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Air

EPA

Nonfossil Fueled Boilers

Emission Test Report
Weyerhaeuser Company
Longview, Washington

NONFOSSIL FUELED BOILERS

Emission Test Report
Weyerhaeuser Company
Longview, Washington

8-12 December 1980

by

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SECTION 1

INTRODUCTION

The nonfossil fueled boiler at the Longview Mill of Weyerhaeuser Company in Longview, Washington was emission tested by Monsanto Research Corporation (MRC) for the U.S. Environmental Protection Agency (EPA) under contract no. 68-02-3547, Work Assignment No. 3. The purpose of testing boiler #11 at Longview was to gather data as background information for the development of possible new source performance standards for nonfossil fueled boilers.

Particulate emissions were determined by simultaneous sampling of four points: inlet and triple outlets of the air pollution control device serving the boiler. The boiler sampled is a large hog fuel fired boiler, producing 420,000 lb steam/hr, controlled by a two-stage multicyclone flyash collector and a three-module Electroscrubber™, an electrostatic granular filter designed to remove particulate matter in a dry form.

The field test work was monitored by Dan Bivins, Field Testing Section, Emission Measurement Branch, EPA. The sampling was directed by Windle H. McDonald of MRC as team leader. The Longview Mill was tested during the week of December 8-12, 1980. The sample collection methods employed were EPA Methods 1 through 5, 7, particle sizing by Andersen cascade impactor, and benzo-alpha-pyrene determination by an XAD-2 resin trap in a modified Method 5 train.

Quality assurance/quality control in the sampling area covered such activities as instrument calibration, using standard or approved sampling methods, chain-of-custody procedures, and protocols for the recording and calculation of data. QA/QC in the analysis area involved using only validated analysis methods, periodic operator QC checking and training, sample QC by the use of splits, reference standards, and spikes, and interlaboratory audits.

SECTION 2

SUMMARY OF RESULTS

Pollutants which were measured for this emission test were particulate matter, particle size, CO_2, CO, NO_x, and BaP. Table 1 presents the sampling and analysis schedule in condensed form.

A total of three particulate emission runs were conducted simultaneously at one of the Electroscrubber inlet ducts and the three outlet stacks. Concurrent opacity readings were to have been taken on the outlet stacks, but were cancelled because of interference from other stacks at the mill. The inlet location sampled during all three test runs was duct #3 (see Figure 6). All EPA Method 5 runs were followed immediately with an Anderson particle sizing and NO_x run.

Test equipment was set up and preliminary stack traverse data were obtained on December 8. No tests were performed but readings were taken of all monitored process parameters. It was learned that the filter bypass valve on Electroscrubber module number 2 was leaking; this could cause the emission test results for that module to be slightly higher than normal.

The first test run began at 12:35 p.m. on December 9, after the feed belt conveyor had been returned to service, and was ended at the outlets after 108 minutes of sampling and 96 minutes at the inlet. Due to equipment problems, the BaP test was not usuable.

Emission test run 2 began at 10:05 a.m. on December 10. During the first few minutes on the test the soot blowers were operating. When over half of the Method 5 was completed, it was noticed that the line which removed the collected ash from the de-entrainment vessel had plugged so the gravel was returned to the bed uncleaned. It was decided to continue the test since the opacity monitor showed only a slight increase (to about 5%). This situation would have gone uncorrected by plant personnel until the opacity reached 10% during normal operation. The BaP test was again not usuable due to equipment problems.

Emission test run 3 began at 9:30 a.m. on December 11, continued with no problems, and ended at 11:23 a.m. One additional set of NO_x samples at stack #3 was taken to redo the samples from run #2, for which insufficient gas volumes were pulled. About halfway through the Method 5 run it was discovered that power had been lost to the number three module. The stack opacity remained low so testing was continued. All three required BaP runs were completed on this day.

Particulate emission calculations and stack gas parameters are summarized in Tables 2 and 3. All outlet test runs were conducted within isokinetic variation limits. The inlet run #3 was 150% isokinetic; it is believed that the orifice manometer malfunctioned, gave false readings, and the operator then changed the probe tip diameter to compensate for the loss of pressure head observed. Accordingly, inlet run #3 is not included in the averages for Tables 2 and 3.

The effects of the soot blow during run #2 on particulate concentration in the stack gas are evident, particularly at the inlet duct sampling and at the outlet of Electroscrubber module #2. For all three runs the stack outlet of module #2 had higher particulate emissions.

Integrated gas analysis results are given in Table 4. Small amounts of CO (less than 0.1%) were detected at the outlet locations. Completed integrated gas analysis results are included with the field data sheets in Appendix B.

TABLE 1. WEYERHAEUSER-LONGVIEW MILL BOILER NO. 11 SAMPLING AND ANALYSIS SCHEDULE

Sampling site	Total number of samples	Sample type	Sampling method	Minimum sampling time	Initial analysis Type	Initial analysis Method
Electroscrubber inlet	3	Particulate matter	EPA 5	60 minutes		
Electroscrubber inlet	3	Particle size distribution	Andersen			
Electroscrubber inlet	3	Integrated gas analysis	EPA 3		CO_2, O_2, CO	EPA 3
Electroscrubber inlet	3	BaP	Modified EPA 5	60 minutes	Fluorescence spectrophotometry	
Electroscrubber outlet	3 x 3	Particulate matter	EPA 5	60 minutes		
Electroscrubber outlet	3 x 3	Particle size distribution	Andersen			
Electroscrubber outlet	3 x 3	Integrated gas analysis	EPA 3		CO_2, O_2, CO	EPA 3
Electroscrubber outlet	3 x 3 runs, 4 samples each	NO_x	EPA 7	15 minute intervals		
Electroscrubber outlet	3	Opacity	EPA 9	30 min before EPA 5 until 30 min after EPA 5		
Boiler feed conveyor	3 samples, 2 fuel analyses	ASTM	Grab	every 15 min during EPA 5 then composite	Ultimate analysis, heating value	ASTM, ASTM

TABLE 2. PARTICULATE EMISSION DATA AND STACK GAS PARAMETERS, BOILER NO. 11, WEYERHAEUSER, LONGVIEW, WASHINGTON, DECEMBER 9-11, 1980 (ENGLISH UNTS)

Run No.	Date	Time, min	Stack temperature, °F	Flow, dscfm	H_2O, %	Isokinetic, %	Emissions: Actual gr/dscf	Emissions: Actual lb/hr	Emissions: Actual lb/mm Btu	Emissions: Corrected to 12% CO_2 gr/dscf
Electroscrubber Inlet (Duct #3)										
1	12/9/80	96	334	71,810	19.71	89.7	0.575	97.9	0.4401	0.2423
2	12/10/80	96	342	69,078	26.09	102.7	0.2644[a]	156.5	0.6856	0.3823[a]
3	12/11/80	96	335	61,822	22.39	150.0	0.1873	99.2	0.4857	0.2204
Average[b]		96	338	70,444	22.90		0.2110	126.7	0.5629	0.3123
Electroscrubber Outlet										
Stack 1										
1	12/9/80	108	316	59,740	21.32	99.1	0.0088	4.5	0.0220	0.0096
2	12/10/80	108	329	66,356	23.96	104.8	0.0085[a]	4.9	0.0213	0.0095[a]
3	12/11/80	108	322	56,929	21.20	97.9	0.0086	4.2	0.0223	0.0100
Average		108	322	61,008	22.16		0.0086	4.5	0.0219	0.0097
Stack 2										
1	12/9/80	108	311	58,393	21.16	98.0	0.0129	6.5	0.0344	0.0166
2	12/10/80	108	317	60,436	24.33	104.3	0.0162[a]	8.4	0.0385	0.0174[a]
3	12/11/80	108	317	54,836	21.51	98.7	0.0138	6.5	0.0355	0.0162
Average		108	315	57,888	22.33		0.0143	7.1	0.0361	0.0167
Stack 3										
1	12/9/80	108	312	58,806	21.18	99.6	0.0082	4.1	0.0211	0.0093
2	12/10/80	108	319	63,708	23.77	105.8	0.0113[a]	6.1	0.0276	0.0124[a]
3	12/11/80	108	313	55,636	21.15	99.1	0.0115	5.5	0.0315	0.0142
Average		108	315	59,383	22.03		0.0103	5.2	0.0267	0.0120

[a]Run 2 included a soot blow.

[b]Average of runs 1 and 2 only.

TABLE 3. PARTICULATE EMISSION DATA AND STACK GAS PARAMETERS, BOILER NO. 11, WEYERHAEUSER, LONGVIEW, WASHINGTON, DECEMBER 9-11, 1980 (METRIC UNITS)

Run No.	Date	Time, min	Stack temperature, °C	Flow, dncmpm	H_2O, %	Isokinetic, %	Emissions: Actual g/dncm	Emissions: Actual kg/hr	Emissions: Actual kg/GJ	Emissions: Corrected to 12% CO_2 g/dncm
Electroscrubber Inlet (Duct #3)										
1	12/9/80	96	168	2,034	19.71	89.7	0.3604	44.0	0.1893	0.5545
2	12/10/80	96	172	1,956	26.09	102.7	0.6052[a]	71.0	0.2948	0.8750[a]
3	12/11/80	96	168	1,751	22.39	150.0	0.4287	45.0	0.2089	0.5044
Average[b]		96	170	1,914	22.90		0.4648	53.3	0.2421	0.6446
Electroscrubber Outlet										
Stack 1										
1	12/9/80	108	158	1,692	21.32	99.1	0.0201	2.04	0.0095	0.0219
2	12/10/80	108	165	1,879	23.96	104.8	0.0195[a]	2.20	0.0092	0.0219[a]
3	12/11/80	108	161	1,612	21.20		0.0197	1.90	0.0096	0.0230
Average		108	161	1,728	22.16		0.0198	2.05	0.0094	0.0223
Stack 2										
1	12/9/80	108	155	1,654	21.16	98.0	0.0295	2.93	0.0148	0.0381
2	12/10/80	108	158	1,712	24.33	104.3	0.0371[a]	3.81	0.0166	0.0398[a]
3	12/11/80	108	158	1,553	21.51	98.7	0.0316	2.94	0.0153	0.0372
Average		108	157	1,640	22.33		0.0327	3.23	0.0155	0.0384
Stack 3										
1	12/9/80	108	156	1,665	21.18	99.6	0.0188	1.88	0.0091	0.0213
2	12/10/80	108	160	1,786	23.77	105.6	0.0259[a]	2.78	0.0119	0.0285[a]
3	12/11/80	108	156	1,576	21.15	99.1	0.0262	2.48	0.0135	0.0324
Average		108	157	1,676	22.03		0.0236	2.38	0.0115	0.0274

[a] Run 2 included a soot blow.

[b] Average of runs 1 and 2 only.

TABLE 4. SUMMARY OF INTEGRATED GAS ANALYSES, WEYERHAEUSER, LONGVIEW, WASHINGTON, DECEMBER 9-11, 1980

Run no.	Date	CO_2, %	O_2, %	CO, %	N_2, %	MW, lb/lb. mole
Electroscrubber inlet:						
1	12/9/80	7.8	10.6	0.0	81.6	28.7
2	12/10/80	8.3	9.8	0.0	82.1	29.8
3	12/11/80	10.2	9.8	0.0	80.0	30.0
Average		8.8	10.1	0.0	81.1	29.8
Electroscrubber outlet:						
Stack 1						
1	12/9/80	11.0	9.4	0.0	79.6	30.1
2	12/10/80	10.7	9.4	0.07	79.8	30.1
3	12/11/80	10.3	9.8	0.07	79.8	30.0
Average		10.7	9.5	0.05	79.8	30.1
Stack 2						
1	12/9/80	9.3	10.1	0.0	80.6	29.9
2	12/10/80	11.2	8.8	0.1	79.9	30.1
3	12/11/80	10.2	9.7	0.0	80.1	30.0
Average		10.2	9.5	0.03	80.2	30.0
Stack 3						
1	12/9/80	10.6	9.7	0.0	79.7	30.1
2	12/10/80	10.9	9.1	0.1	79.9	30.1
3	12/11/80	9.7	10.4	0.03	79.8	30.0
Average		10.4	9.7	0.04	78.8	30.1

Particle sizing by Andersen cascade impactor was sampled at the inlet and three outlet locations. Each Andersen run immediately followed the particulate emission test run. Results are presented in Table 5; complete Andersen run results are furnished with field data sheets in Appendix B. A larger fraction of particles in the >12 μm size range was found in all three outlet stacks during run 2 Also, outlet of module 2 showed consistently larger particles, probably related to the increased Method 5 test results at module 2 for all tests.

Emissions of benzo-alpha-pyrene (BaP), a polynuclear aromatic hydrocarbon with carcinogenic potential, were measured at the Electroscrubber inlet. Table 6 summarizes the results. Complete results are shown in Appendix A; and field data sheets and analytical results are given in Appendix D.

Emissions of NO_x were measured at the three Electroscrubber outlet locations. Table 7 contains the summarized NO_x emission results; complete results are given in Appendix A and QA/QC results of NO_x analysis are given in Appendix C.

During each particulate emission test run a composited fuel sample was taken. Table 8 presents the results of the fuel ultimate analyses and Btu content. Boiler operating conditions during testing are summarized in Table 9; complete boiler process data are furnished in Appendix E.

The boiler and Electroscrubber were operated normally during all of the tests. The results of the test on the outlet of module 2 may be slightly higher than normal for all three Method 5 test runs. The results of Method 5 run three for module number 3 may also be slightly higher than normal due to the power failure. The opacities of these stacks were not significantly affected however. Therefore, the results from these tests should be representative of particulate emissions from this location.

TABLE 5. SUMMARY OF ANDERSEN PARTICLE SIZING RESULTS, WEYERHAEUSER, LONGVIEW, WASHINGTON, DECEMBER 9-11, 1980

Electroscrubber inlet								
Run 1-I			Run 2-I			Run 3-I		
Flow rate (ACFM): Percent ISO:			Flow rate (ACFM): Percent ISO:			Flow rate (ACFM): Percent ISO:		
Percent in size range	Cumulative percent less than size range	Size range, microns	Percent in size range	Cumulative percent less than size range	Size range, microns	Percent in size range	Cumulative percent less than size range	Size range, microns
7.5	92.5	>12.5	2.8	97.1	>18.0	2.3	97.9	>14.0
1.2	91.3	7.8-12.5	6.4	90.7	12.0-18.0	4.5	93.4	8.9-14.0
3.0	88.3	5.4-7.8	13.5	77.2	7.8-12.0	9.4	84.0	6.1-8.9
18.1	70.2	2.3-5.4	14.3	62.9	5.4-7.8	8.4	74.6	4.2-6.1
34.3	35.9	1.2-2.3	19.1	43.8	3.4-5.4	15.4	59.2	2.6-4.2
12.5	23.4	0.72-1.2	19.9	23.9	1.7-3.4	24.3	34.9	1.3-2.6
			8.9	15.0	1.1-1.7	12.3	22.5	0.81-1.3
12.5	10.9	0.48-0.72	2.8	12.2	0.74-1.1	11.6	10.9	0.56-0.81
10.9	0	0-0.48	12.2	0	0-0.74	10.9	0	0-0.56

Electroscrubber outlet								
Run 1-Stack 1			Run 2-Stack 1			Run 3-Stack 1		
Flow rate (ACFM): 0.63 Percent ISO: 104.1			Flow rate (ACFM): 0.75 Percent ISO: 104.2			Flow rate (ACFM): 0.54 Percent ISO: 104.2		
Percent in size range	Cumulative percent less than size range	Size range, microns	Percent in size range	Cumulative percent less than size range	Size range, microns	Percent in size range	Cumulative percent less than size range	Size range, microns
25.5	74.5	>13.5	36.1	63.0	>12.4	5.9	94.2	>13.3
19.6	54.9	8.4-13.5	3.7	59.3	7.7-12.4	0.0	94.2	9.1-13.3
5.9	49.0	5.8-8.4	0.0	59.3	5.7-7.7	7.6	86.6	6.2-9.1
0.0	49.0	3.9-5.8	0.0	59.3	3.6-5.2	0.5	86.1	4.2-6.2
0.0	49.0	2.5-3.9	0.0	59.3	2.3-3.6	0.2	85.9	2.7-4.2
0.0	49.0	1.22-2.5	0.0	59.3	1.1-2.3	3.2	82.7	1.3-2.7
13.7	35.3	0.77-1.22	3.7	55.6	0.70-1.1	4.4	78.3	0.84-1.3
0.0	35.3	0.52-0.77	0.0	55.6	0.48-0 7	8.3	70.0	0.57-0.84
35.3	0	0-0.52	55.6	0	0-0.70	70.0	0	0-0.67

(continued)

TABLE 5 (continued)

Electroscrubber outlet								
Run 1-Stack 2			Run 2-Stack 2			Run 3-Stack 2		
Flow rate (ACFM): 0.36 Percent ISO: 109.7			Flow rate (ACFM): 0.72 Percent ISO: 106.4			Flow rate (ACFM): 0.65 Percent ISO: 102.2		
Percent in size range	Cumulative percent less than size range	Size range, microns	Percent in size range	Cumulative percent less than size range	Size range, microns	Percent in size range	Cumulative percent less than size range	Size range, microns
43.5	56.6	>19.5	46.3	53.6	>12.5	23.2	76.8	>13.2
0.0	56.5	12.2-19.5	1.2	52.4	7.8-12.5	3.6	73.2	8.4-13.2
0.0	56.5	8.3-12.2	0.0	52.4	5.4-7.8	8.9	64.3	5.7-8.4
8.7	47.8	5.6-8.3	0.0	52.4	3.6-5.4	0.0	64.3	3.7-5.7
0.0	47.8	3.6-5.6	0.0	52.4	2.3-3.6	9.8	54.5	2.4-3.7
0.0	47.8	1.8-3.6	7.3	45.1	1.13-2.3	8.0	46.5	1.2-2.4
0.0	47.8	1.1-1.8	0.0	45.1	0.72-1.13	6.3	40.2	0.75-1.2
8.7	39.1	0.79-1.1	0.0	45.1	0.48-0.72	2.7	37.5	0.52-0.75
39.1	0	0-0.79	45.1	0	0-0.48	37.5	0	0-0.52

Electroscrubber outlet								
Run 1-Stack 3			Run 2-Stack 3			Run 3-Stack 3		
Flow rate (ACFM): 0.30 Percent ISO: 109.6			Flow rate (ACFM): 0.63 Percent ISO: 106.6			Flow rate (ACFM): 0.60 Percent ISO: 102.2		
Percent in size range	Cumulative percent less than size range	Size range, microns	Percent in size range	Cumulative percent less than size range	Size range, microns	Percent in size range	Cumulative percent less than size range	Size range, microns
4.6	95.3	>19.5	28.0	72.0	>13.5	1.9	98.1	>13.7
2.6	92.7	12.2-19.5	0.0	72.0	8.4-13.5	0.0	98.1	8.6-13.7
1.2	91.5	8.3-12.2	10.7	61.3	5.8-8.4	2.8	95.3	5.8-8.6
0.0	91.5	5.6-8.3	0.0	61.3	3.9-5.8	0.0	95.3	4.0-5.8
0.0	91.5	3.6-5.6	0.0	61.3	2.3-3.9	0.0	95.3	2.5-4.0
0.0	91.5	1.8-3.6	4.0	57.3	1.22-2.5	21.7	73.6	1.3-2.5
1.9	89.6	1.1-1.8	0.0	57.3	0.77-1.22	21.7	51.9	0.79-1.3
0.0	89.6	0.29-1.1	8.0	49.3	0.52-0.77	17.0	34.9	0.54-0.79
89.6	0	0-0.79	49.3	0	0-0.52	34.9	0	0-0.54

TABLE 6. SUMMARY OF BaP EMISSION RESULTS, ELECTROSCRUBBER INLET, WEYERHAEUSER, LONGVIEW, WASHINGTON, DECEMBER 9-11, 1980

Parameter	Run 1	Run 2	Run 3	Average
Date	12/11/80	12/11/80	12/11/80	
Test run time, min	96	96	96	96
Stack temperature,				
°F	334	337	336	336
°C	168	170	169	169
Stack flow,				
dscfm	64,480	65,506	70,453	66,813
dncmpm	1,827	1,856	1,996	1,893
Moisture, %	20.6	25.4	21.0	22.3
Isokinetic, %	95.0	99.9	96.7	-
Emission loading,				
lb/dscf	1.60×10^{-11}	3.26×10^{-10}	1.75×10^{-11}	1.20×10^{-10}
mb/dncm	2.58×10^{-4}	5.25×10^{-3}	2.82×10^{-4}	1.93×10^{-3}
Emission rate,				
lb/hr	6.19×10^{-5}	1.28×10^{-3}	7.40×10^{-5}	4.72×10^{-4}
bg/hr	2.83×10^{-5}	5.80×10^{-4}	3.38×10^{-5}	2.14×10^{-4}

TABLE 7. SUMMARY OF NO_x EMISSIONS, WEYERHAEUSER ELECTROSCRUBBER OUTLET, LONGVIEW, WASHINGTON, DECEMBER 9-11, 1980

Run No.	Date	ppm	lb/dscf x 10^{-6}	lb/hr[a]	lb/mm Btu[b]	g/ncm	kg/hr[a]
Stack 1:							
1-1	12/9/80	93.9	11.04	39.6	0.1934	0.177	17.95
1-2		268.4	31.75	113.8	0.5562	0.509	51.63
1-3		201.8	23.88	85.6	0.4184	9.382	38.82
1-4		205.1	24.26	87.0	0.4250	0.389	39.45
Average		192.1	22.73	81.5	0.3982	0.364	36.96
2-1	12/10/80	241.1	28.53	113.6	0.4785	0.457	51.52
2-2		224.6	26.57	105.8	0.4655	0.426	47.98
2-3		255.3	30.21	120.3	0.6060	0.484	54.55
2-4		292.3	34.59	137.7	0.6060	0.554	62.46
Average		253.3	29.97	119.3	0.5251	0.480	54.13
3-1	12/11/80	230.8	27.31	93.3	0.4957	0.437	42.31
3-2		262.5	31.06	106.1	0.5638	0.437	42.31
3-3		259.7	30.73	105.0	0.5578	0.492	47.61
3-4		248.5	29.40	100.4	0.5336	0.471	45.55
Average		250.4	29.62	101.2	0.5376	0.474	45.90
Stack 2:							
1-1	12/9/80	65.0	7.69	26.9	0.1435	0.123	12.21
1-2		253.7	30.02	105.2	0.5600	0.481	47.72
1-3		66.7	7.89	27.6	0.1472	0.126	12.53
1-4		188.1	22.26	80.0	0.4153	0.357	35.38
Average		143.4	16.97	59.4	0.3166	0.272	26.96
Stack 2							
2-1	12/10/80	249.8	29.56	107.2	0.4922	0.473	48.62
2-2		251.9	29.8	108.1	0.4962	0.477	49.02
2-3		250.1	29.60	107.3	0.4929	0.474	48.68
2-4		238.2	28.18	102.2	0.4692	0.451	46.35
Average		247.5	29.29	106.2	0.4877	0.469	48.17

(continued)

TABLE 7. (continued)

Run No.	Date	ppm	lb/dscf x 10^{-6}	lb/hr[a]	lb/mm Btu[b]	g/ncm	kg/hr[a]
3-1	12/11/80	238.8	28.25	93.0	0.5082	0.453	42.16
3-2		230.3	27.25	89.6	0.4902	0.436	40.66
3-3		313.3	37.07	122.0	0.6668	0.594	55.32
3-4		225.5	26.68	87.8	0.4799	0.427	39.82
Average		252.0	29.81	98.1	0.5362	0.477	44.49
Stack 3:							
1-1	12/9/80	216.4	25.61	90.4	0.4607	0.410	40.99
1-2		261.0	30.88	109.0	0.5555	0.495	49.43
1-3		121.9	14.42	50.9	0.2594	0.231	23.07
1-4		162.7	19.25	67.9	0.3463	0.308	30.80
Average		190.5	22.54	79.5	0.4055	0.361	36.07
2-1	12/11/80	210.8	24.94	83.3	0.4258	0.399	37.76
2-2		193.2	22.86	76.3	0.3903	0.366	34.61
2-3		182.2	21.56	72.0	0.3681	0.345	32.65
2-4		100.0	11.84	39.5	0.2022	0.190	17.92
Average		171.6	20.30	67.8	0.3466	0.325	30.74
3-1	12/11/80	173.4	20.52	68.5	0.3937	0.329	31.06
3-2		171.2	20.26	67.6	0.3888	0.324	30.67
3-3		210.0	24.85	82.9	0.4768	0.398	37.62
3-4		204.1	24.15	80.6	0.4634	0.387	36.56
Average		189.7	22.44	74.9	0.4306	0.359	33.98

[a]Based on stack flow rate from corresponding Method 5 run.
[b]Based on F-factor of 9,640 dscf/mm Btu for wood bark.

TABLE 8. SUMMARY OF BOILER FUEL ULTIMATE ANALYSES, WEYERHAEUSER, LONGVIEW, WASHINGTON, DECEMBER 9-11, 1980

Sample number	Date	Carbon, percent	Hydrogen, percent	Nitrogen, percent	Sulfur, percent	Oxygen, percent	Ash, percent	Moisture, percent	Fuel value, Btu/lb
Run 1	12/9/80								
as received[a]		22.39	8.42	0.06	0.02	66.94	2.17	54.87	3,711
dry basis		49.61	5.04	0.14	0.04	40.36	4.82	-	8,224
Run 2	12/10/80								
as received[a]		19.89	7.82	0.07	0.03	68.56	3.63	57.08	3,665
dry basis		46.35	3.33	0.16	0.06	41.64	8.45	-	8,541
Run 3	12/11/80								
as received[a]		18.63	7.10	0.05	0.04	68.57	5.62	55.94	3,542
dry basis		42.27	1.91	0.12	0.08	42.87	12.76	-	8,039
Average, all runs									
as received[a]		20.30	7.78	0.06	0.03	68.02	3.81	55.96	3,639
dry basis		40.08	3.43	0.14	0.06	41.62	8.68	-	8,268

[a]Includes moisture.

TABLE 9. BOILER AND APCD OPERATING CONDITIONS DURING TESTING, WEYERHAEUSER, LONGVIEW, WASHINGTON DECEMBER 8-11, 1980

Parameter	Date			
	8 Dec	9 Dec	10 Dec	11 Dec
Steam Flow, lb/hr	400,000	401,000	400,000	347,000
Steam Pressure @ superheater, psig	1,200	1,200	1,200	1,170
Total wood air flow, % recorder scale	62	66.5	75.3	65.4
Hog fuel rate to boiler, tons	-	80.0	85.2	67.9
Flue gas O_2 @ boiler outlet, %	3.5	5.5	5.5	6.4
Electroscrubber ΔP, inches of water gage				
Module 1	5.3	5.3	6.4	5.1
Module 2	5.4	5.5	6.7	5.9
Module 3	5.7	5.6	6.8	6.5

SECTION 3

PROCESS DESCRIPTION

Weyerhaeuser Company operates a major pulp, paper, and chemical complex at Longview. There are ten boilers in all operating at the mill for process steam and electrical power.

Power boiler #11 at Longview, purchased from Foster-Wheeler, is one of the largest operating hog fuel power boilers in the United States. At full capacity, it is rated at producing 30 MW of power, and drives a General Electric turbine as well as producing process steam. Steam production (1250 psig) is rated at 420,000 lb/hr when using 55% moisture hog fuel and 575,000 lb/hr on dry hog fuel, oil or gas. Boiler #11 is a traveling grate type and accepts a hog fuel specie mix of cedar, hemlock, and fir.

Emission control for boiler #11 consists of a two-stage UOP multiclone flyash collector (6 inch diameter, multiple-tube) which lowers the grain loading to about 0.4 gr/dscf (corrected to 12% CO_2). The multiclone catch from the first stage is slurried, wet sieved, then dropped in a wet state onto the hog fuel feed belt. The partially cleaned gases then travel to the old boiler exhaust stack where an ID fan pushes the exhaust gas to a three-module Electroscrubber®, a dry electrostatic granular filter device installed in 1979 and manufactured by Combustion Power Company, Inc., a Weyerhaeuser subsidiary. Figure 1 illustrates the boiler and emission control system.

Conceptually, as shown in Figure 2, each module of the Electroscrubber system consists of a cylindrical vessel containing two concentric louvered cylindrical tubes. The annular space between the tubes is filled with pea-sized gravel media. The particulate laden exhaust gas enters the filter through the tops of the elements and discharges out the sides. Dirty gas is distributed by louvers and passed through the filter media at velocities ranging from 100-150 ft/min. Particulate is removed from the gas stream by impaction with the media, enhanced by electrostatic forces and diffusion. Since the gas flows from a smaller diameter (the inside of the elements) to a larger diameter (the outside shell of the elements) the gas velocity is decreasing as it exits. This helps reduce re-entrainment of the collected particulate into the cleaned gas. Cleaned gases exit directly through

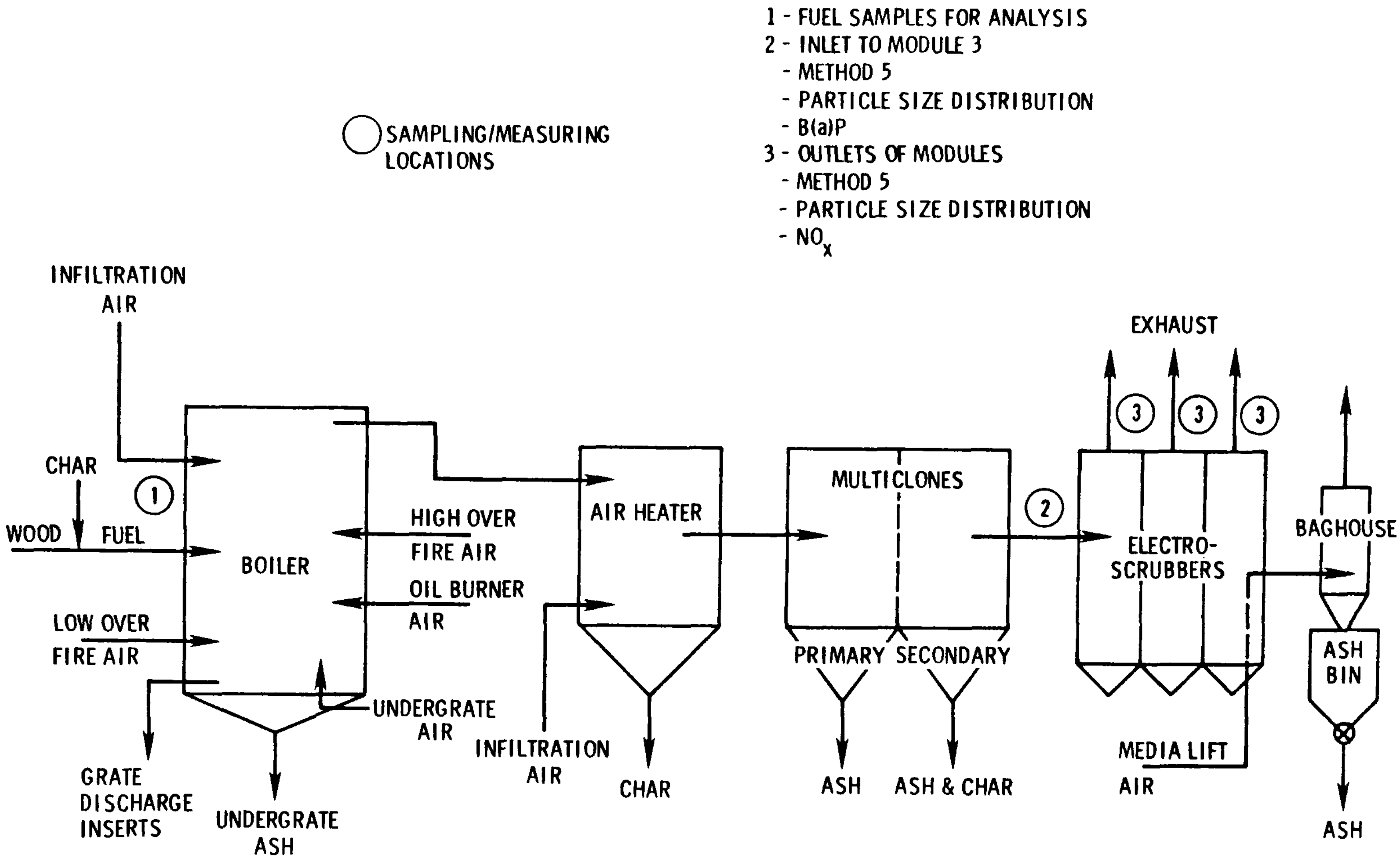


Figure 1. Boiler and emissions control system flow schematic showing sampling locations.

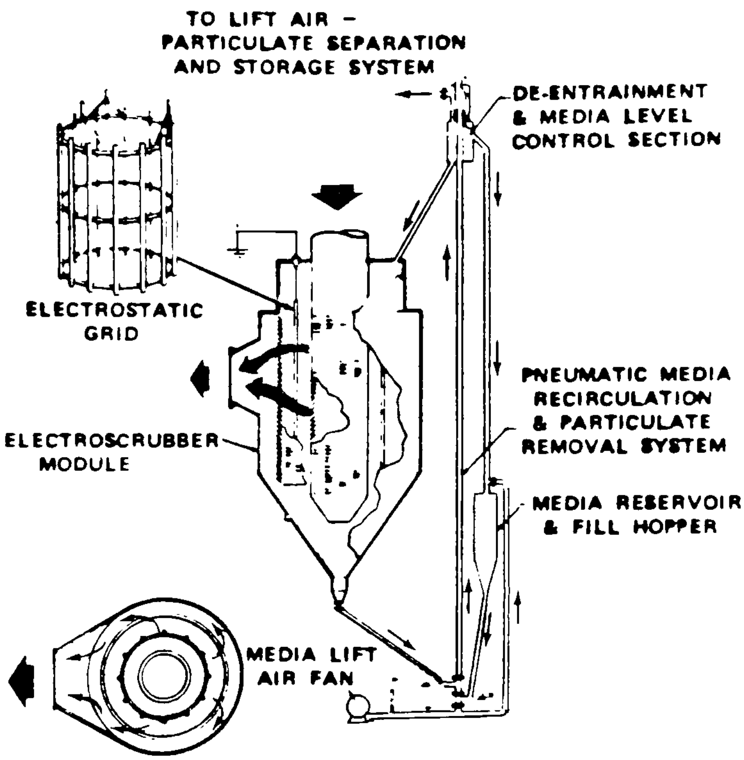


Figure 2. Electroscrubber module schematic.

a free standing exhaust stack at the side of each electroscrubber module.

An electrical conductor (electrostatic grid) is positioned within the media bed and produces an electrical field between the conductor and the inlet and outlet louvers by the high voltage ($\sim$20,000 volts) applied to the conductor. As the particles migrate through the rock filter, the electrical field either attracts or repels the particle, depending upon its charge, towards one of the rocks where it is captured by impaction and retained.

To prevent a filter cake from forming on the face of the filter, and the resulting potential plugging problems and high pressure drop, the filtering media is continuously, but slowly (6-10 ft/hr), moved downward in a plug or mass flow. The resulting churning action across each louver opening prevents a filter cake from forming. To provide cleaning of the louver face, the louvers are designed so that some of the media is pushed through each louver opening thus preventing any bridging or buildup of particulate material.

The particulate laden media is continuously removed at the bottom of the Electroscrubber where it is transported by a pneumatic conveying system to the air/particulate de-entrainment section of the system. The action of the gravel media being transported vertically in the pneumatic lift pipe separates the particulate from the media so that the particulate can be pneumatically removed from the de-entrainment section for pneumatic transport to a particulate separation (fabric filter baghouse) and storage silo. The clean gravel media then drains by gravity from the de-entrainment section and is returned to the top of the Electroscrubber unit for recycling.

As shown in detail in Figure 3, the pneumatic media recirculation and particulate removal system is comprised of: a seal leg, an "L" valve, a media lift pipe, and a de-entrainment section, a media reservoir, and fill hopper. The air transporting the media is supplied by a standard air fan furnished with the equipment.

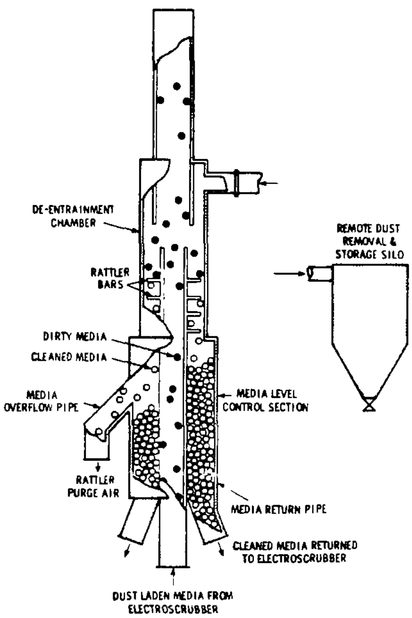


Figure 3. Electroscrubber de-entrainment and level control system.

The media from the Electroscrubber is pneumatically conveyed to the de-entrainment vessel through the vertical lift pipe. The air velocity is approximately 80 ft/sec. where the slip velocity of the media in relation to the wall of the lift pipe does not exceed 15 ft/sec. The air flow and pressure required to lift the media is comparatively-low and at a maximum requires about one pound of air per 20 pounds of media. The maximum air pressure required is approximately 7 psig. To prevent the lift air from flowing into the media outlet section of the Electroscrubber, a seal leg of sufficient length is used to function as a media/air valve.

Figure 4 illustrates a whole Electroscrubber module, as installed at Longview. The entire three-module installation is depicted

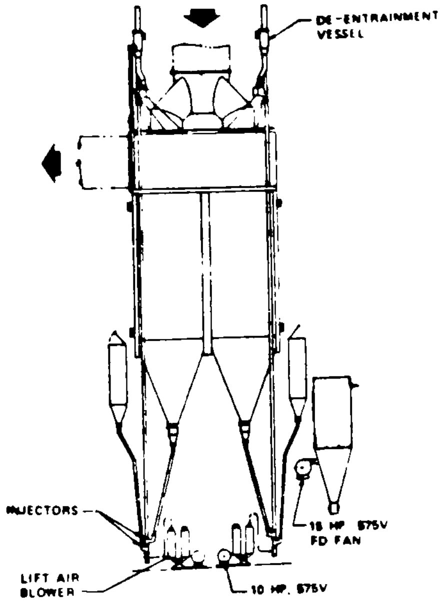


Figure 4. Longview electroscrubber module.

in Figure 5, which also illustrates the placement of the pulsed-jet baghouse used to clean the ash line. The Electroscrubber system is designed to accept 420,000 acfm of flue gas at a temperature of 345°F with a moisture content of 20%. Pressure drop through the Electroscrubber ranges from 2.8 to 5.2 inches H_2O.

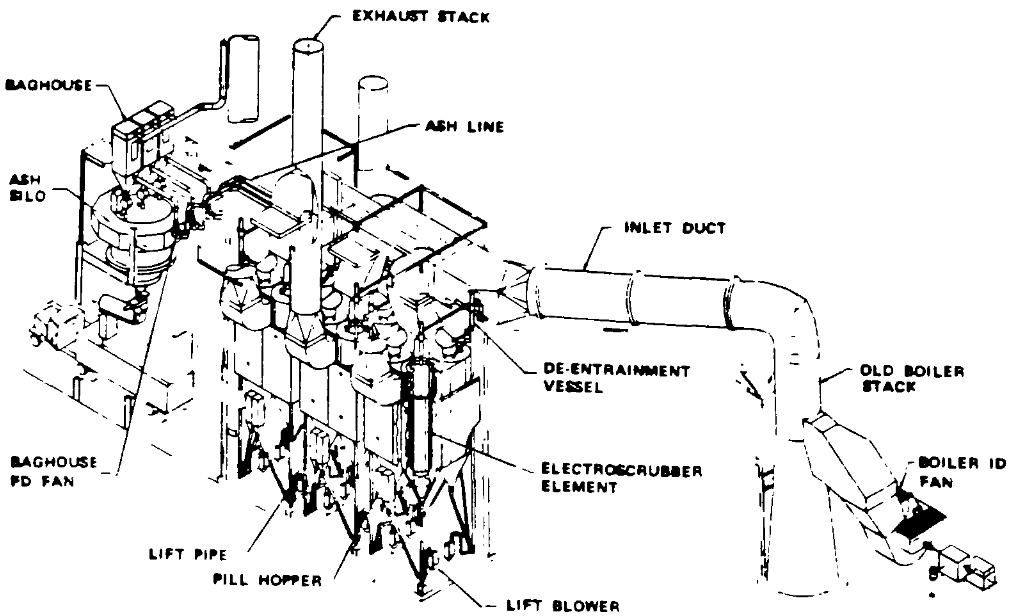


Figure 5. Schematic diagram of three-module electroscrubber system at Weyerhaeuser Longview mill.

SECTION 4

LOCATION OF SAMPLING POINTS

As a result of the pretest survey, the sampling program included one inlet duct to the Electroscrubber system and the three outlet stacks, each stack serving one Electroscrubber module. Simultaneous sampling for particulate emissions using EPA Method 5 was performed at the four locations.

Electroscrubber Inlet

A schematic drawing of the Electroscrubber inlet ductwork is provided in Figure 5. No sampling ports exist while the inlet duct is a single exhaust duct. The horizontal circular portion of the duct from the old boiler stack is over 60 ft above ground level with no access for a sampling crew and equipment. As the duct approaches the Electroscrubber modules, it is joined to a rectangular duct (13.83 ft x 9.83 ft). This rectangular duct then splits into three rectangular ducts, each of which feeds an Electroscrubber module, as depicted in Figure 6. Baffles are built into the rectangular feeder duct to channel the exhaust gas into three streams. Each duct portion has four 7-inch flanged ports aligned vertically in the 9.83 ft duct face with individual gate valves installed.

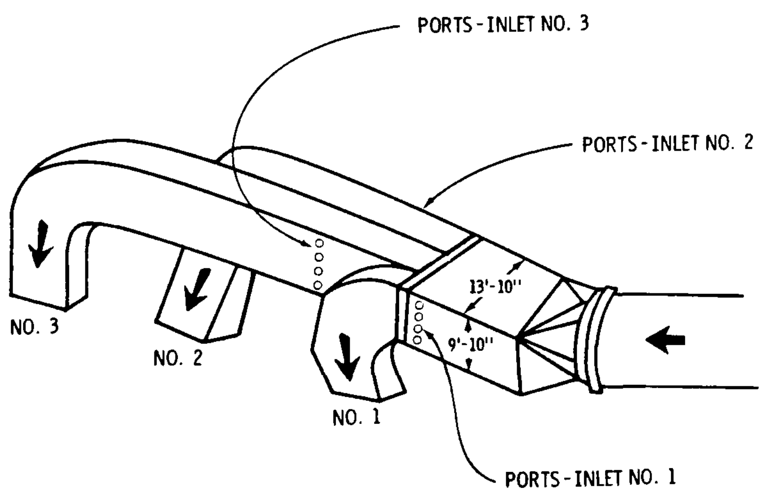
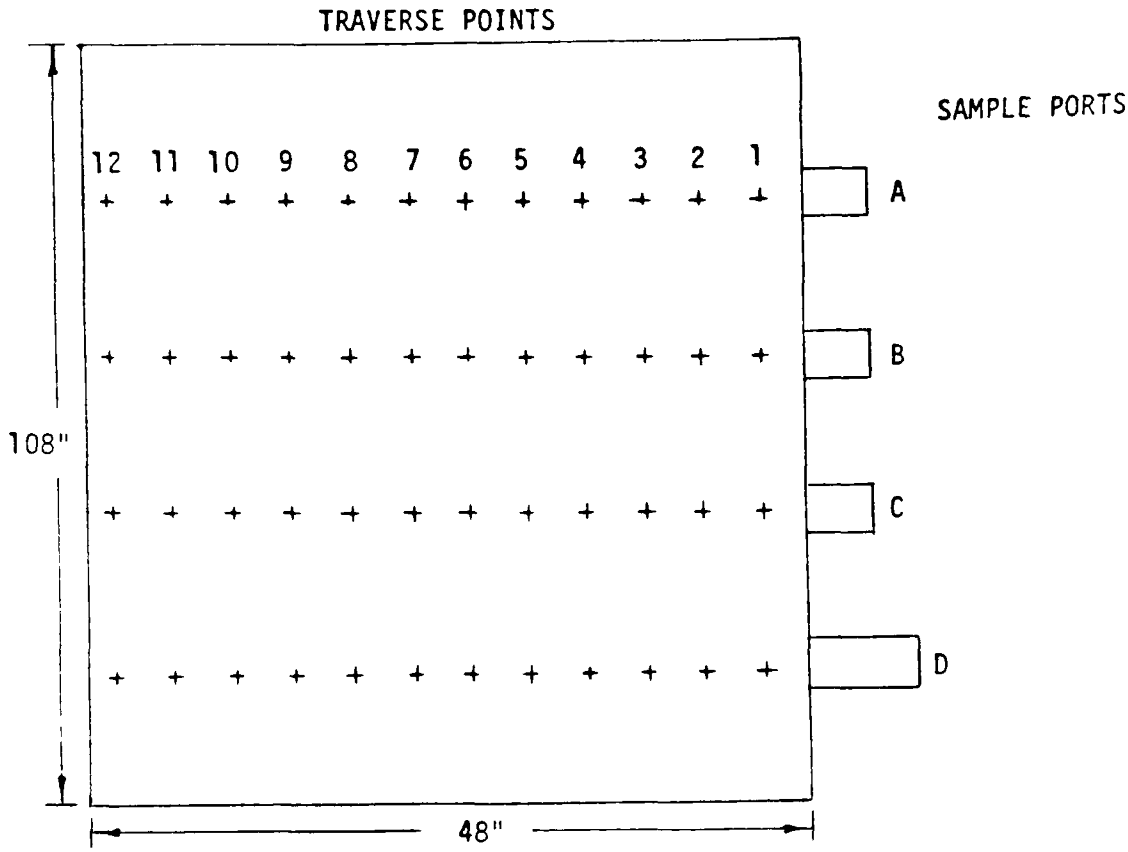


Figure 6. Location of Electroscrubber inlet sampling ports, Weyerhaeuser, Longview, Washington.



Cross Section of Inlet Duct 3.

Traverse Point Number	Distance From Duct Wall (Inches)
1	2.0
2	6.0
3	10
4	14
5	18
6	22
7	26
8	30
9	34
10	38
11	42
12	46

Figure 7. Sampling port and point locations at inlet duct 3

The sampling location of duct #3 is less than 1/2 duct diameter from the nearest upstream disturbance (split), and over four equivalent duct diameters from the nearest downstream disturbance (bend). Forty-eight sampling points were selected with twelve points in each of the four ports, as shown in Figure 7.

Electroscrubber Outlet

Each of the Electroscrubber modules has a separate outlet stack; hence, there were three outlet sampling locations. Fortunately, a common platform serves the three stacks with ample room and electrical power. Figure 8 is a top view of the sampling platform area, with dimensions noted. Outlet ports on each stack, 7-inch diameter with flange caps and 90° apart, are located 3 ft above the platform floor for each of the end stacks and 5 ft above the floor for the center stack. Lear Siegler in-stack opacity meters are installed below the ports on each stack.

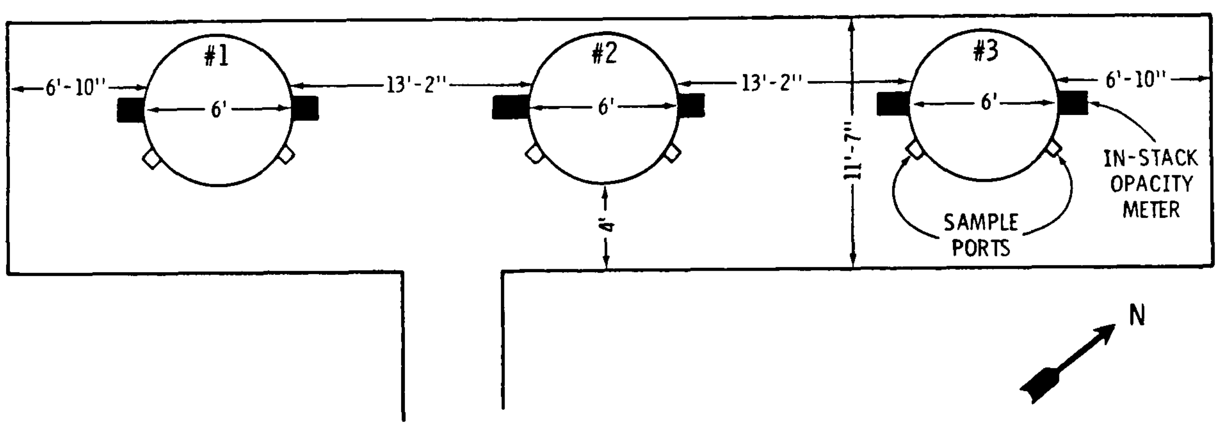


Figure 8. Electroscrubber triple stack outlet sampling location, top view, Weyerhaeuser, Longview, Washington.

The circular stacks are each 6 ft in diameter. The nearest upstream disturbance was an expansion about 28 ft (>4 diameters) away, and the nearest downstream disturbance was the stack outlet about 40 ft (>6 diameters) away. Figure 9 provides a side view of the outlet sampling location. Thirty-six sampling points were selected with eighteen points in each port.

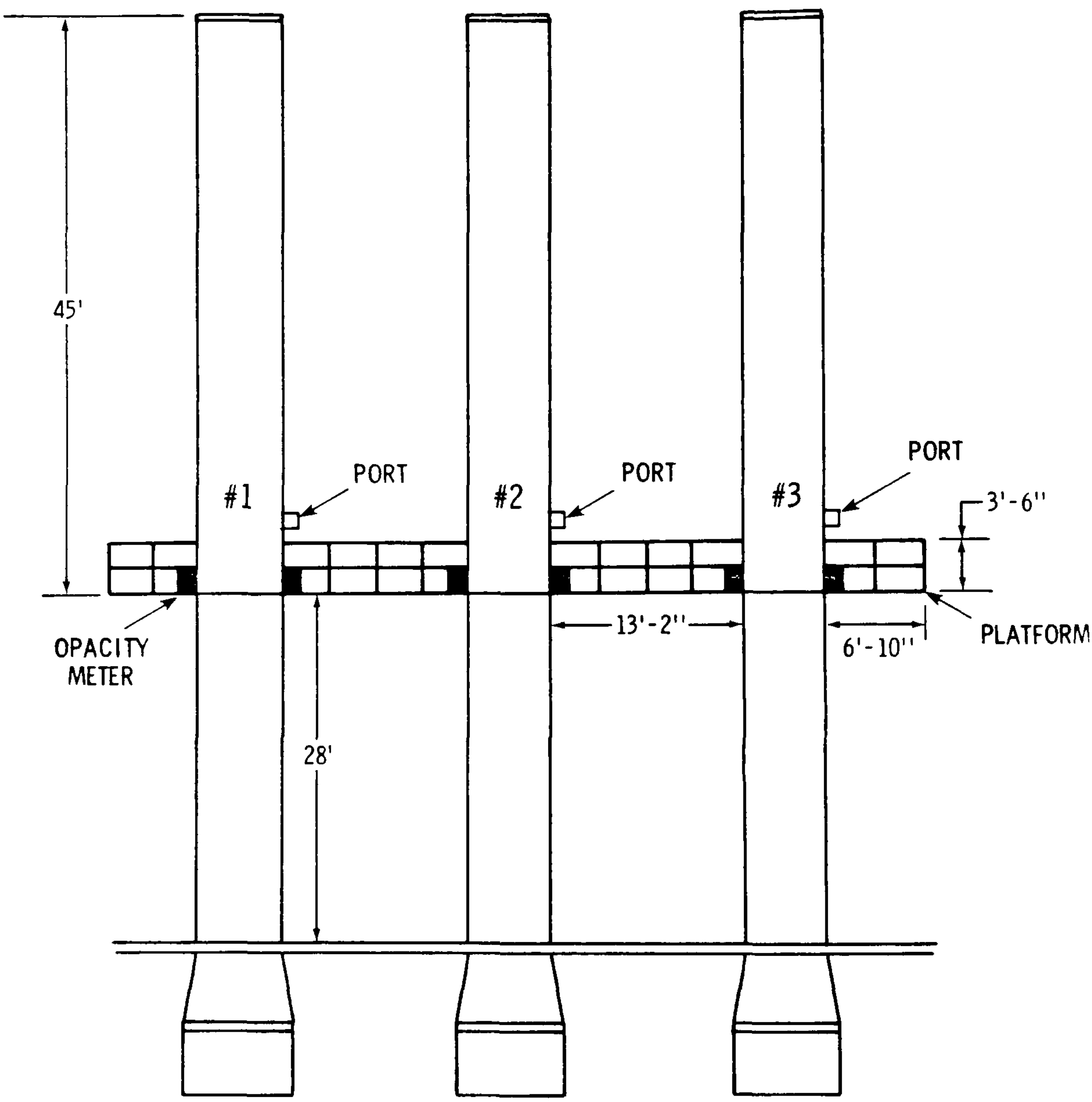


Figure 9. Electroscrubber triple stack outlet sampling location, side view, Weyerhaeuser, Longview, Washington.

SECTION 5

SAMPLING AND ANALYTICAL PROCEDURES

The Weyerhaeuser-Longview Mill was sampled for particulate matter, particle size, opacity, integrated gas analysis, BaP, NO_x, and fuel analysis.

The following describes the methods used.

Sampling Procedures

Particulate Matter--

Sampling for particulates was performed using the method outlined in the Federal Register (40 CFR 60, Subpart A), Method 5, "Determination of Particulate Emissions from Stationary Sources," modified so that the sample box temperature was 325°F instead of 250°F. A 5-ft glass-lined probe with pre-filter cyclone was used at the inlet sampling location, and an 8-ft stainless steel probe without cyclone was used at the outlet. A six-step cleanup was used on the stainless steel probes.

Particle Size--

Sampling for particle size was performed using an Andersen cascade impactor with seven stages and a back-up filter.

The sampling train used consisted of the following equipment listed in order of the flow: a 10-mm diameter probe tip; a curved (90°) probe tip to Andersen head connector; standard Andersen heads; a probe; a Smith-Greenburg impinger with water, then one charged with color indicating silica gel; and an EPA-5 console equipped with a dry gas meter, digital electronic thermometer and an inclined manometer. Also, an S-type pitot tube was connected to the probe so the stack pressure could be continually monitored. A 5-ft glass-lined probe with pre-separator was used at the inlet sampling location, and an 8 ft stainless steel probe without preseparator was used at the outlet location.

A total of three particle sizing runs were made simultaneously at the inlet and outlet locations. Each run was conducted for about 5-10 minutes under isokinetic conditions at the inlet location and for 15-25 minutes at the stack outlet. At the completion of each run, the moisture collected was measured and the Andersen heads were opened, filters removed.

All weight measurements were made with a Mettler analytical balance. The balance was calibrated daily and rezeroed before each weight determination. Calculations were performed using the methods and tables provided in the Andersen manual.

Opacity--
Visible emissions of the outlet stacks were to be read during particulate sampling by a certified smoke reader; however, readings were cancelled due to interferences in the background from steam plume sources.

Integrated Gas Composition--
Exhaust gas sampling was performed using the method outlined in the Federal Register, Method 3, "Gas Analysis for Carbon Dioxide Oxygen, Excess Air, and Dry Molecular Weight."

Nitrogen Oxides--
Sampling for NO_x was performed using the method outlined in the Federal Register, Method 7, "Determination of Nitrogen Oxide Emissions from Stationary Sources."

Benzo-alpha-pyrene--
A Battelle trap, preloaded with XAD-2 resin to adsorb BaP and wrapped in aluminum foil to prevent visible and ultraviolet light from reaching the resin, was incorporated in a Method 5 sampling train. The Battelle trap was heated and maintained at a temperature of 127°F by a thermostatically controlled recirculating water bath. Figure 10 is a schematic of a typical BaP modified Method 5 train. Figure 11 illustrates the XAD-2 sorbent resin trap.

The front half of the sampling train consisted of a stainless steel nozzle, a heated three foot glass sample probe, a heated flex line, a heated glass fiber filter, and a cooling coil used as a spacer to help accomodate the XAD-2 resin trap. The Battelle trap that contained the XAD-2 resin was held in an upright condition with the gas flow passing through from the top towards the frit. The back half of the train consisted of four impingers that held: 100 grams water, 100 grams water, blank and 200 grams silica gel as a dessicant. An internal thermocouple at the exit of the fourth impinger was used to read the internal gas temperature. The four impingers were kept in an ice water bath to help cool the gas stream.

At the conclusion of each test, the sampling train was disassembled, sealed and moved to the clean area for recovery. The dry particulate in the cyclone is removed and placed in an amber 250 mL bottle. The nozzle, glass probe liner, cyclone, heated flex line, filter housing, and the spacer - condenser were rinsed with Burdick and Jackson Distilled-In-Glass methylene chloride. Any adhering particulate was loosened with a nylon brush and the train was rinsed again with methylene chloride. The rinses were placed in a 950 mL amber glass bottle and labeled.

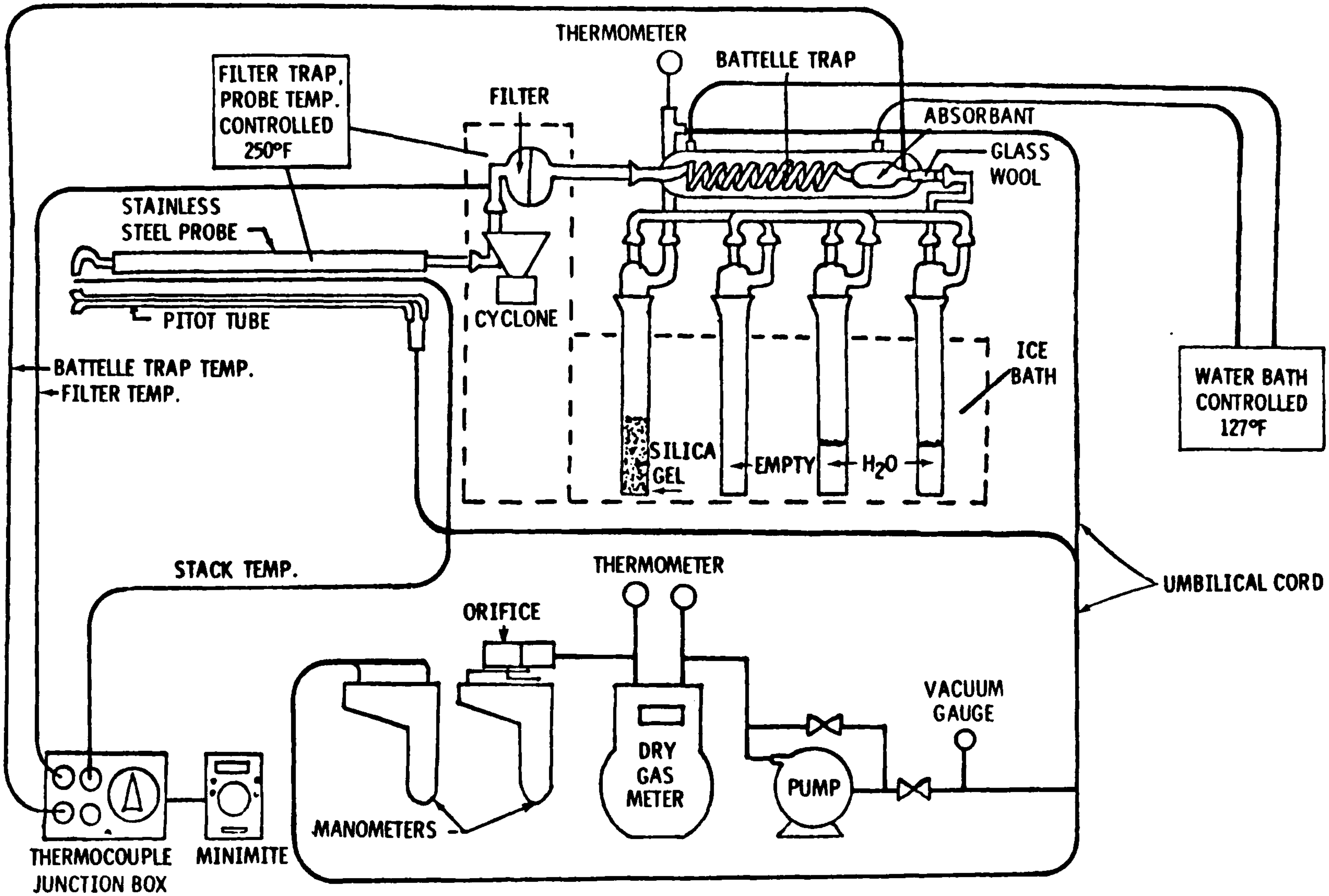


Figure 10. BaP sample train.

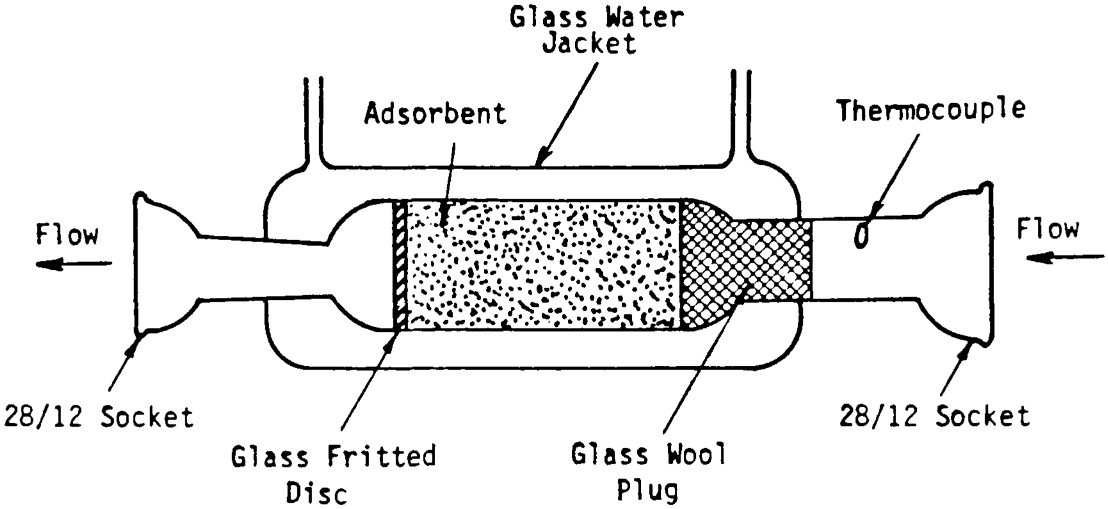


Figure 11. Schematic of sorbent trap.

was rinsed again with methylene chloride. The rinses were placed in a 950 mL amber glass bottle and labeled.

The filters were removed, folded, and placed in a 250 mL amber glass bottle.

The impingers were each weighed and the combined weight gain was the amount of water codensate collected. The contents of the first impinger were saved in a 950 mL amber glass bottle as a check on resin break through.

Fuel--
Fuel samples were grabbed in polyethylene bags from the bark conveyer to the boilers every 15 min during each test run, then composited afterwards for one fuel sample per run.

Analytical Procedures

Particulate Matter--
Analytical procedures were performed using the methods described in EPA Method 5, previously mentioned in the sampling procedures section.

Nitrogen Oxides--
Analytical procedures were performed using the methods described in EPA Method 7, previously mentioned in the sampling procedures section.

Benzo-alpha-pyrene--
Each test run resulted in five fractions. These are: an impinger wash, which consists of the water and rinse from the impinger train; a probe rinse, which consists of the methylene chloride rinse of the probe and lines; the particulate filter; the cyclone catch; and the XAD-2 resin.

Some sample preparation was required prior to analysis. For the impinger samples, the preparation consisted of five 10 mL extractions of the water with cyclohexane. The extractions were performed in separatory funnels.

The probe rinse samples were filtered and placed in Kuderna-Danish concentrators (KD). Seven mL of cyclohexane was added to each sample prior to being concentrated. When the methylene chloride had evaporated, the remaining sample was rinsed with cyclohexane and brought to 25 mL cyclohexane.

The particulate filters along with the cyclone catch samples were placed in cellulose extraction thimbles in soxhlet extraction apparatus and extracted for eight hours with 150 mL cyclohexane. The cyclone catch was filtered and the water was extracted with five 30 mL portions of cyclohexane. The cyclohexane extract and the filtered cyclone catch were placed in a soxhlet extraction apparatus and extracted for eight hours separately from the filter.

The XAD-2 resin from each test run was removed from the Battelle trap, placed in cellulose thimbles, and extracted with 250 mL cyclohexane in soxhlet extraction apparatus for eight hours.

The cellulose thimbles used for the extractions were extracted with pure cyclohexane and the extract was analyzed for BaP prior to their use to check for contamination. The thimble was checked with a black light to conform complete extraction. Since BaP will photodegrade under exposure to light, all extractions and KD procedures were conducted under a yellow safe-light screen. The extract was stored in an amber bottle at 4°C until the analysis was performed.

The samples were analyzed for BaP using the fluorescence spectrophotometric procedure. This method is preferred over the thin layer chromatographic (TLC) method for low level BaP analysis, as the TLC method has only 0.01 the sensitivity of direct liquid measurement. The thin layer chromatography separation method with measurement by scanning *in-situ* with a scanning attachment for the spectrofluorometer was originally chosen, but lacked the sensitivity required for the analysis.

All the samples were analyzed on an Aminco SPF-125S spectrofluorometer. The excitation monochromater wavelength was set at 388 nm with a slit width of 1 mm (11 nm bandpass). The emission monochromater wavelength was set at 430 nm with a 0.5 mm slit width (0.5 nm bandpass). This produced the maximum peak height for BaP. The instrument becomes extremely substance specific at these very narrow slit widths and can measure BaP concentrations as low as 0.001 ppm. The fluorescence is expressed as a relative intensity value which is converted to BaP concentrations by analysis of a set of known standards. A standard curve is then plotted, and the μg/mL in the sample is then determined by the sample's relative intensity compared to the graph of the standards. A standard was analyzed after every four samples to be certain that there was no loss of sensitivity. Blanks were run before every sample to be certain that there was no contamination present in the cuvette.

For analytical purposes, the samples were divided into sections. The analysis of the filter consisted of the filter and cyclone catch combined. The XAD-2 resin was analyzed independently. The probe rinse was filtered and the filtrate (rinse) was analyzed separately from the particulate accumulated on the filter. These results can be seen in Appendix A. The impinger wash which was recovered as a check on the resin breakthrough was analyzed independently. The results showed 0 μg of BaP, indicating no breakthrough of resin, and so was not included in the sample total.

Fuel--

Analysis of the bark feed was performed using ASTM D 3178 for carbon and hydrogen, ASTM D 3176 for oxygen, ASTM D 3179 for nitrogen, ASTM D 3177 for sulfur, and ASTM D 3174 for ash. Fuel value was determined using ASTM D 2015.

Quality Assurance/Quality Control--

Results of quality control tests are furnished with the analytical data sheets provided in Appendix C.