United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EMB Report 80-WFB-2
February 1980

Air

EPA

Nonfossil Fueled Boilers

Emission Test Report
Owens-Illinois
Forest Products Division
Big Island, Virginia

NONFOSSIL FUELED BOILERS

Emission Test Report
Owens-Illinois
Forest Products Division
Big Island, Virginia

12-15 December 1979

Project No.: 80-WFB-2

Prepared for

Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Measurement Branch
Research Triangle Park
North Carolina 27711

by

James A. Peters and Windle H. McDonald

Contract 68-02-2818, Work Assignment No. 23

February 1980

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTION 1

INTRODUCTION

The Big Island Paper Mill of Owens-Illinois, Inc., Forest Products Division, in Big Island, Virginia was emission tested by Monsanto Research Corporation (MRC) for the U.S. Environmental Protection Agency (EPA) under Contract Number 68-02-2818, Work Assignment Number 23. The purpose of testing the Big Island Mill was to gather data that could possibly be used to support the setting of standards of performance for the non-fossil fuel boiler industry; in this case, the production of process steam from firing wood bark and sawdust waste in conjunction with coal. Gaseous, particulate and trace metal emissions were determined by simultaneous sampling of four points: inlets and outlets of control devices at two parallel boilers. The two boiler units sampled consisted of one firing 100% wood waste and another firing 100% coal. Each boiler is equipped with a multicyclone, the outlets of which feed a common exhaust duct. This exhaust duct is split into two equal streams each equipped with a five-stage electrostatic precipitator (ESP).

The field test work was monitored by Dan Bivins, Field Testing Section, Emission Measurement Branch, EPA. The sampling performed by MRC was directed by Windle H. McDonald as team leader. The Big Island Mill was sampled by MRC during the week of December 10-15, 1979. The sample collection methods employed were EPA Methods 3, 5, 6, 7, and 9, with trace metals collected in the back half of the Method 5 sampling train, and particulate sizing by Andersen cascade impactor. The trace metals collected were analyzed using atomic absorption spectrophotometry (AAS).

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

During this field test a total of three particulate matter emission runs were conducted at four locations simultaneously. The cyclone inlet and ESP outlet of boiler #4 are designated as the Trackside locations (because of their physical proximity to the railroad tracks to the plant), and the cyclone inlet and ESP outlet of boiler #5 are designated as the Riverside locations. The stack sampling procedure consisted of extracting four samples simultaneously for each test, one from each multiclone inlet duct and one from each ESP outlet stack.

Boiler #4 (Trackside) was 100% coal-fired and boiler #5 (Riverside) was 100% wood-fired. Sootblowing is performed on both boilers at the beginning of each plant shift, at 7:00 A.M., 3:00 P.M., and 11:00 P.M. During this emission test no sootblows were made during any of the three runs.

The normal operating mode of the two boilers sampled is to operate the Trackside (coal-fired) boiler at a constant loading, and to vary the Riverside (wood-fired) boiler loading with demand. This operating mode was continued during all three sampling runs. The output loading of the Riverside boiler varied from 50,000 to 150,000 lb steam/hr, while the Trackside boiler load varied from 90,000 to 150,000 lb steam/hr. During Test 3 a greater portion of the plant load (about 150,000 lb/hr) was being carried by the coal-fired boiler because of lower bark availability on Saturdays.

On December 11, one electrostatic precipitator was out of service and under repair. At approximately 4:00 P.M. the precipitator was returned to full service, with all five fields of both precipitators operating normally with rapping being performed automatically. Once the plant operation became normal, preliminary velocity traverses for nozzle sizing were made.

Emission test run #1 began at 1:25 P.M. on December 12. After approximately 25 minutes of sampling, one train's filter plugged, and sampling was interrupted for two hours. The sampling then ran normally until 4:50 P.M. when a paper machine breakdown reduced boiler load to about 10% of normal and testing was interrupted. At 5:50 P.M. the plant returned to normal operation, and the test was completed at 6:31 P.M.

On December 14 sampling began at 11:25 A.M. for test run #2, and was completed at 2:55 P.M. without major incident, with the exception of low velocity in one duct causing an extended sampling time.

On December 15 sampling started at 10:45 A.M. for test run #3, and was completed at 1:15 P.M. without incident. A paper machine breakdown occurred in the plant during the sampling period, but the time coincided with port changes so that sampling was unaffected.

Emissions of particulate matter and stack gas parameters are summarized in Tables 1 and 2. All test runs were conducted within isokinetic variation. Stack flow rates averaged 26% higher at the outlet over the inlet on the Riverside unit and 62% on the Trackside unit. The source of additional flow is not known. Integrated gas analysis results are given in Table 3; small amounts of CO were detected at the cyclone inlet of the wood-fired boiler.

Test runs for SO_2 and NO_x emissions were made immediately prior or after each particulate emission test. Results of SO_2 emissions are given in Table 4; runs 1-B at the Riverside outlet and 1-A at the Trackside outlet are suspect due to their very low values. No analysis errors were found and field data sheets indicated no problems, but subcontracted personnel performed the sampling and may have made procedural mistakes. Statistical tests for outlying data indicate that these data cannot be excluded. Table 5 contains the summarized results of NO_x emissions.

Particulate sizing by Andersen cascade impactor was done at the inlet and outlet of the Riverside emission control units (wood-fired) and the outlet only of the Trackside (coal-fired) since uncontrolled emissions from coal-fired boilers have been well characterized. Results are presented in Table 6; three runs were outside of isokinetic variation due to low sampler flowrates.

Opacity readings were taken by a certified observer during each emission test. Summarized results of opacity readings are given in Table 7. Plume readings hovered around 15% opacity during runs 1 and 2, and around 10% opacity during run 3. Complete opacity results are furnished in Appendix C.

Samples of fuel were collected during each emission test run for ultimate analysis. Table 8 presents a summary of analysis results of the bark and coal fuels.

Plant operating data for each of three emission tests is summarized in Table 9. Complete operating data taken during testing is contained in Appendix B. The coal and bark feed rates given in Table 9 were not directly measured since the plant measures only

TABLE 1. PARTICULATE EMISSION DATA AND STACK GAS PARAMETERS, OWENS-ILLINOIS, BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979 (ENGLISH UNITS)

Run number	Date	Time, min	Temperature, °F	Flow, dscfm	H_2O, percent	Isokinetic, percent	Emissions: Actual			Emissions: Corrected to 12 percent CO_2
							gr/dscf	lb/hr	lb/mm Btu	gr/dscf
Riverside Inlet Boiler #5										
1	12/12/79	98	305	63,323	6.34	98.1	0.7956	431.8	3.4270	1.5399
2	12/14/79	98	299	58,678	13.66	106.4	2.0713	1,041.6	7.4667	4.6029
3	12/15/79	98	287	53,945	12.54	96.1	2.1854	1,010.3	9.4509	3.8569
Average		98	297	58,649	10.85		1.6841	827.9	6.7815	3.3332
Trackside Inlet Boiler #4										
1	12/12/79	90	355	52,412	6.46	96.5	3.8476	1,728.2	8.3852	5.3070
2	12/14/79	135	378	44,962	4.31	105.0	3.3882	1,305.6	6.1906	5.0823
3	12/15/79	112.5	401	45,685	6.22	96.4	3.8552	1,509.4	6.2141	5.6418
Average		112.5	378	47,686	5.66		3.6970	1,514.4	6.9300	5.3437
Riverside Outlet										
1	12/12/79	98	324	72,661	8.37	95.3	0.0888	55.3	0.4389	0.1747
2	12/14/79	96	312	73,719	9.87	95.5	0.1255	79.3	0.5685	0.3204
3	12/15/79	96	315	75,293	7.25	95.5	0.0951	61.4	0.5744	0.1678
Average		97	317	73,891	8.50		0.1031	65.3	0.5273	0.2210
Trackside Outlet										
1	12/12/79	96	315	76,571	8.49	99.5	0.1277	83.8	0.4066	0.3191
2	12/14/79	96	307	77,770	8.99	99.5	0.1183	78.9	0.3741	0.2448
3	12/15/79	96	304	76,822	8.18	99.9	0.1002	66.0	0.2717	0.1718
Average		96	309	77,054	8.55		0.1154	76.2	0.3508	0.2453

TABLE 2. PARTICULATE EMISSION DATA AND STACK GAS PARAMETERS, OWENS-ILLINOIS BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979 (METRIC UNITS)

Run number	Date	Time, min	Temperature, °C	Flow, dncmpm	H_2O, percent	Isokinetic, percent	Emissions: Actual, gr/dncm	Emissions: Actual, kg/hr	Emissions: Actual, kg/GJ	Emissions: Corrected to 12 percent CO_2, gr/dncm
Riverside Inlet Boiler #5										
1	12/12/79	98	152	1,793	6.34	98.1	1.8211	195.8	1.4733	3.5247
2	12/14/79	98	148	1,662	13.66	106.4	4.7410	472.5	3.2099	10.5356
3	12/15/79	98	142	1,528	12.54	96.1	5.0022	458.3	4.0629	8.8274
Average		98	147	1,661	10.85		3.8548	375.5	2.9154	7.6292
Trackside Inlet Boiler #4										
1	12/12/79	90	180	1,484	6.46	96.5	8.8067	783.9	3.6041	12.1472
2	12/14/79	135	192	1,273	4.31	105.0	7.7553	592.2	2.6616	11.6330
3	12/15/79	112.5	205	1,294	6.22	96.4	8.8242	684.7	2.6715	12.9135
Average		112.5	192	1,350	5.66		8.4621	686.9	2.9791	12.2312
Riverside Outlet										
1	12/12/79	98	162	2,058	8.37	95.3	0.2033	25.1	0.1889	0.3999
2	12/14/79	96	156	2,088	9.87	95.5	0.2872	36.0	0.2446	0.7333
3	12/15/79	96	157	2,132	7.25	95.5	0.2178	27.8	0.2465	0.3844
Average		97	158	2,093	8.50		0.2361	29.6	0.2267	0.5059
Trackside Outlet										
1	12/12/79	96	157	2,168	8.49	99.5	0.2922	38.0	0.1747	0.7305
2	12/14/79	96	153	2,202	8.99	99.5	0.2709	35.8	0.1609	0.5605
3	12/15/79	96	151	2,176	8.18	99.9	0.2293	29.9	0.1167	0.3931
Average		96	154	2,182	8.55		0.2641	34.6	0.1508	0.5614

TABLE 3. SUMMARY OF INTEGRATED GAS ANALYSES, OWENS-ILLINOIS BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979

Run number	Date	CO_2, percent	O_2, percent	CO, percent	N_2, percent	MW, lb/lb mole
Riverside Inlet Boiler #5						
1	12/12/79	6.2	13.99	0.55	79.3	29.56
2	12/14/79	5.4	14.8	0.2	79.6	29.47
3	12/15/79	6.8	11.2	0.0	82.0	29.54
Trackside Inlet Boiler #4						
1	12/12/79	8.7	11.4	0.0	79.8	29.86
2	12/14/79	8.0	10.4	0.0	81.6	29.70
3	12/15/79	8.2	10.9	0.0	80.9	29.75
Riverside Outlet						
1	12/12/79	6.1	13.99	0.0	80.0	29.56
2	12/14/79	4.7	14.6	0.0	80.7	29.34
3	12/15/79	6.8	13.2	0.0	80.0	29.62
Trackside Outlet						
1	12/12/79	5.2	15.6	0.0	79.2	29.41
2	12/14/79	5.8	13.8	0.0	80.4	29.48
3	12/15/79	7.0	11.2	0.0	81.8	29.57

TABLE 4. SUMMARY OF SO_2 EMISSION RESULTS, OWENS-ILLINOIS, BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979

Run number	Date	lb/dscf x 10^{-6}	lb/hr[a]	lb/mm Btu
Riverside Outlet				
1-A	12/12/79	30.27	128.74	1.022
1-B	12/12/79	1.28	5.47	0.043
2-A	12/14/79	42.20	186.66	1.338
2-B	12/14/79	37.89	167.60	1.201
3-A	12/15/79	8.17	36.12	0.338
3-B	12/15/79	22.38	98.98	0.926
Average		23.70	103.93	0.811
Trackside Outlet				
1-A	12/12/79	0.72	3.32	0.016
1-B	12/12/79	19.87	91.29	0.443
2-A	12/14/79	33.99	158.49	0.751
2-B	12/14/79	26.52	123.63	0.586
3-A	12/15/79	19.09	89.01	0.366
3-B	12/15/79	34.85	162.52	0.669
Average		22.51	104.71	0.472

[a]Based on corresponding EPA Method 5 run for volumetric flow rate (dscfm).

TABLE 5. SUMMARY OF NO_x EMISSION RESULTS, OWENS-ILLINOIS, BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979

Run Number	Date	ppm	lb/dscf x 10^{-6}	lb/hr[a]	lb/mm Btu x 10^{-3}	g/ncm x 10^{-2}	kg/hr[a]
Riverside Outlet							
1-1	12/12/79	2.22	0.262	1.143	9.071	0.420	0.519
1-2	12/12/79	0.11	0.013	0.055	0.437	0.020	0.025
1-3	12/12/79	0.12	0.014	0.061	0.484	0.022	0.028
Average		0.82	0.096	0.420	3.331	0.154	0.191
2-1	12/14/79	3.70	0.438	1.936	13.878	0.701	0.878
2-2	12/14/79	3.82	0.451	1.997	14.315	0.723	0.906
2-3	12/14/79	3.81	0.451	1.994	14.294	0.722	0.904
2-4	12/14/79	3.40	0.403	1.780	12.760	0.645	0.808
Average		3.68	0.436	1.927	13.812	0.698	0.874
3-1	12/15/79	1.35	0.160	0.707	6.614	0.256	0.321
3-2	12/15/79	3.84	0.455	2.011	18.812	0.728	0.912
3-3	12/15/79	2.21	0.261	1.155	10.804	0.418	0.524
Average		2.44	0.289	1.278	11.948	0.463	0.580
Trackside Outlet							
1-1	12/12/79	2.50	0.296	1.360	6.599	0.474	0.617
1-2	12/12/79	0.13	0.015	0.069	0.335	0.024	0.031
1-3	12/12/79	2.07	0.245	1.126	5.463	0.392	0.511
Average		1.57	0.185	0.852	4.132	0.297	0.170
2-1	12/14/79	2.78	0.329	1.537	7.288	0.527	0.697
2-2	12/14/79	2.74	0.325	1.514	7.179	0.520	0.687
2-3	12/14/79	2.04	0.241	1.124	5.330	0.386	0.510
2-4	12/14/79	2.58	0.305	1.423	6.747	0.488	0.645
Average		2.54	0.300	1.400	6.636	0.480	0.635
3-1	12/15/79	2.67	0.316	1.475	6.072	0.506	0.669
3-2	12/15/79	3.42	0.405	1.888	7.773	0.648	0.856
3-3	12/15/79	4.01	0.475	2.216	9.123	0.761	1.005
Average		3.37	0.399	1.860	7.656	0.638	0.843

[a]Based on corresponding EPA Method 5 run for volumetric flow rate (dscfm).

TABLE 6. SUMMARY OF ANDERSEN PARTICLE SIZING RESULTS, OWENS-ILLINOIS, BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979

Riverside Cyclone Inlet

Run RI-1			Run RI-2			Run RI-3		
Flow rate (ACFM): 0.26			Flow rate (ACFM): 0.32			Flow rate (ACFM): 0.26		
% ISO: 106.3			% ISO: 99.4			% ISO: 99.4		
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
25.3	84.9	>19.5	47.8	52.1	>17.5	21.1	78.9	>19.5
16.2	59.6	13.3 - 19.5	0.7	51.4	11.9 - 17.5	3.4	75.5	13.3 - 19.5
14.9	43.4	8.9 - 13.3	11.6	39.8	7.95 - 11.9	14.3	61.2	8.9 - 13.3
19.5	23.9	6.1 - 8.9	8.7	31.1	5.5 - 7.95	14.3	46.9	6.1 - 8.9
1.3	22.6	3.9 - 6.1	12.3	18.8	3.45 - 5.5	8.2	38.7	3.9 - 6.1
3.2	19.4	2.03 - 3.9	6.5	12.3	1.8 - 3.45	6.8	31.9	2.03 - 3.9
1.9	17.5	1.25 - 2.03	3.6	8.7	1.11 - 1.8	7.5	24.4	1.25 - 2.03
3.2	14.3	0.84 - 1.25	0.7	8.0	0.75 - 1.11	8.8	15.6	0.84 - 1.25
14.3	0	0 - 0.84	8.0	0	0 - 0.75	15.6	0	0 - 0.84

Riverside ESP Outlet

Run RO-1			Run RO-2			Run RO-3		
Flow rate (ACFM): 0.23			Flow rate (ACFM): 0.214			Flow rate (ACFM): 0.24		
% ISO: 98.95			% ISO: 85.6			% ISO: 93.55		
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
6.8	93.3	>22.0	7.3	92.8	>23.0	18.0	82.0	>21.6
2.1	91.2	14.0 - 22.0	23.7	69.1	14.5 - 23.0	4.6	77.4	13.9 - 21.6
4.4	86.8	9.4 - 14.0	7.3	61.8	9.9 - 14.5	7.6	69.8	9.3 - 13.9
40.0	46.8	6.25 - 9.4	4.4	57.4	6.7 - 9.9	15.8	54.0	6.4 - 9.3
31.4	15.4	4.15 - 6.25	12.6	44.8	4.4 - 6.7	16.1	37.9	4.05 - 6.4
8.0	7.4	2.15 - 4.15	16.9	27.9	2.2 - 4.4	16.1	21.8	2.11 - 4.05
2.6	4.8	1.33 - 2.15	18.8	9.1	1.35 - 2.2	5.7	16.1	1.3 - 2.11
2.4	2.4	0.9 - 1.33	8.4	0.7	0.9 - 1.35	0.8	15.3	0.89 - 1.3
2.4	0	0 - 0.9	0.7	0	0 - 0.9	15.3	0	0 - 0.89

Trackside ESP Outlet

Run TO-1			Run TO-2			Run TO-3		
Flow rate (ACFM): 0.41			Flow rate (ACFM): 0.40			Flow rate (ACFM): 0.18		
% ISO: 103.2			% ISO: 72.3			% ISO: 38.6		
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
19.3	80.7	>16.5	7.2	93.0	>17.5	0	100	>25.0
7.6	73.1	10.5 - 16.5	13.2	79.8	11.0 - 17.5	1.4	98.7	16.0 - 25.0
0.6	72.5	7.1 - 10.5	10.2	69.6	7.3 - 11.0	9.9	88.8	10.8 - 16.0
2.3	70.2	4.85 - 7.1	10.0	59.6	4.9 - 7.3	9.9	78.9	7.4 - 10.8
11.1	59.1	3.05 - 4.85	11.4	48.2	3.4 - 4.9	11.3	67.6	4.7 - 7.4
31.6	27.5	1.6 - 3.05	15.0	33.2	1.6 - 3.4	13.4	54.2	2.4 - 4.7
11.1	16.4	0.97 - 1.6	17.2	16.0	0.98 - 1.6	21.1	33.1	1.5 - 2.4
4.7	11.7	0.66 - 0.97	9.6	6.4	0.68 - 0.98	19.0	14.1	1.05 - 1.5
11.7	0	0 - 0.66	6.4	0	0 - 0.68	14.1	0	0 - 1.05

TABLE 7

SUMMARY OF VISIBLE EMISSIONS, OWENS-ILLINOIS, BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979

Owens-Illinois, Run R-1

Date: 12/12/79
Type of Discharge: stack
Height of Point of Discharge: 190 ft
Wind Direction: N-NW
Color or Plume: white-gray
Observer Name: S. Carter
Distance from Observer to Discharge Point: 100-150 yds
Direction of Observer from Discharge Point: West
Height of Observation Point: ground level

Type of Plant: Paper mill
Location of Discharge: Riverside stack
Description of Sky: scattered clouds
Wind Velocity: 0-5 mph
Detached Plume: no
Duration of observation: 138 min

SUMMARY OF AVERAGE OPACITY

Set Number	Time Start	Time End	Opacity Sum	Opacity Average
1	13:10	13:15	340	14.2
2	13:16	13:21	360	15.0
3	13:22	13:27	360	15.0
test began				
4	13:28	13:33	370	15.4
5	13:34	13:39	430	17.9
6	13:40	13:45	365	15.2
7	13:46	13:51	350	14.6
8	13:52	13:57	360	15.0
test interrupted				
9	15:50	15:55	305	12.7
10	15:56	16:01	510	21.3
11	16:02	16:07	365	15.2
12	16:08	16:13	555	23.1
test interrupted				
13	16:30	16:35	335	14.0
14	16:36	16:41	435	18.1
15	16:42	16:47	360	15.0
16	16:48	16:53	350	14.6
17	16:54	16:59	360	15.0
18	17:00	17:05	325	13.5
test interrupted				
19	17:50	17:55	360	15.0
20	17:56	18:01	370	15.4
21	18:02	18:07	365	15.2
22	18:08	18:13	360	15.0
23	18:14	18:19	360	15.0
tested ended				
Average, all sets				15.6%

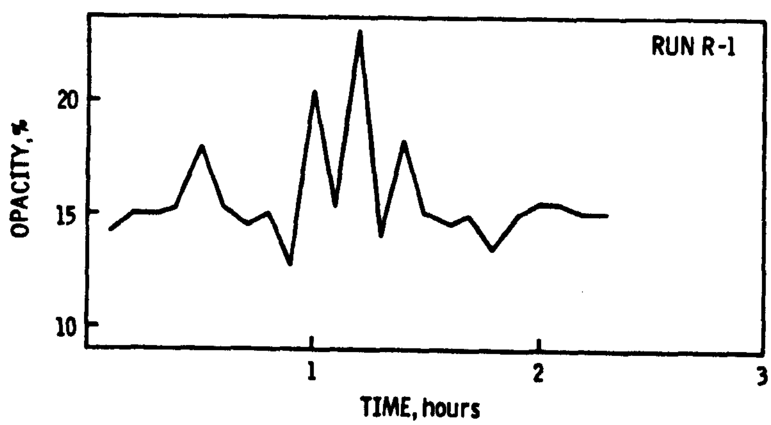

TABLE 7 (continued)

Owens-Illinois, Run R-2

Date: 12/14/79
Type of Discharge: stack
Height of Point of Discharge: 190 ft
Wind Direction: NW
Color or Plume: white-gray
Observer Name: S. Carter
Distance from Observer to Discharge Point: 100-150 yds
Direction of Observer from Discharge Point: West
Height of Observation Point: ground level

Type of Plant: Paper mill
Location of Discharge: Riverside stack
Description of Sky: clear
Wind Velocity: 0-5 mph
Detached Plume: no
Duration of observation: 126 min

SUMMARY OF AVERAGE OPACITY

Set Number	Time Start	Time End	Opacity Sum	Opacity Average
1	11:10	11:15	360	15.0
2	11:16	11:21	360	15.0
3	11:22	11:27	455	19.0
test began				
4	11:28	11:33	360	15.0
5	11:34	11:39	360	15.0
6	11:40	11:45	395	16.5
7	11:46	11:51	360	15.0
8	11:52	11:57	360	15.0
9	11:58	12:03	360	15.0
test interrupted				
10	12:34	12:39	420	17.5
11	12:40	12:45	360	15.0
12	12:46	12:51	360	15.0
13	12:52	12:57	360	15.0
14	12:58	13:03	360	15.0
15	13:04	13:09	535	22.3
16	13:10	13:15	360	15.0
17	1316	13:21	360	15.0
18	13:22	13:27	360	15.0
19	13:28	13:33	360	15.0
20	13:34	13:39	360	15.0
21	13:40	13:45	360	15.0
test ended				
Average, all sets				15.7%

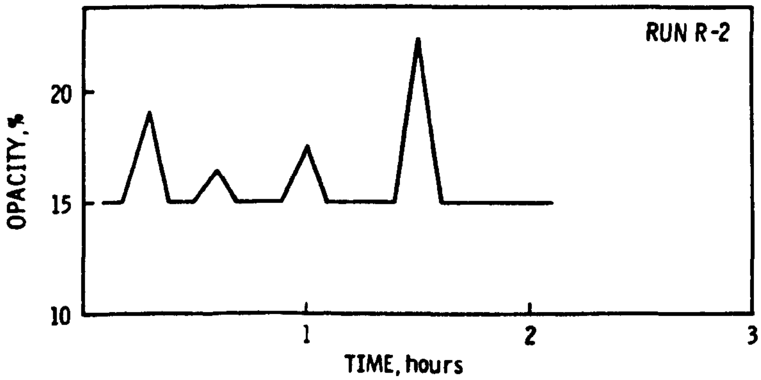

TABLE 7 (continued)

Owens-Illinois, Run R-3

Date: 12/15/79
Type of Discharge: stack
Height of Point of Discharge: 190 ft
Wind Direction: NW
Color or Plume: white-gray
Observer Name: V MacKnight
Type of Plant: Paper mill
Location of Discharge: Riverside stack
Description of Sky: partly cloudly and hazy
Wind Velocity: 5-10 mph
Detached Plume: no
Duration of observation: 144 min
Distance from Observer to Discharge Point: 100-150 yds
Direction of Observer from Discharge Point: West
Height of Observation Point: ground level

SUMMARY OF AVERAGE OPACITY

Set Number	Time Start	Time End	Opacity Sum	Opacity Average
1	10:00	10:05	250	10.4
2	10:06	10:11	430	17.9
3	10:12	10:17	345	14.4
4	10:18	10:23	265	11.0
5	10:24	10:29	255	10.6
6	10:30	10:35	245	10.2
7	10:36	10:41	505	21.0
8	10:42	10:47	240	10.0
test begins				
9	10:48	10:53	240	10.0
10	10:54	10:59	280	11.7
11	11:00	11:05	305	12.7
12	11:06	11:11	255	10.6
13	11:12	11:17	335	14.0
14	11:18	11:23	255	10.6
15	11:24	11:29	305	12.7
16	11:30	11:35	295	12.3
test interrupted				
17	11:52	11:57	285	11.9
18	11:58	12:03	275	11.5
19	12:04	12:09	255	10.6
20	12:10	12:15	275	11.5
21	12:16	12:21	490	20.4
22	12:22	12:27	285	11.9
23	12:28	12:33	240	10.0
24	12:34	12:39	285	11.9
test ended				
Average, all sets				12.5%

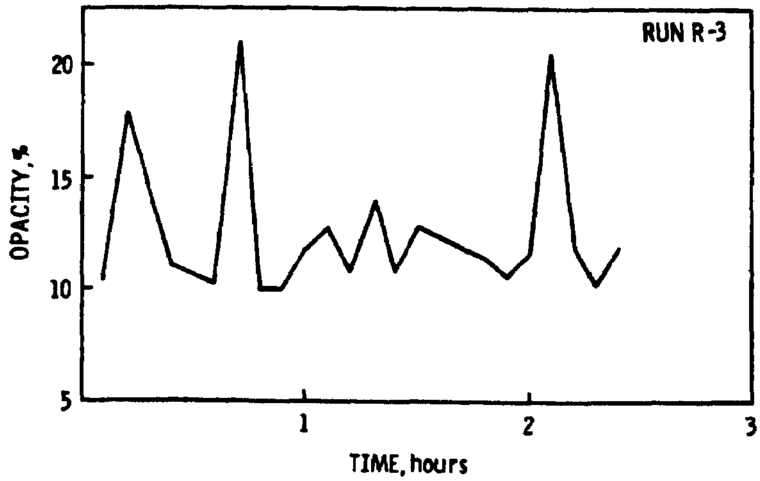

TABLE 7 (continued)

Owens-Illinois, Run T-1

Date: 12/12/79
Type of Discharge: stack
Height of Point of Discharge: 190 ft
Wind Direction: N-NW
Color or Plume: white-gray
Observer Name: S. Carter
Distance from Observer to Discharge Point: 100-150 yds
Direction of Observer from Discharge Point: West
Height of Observation Point: ground level

Type of Plant: Paper mill
Location of Discharge: Trackside stack
Description of Sky: scattered clouds
Wind Velocity: 0-5 mph
Detached Plume: no
Duration of observation: 120 min

SUMMARY OF AVERAGE OPACITY				
Set	Time		Opacity	
Number	Start	End	Sum	Average
1	13:10	13:15	340	14.2
2	13:16	13:21	360	15.0
3	13:22	13:27	360	15.0
test began				
4	13:28	13:33	370	15.4
5	13:34	13:39	335	14.0
6	13:40	13:45	350	14.6
7	13:46	13:51	350	14.6
8	13:52	13:57	470	19.6
test interrupted				
9	15:50	15:55	315	13.1
10	15:56	16:01	360	15.0
11	16:02	16:07	360	15.0
test interrupted				
12	16:30	16:35	370	15.4
13	16:36	16:41	335	14.0
14	16:42	16:47	360	15.0
15	16:48	16:53	455	19.0
test interrupted				
16	17:50	17:55	340	14.2
17	17:56	18:01	360	15.0
18	18:02	18:07	360	15.0
19	18:08	18:13	360	15.0
20	18:14	18:19	370	15.4
test ended				
Average, all sets				15.2%

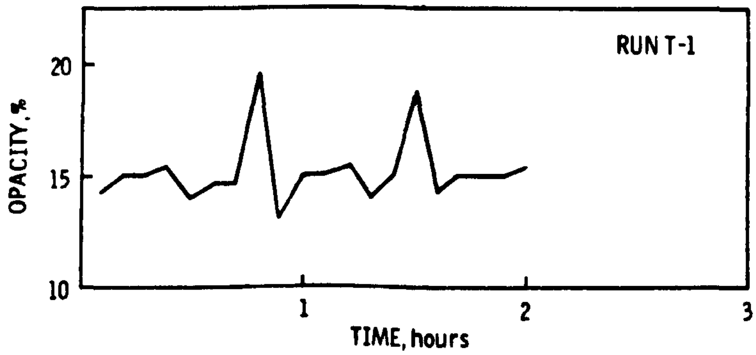

TABLE 7 (continued)

Owens-Illinois, Run T-2

Date: 12/14/79
Type of Discharge: stack
Height of Point of Discharge: 190 ft
Wind Direction: NW
Color of Plume: white-gray
Observer Name: S. Carter
Distance from Observer to Discharge Point: 100-150 yds
Direction of Observer from Discharge Point: West
Height of Observation Point: ground level

Type of Plant: Paper mill
Location of Discharge: Trackside stack
Description of Sky: clear
Wind Velocity: 0-5 mph
Detached Plume: no
Duration of observation: 150 min

SUMMARY OF AVERAGE OPACITY

Set Number	Time Start	Time End	Opacity Sum	Opacity Average
1	11:10	11:15	360	15.0
2	11:16	11:21	360	15.0
3	11:22	11:27	360	15.0
test began				
4	11:28	11:33	360	15.0
5	11:34	11:39	360	15.0
6	11:40	11:45	380	15.8
7	11:46	11:51	360	15.0
8	11:52	11:57	360	15.0
9	11:58	12:03	360	15.0
10	12:04	12:09	360	15.0
11	12:10	12:15	360	15.0
12	12:16	12:21	360	15.0
13	12:22	12:27	360	15.0
14	12:28	12:33	400	16.7
15	12:34	12:39	360	15.0
16	12:40	12:45	360	15.0
17	12:46	12:51	360	15.0
test interrupted				
18	12:56	13:01	360	15.0
19	13:02	13:07	360	15.0
20	13:08	13:13	360	15.0
21	13:14	13:19	490	20.4
22	13:20	13:25	360	15.0
23	13:26	13:31	360	15.0
24	13:32	13:37	360	15.0
25	13:38	13:43	360	15.0
test ended				
Average, all sets				15.3%

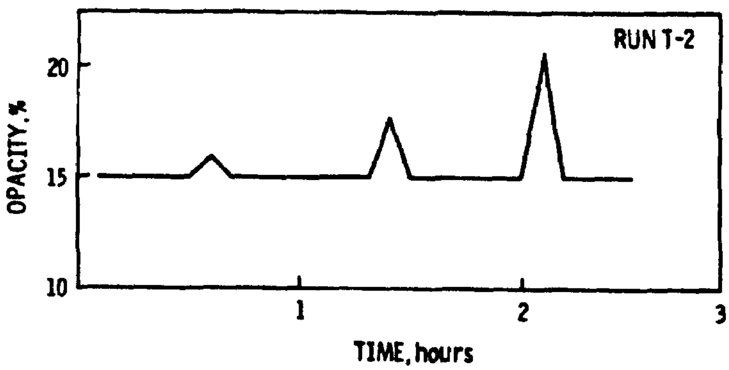

TABLE 7 (continued)

Owens-Illinois, Run T-3

Date: 12/15/79
Type of Discharge: stack
Height of Point of Discharge: 190 ft
Wind Direction: NW
Color or Plume: white-gray
Observer Name: V MacKnight
Distance from Observer to Discharge Point: 100-150 yds
Direction of Observer from Discharge Point: West
Height of Observation Point: ground level

Type of Plant: Paper mill
Location of Discharge: Trackside stack
Description of Sky: partly cloudly and hazy
Wind Velocity: 5-10 mph
Detached Plume: no
Duration of observation: 144 min

SUMMARY OF AVERAGE OPACITY

Set Number	Time Start	Time End	Opacity Sum	Opacity Average
1	10:00	10:05	245	10.2
2	10:06	10:11	305	12.7
3	10:12	10:17	250	10.4
4	10:18	10:23	240	10.0
5	10:24	10:29	430	17.9
6	10:30	10:35	260	10.8
7	10:36	10:41	245	10.2
test began				
8	10:42	10:47	240	10.0
9	10:48	10:53	240	10.0
10	10:54	10:59	250	10.4
11	11:00	11:05	280	11.7
12	11:06	11:11	255	10.6
13	11:12	11:17	255	10.6
14	11:18	11:23	250	10.4
15	11:24	11:29	320	13.3
16	11:30	11:35	240	10.0
test interrupted				
17	11:52	11:57	295	12.3
18	11:58	12:03	305	12.7
19	12:04	12:09	505	21.0
20	12:10	12:15	335	14.0
21	12:16	12:21	255	10.6
22	12:22	12:27	240	10.0
23	12:28	12:33	260	10.8
24	12:34	12:39	255	10.6
test ended				
Average, all sets				11.7%

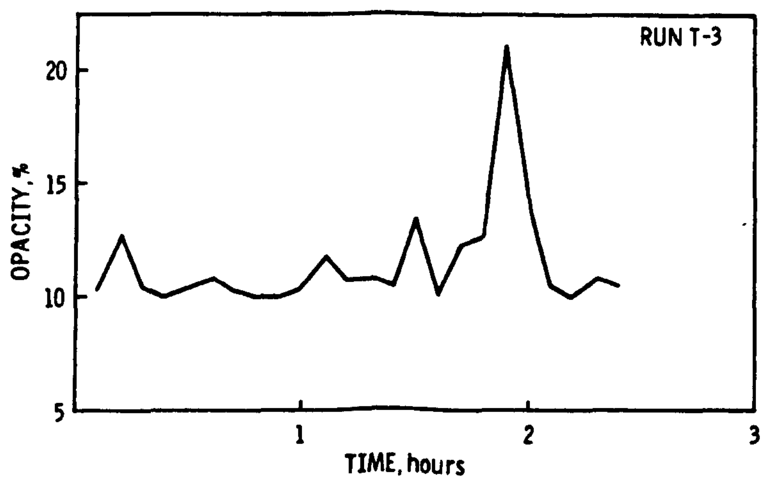

TABLE 8. SUMMARY OF FUEL ULTIMATE ANALYSES, OWENS-ILLINOIS, BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979

Sample number	Date	Carbon, percent	Hydrogen, percent	Nitrogen, percent	Sulfur, percent	Ash, percent	Oxygen, percent	Fuel value, Btu/lb
Trackside coal bin boiler #4								
Run 1	12/12/79							
as received		58.21	4.16	0.94	0.56	19.70	16.43	11,104
dry basis		61.94	3.71	1.00	0.60	20.96	11.79	11,815
Run 2	12/14/79							
as received		68.84	5.37	1.53	1.09	10.52	12.65	12,416
dry basis		73.52	4.98	1.63	1.16	11.23	7.48	13,258
Run 3	12/15/79							
as received		61.56	4.68	1.19	0.97	16.28	15.32	11,624
dry basis		64.20	4.40	1.24	1.01	16.98	12.17	12,122
Riverside bark screw feeder boiler #5								
Run 1	12/12/79							
as received		26.27	8.07	0.12	0.02	2.17	63.35	4,615
dry basis		46.58	5.73	0.21	0.03	3.84	43.61	8,183
Run 2	12/14/79							
as received		25.67	8.10	0.15	0.02	2.23	63.83	4,675
dry basis		45.74	5.73	0.26	0.03	3.98	44.26	8,330
Run 3	12/15/79							
as received		24.72	8.09	0.13	0.01	2.82	64.23	4,527
dry basis		45.13	5.59	0.24	0.02	5.14	43.88	8,265

TABLE 9. AVERAGE BOILER OPERATING PARAMETERS DURING TESTING, OWENS-ILLINOIS, BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979

Boiler	Test 1	Test 2	Test 3
Boiler test time, min	120	171	100
Boiler #4 (Trackside)			
Steam production, 10^3 lb/hr	123	126	145
Steam pressure, psig	585	578	580
Steam heat output, mm Btu/hr[a]	206.1	210.9	242.9
Coal feed rate, ton/hr[b]	6.9	7.0	8.1
Boiler #5 (Riverside)			
Steam production, 10^3 lb/hr	95.5	105	81
Steam pressure, psig	607.5	607	618
Steam temperature, °F	650	665	651
Steam heat output, mm Btu/hr	126.0	139.5	106.9
Bark feed rate, ton/hr[b]	14.0	15.6	12.1

[a]Assumes that steam is saturated; no data on steam temperature furnished.

[b]Calculated by plant personnel based on historical use patterns; estimated to be within ± 1 ton/hr.

daily use rates; the rates given were based on historical usage data as determined by plant operating personnel.

Trace metal emissions collected during particulate testing are summarized in Table 10. Filter particulate matter, probe washings, and impinger catches were analyzed for mercury, cadmium, lead, nickel, manganese, and arsenic. Flyash samples from the ESP's were also analyzed for trace metals, and results are presented in Table 11. Removal efficiencies of trace metals by the control equipment tend to be low; in some cases, an increase from inlet to outlet can be observed due to mixing of the exhaust streams between the Trackside and Riverside boilers.

The two boilers and the electrostatic precipitators operated normally during all three sampling runs; hence, the data should be representative of this type of non-fossil fuel fired boiler facility.

TABLE 10. SUMMARY OF TRACE METAL EMISSIONS, OWENS-ILLINOIS, BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979

Boiler	Hg	Cd	Pb	Ni	Mn	As
Riverside (wood-fired) Inlet						
Run 1-RI						
Filter catch, μg	5.2	6.3	230.9	62.0	8,493.9	11.0
Front wash catch, μg	0.3	5.9	96.9	279.6	16,399.9	7.8
Impinger catch, μg	BDL	BDL	13.7	3.0	6.1	BDL
Emission rate, lb/hr	7.34×10^{-4}	1.72×10^{-3}	4.80×10^{-2}	4.85×10^{-2}	3.50	2.65×10^{-3}
Emission factor, lb/mm Btu	5.5×10^{-6}	1.29×10^{-5}	3.62×10^{-4}	3.65×10^{-4}	2.64×10^{-2}	1.99×10^{-5}
Run 2-RI						
Filter catch, μg	BDL	5.0	181.0	39.5	5,997.0	25.2
Front wash catch, μg	0.5	6.7	140.3	287.4	27,002.4	28.4
Impinger catch, μg	BDL	BDL	BDL	BDL	6.2	1.8
Emission rate, lb/hr	6.49×10^{-5}	1.52×10^{-3}	4.17×10^{-2}	4.24×10^{-2}	4.28	7.19×10^{-3}
Emission factor, lb/mm Btu	4.41×10^{-7}	1.03×10^{-5}	2.83×10^{-4}	2.88×10^{-4}	2.91×10^{-2}	4.88×10^{-5}
Run 3-RI						
Filter catch, μg	BDL	4.0	133.3	26.9	5,491.3	20.5
Front wash catch, μg	0.5	4.0	91.7	205.9	22,000.3	15.9
Impinger catch, μg	0.1	BDL	BDL	BDL	6.0	BDL
Emission rate, lb/hr	8.62×10^{-5}	1.15×10^{-3}	3.23×10^{-2}	3.35×10^{-2}	3.95	5.23×10^{-3}
Emission factor, lb/mm Btu	7.65×10^{-7}	1.02×10^{-5}	2.87×10^{-4}	2.97×10^{-4}	3.50×10^{-2}	4.64×10^{-5}
Average - RI runs						
Emission rate, lb/hr	2.98×10^{-4}	1.46×10^{-3}	4.07×10^{-2}	4.15×10^{-2}	3.91	5.02×10^{-3}
Emission factor, lb/mm Btu	2.23×10^{-6}	1.11×10^{-5}	3.11×10^{-4}	3.17×10^{-4}	3.02×10^{-2}	2.84×10^{-5}
Riverside (wood-fired) Outlet						
Run 1-RO						
Filter catch, μg	35.3	6.2	318.5	317.0	4,193.2	485.8
Front wash catch, μg	0.2	4.7	147.0	122.0	270.0	123.3
Impinger catch, μg	0.3	BDL	5.7	3.0	3.1	1.0
Emission rate, lb/hr	3.78×10^{-3}	1.15×10^{-3}	4.95×10^{-2}	4.64×10^{-2}	0.47	6.41×10^{-2}
Emission factor, lb/mm Btu	2.85×10^{-5}	8.62×10^{-6}	3.72×10^{-4}	3.49×10^{-4}	3.53×10^{-3}	4.82×10^{-4}
Run 2-RO						
Filter catch, μg	4.0	1.2	110.9	29.4	1,021.0	158.1
Front wash catch, μg	0.4	3.2	240.0	184.0	210.0	114.1
Impinger catch, μg	1.9	BDL	BDL	BDL	2.3	1.1
Emission rate, lb/hr	1.07×10^{-3}	7.48×10^{-4}	5.97×10^{-2}	3.63×10^{-2}	0.21	4.65×10^{-2}
Emission factor, lb/mm Btu	7.28×10^{-6}	5.08×10^{-6}	4.05×10^{-4}	2.47×10^{-4}	1.42×10^{-3}	3.16×10^{-4}
Run 3-RO						
Filter catch, μg	0.2	1.2	110.8	34.4	721.1	110.6
Front wash catch, μg	0.3	3.5	270.0	136.0	135.9	63.6
Impinger catch, μg	1.4	BDL	BDL	BDL	2.7	6.2
Emission rate, lb/hr	3.23×10^{-4}	7.99×10^{-4}	6.47×10^{-2}	2.90×10^{-2}	0.15	3.07×10^{-2}
Emission factor, lb/mm Btu	2.86×10^{-6}	7.08×10^{-6}	5.74×10^{-4}	2.57×10^{-4}	1.30×10^{-3}	2.72×10^{-4}
Average-RO runs						
Emission rate, lb/hr	1.72×10^{-3}	8.99×10^{-4}	5.80×10^{-2}	3.72×10^{-2}	0.28	4.71×10^{-2}
Emission factor, lb/mm Btu	1.29×10^{-5}	6.93×10^{-6}	4.50×10^{-4}	2.84×10^{-4}	2.08×10^{-3}	3.57×10^{-4}

(continued)

TABLE 10 (continued)

Boiler	Hg	Cd	Pb	Ni	Mn	As
Trackside (coal-fired) Inlet						
Run 1-TI						
Filter catch, μg	0.6	0.8	163.6	293.3	1,622.4	528.5
Front wash catch, μg	1.2	4.7	290.1	382.9	5,999.3	303.0
Impinger catch, μg	0.2	BDL	9.7	3.0	7.1	BDL
Emission rate, lb/hr	2.32×10^{-5}	6.41×10^{-4}	5.40×10^{-2}	7.91×10^{-2}	0.89	9.69×10^{-2}
Emission factor, lb/mm Btu	1.07×10^{-7}	2.95×10^{-6}	2.48×10^{-4}	3.64×10^{-4}	4.09×10^{-3}	4.45×10^{-4}
Run 2-TI						
Filter catch, μg	1.5	1.0	346.0	292.1	547.0	918.4
Front wash catch, μg	0.2	4.6	330.3	376.4	5,000.2	735.8
Impinger catch, μg	13.8	BDL	17.9	5.0	6.3	22.8
Emission rate, lb/hr	1.11×10^{-3}	4.00×10^{-4}	4.96×10^{-2}	4.81×10^{-2}	0.40	0.12
Emission factor, lb/mm Btu	4.98×10^{-6}	1.80×10^{-6}	2.23×10^{-4}	2.16×10^{-4}	1.78×10^{-3}	5.38×10^{-4}
Run 3-TI						
Filter catch, μg	0.3	1.6	341.9	314.0	582.0	906.2
Front wash catch, μg	BDL	2.6	309.5	433.3	2,800.0	142.2
Impinger catch, μg	8.2	BDL	BDL	BDL	5.4	3.1
Emission rate, lb/hr	7.93×10^{-4}	3.92×10^{-4}	6.08×10^{-2}	6.98×10^{-2}	0.32	9.82×10^{-2}
Emission factor, lb/mm Btu	3.10×10^{-6}	1.53×10^{-6}	2.37×10^{-4}	2.72×10^{-4}	1.23×10^{-3}	3.83×10^{-4}
Average-TI runs						
Emission rate, lb/hr	6.42×10^{-4}	4.78×10^{-4}	5.48×10^{-2}	6.57×10^{-2}	0.54	1.05×10^{-1}
Emission factor, lb/mm Btu	2.73×10^{-6}	2.09×10^{-6}	2.36×10^{-4}	2.84×10^{-4}	2.37×10^{-3}	4.55×10^{-4}
Trackside (coal-fired) Outlet						
Run 1-TO						
Filter catch, μg	0.5	0.8	31.1	34.6	1,048.3	82.9
Front wash catch, μg	0.1	39.0	400.0	122.0	490.0	627.3
Impinger catch, μg	BDL	BDL	3.7	BDL	3.1	BDL
Emission rate, lb/hr	9.70×10^{-5}	6.44×10^{-3}	7.03×10^{-2}	2.53×10^{-2}	0.25	0.11
Emission factor, lb/mm Btu	4.46×10^{-7}	2.96×10^{-5}	3.23×10^{-4}	1.16×10^{-4}	1.15×10^{-3}	5.28×10^{-4}
Run 2-TO						
Filter catch, μg	0.5	1.0	60.8	26.9	1,232.5	127.8
Front wash catch, μg	0.3	5.7	127.0	84.0	360.0	119.5
Impinger catch, μg	2.2	BDL	BDL	BDL	2.6	2.0
Emission rate, lb/hr	4.85×10^{-4}	1.08×10^{-3}	3.04×10^{-2}	1.79×10^{-2}	0.26	4.03×10^{-2}
Emission factor, lb/mm Btu	2.18×10^{-6}	4.87×10^{-6}	1.37×10^{-4}	8.06×10^{-5}	1.16×10^{-3}	1.81×10^{-4}
Run 3-TO						
Filter catch, μg	0.5	0.8	53.0	23.3	1,120.8	116.3
Front wash catch, μg	BDL	2.6	60.0	93.0	350.0	63.6
Impinger catch, μg	0.1	BDL	BDL	BDL	1.7	BDL
Emission rate, lb/hr	9.67×10^{-5}	5.48×10^{-4}	1.82×10^{-2}	1.87×10^{-2}	0.24	2.90×10^{-2}
Emission factor, lb/mm Btu	3.77×10^{-7}	2.14×10^{-6}	7.11×10^{-5}	7.32×10^{-5}	9.26×10^{-4}	1.13×10^{-4}
Average-TO runs						
Emission rate, lb/hr	2.26×10^{-4}	2.69×10^{-3}	3.96×10^{-2}	2.06×10^{-2}	0.25	5.98×10^{-2}
Emission factor, lb/mm Btu	1.00×10^{-6}	1.22×10^{-6}	1.77×10^{-4}	8.99×10^{-5}	1.08×10^{-3}	2.74×10^{-4}

Note: BDL = Below detection limit. Detection limits vary for each element and sample size, and can be found in Appendix D - Analytical Data Sheets.

TABLE 11. SUMMARY OF ESP FLY ASH ANALYSIS FOR TRACE METALS, OWENS-ILLINOIS, BIG ISLAND, VIRGINIA, DECEMBER 12-15, 1979

Run number	Date	Trace metal concentration, µg/g					
		Hg	Cd	Pb	Ni	Mn	As
Riverside ESP (Boiler #5)							
1	12/12/79	0.36	1.6	148.0	30.1	2,040.8	1.5
2	12/14/79	16.0	0.95	8.0	37.6	1,052.1	2.3
3	12/15/79	1.1	2.4	16.5	34.6	2,505.0	1.9
Trackside ESP (Boiler #4)							
1	12/12/79	0.05	0.75	8.0	9.5	205.0	<0.25
2	12/14/79	0.65	0.95	<2.5	10.5	230.5	1.4
3	12/15/79	0.8	1.4	<2.5	8.5	115.2	0.45

SECTION 3

PROCESS DESCRIPTION

The Big Island Mill manufactures paper products, and operates three boilers for process steam, two of which are in operation at all times. The third boiler is on secondary status. Boiler #3 uses wood bark and sawdust as fuel, is normally on standby, and has a design capacity of 60,000 lbs steam per hour. The operating boilers are Boiler #4 (Trackside boiler) which is a Combustion Engineering, Inc. pulverized coal dry bottom boiler with a design capacity of 140,000 lbs steam per hour and Boiler #5 (Riverside boiler) which is a Foster Wheeler stoker-grate coal or refuse boiler with a design capacity of 200,000 lbs steam per hour. The Riverside boiler was historically fired with 80% coal, 20% bark, but that ratio has been switched as the plant burns as much bark as possible now--up to 100% bark in the Riverside boiler.

Each boiler is exhausted to Zurn multicyclone units (type MTSA), installed in 1970 and 1971, then ducted to a common duct which leads to a pair of United McGill electrostatic precipitators, as shown in Figure 1. The twin ESP's contain ten fields, five on each side, and are designed to handle a flow of 300,000 acfm. Installed in 1978, the twin ESP's exhaust to a pair of stacks which terminate 190 ft above ground level.

The plant is located between railroad tracks and the James River, hence the two precipitators are designated the Riverside unit and Trackside unit, respectively.

The plant operations are best termed as continuous. The schedule is based on 24 hours a day operation, seven days a week.

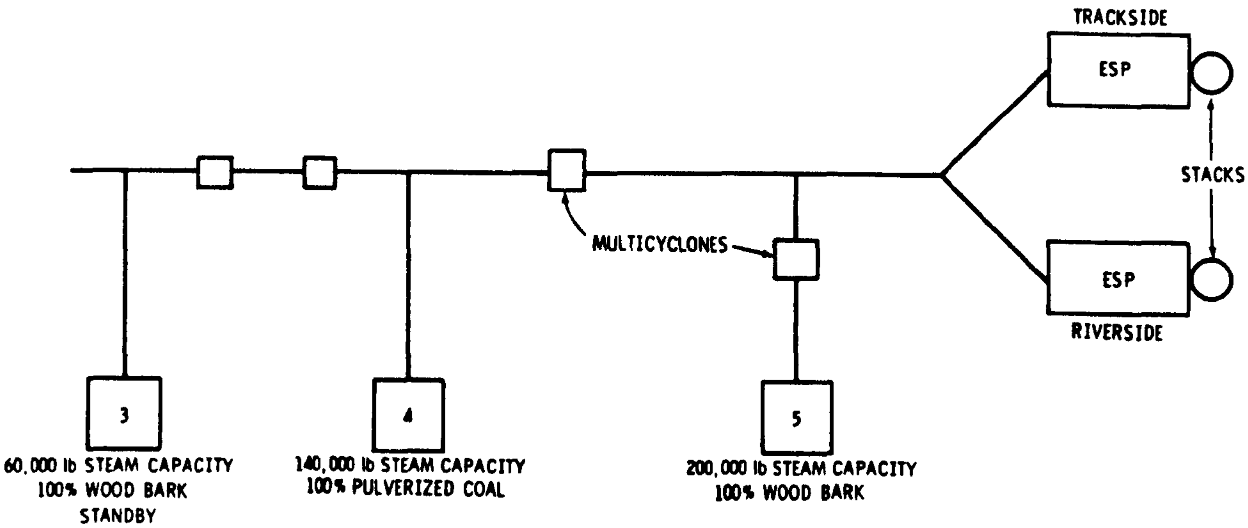

Figure 1. Schematic diagram of boilers at Owens-Illinois, Forest Product Division, Big Island, Virginia

SECTION 4

LOCATION OF SAMPLING POINTS

As a result of the pretest survey, the sampling program included the inlets to the multicyclone units of boilers #4 and #5 and the outlets of the ESP units at the stack platform. Simultaneous sampling for particulates using EPA Method 5 was performed at the four locations. The common duct leading to the ESP units branched and had existing sampling ports but was eliminated from consideration in this program due to the proximity of disturbances.

Sampling ports at the inlet of the cyclone on boiler #4 were utilized as is. The duct leading to the multicyclones was rectangular and measured 74 in. by 98 in. with five 4 in. capped ports installed 81 inches above floor level in the 98 in. face. The direction of flow when facing the ports was upward. The nearest upstream disturbance was approximately one duct diameter away and the nearest downstream disturbance was also one duct diameter away.

Sampling ports for boiler #5 cyclone inlet were installed by a local contractor prior to the test. This location had seven 4 in. flanged ports unevenly spaced in a 116 in. by 122 in. rectangular duct. Figure 2 illustrates the duct configuration of the Riverside inlet sampling location. The nearest disturbances were two duct diameters upstream and one diameter downstream. The U-shaped ductwork resulted in a gas flow pattern which was not cyclonic but tended to stay close to the outside edge of the U-shape.

The twin ESP outlet locations were circular stacks, 84 in. diameter, each with two 4 in. ports at 90° from each other. The top of the stack was one diameter downstream and the nearest upstream disturbance was an expansion 2-1/2 diameters away.

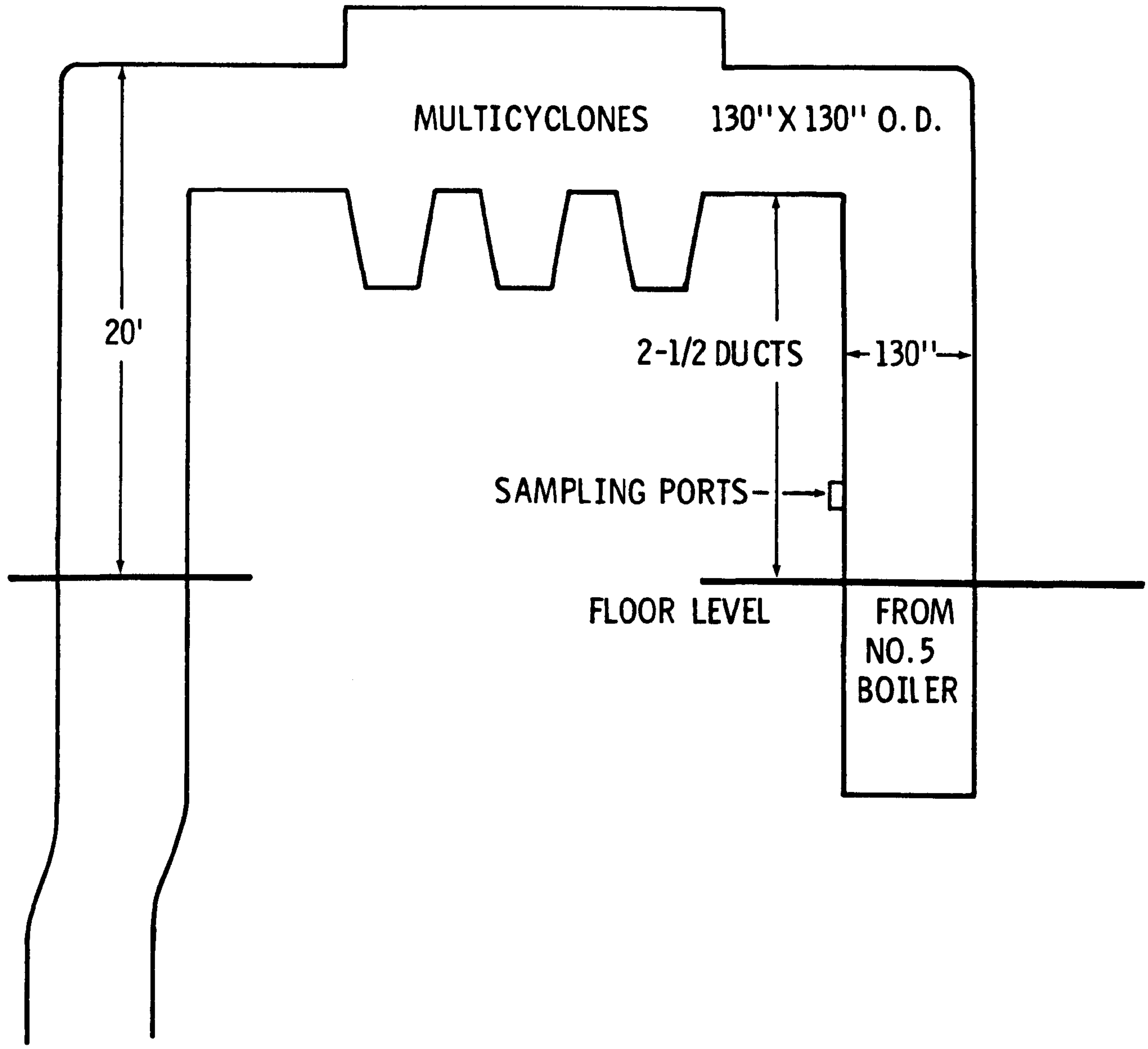

Figure 2. Inlet to boiler #5 multicyclones.

SECTION 5

SAMPLING AND ANALYTICAL PROCEDURES

The Owens-Illinois Big Island Mill was sampled for particulate matter, particle size, opacity, trace metals, SO_2, NO_x, integrated gas analysis, flyash for trace metals, and fuel analysis.

The following describes the methods used.

SAMPLING PROCEDURES

Particulate

Sampling for particulates was performed using the method outlined in the Federal Register, Method 5, "Determination of Particulate Emissions from Stationary Sources," modified so that the sample box temperature was 325°F instead of 250°F.

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 4 foot stainless steel 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 total of 3 particle sizing runs were made simultaneously at the Riverside inlet location and both outlet locations. Each run was conducted for 5 minutes under isokinetic conditions at the Riverside inlet location and from 16 to 30 minutes at the stack outlets.

At the completion of each run, the moisture collected was measured and the Andersen heads were opened and oven-dried for three hours. After drying, each stage was weighed, then the filter was removed and the stage assemblies were cleaned, desiccated and reweighed to provide partial tare weights. The tare weights of the filters were taken during the assembly of the heads (after desiccation for 24 hours).

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.

Trace Metals

A modification of the back half of the EPA Method 5 sampling system was employed for trace elements. The impinger portion of the train is designed to collect vapor phase organic materials; Table 12 presents the impinger content and order. Figure 3 illustrates the train components and sample recovery procedures.

TABLE 12. CONTENT AND ORDER OF THE IMPINGER PORTION OF THE MODIFIED METHOD 5 TRAIN

Impinger	Reagent[a]	Quantity	Purpose
1	6M H_2O_2	100 mL	Trap reducing gases such as SO_2 to prevent depletion of oxidative capability of other impingers.
2	Empty		
3, 4	0.2M $(NH_4)_2S_2O_8$ + 0.2M $AgNO_3$	200 mL (each)	Collect volatile trace elements by oxidative dissolution.
5	Silica gel	200 g	Prevent moisture from reaching pump and dry gas test meter.

[a]M - molar; 1M = one mole of solute per liter of solution.

Sulfur Dioxide

Sampling for SO_2 was performed using the method outlined in the Federal Register, Method 6, "Determination of Sulfur Dioxide Emissions from Stationary Sources."

Opacity

Visible emissions were read during particulate sampling by a certified smoke reader who met the specification of Federal Register, Method 9, "Visual Determination of the Opacity of Emissions from Stationary Sources."

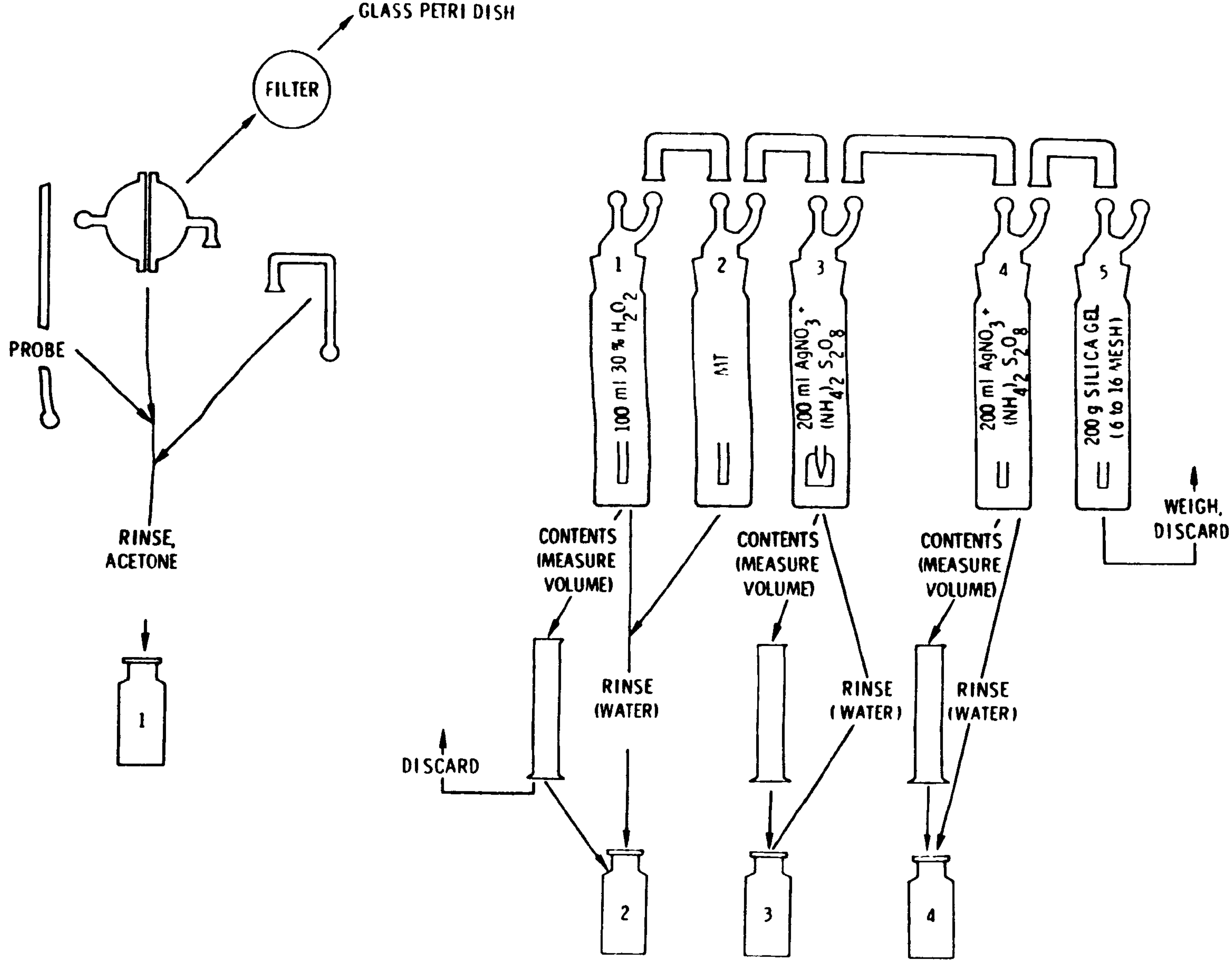

Figure 3. Train components and sample recovery procedure employing modified Method 5 equipment.

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."

Integrated Gas Analysis

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

Fuel

Fuel samples were grabbed in 1 liter nalgene bottles from the coal bins feeding boiler #4 and the bark screw feeder to boiler #5 just prior, during and just after each test run.

Ash

Flyash samples from the ESP units were grabbed during each Method 5 run.

ANALYTICAL PROCEDURES

Particulate, SO_2, NO_x, Gas Analysis

All analytical procedures were performed using the methods described in EPA Methods 3, 5, 6, and 7, previously mentioned in the Sampling Procedures section.

Trace Metals

The particulate fractions of the Method 5 samples were analyzed for trace metals. After final weights were obtained on the particulate washes and filters, the fractions were digested with nitric acid and analyzed by Atomic Absorption Spectroscopy (AAS). The impingers containing ammonium persulfate/silver nitrate were reduced in volume by evaporation, digested with 1:1 $HCl:H_2O$ and analyzed by AAS. Ash samples were also digested with nitric acid and analyzed by AAS. Mercury analyses were performed using the cold vapor method where the AA flame is shutoff; arsenic was analyzed using the hydride generation method to produce an arsine; all other metals were analyzed by conventional flame AAS.

Fuel

Analysis of the coal and 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 D.