam. Inorganic chemicals from the black liquor are recovered as a molten smelt at the bottom of the furnace. The smelt, consisting of sodium carbonate and sodium sulfide, is dissolved in water and transferred to a causticizing

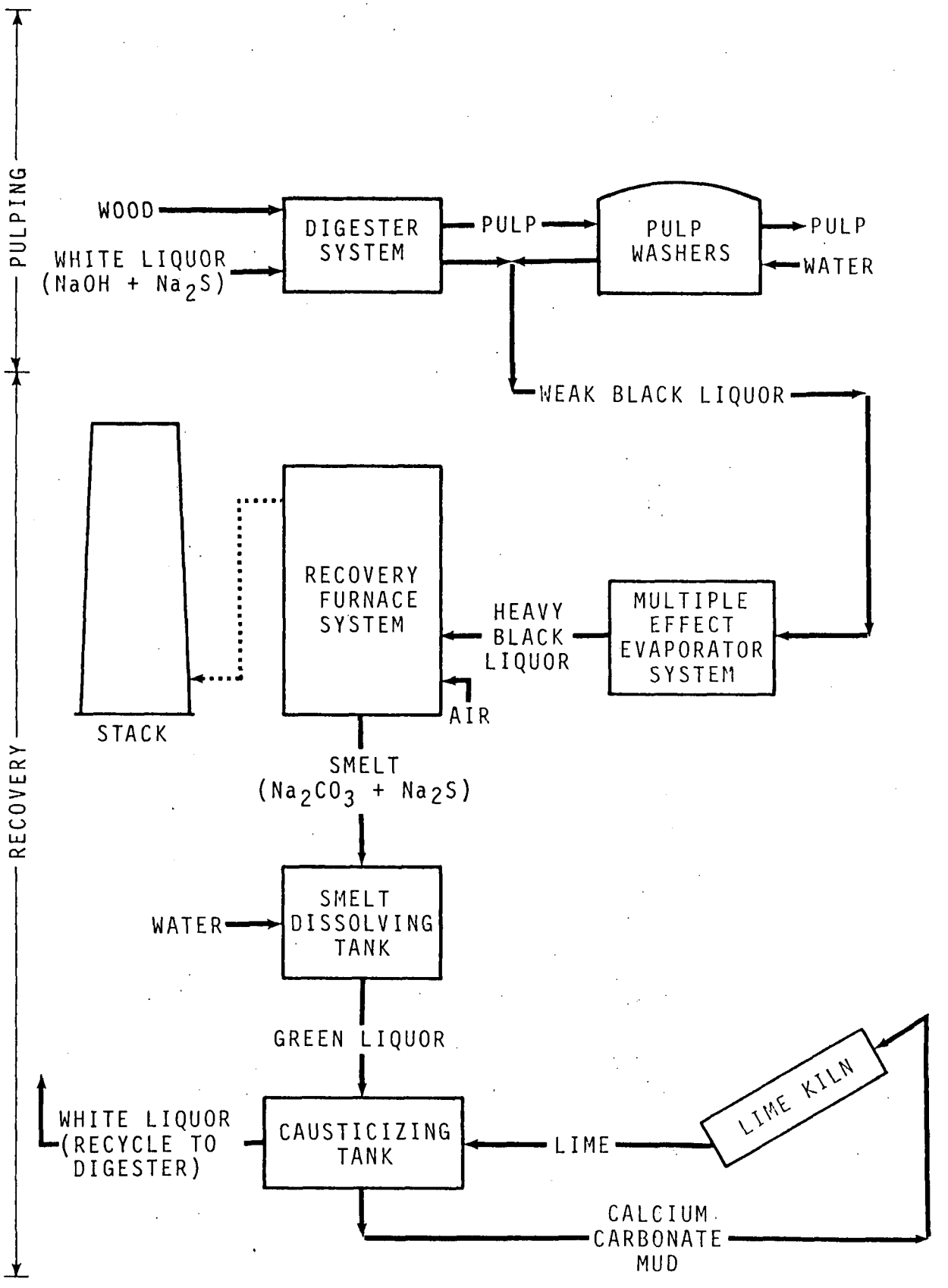

Figure 4.1. The Kraft pulping process at the St. Regis mill in Tacoma, Washington.

tank. Lime added to this tank converts sodium carbonate to sodium hydroxide, completing the regeneration of white liquor, which is then recycled to the digester. The calcium carbonate mud that precipitates from the causticizing tank, is recycled to a kiln to regenerate lime.

B. Recovery Furnace

The Number 9 recovery furnace was designed by Combustion Engineering to burn 108,000 pounds of black liquor solids per hour, which corresponds to a pulp production rate of about 863 tons per day. Auxiliary fuel oil is also burned.

The furnace is not equipped with direct contact evaporators. Special steam heated evaporators, called concentrators, are used instead. With this design, gases leaving the furnace are not used to concentrate the incoming black liquor. Instead, the gases preheat the combustion air in two parallel heat exchangers called laminaire heaters, as shown in Figure 4.2.

Steam is generated in the recovery furnace to provide some of the process heat requirements. A portion of the steam is used within the furnace to blow soot from the boiler tubes. The soot blowers operate one at a time, with each complete sequence taking about 2 1/2 hours. A new cycle begins as soon as the previous cycle ends, so that the soot blowers operate continually.

C. Electrostatic Precipitator

The exhaust gases from the Number 9 recovery furnace are cleaned in an electrostatic precipitator. The precipitator was installed in 1973 by Wheelabrator-Lurgi. The unit was designed

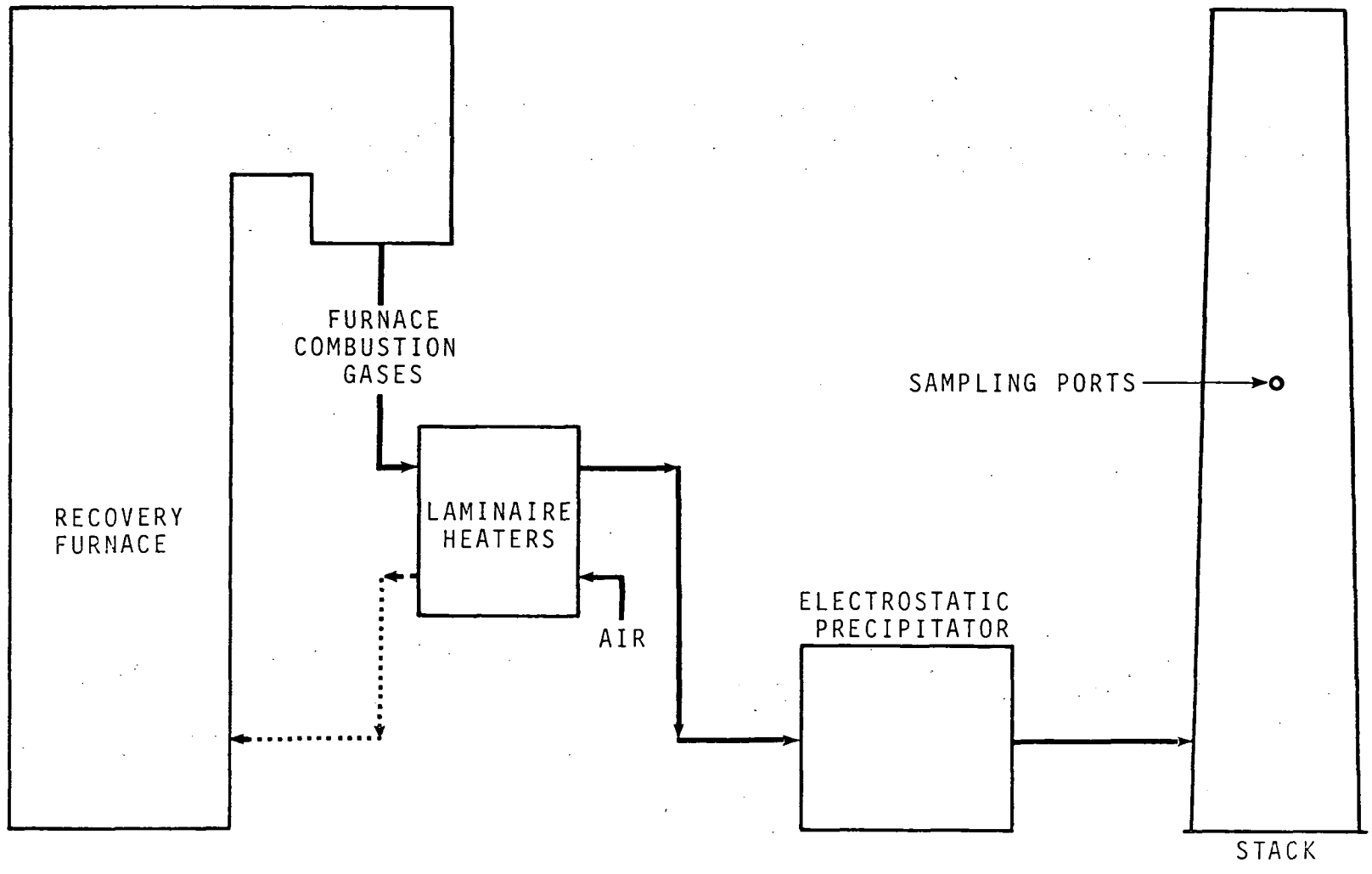

Figure 4.2. Recovery furnace and precipitator at the St. Regis Mill in Tacoma, Washington.

to treat combustion gases at a rate of 400,000 ACFM, at a temperature of 350-475°F.

The precipitator has two parallel chambers with four sections in each chamber. The middle sections have independent power supplies; the two inlet sections share one power supply and the two outlet sections share one power supply.

The insulator compartment is heated to protect it from corrosive condensation. Five fans blow hot air over the insulators, with each fan supplying about 800 CFM. The total heating air is only 1 percent of the design capacity of the precipitator, and does not lower the particulate concentration significantly.

Dust collecting on the precipitator electordes is shaken loose by a system of rappers. The rappers operate in continual cycles, with each cycle lasting 3 1/2 minutes. The collected dust falls into dry hoppers and is removed by screw conveyors to a mix tank. In the tank, the dust is dissolved in black liquor and recycled to the process. If the conveyors are stopped by a malfunction, the precipitator power is automatically shut off to prevent clogging the conveyors. This happened twice during the test series. Each time, the precipitator was off for only a few minutes but the surge of particulate through the stack forced the cancellation of both test runs.

The precipitator is located near ground level and the exhaust gases discharge through a tall stack.

D. Lime Kiln and Venturi Scrubber

The Number 2 lime kiln was designed by Traylor Company to produce 80 tons of lime per day. This is equivalent to a pulp production rate of about 320 tons per day. This rotary kiln is 170 feet long, with an inside diameter of 8 1/2 feet. It is fired with either natural gas or No. 6 fuel oil.

The feed to the kiln is the calcium carbonate slurry that precipitates from the causticizing tanks. The slurry is washed and then dried on a rotary vacuum drum, as shown in Figure 4.3. The dried cake is removed from the drum on a knife edge and conveyed to the kiln. In the kiln, the calcium carbonate mud is roasted and carbon dioxide is driven off, leaving calcium oxide (lime) as product.

Noncondensable gases from the multiple-effect evaporators are burned to destroy odors. These gases are burned in either of the two kilns operated at the plant. Dregs from the green liquor clarifier are not burned in the kilns.

The combustion gases from the kiln are cleaned in an adjustable throat venturi scrubber. They then pass through a demister and out a 100 foot stack. The scrubbing water is recycled from the demister and blended with fresh water makeup. A portion of the recycled water is purged to prevent excessive accumulation of solids, and used elsewhere in the process.

Process Operation

A. General

The purpose of the tests was to measure emission levels during

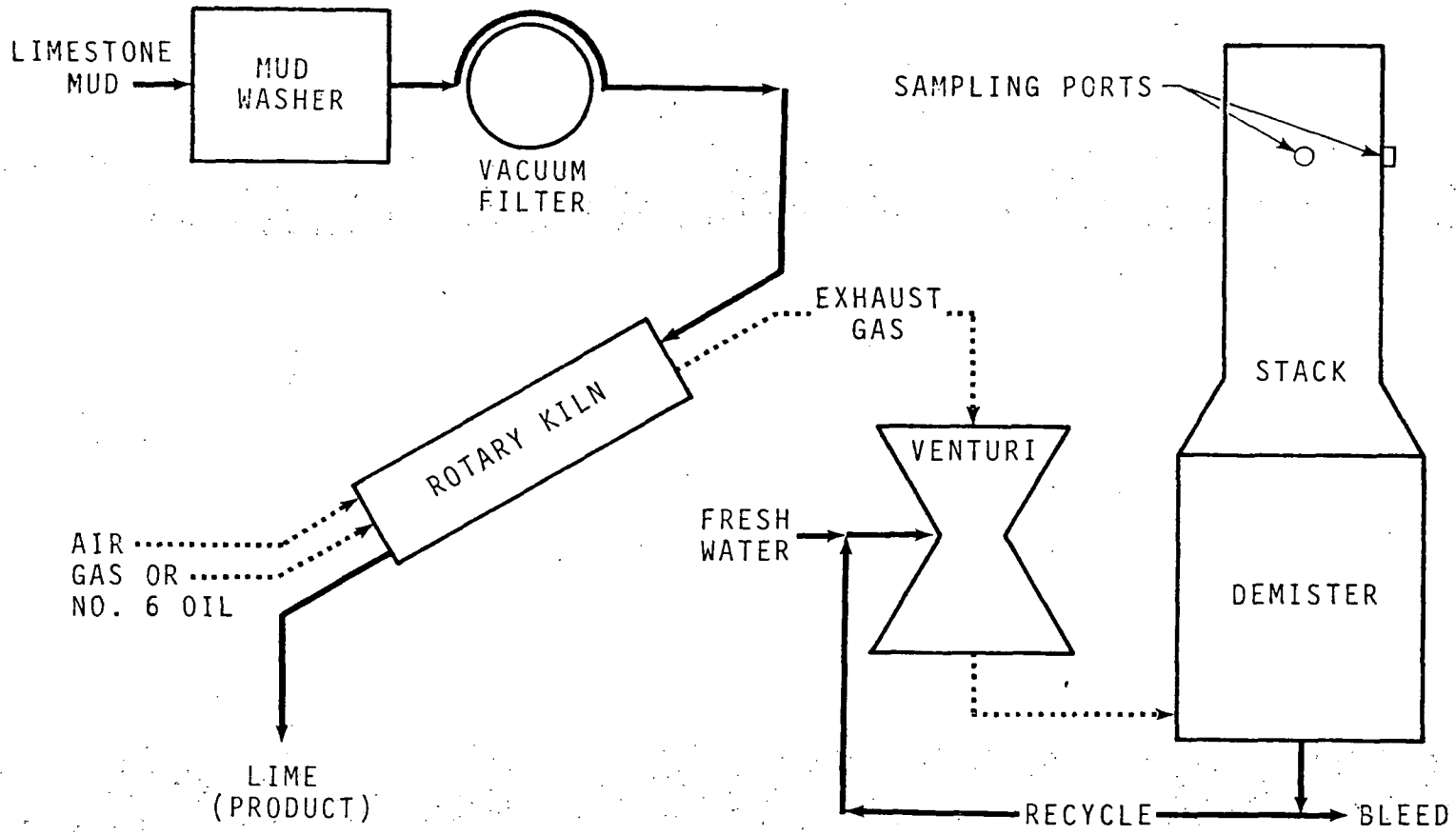

Figure 4.3. Flow diagram of the No. 2 lime kiln at the St. Regis mill in Tacoma, Washington.

normal plant operation. Process conditions were carefully observed, and testing was done only when the test facility appeared to be operating normally.

The laminaire heaters on the furnace are cleaned daily. During cleaning, the flow rate of black liquor to the furnace is reduced. By arrangement with the plant, the heaters were cleaned after the test periods, so that during the test the full charge of black liquor would go to the furnace.

As previously mentioned the precipitator lost power twice because of malfunctions to the screw conveyors under the hoppers. Power was lost at 1130 hours on February 13, and at 1247 hours on February 19. Particulate sampling was stopped on both occasions and the test runs were aborted.

The plant has installed a Lear-Siegler transmissometer to monitor the stack gas opacity. The chart record of this instrument was very steady throughout the tests, indicating an opacity of 4.5 to 6 percent. The opacity readings were observed to increase slightly when the black liquor charging rate increased by about 40 gpm. During both precipitator malfunctions mentioned above, the opacity readings went off scale. The readings are recorded on the process data sheets in Appendix B.

During the tests, important process conditions were monitored and recorded on data sheets. Readings were taken about once every half-hour. These data, and a key to the entries, are in Appendix B. The readings made on the precipitator include voltage and amperage of the primary and secondary circuits of all six

control fields. Charging rate and other significant operating variables were also recorded. Furnace temperatures cound not be recorded because the monitors were not operational.

Based on available precess data and conversations with the operators, the furnace and precipitator operated normally during the tests, with the exception of the two precipitator power-outages. The black liquor charging rate was in its normal range of 190 to 240 gpm. Soot blowers operatied continually during the testing, as normal.

The gas flow rate through the precipitator during the tests is compared to the design flow rate in Table 4.1 below. As shown, the flow rate during the tests averaged 74 percent of the design rate.

Table 4.1. Gas Flow Rates Through the Precipitator

Run Number	Date, 1974	Gas Flow Rate, ACFM		% of Design
		During Test	Design	
1-1	Feb. 12	274,310	400,000	69
1-2	Feb. 13	292,782	400,000	73
1-3	Feb. 14	312,178	400,000	78
1-4	Feb. 15	299,248	400,000	75
1-5	Feb. 18	294,630	400,000	74
				74 Avg.

C. Lime Kiln

During the tests, important process conditions were monitored and recorded on data sheets. Readings were taken about every half-

hour. These records and a key to the entries are in Appendix B. As far as known from the process information and conversations with the operators, the kiln and scrubber operated normally during the tests. The main process information is summarized in Table 4.2 below.

As shown, the particulate emissions ranged from 0.04 to 0.11 gr/dscf. The three highest emissions occurred while the kiln was fired with oil; the two lowest emissions occurred while the kiln was fired with natural gas; an intermediate emission level occurred when the kiln was fired with oil for half the sampling period, and then switched to gas. It should also be noticed that the kiln charging rate was lower during gas firing (50 compared to 60 gpm of mud). The combination of gas firing and lower charging rate apparently reduced particulate emissions about 50 percent.

Table 4.2. Summary of Lime Kiln Process Data During Particulate Sampling

Test	Date 1974	Sampling Hours	Mud Charging Rate, gpm	Venturi Pressure Drop, in H_2O	Fuel Gas Rate, mscfh	Fuel Oil Rate, lb/hr	Particulate Emissions, gr/dscf (total)
2-1	Feb. 12	1225-1555	60-61	31-32.5	0	1650-1760	0.11
2-2	Feb. 13	1000-1225	60	32-32.5	0	1660-1780	0.10
2-3	Feb. 13	1400-1628	60	32-32.5	0	1680-1710	0.12
2-4	Feb. 14	0908-1213	0-60[a]	30-32	25-27[b]	0-1790[b]	0.09
2-5	Feb. 14	1235-1538	50-60	29.9-31	22-26	0	0.06
2-6	Feb. 14	1605-1834	50	24.5-28	22	0	0.04

[a] Feed was off briefly while the kiln was switched from oil to gas firing.
[b] Kiln was switched from oil to gas at 1025 hours.

V. LOCATION OF SAMPLING POINTS

Recovery Furnace

Figure 5.1 illustrates the locations of the sampling ports and points for Recovery Boiler No. 4. The sampling site was located at a point approximately 70 ft. (5.0 stack diameters) from the top of the stack and 74 ft. (6.7 diameters) from the outlet of the ESP (also the closest upstream disturbance). The diameter of the stack at the sampling site is 14.0 ft. Twenty eight (28) traverse points (14 along each of two perpendicular diameters) were selected as prescribed by the Method 1 of the Federal Register.[1]

The sampling platform was especially constructed for testing and consisted of a metal grating floor surrounding the stack and enclosed on the top and sides by corrugated plastic. Access to the sampling points was accomplished through four (4) ports (at 90° separation), since the 14.0 ft. diameter stack was too wide to traverse along one diameter through a single port.

Lime Kiln

Locations of the sampling ports and points for Lime Kiln No. 2 are shown in Figure 5.2. The sampling site was located at a point approximately 30 ft. (7.5 stack diameters) from the top of the stack and 10 ft. (2.5 stack diameters) from the demister exit (also the nearest upstream restriction). The diameter of the stack at the sampling site is 4.0 ft. Forty

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

SAMPLE POINT LOCATION FROM INNER STACK WALL
(inches)

N-1	3.0	E-1	3.0	S-1	3.0	W-1	3.0
2	9.5	2	9.5	2	9.5	2	9.5
3	16.75	3	16.75	3	16.75	3	16.75
4	24.5	4	24.5	4	24.5	4	24.5
5	33.75	5	33.75	5	3.75	5	33.75
6	47.5	6	47.5	6	47.5	6	47.5
7	61.5	7	61.5	7	61.5	7	61.5

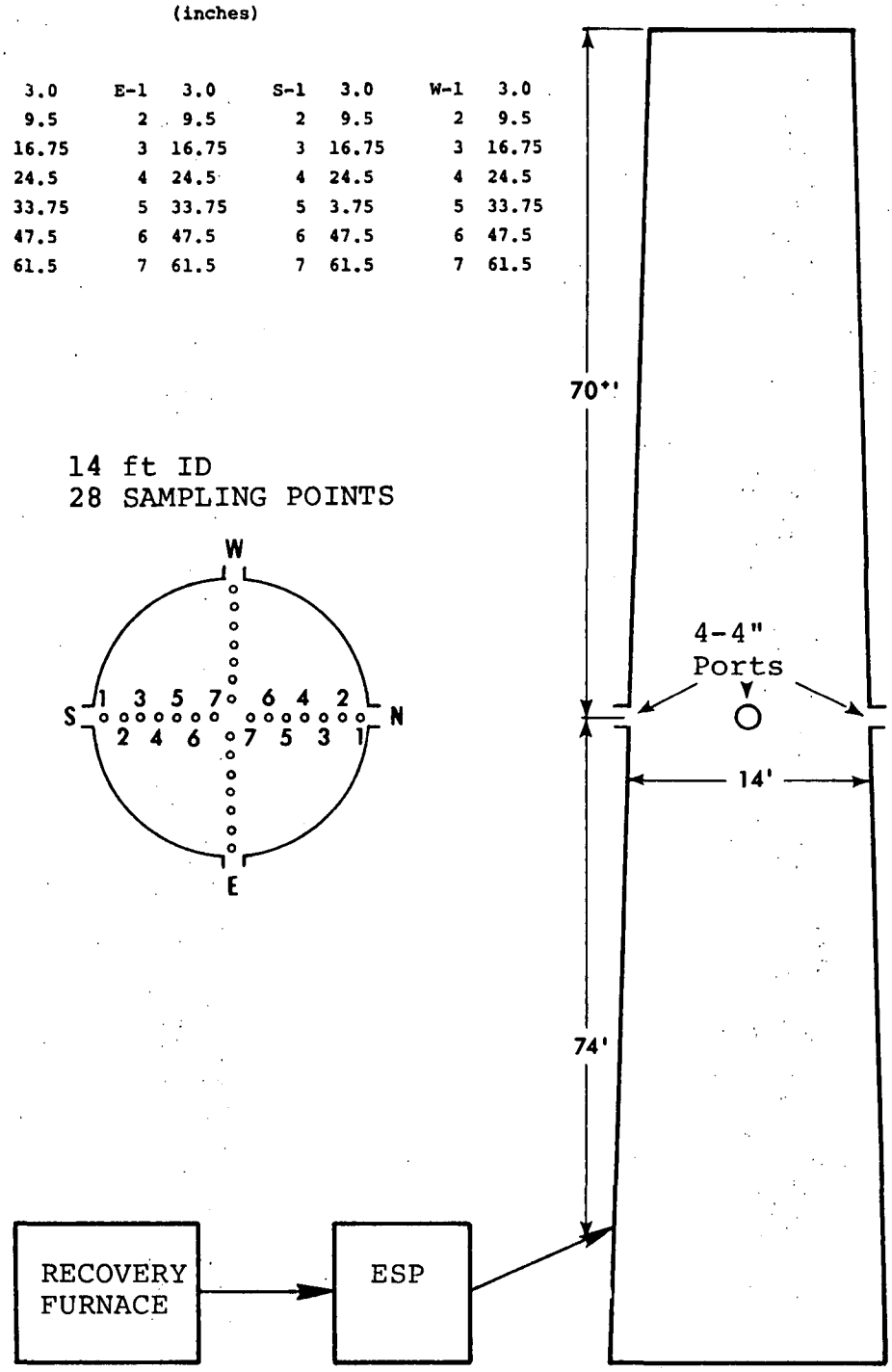

Figure 5.1 Sample port and point locations on Recovery Furnace No. 4.

SAMPLE POINT LOCATION FROM INNER STACK WALL
(inches)

S-1	1.0	S-11	29.5	W-1	1.0	W-11	29.5
2	2.0	12	33.5	2	2.0	12	33.5
3	3.25	13	36.0	3	3.25	13	36.0
4	4.5	14	38.25	4	4.5	14	38.25
5	6.5	15	40.0	5	6.5	15	40.0
6	8.0	16	41.5	6	8.0	16	41.5
7	9.75	17	43.5	7	9.75	17	43.5
8	12.0	18	44.75	8	12.0	18	44.75
9	14.25	19	46.0	9	14.25	19	46.0
10	18.25	20	47.0	10	18.25	20	47.0

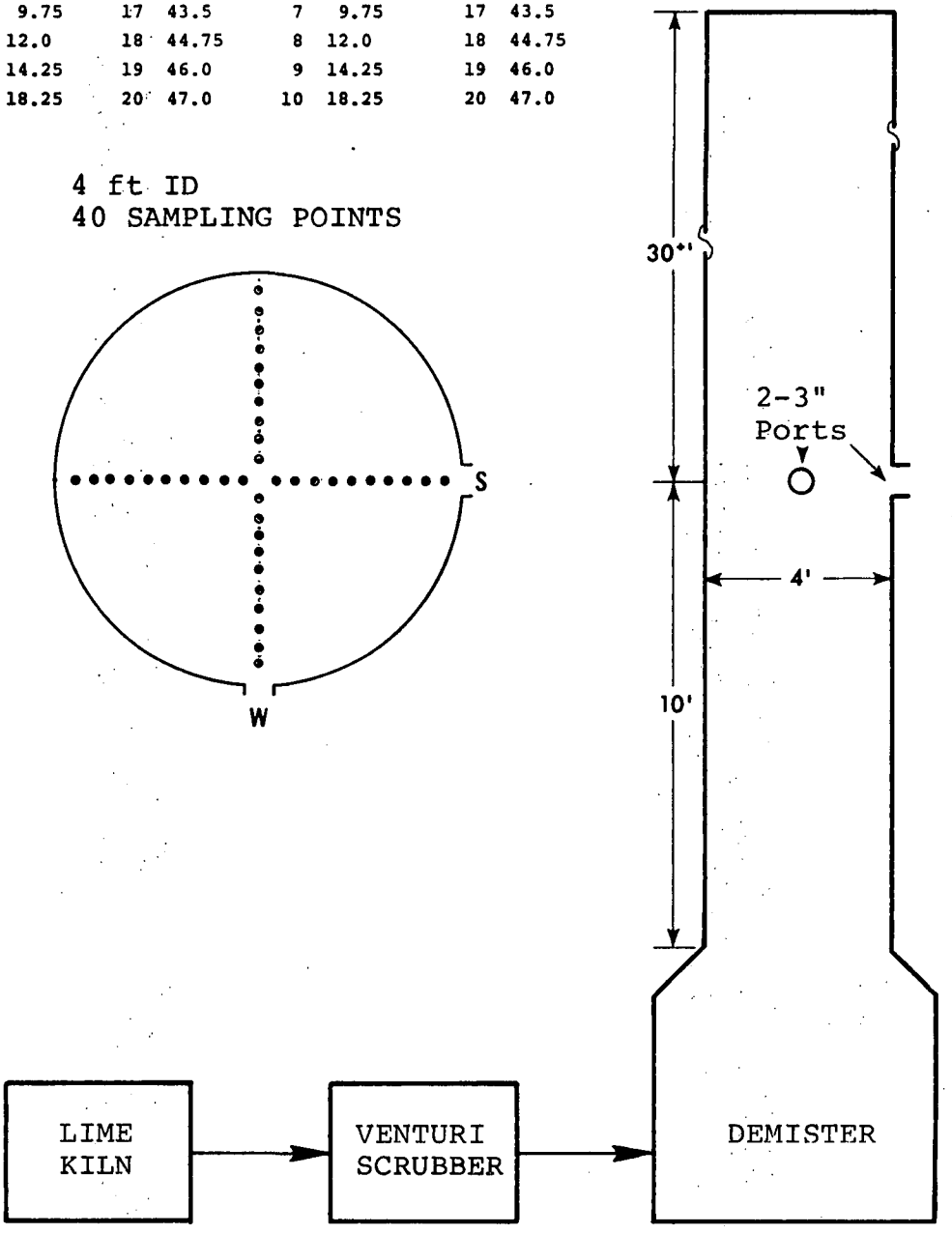

Figure 5.2 Sample port and point locations on Lime Kiln No. 2.

(40) sampling points (20 along each of two perpendicular diameters) were selected, as prescribed by Method 1 of the Federal Register.[1]

The sampling platform was especially constructed for sampling and consisted of a metal grating floor around approximately 270° of the stack circumference enclosed on the top and sides. Access to the sampling points was provided by two ports at 90° separation.

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

VI. SAMPLING AND ANALYTICAL PROCEDURES

All sampling procedures were selected by EPA prior to field sampling. All analyses of collected samples were performed by PEDCo. Appendix E contains detailed descriptions of the sampling and analytical procedures employed for the tests. These procedures are described briefly below.

Velocity and Gas Temperature

All gas velocities were measured with a calibrated type S pitot tube and inclined draft gage. In all cases velocities were measured at each sampling point across the stack diameter to determine an average value according to procedures described in the Federal Register[1] - Method 2. Temperatures were measured with long stem dial thermometers.

Molecular Weight

An integrated sample of the stack gases was collected daily throughout the testing periods by pumping the gas into a Tedlar^{R} plastic bag at the rate of approximately 0.015 CFM. This bag sample was then analyzed with an Orsat analyzer for CO_2, O_2, and CO as described in the Federal Register[1], Method 3.

Particulates

Method 5 as described in Federal Register[2], was used to measure particulate matter. A rigid train consisting of a heated glass lined probe, a 3" glass fiber filter, and a series of Greenburg-Smith impingers was employed in all particulate tests. A water wash of the probe and filter portion of the train was made in addition to the acetone rinse.

1) Federal Register, Vol. 36, No. 247, December 23, 1971
2) Federal Register, Vol. 36, No. 159, August 17, 1971