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

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

CHEMICAL
WOOD PULPING
AP-42 Section 10.2
Reference Number
8

SOURCE TEST REPORT

EPA No.: 72-PC-11

Particulate and Gaseous Emissions From A Kraft Pulp Mill

U. S. PLYWOOD - CHAMPION PAPERS

Pasadena, Texas

EPA Contract No.: 68-02-0232
Task No.: 7

Environmental Engineering, Inc.
2324 Southwest 34th Street
Gainesville, Florida 32601

I. INTRODUCTION

In accordance with Section 111 of the Clean Air Act as amended of 1970, the Environmental Protection Agency is charged with the establishment of performance standards for new stationary sources which may contribute significantly to air pollution. These standards are based upon the best air pollution control technology that has been demonstrated.

This report presents the results of an extensive source testing program conducted at Champion Paper Company, Pasadena, Texas, June 3-9, 1972, to obtain data for a partial basis in consideration of new source performance standards in the kraft pulping industry.

Stack emissions were measured from the chemical recovery boiler for particulate, sulfur dioxide, reduced sulfur compounds, oxides of nitrogen, carbon dioxide, carbon monoxide, and oxygen. Emissions from the first and second stages (individually vented) of the black liquor oxidation system were also measured for sulfur dioxide and reduced sulfur. The recovery boiler utilizes a cascade direct contact evaporator and strong black liquor oxidation and exit gases are controlled with an electrostatic precipitator.

Reduced sulfur compounds were measured by flame photometric gas chromatography and coulometric titration. Carbon monoxide and carbon dioxide were measured with infrared analyzers and oxygen was monitored with a paramagnetic oxygen analyzer. All other stack emissions were measured with EPA reference methods.

II. SUMMARY AND DISCUSSION OF RESULTS

Table 1 summarizes results of gaseous sulfur determinations utilizing both flame photometric and coulometric detection systems. All summary results are reported in terms of TRS as H_2S. TRS is defined as hydrogen sulfide plus methyl mercaptan plus dimethyl sulfide plus dimethyl disulfide; all compounds are reported as hydrogen sulfide. It should also be noted that dimethyl disulfide (RSSR) concentrations, determined with the chromatographic system, are assumed to yield twice those concentrations when considered as hydrogen sulfide. Complete gaseous sulfur data is contained in Appendix A.

Results from the particulate emission tests on the recovery furnace are shown in Table 2. Emission rates were calculated on the basis of the moisture content determined from a separate moisture test instead of the condensed moisture in the impingers. The reason for this is that the evaporation rate of the isopropanol in the impingers was found to be excessive based upon previous tests.

The third and fourth impingers, which contained 3% hydrogen peroxide, were analyzed for sulfur dioxide by using barium perchlorate titrations. The data are also included in Table 2.

Complete particulate and sulfur dioxide data are contained in Appendix B.

Daily mean concentrations for oxygen, carbon dioxide, and carbon monoxide are presented in Table 3. The results are reported on a dry gas basis. Complete results of the gas concentrations at 15-minute intervals are included in Appendix C.

The results from the nitrogen oxide emission testing are summarized in Table 4. Complete NO_x data are included in Appendix B.

Table 1

TRS DAILY AVERAGES

(Coulometric and Flame Photometric Detection)

U. S. PLYWOOD - CHAMPION PAPERS
Pasadena, Texas

Date	Source	Flame Photometric Detection			Coulometric Detection		
		ppm (1)	lbs/hr	lbs/ADTP	ppm	lbs/hr	lbs/ADTP
6-3-72	PPT Outlet	2.02 (2)	1.54		4.1	3.13	
6-4-72	PPT Outlet	1.41 (3)	1.06		2.9	2.19	
6-5-72	PPT Outlet	1.40	1.06		2.7	2.04	
6-6-72	PPT Outlet	1.54	1.16		2.5	1.88	
6-7-72	PPT Outlet	0.77	0.58		2.9	2.19	
6-8-72	PPT Outlet	1.58	1.20		3.1	2.35	
6-9-72	1st Stage BLO (5)	38.90	1.21		48.8	1.52	
	2nd Stage BLO	23.25	0.62		6.8	0.18	

(1) Parts per million by volume - Dry Gas Basis
(2) H_2S only
(3) RSR & RSSR
(4) H_2S & RSH
(5) BLO - Black Liquor Oxidation

TABLE 2

PARTICULATE AND SULFUR DIOXIDE EMISSIONS

	Run #1	Run #2	Run #3
Date	6/3/72	6/5/72	6/6/72
Time Began	12:45	9:25	9:52
Time End	18:23	13:05	13:32
Barometric Pressure, In. Hg Absolute	30	30	30
Meter Orifice Pressure Drop, In. H_2O	0.14	0.14	0.09
Vol. Dry Gas @ Meter Conditions, ft^3	42.431	42.530	45.294
Average Gas Meter Temperature, °F.	86	87	89
Vol. Dry Gas @ S.T.P.*, ft^3	41.312	41.333	43.853
Stack Gas Moisture, % Volume	25.5	25.3	21.9
% CO_2	10.4	10.7	11.8
% O_2	10.7	11.4	10.1
% CO	0	0	0
% N_2	78.9	77.9	78.1
Average Stack Gas Temperature, °F.	314.2	304.2	302.6
Stack Pressure, In. Hg Absolute	30.07	30.07	30.07
Stack Gas Velocity @ Stack Cond., fpm	4633	4683.6	4554.1
Stack Gas Flow Rate @ S.T.P.*, scfm	141512	145321	148042
Net Time of Test, min.	180	200	200
Percent Isokinetic	113.4	99.4	103.5
Particulate Concentrations, grains/scf			
Front half and Filter	0.085	0.096	0.092
Total	0.184	0.199	0.197
Particulate Emissions, lbs/hr			
Front half and Filter	103.32	110.07	116.51
Total	223.04	248.18	250.03
Particulate Emissions, lbs/ton[1]			
Front half and Filter	4.13	4.40	4.66
Total	8.92	9.93	10.00
SO_2 Emissions, lbs/hr	14.77	63.82	Neg.

) AVG ~145x10^3

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*Dry, 70°F., 29.92 in. Hg

[1] Based upon 600 tons ADP/day

Table 3

Carbon Dioxide, Oxygen, and Carbon Monoxide Concentrations

Date	Daily Averages		
	CO (ppm)	CO_2 %	O_2 %
6/3/72	153	10.4	10.7
6/4/72	93	8.2	11.4
6/5/72	84	10.7	11.4
6/6/72	95	11.8	10.1
6/7/72	102	12.9	10.1
6/8/72	51	11.1	9.9

AVG = 96 ppm

Table 4

Nitrogen Oxide Concentrations No. 6 Recovery Furnace Outlet

Date	Time	NO_x, ppm
6/3/72	1605	19.3
	1830	19.8
6/5/72	1400	19.8
	1630	24.2
	1700	17.9
6/6/72	1440	20.2
	1535	34.3
	1600	34.5

III. PROCESS DESCRIPTION AND OPERATION

The Champion International Plant at Pasadena, Texas is a complete mill, producing 600 tons of fine paper and newsprint per day from its own bleached kraft pulp and groundwood. The EPA test program at this mill was limited to two facilities; the black liquor oxidation system, and the recovery furnace system. These systems are a small but important part of the plant complex, and are part of the process for recovering spent cooking chemicals from the kraft pulping operation. Diagrams of both systems are shown in Figure 1.

Process Description

A. General

The mill produces kraft pulp by cooking wood chips in white liquor, a water solution of sodium hydroxide and sodium sulfide. The spent cooking solution, called black liquor, is treated to regenerate cooking solution. During regeneration, the black liquor is concentrated in evaporators and then burned in a recovery furnace. At the furnace bottom, inorganic chemicals are recovered as a sodium carbonate-sodium sulfide smelt. The molten smelt is tapped off and dissolved in water. The resulting mixture, called green liquor, is drawn from the dissolving tank and treated with lime to complete the regeneration of cooking solution.

Heat released in the recovery furnace from combustion of the black liquor is used to generate process steam and to complete the evaporation of additional black liquor. The recovery furnace, sometimes called a recovery boiler, employs water walls and boiler tubes to absorb part of the available heat. Combustion gases leave the furnace at about 700°F and go to a direct contact evaporator; black liquor, fed countercurrently to this unit, contacts the hot gases directly and is evaporated to a solids content of about 60 percent. The concentrated liquor is sprayed into the furnace; combustion gases leaving the direct contact evaporator are cleaned in an electrostatic precipitator and then vented to the atmosphere through a tall stack.

Chemical reactions between the combustion gases and black liquor in the direct contact evaporator can generate hydrogen sulfide. To inhibit these reactions the black liquor is first sparged with air in a two stage oxidation system. Oxidation converts sulfide in the liquor to thiosulfate and effectively reduces subsequent hydrogen sulfide formation.

B. Recovery Furnace System

The test unit was installed in 1958 and designated the #6 recovery furnace. This furnace was designed by Babcock and Wilcox for a heat input of 575 million BTU per hour, equivalent to a pulp production rate of 650 tons per day. Associated with this furnace is a cascade direct contact evaporator.

A portion of the product steam is used to blow soot from the boiler tubes. Tubes are cleaned continuously, one section at a time.

C. Oxidation System

The oxidation system was designed by Champion to oxidize strong black liquor by sparging with air in two sequential stages. The first stage was installed in 1951 and the second stage in 1967. In each stage, air is blown through the black liquor and vented through a cyclone to the atmosphere. Number 2 heating oil is pumped to the second stage at about 15 gallons per hour to inhibit foaming, and each stage has a foam breaker. Black liquor from the cyclones and foam breakers are recycled. The oxidation system serves two recovery furnaces with a total equivalent pulp production of 900 tons per day.

D. Electrostatic Precipitator

The precipitator was designed for a collection efficiency of 98 percent and installed by the Koppers Company in 1958. Inlet gas is divided into three parallel chambers, and each chamber has three fields. The inlet fields of chambers 1 and 2 are coupled electrically; the center fields of chambers 2 and 3 are also coupled. Accordingly, the precipitator has seven separately controlled sections.

Rappers operate every 2 1/2 minutes; during each cycle the inlet sections rap for 5 seconds, followed by the center sections for 10 seconds, and the outlet sections for 15 seconds. Salt cake drops to the hoppers and is recycled to the recovery furnace by circulating black liquor.

Process Operation

During testing, records were kept of process variables for the recovery furnace, electrostatic precipitator, and the black liquor oxidation system. Wherever process monitors were available, operating conditions that affect emission rates were recorded. The raw process data sheets and a key explaining the entries are included in the Appendix D.

A. Recovery Furnace

The process records, as well as statements by the operators, indicate that during the tests the recovery furnace was operated normally. The observed ranges of major operating variables are given in Table 5; where information is available from the company, the design and normal values are also shown. As seen from the table, black liquor feed rate, solids content, and steam temperature, pressure, and production rate, were all within a few percent of normal; reduction ratio was greater than 95 percent, as proper. (Reduction ratio, determined from green liquor samples, is the concentration of sodium sulfide divided by the sum of sodium sulfide and sodium carbonate concentrations.) These records show that the furnace received a normal charge and performed its major functions (production of smelt and steam) in a normal way during the tests.

Many operating parameters (such as distribution of furnace combustion air, manner of spraying feed liquor, etc.) affect furnace emissions. Those that could be monitored were recorded. There is no indication from the records or from operators' statements that unusual practices were followed.

The sodium sulfide concentration in black liquor fed to the direct contact evaporator is a process variable of special interest, because of its strong influence on the generation of hydrogen sulfide. Sulfide levels are determined routinely by the Company and were made available for the test period. As shown in Table 6, sulfide levels were frequently undetectable; the highest levels (June 5 and 6) caused no measurable increases in hydrogen sulfide emissions.

B. Black Liquor Oxidation System

A limited amount of process data was obtained June 9 during tests on the oxidation system. Readings of the available process monitors were recorded on data sheets included in the appendix. These data are summarized in Table 7.

As far as known from the process data and statements by the operators, the oxidation system was operated normally during the test.

C. Electrostatic Precipitator

Precipitator operation was monitored during all the furnace tests. Primary current, secondary current, and secondary voltage in each of the seven control sections were recorded hourly. The raw data sheets are included in the appendix. These data are summarized in Table 8; information supplied by Champion International on design and normal operating conditions is included where available.

During most of the particulate sampling the precipitator was operated normally. The major exception occurred in the first run; during the last hour of sampling, the primary current in one control section dropped from about 78 to 46 amperes. (Particulate emissions, however, were lowest for this run.) The second run was postponed a day until the precipitator was repaired. When the faulty section was cleaned out and several damaged collector plates were welded into place, normal current was restored.

Table 5. SUMMARY OF THE RECOVERY FURNACE PROCESS DATA

Operating Condition	Units	Design[a]	Normal	During Test 6/3-8/72	Item No. on Data Sheets
Black Liquor Feed Rate	GPM	200[b]	208	214-223	10
Black Liquor Solids Content	Wt. %	67	65	64.2-66.5	14
Steam Production[c]	10^3 lb/hr	299	225[d]	200 - 255	1
Steam Temperature	°F	750	700	670 - 750	4
Steam Pressure	psig	375	330	321 - 357	5
Reduction Ratio[e]	%			95.7 - 97.1	

[a] Information supplied by Champion International.

[b] Calculated by Champion International from design heat input using current operating parameters.

[c] Net production, not including steam used for soot blowing in the recovery furnace.

[d] Original design did not contemplate current rate of saturated steam usage for soot blowing.

[e] $(100)(Na_2S)/(Na_2S + Na_2SO_4)$

Table 6. SODIUM SULFIDE CONCENTRATIONS IN BLACK LIQUOR FED TO THE DIRECT CONTACT EVAPORATOR

Date 1972	Time 24 hour	Sodium Sulfide[a] grams/liter
3	1330	0.0
4	0700	0.117
4	1430	0.0
5	0730	0.390
5	1500	0.0
6	0745	0.265
6	1530	0.156
7	0645	0.195
7	0710	0.0
8	1315	0.0
9	0640	0.0

(a) Determined by Champion International by potentiometric titration.

Table 7. SUMMARY OF PROCESS DATA FOR THE BLACK LIQUOR OXIDATION SYSTEM

Stage 1

Operating Condition	Units	Design	Normal	During Test (6/9/72)
Black Liquor Feed Rate	GPM	585	542	350 - 500
Air Feed Rate	SCFM	6000		not measured
Air Feed Pump Pressure	psig	6		6 1/4 - 6 1/2

Stage 2

Operating Condition	Units	Design	Normal	During Test (6/9/72)
Air Feed Rate	SCFM	3000		not measured
Air Feed Pump Pressure	psig	6		6 3/4

NOTE: Stage 2 liquor feed rate is not measured; it is slightly less than stage 1 because of evaporative water losses in stage 1.

Table 8. SUMMARY OF PROCESS DATA FOR THE ELECTROSTATIC PRECIPITATOR

Operating Condition	Units	Design	Normal	During Test 6/3,5,6/72
Gas Volume	10^3 ACFM	281	265	273-281
Gas Temperature	°F	325-350	325	303-314
Inlet Loading	gr/SDCF	2.5-6.0	4.0	---
Outlet Loading	gr/SDCF	0.05(a)	0.10(a)	0.085-0.096(b)
Efficiency	%	98	97.5	---
Primary Current	amps	90	85-95	46 - 96(c)
Primary Voltage	volts	440		310 - 400
Secondary Voltage	10^3 volts	65	45-60	
Secondary Current				325 - 490

(a) Texas Air Control Board method; similar to EPA Method 5.

(b) EPA Method 5; front half only.

(c) Primary current in one control section was low for about 30 minutes; minimum current at all other times during particulate testing was 70 amps.

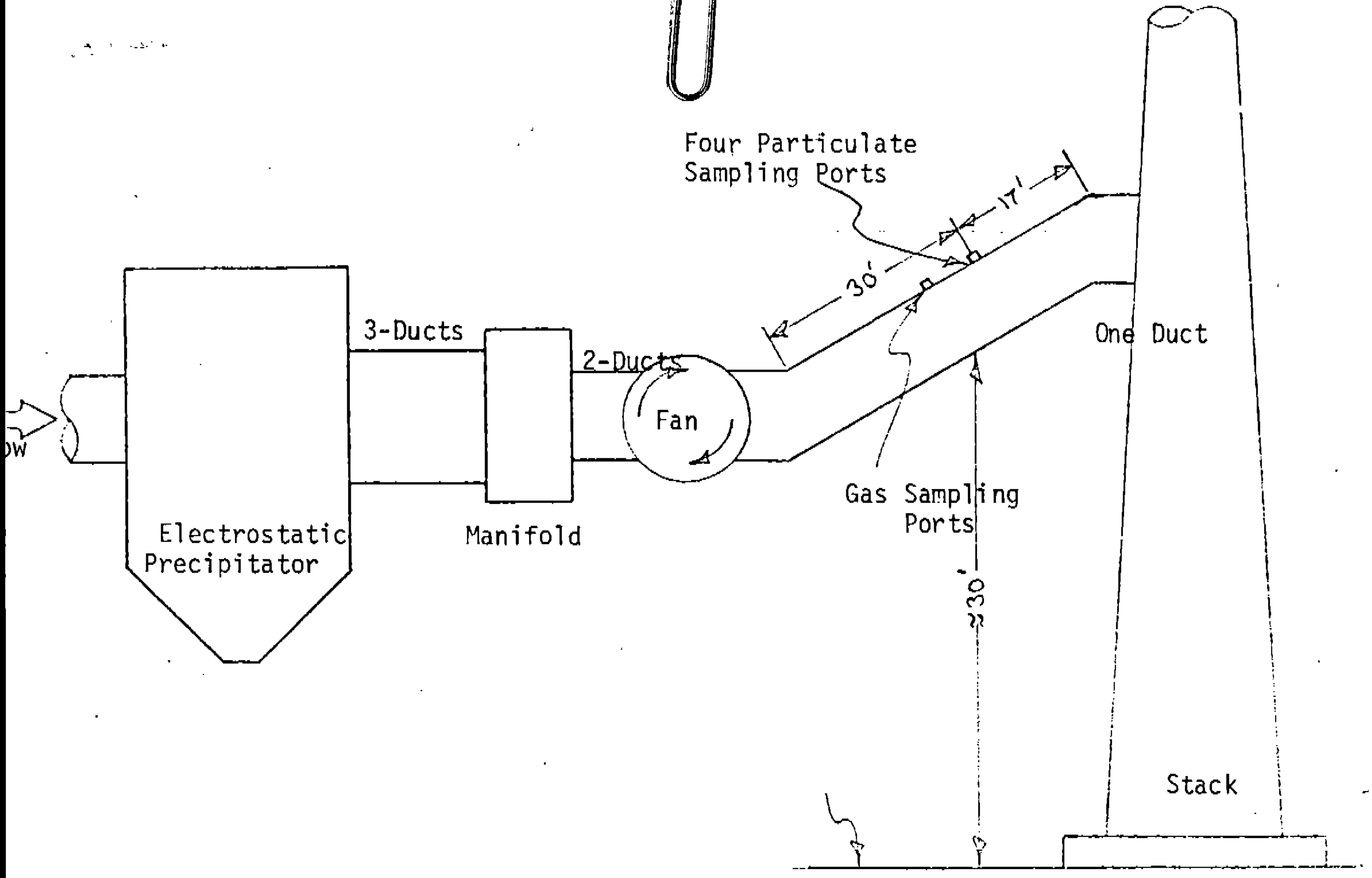
IV. LOCATION OF SAMPLING POINTS

The outlet stack from the electrostatic precipitator on the No. 6 recovery furnace was sampled at the rectangular duct entering tnto the vertical stack, as shown in Figures 2 and 3.

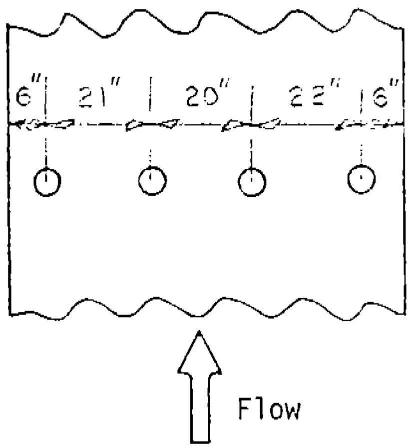
The traverse points sampled in each of the four ports are as follows:

Sample Point No.	Distance From Inside Wall, In.
1	5 3/4
2	17 1/4
3	28 3/4
4	40 1/4
5	51 3/4
6	63 1/4
7	74 3/4
8	86 1/4
9	97 3/4
10	109 1/4

NOTE: The traverse points were utilized for determination of particulates, gas volumes, moisture and other necessary stack gas parameters. The gaseous constituents were extracted from the source gas stream based upon the assumption that the gases were homogeneously mixed. Therefore, gaseous sulfurs, nitrogen oxides, carbon dioxide, oxygen and carbon monoxide were sampled from relatively fixed points in the gas handling system.



SIDE VIEW OF NO. 6 RECOVERY
FURNACE GAS OUTLET
Figure 2



TOP VIEW OF PARTICULATE
SAMPLING PORTS
Figure 3

Ref 6

SOURCE TEST REPORT
EPA No.: 72-PC-13

Particulate and Gaseous Emissions From A Kraft Pulp Mill

AMERICAN CAN COMPANY
Halsey, Oregon

EPA Contract No.: 68-02-0232
Task No.: 10

Environmental Engineering, Inc.
2324 Southwest 34th Street
Gainesville, Florida 32601

I. INTRODUCTION

In accordance with Section 111 of the Clean Air Act as amended of 1970, the Environmental Protection Agency is charged with the establishment of performance standards for new stationary sources which may contribute significantly to air pollution. These standards are based upon the best air pollution control technology that has been demonstrated.

This report presents the results of an extensive source testing program conducted at American Can Company, Halsey, Oregon, July 13-21, 1972, to obtain data for a partial basis in consideration of new source performance standards in the kraft pulping industry.

Stack emissions were measured from the chemical recovery boiler for particulate, sulfur dioxide, reduced sulfur compounds, oxides of nitrogen, carbon dioxide, carbon monoxide, and oxygen. Emissions from the smelt dissolving tank vent were also measured for particulates, sulfur dioxide, reduced sulfur, CO_2, O_2, and oxygen. The recovery boiler is the direct-fired type and exit gases are controlled with an electrostatic precipitator. The smelt dissolving tank vent is controlled with a water scrubber packed with plastic Pall rings.

Reduced sulfur compounds were measured by flame photometric gas chromatography and coulometric titration. All other stack emissions were measured with EPA reference methods.

II. SUMMARY AND DISCUSSION OF RESULTS

Table 1 summarizes results of gaseous sulfur determinations utilizing both flame photometric and coulometric detection systems. All summary results are reported in terms of TRS as H_2S. TRS is defined as hydrogen sulfide plus methyl mercaptan plus dimethyl disulfide; all compounds are reported as hydrogen sulfide. It should also be noted that dimethyl disulfide (RSSR) concentrations, determined with the chromatographic system, are assumed to yield twice those concentrations when considered as hydrogen sulfide.

Results from the particulate emission tests on the recovery furnace are shown in Table 2. Emission rates were calculated on the basis of the moisture content determined from a separate moisture test instead of the condensed moisture in the impingers. The reason for this is that the evaporation rate of the isopropanol in the impingers was found to be excessive based upon previous tests.

Results from the particulate emission tests on the smelt tank are shown in Table 3. Emission results from the smelt dissolving tank were calculated by using the moisture content determined from the assumption that the stack gases were saturated at the dry bulb temperature.

The third and fourth impingers, which contained 3% hydrogen peroxide, were analyzed for sulfur dioxide by using barium perchlorate titrations. The data are also included in Tables 2 and 3.

Complete particulate and sulfur dioxide data are contained in Appendix B.

Daily mean concentrations for oxygen, carbon dioxide, and carbon monoxide are presented in Table 4. The very low CO_2 and very high O_2 concentrations experienced on July 13 and 14 were the result of system leaks. On July 15, a new probe was installed and a thorough system leak check was conducted. Subsequent concentrations are believed to be representative of actual source concentrations. The results are reported on a dry gas basis.

All gas concentrations are reported at five-minute intervals and the maximum, minimum, and mean concentrations with the regression coefficients for calibration curves are presented in Appendix C.

The results from the nitrogen oxide emission testing are summarized in Table 5. Complete NO_x data are included in Appendix B.

TABLE 1
TRS DAILY AVERAGES
COULOMETRIC AND FLAME PHOTOMETRIC DETECTION

AMERICAN CAN COMPANY
Halsey, Oregon

Date	System	Flame Photometric Detection			Coulometric Detection		
		ppm(1)	lbs/hr	lbs/ADTP*	ppm	lbs/hr	lbs/ADTP*
7-13-72	Precipitator Outlet	1.60(2)	0.71	0.051	0.34	0.15	0.011
7-14-72	Precipitator Outlet	0.24(3)	0.11	0.0079	0.74	0.33	0.024
7-15-72	Precipitator Outlet	0.51(4)	0.23	0.016	0.67	0.30	0.022
7-17-72	Precipitator Outlet	0.26(4)	0.12	0.0086	0.72	0.32	0.023
7-18-72	Precipitator Outlet	0.33(4)	0.15	0.011	0.52	0.23	0.016
7-19-72	Precipitator Outlet	0.40(4)	0.18	0.013	0.32	0.14	0.010
7-20-72	Precipitator Outlet	0.34(4)	0.15	0.011	0.35	0.15	0.011
7-21-72	Smelt Tank Outlet	2.01(2)	0.86	0.062	0.35	0.15	0.011

(1) Parts per million by volume - dry gas basis
(2) H_2S & RSR only
(3) RSR only
(4) RSR & RSSR only

*Based on 334.5 ATDP/day

TABLE 2

PARTICULATE EMISSIONS RECOVERY FURNACE OUTLET

	Run #1	Run #2	Run #3
Date	7/13/72	7/14/72	7/15/72
Time Began	1400	1245	1128
Time End	1755	1550	1500
Barometric Pressure, In. Hg Absolute	30.25	30.25	30.10
Meter Orifice Pressure Drop, In. H_2O	0.93	0.63	0.81
Vol. Dry Gas @ Meter Conditions, ft^3	122.664	80.770	91.567
Average Gas Meter Temperature, °F.	83	85	88
Vol. Dry Gas @ S.T.P.*, ft^3	121.321	79.506	89.268
Stack Gas Moisture, % Volume	20.4^{**}	20.4^{**}	20.4^{**}
% CO_2	12.0	11.5	11.3
% O_2	8.0	8.5	8.5
% CO	0.0025	0.003	0.0035
% N_2	80	80	80
Average Stack Gas Temperature, °F.	395	400	415
Stack Pressure, In. Hg Absolute	30.03	30.03	29.88
Stack Gas Velocity @ Stack Cond., fpm	3459	3428	3555
Stack Gas Flow Rate @ S.T.P.*, scfm	85,167	83,820	85,579
Net Time of Test, min.	176.5	144	144
Percent Isokinetic	114.3	93.3	
Particulate Concentrations, grains/scf			
Front half and Filter	0.120	0.111	0.132
Total	0.130	0.123	0.139
Particulate Emissions, lbs/hr			
Front half and Filter	87.58	79.78	96.55
Total	94.87	88.44	102.10
Particulate Emissions, lbs/ton			
Front half and Filter	6.28	5.72	6.93
Total	6.81	6.34	7.32
SO_2 Emissions, lbs/hr			
3rd Impinger	0.06	Neg.	0.005
4th Impinger	0.006	Neg.	0.03

*Dry, 70°F., 29.92 in. Hg

**Moisture determined from separate test

TABLE 3

PARTICULATE EMISSIONS
SMELT TANK

	Run #1	Run #2	Run #3
Date	7/12/72	7/19/72	7/21/72
Time Began	1450	1435	1301
Time End	1705	1700	1600
Barometric Pressure, In. Hg Absolute	30.2	30.0	30.0
Meter Orifice Pressure Drop, In. H_2O	1.57	1.51	
Vol. Dry Gas @ Meter Conditions, ft^3	106.875	120.623	
Average Gas Meter Temperature, °F.	98.5	101.0	
Vol. Dry Gas @ S.T.P.*, ft^3	102.739	114.660	
Stack Gas Moisture, % Volume	25.0***	24.0***	22.0***
% CO_2	0.06	0.06	0.06
% O_2	20.0	20.0	20.0
% CO	0.002	0.002	0.002
% N_2	79.9	79.9	79.9
Average Stack Gas Temperature, °F.	150	148	144
Stack Pressure, In. Hg Absolute	30.2	30.0	30.0
Stack Gas Velocity @ Stack Cond., fpm	2901#	3666#	3437#
Stack Gas Flow Rate @ S.T.P.*, scfm	7,442**	7,442**	7,442**
Net Time of Test, min.	132	132	132
Percent Isokinetic	120.7#	47.0#	68.0#
Particulate Concentrations, grains/scf			
Front half and Filter	0.047	0.063	0.078
Total	0.050	0.066	0.083
Particulate Emissions, lbs/hr			
Front half and Filter	2.97	4.04	4.95
Total	3.18	4.22	5.35
Particulate Emissions, lbs/ton ADP			
Front half and Filter	0.213	0.290	0.355
Total	0.228	0.303	0.384
SO_2 Emissions, lbs/hr	Neg.	Neg.	Neg.

*Dry, 70° F., 29.92 in. Hg

#Velocity measurements were affected by tangential flow in the outlet stack

**Gas flow was determined from inlet stack velocity measurements

***Moisture determined by assuming stack gas was saturated

TABLE 4

AMERICAN CAN COMPANY - HALSEY, OREGON
NO. 3 RECOVERY BOILER
O_2, CO_2, AND CO
DAILY MEAN CONCENTRATIONS

Date	Mean Concentration (dry basis)		
	O_2 (%)	CO_2 (%)	CO (ppm)
*7-12-72	17.9	3.4	88
*7-13-72	16.1	4.7	113
7-14-72	8.1	12.3	132
7-15-72	7.6	12.4	85
7-17-72	7.4	13.3	72
7-18-72	7.7	12.7	156
7-19-72	8.0	12.0	90
7-20-72	8.0	12.4	36

AVG = 95 ppm

* Results due to leak in probe and subsequent dilution with ambient air.

TABLE 5

NITROGEN OXIDE CONCENTRATIONS RECOVERY FURNACE OUTLET

Date	Time	NO_x, ppm
7/13/72	1340	44
	1630	38
	1810	43
7/14/72	1230	8
	1450	43
	1600	16
7/15/72	1055	44
	1335	48
	1500	63

III. PROCESS DESCRIPTION AND OPERATION

The American Can operation at Halsey, Oregon is a complete pulp and paper mill, producing about 300 tons of bleached kraft pulp per day. From this, about 200 tons per day of tissue, towels, and napkins are made; the remaining pulp, about 100 tons per day, is shipped to other mills.

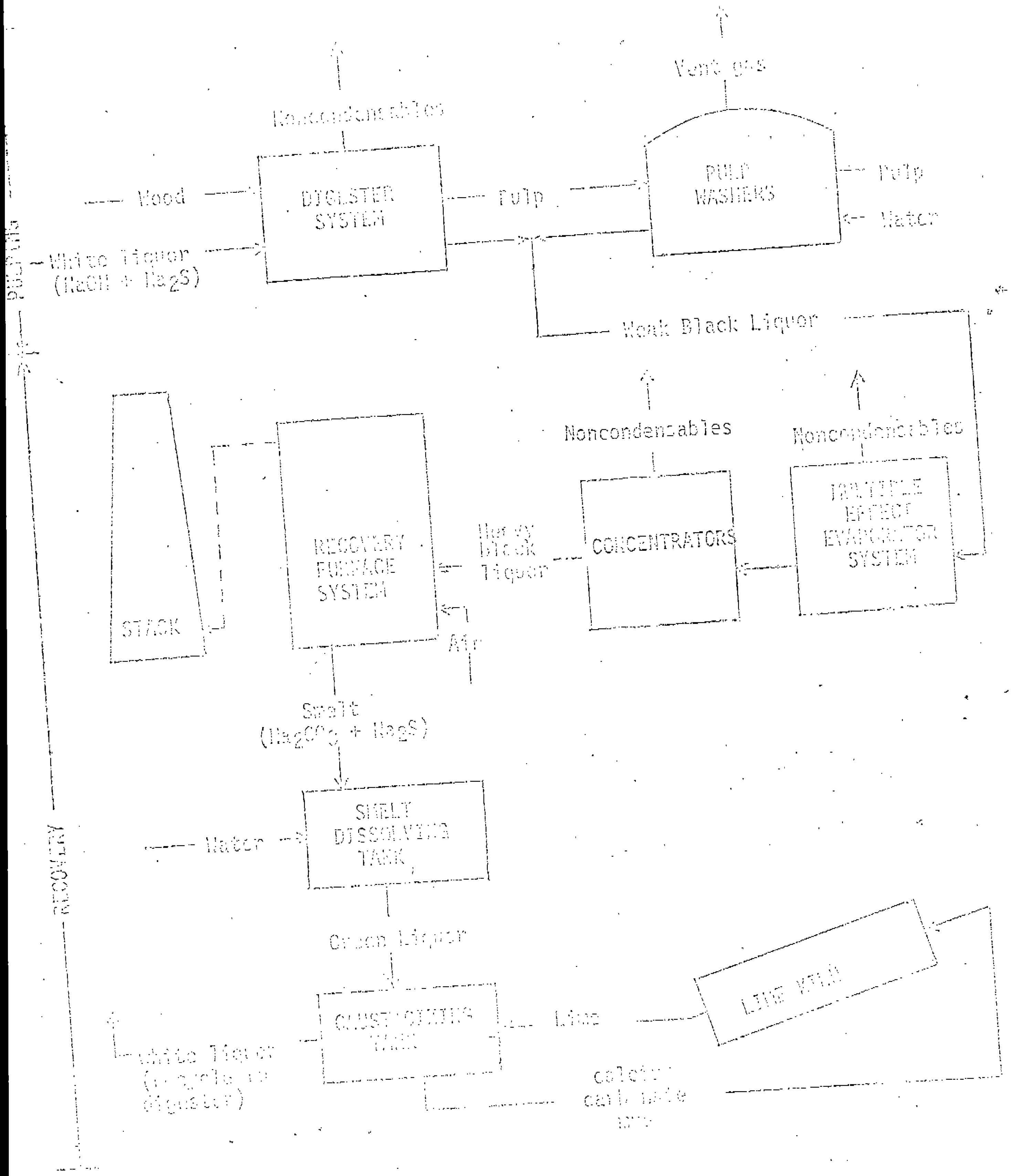
Process Description

A. General

Kraft pulp is produced from wood as shown in Figure 1. The wood used at Halsey is mostly fir, mixed with less than 5 percent of hemlock, silver spruce, and cedar. All the wood is residual material from neighboring sawmills. Sawdust and chips are kept segregated and processed in two separate continuous digesters.

In the pulping process, wood is cooked in the digesters under pressure at elevated temperature. The cooking chemicals (a water solution of sodium hydroxide and sodium sulfide called "white liquor") chemically dissolve the wood lignin. The freed wood cellulose, or pulp, is filtered from the spent liquor and washed. After being bleached, most of the pulp is made into paper.

The balance of the process is designed to recover cooking chemicals. Spent cooking liquor and the pulp wash water are combined for treatment. The combined stream, called weak black liquor, is concentrated in multiple-effect evaporators. The final two effects

PULPING
RECOVERY
Noncondensables
Vent gas
Wood
DIGESTER SYSTEM
Pulp
PULP WASHERS
Pulp
Water
White liquor
(NaOH + Na2S)
Weak Black Liquor
Noncondensables
Noncondensables
STACK
RECOVERY FURNACE SYSTEM
Heavy Black Liquor
CONCENTRATORS
MULTIPLE EFFECT EVAPORATOR SYSTEM
Air
Smelt
(Na2CO3 + Na2S)
SMELT DISSOLVING TANK
Water
Green Liquor
CAUSTICIZING TANK
Lime
LIME KILN
White liquor
(recycle to digester)
calcium carbonate mud

[illegible] 1. [illegible]

are specially designed to handle the thickened black liquor. These effects are called "concentrators" and replace the conventional direct contact evaporator used in most mills. Liquor leaving the concentrators, containing about 37 percent water, is fed to the recovery furnace. The organic constituents (principally dissolved lignin) burn, and the heat is used to generate process steam. Inorganic chemicals in the black liquor collect at the bottom of the furnace as a molten smelt. The smelt is a mixture of sodium carbonate and sodium hydroxide. After being tapped from the furnace it is dissolved in water and transferred to a causticizing tank. Lime added to this tank converts sodium carbonate to sodium hydroxide, completing the regeneration of white liquor for recycle to the digesters. A calcium carbonate mud precipitates from the causticizing tank, and is recycled to a kiln to regenerate lime.

Two of the above process facilities were tested by EPA; the recovery furnace system, and the smelt dissolving tank. These facilities are described below.

B. Recovery Furnace System

The recovery furnace system consists of a recovery furnace and an electrostatic precipitator. The system is shown in Figure 2.

The recovery furnace was designed by Babcock and Wilcox to burn 1.2 million pounds of black liquor solids per day, which is equivalent to a pulp production rate of 300 tons per day. Hot black liquor is sprayed into the furnace through nozzles located near the furnace bottom. Occasionally, when extra heat is needed or when the black liquor supply is temporarily interrupted, natural gas or oil is burned.

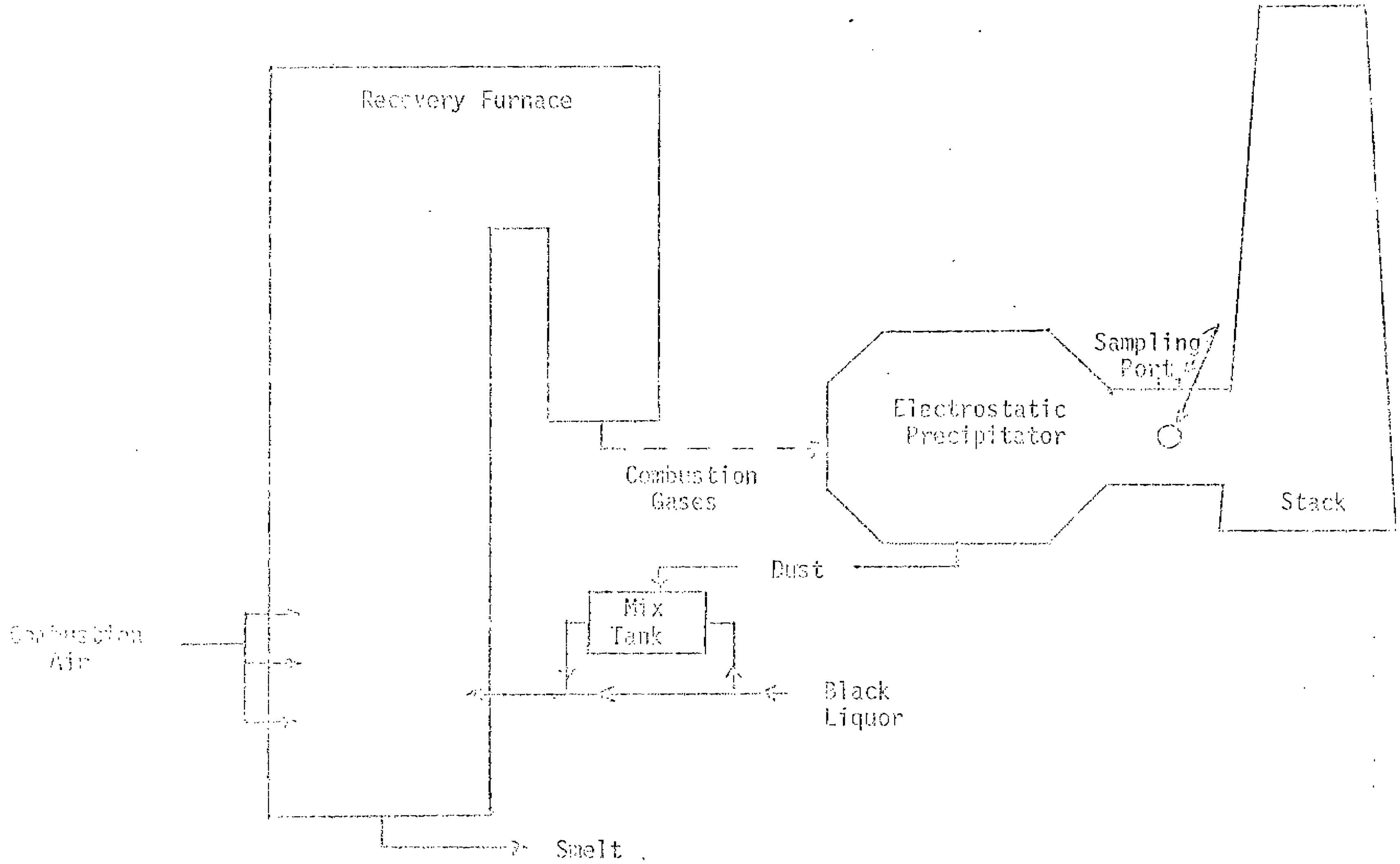


Figure 2. Recovery Furnace System at the American Can Company Mill in Halsey, Oregon.

Preheated combustion air is blown in at three levels. Beginning with the lowest levels, the streams are called primary, secondary, and tertiary air. The vent gases from the pulp washers, which contain odorous gases, are mixed with the combustion air and burned in the furnace.

To utilize the black liquor heat of combustion, the recovery furnace is constructed with water walls and contains many boiler tubes. Steam is produced at the rate of about 200,000 pounds per hour, providing part of the process requirements. The remaining steam needs are met with a conventional gas-fired power boiler.

The boiler tubes in the recovery furnace accumulate particulate from the combustion gases. These deposits are continually removed by blowing steam over the tubes. About 10 percent of the steam produced in the recovery furnace is used in the soot blowers.

The last stages for concentrating black liquor prior to burning are special evaporators called concentrators. The steam heated concentrators replace the direct contact evaporators used in most other mills. Two concentrators are used in series, with a third as a standby replacement. The units are rotated frequently and cleaned while on standby.

Combustion gases leaving the recovery furnace are cleaned in an electrostatic precipitator and then exhaust from a 300 foot stack. (Gases from the plant's lime kiln are also discharged through this stack.) The precipitator was constructed by Research Cottrell. It has a dry bottom with two parallel chambers and three electrical control sections in each chamber. The design efficiency is 99.5 percent.

The material collected in the precipitator is principally a mixture of sodium sulfate and sodium carbonate. These compounds are valuable process chemicals. After being removed from the hoppers, the precipitated dust is dumped into a mix tank and dissolved in black liquor for recycle to the furnace. Vent gases from the mix tank are burned in the furnace to control odors.

Additional sodium sulfate, to make up for stack losses, is dissolved into the black liquor just before firing. The normal makeup rate is about 700 pounds of sodium sulfate per hour.

C. Smelt Dissolving Tank

Molten smelt formed in the bottom of the recovery furnace is tapped off into a tank filled with water. The smelt dissolves in the water to form "green liquor". The green liquor is then pumped from the tank for further processing.

Contact with the hot smelt thoroughly agitates the receiving water, and causes the formation of large amounts of steam. The steam is vented to the atmosphere through a scrubber to remove particulates. The smelt dissolving tank and scrubber are shown in Figure 3.

The scrubber is packed with plastic cylinders known as Pall rings. An induced draft fan draws the gases up through the packing where they are scrubbed countercurrently with water. The scrubbing water is a blend of several discharge streams in the mill, but the major portion is weak wash (water that was used to wash the mud being charged to the lime kiln). Two water streams leave the scrubber. One stream is recycled by blending it with the incoming [illegible] the second stream goes to the smelt dissolving tank. [illegible]

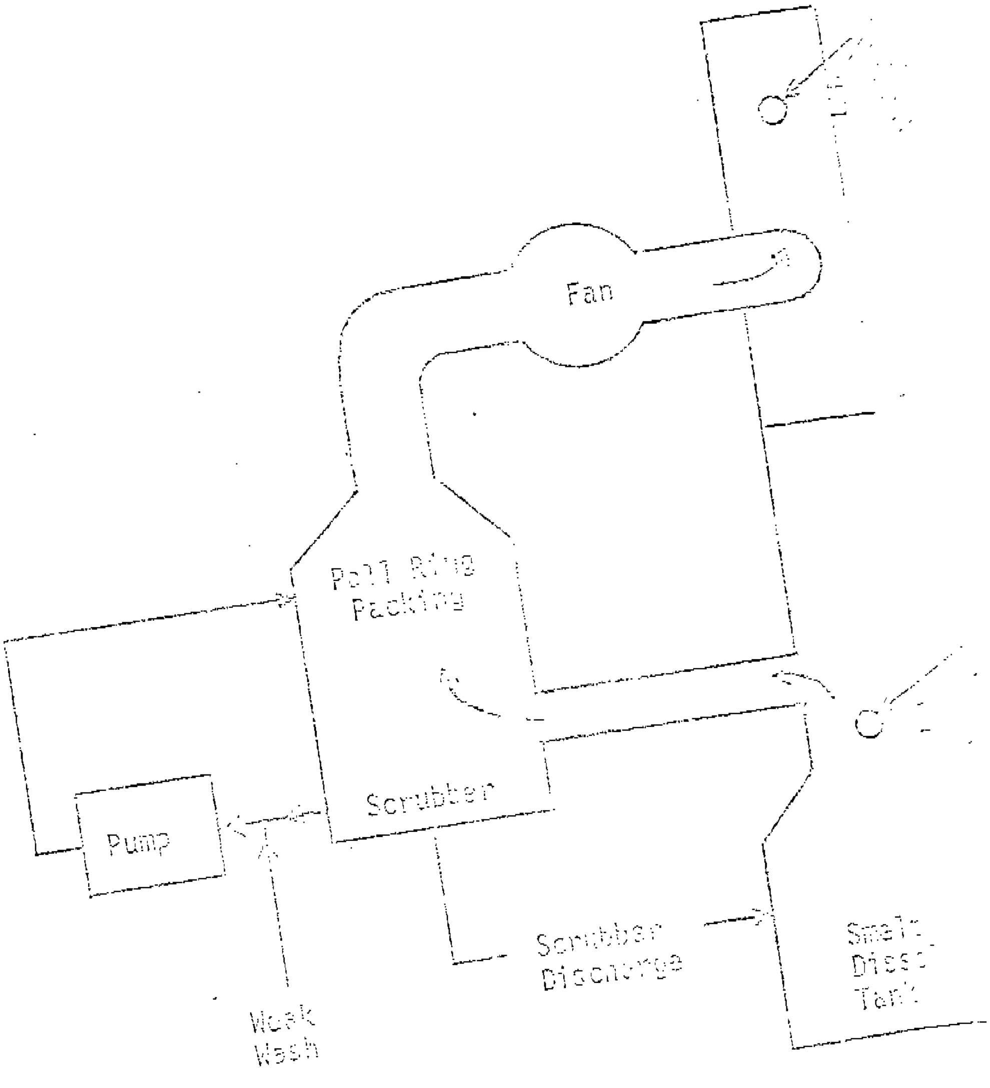

Fan
Pall Ring
Packing
Scrubber
Pump
Weak
Wash
Scrubber
Discharge
Smel
Diss
Tan

Figure 3. [illegible]

Process Operation

A. General

The purpose of the test program was to measure emission levels during normal plant operation. Process conditions were carefully observed, and testing was done only when the test facility appeared to be operating normally. During the tests, important operating conditions were monitored and recorded on process data sheets. The process data are summarized below.

B. Recovery Furnace

During the tests, major furnace operating conditions were monitored from the control room. Half-hourly readings were recorded on process data sheets. The records and a key explaining the entries are included in the appendix.

Steam production, black liquor feed rate, and saltcake addition rate were each monitored on two instruments. One instrument, a chart recorder, gave instantaneous values; the second instrument indicated running totals. On July 15, comparisons were made between the two instruments. Average flow rates were computed by dividing the difference in integrator readings by the time between readings. The average chart flow rate for the same time interval was determined by inspection and compared. The integrator readings were found to be 1 percent lower than the chart readings for steam production and black liquor flow rate. For salt cake addition rate, however, the integrator readings were 18 percent less than the chart readings. The Company indicated that the chart readings (item 20 on the process data sheets) are more reliable.

Samples of black liquor (as fired) were taken during the tests. Each day's sample was composed of several portions taken at approximate intervals of 90 minutes. To inhibit vaporization of water, the hot black liquor was drawn through a cooling coil. This procedure reduced the temperature from about 259 to about 206°F. The samples were analyzed for heat content, percent solids, and pH. Results of the analyses are given in the Summary of Test Results section of this report.

A green liquor sample was taken from the smelt dissolving tank during each day of testing. The samples were analyzed to determine reduction ratio, a measure of the conversion of sodium sulfate to sodium sulfide within the recovery furnace. Analytical results are given in the Summary of Test Results section of this report.

Sulfidity levels during the tests were reported by the Company to be about 22 percent. Normal levels for this mill are reportedly 21 to 22 percent. These low sulfidities account in part for the relatively low levels of SO_2 measured from the recovery furnace.

The observed ranges of major operating conditions during the tests are summaried in Table 6. Black liquor feed rate was very steady between 128 and 132 gallons per minute. The black liquor solids content ranged narrowly between 62.0 and 62.5 percent. Black liquor heat content, determined from six composite samples, varied from 3697 to [illegible] BTU per pound of liquor (wet basis). Total steam production (including what was used for blowing soot) was normally about 210,000 pounds per hour but on one occasion reached 2[illegible],000. Reduction ratio determined from seven samples ranged from 71.0 to 87.0 indicating a somewhat low degree of [illegible] reduction in the furnace.

Table 6. SUMMARY OF THE RECOVERY FURNACE PROCESS DATA

Operating Condition	Units	Range During Test (July 12-21, 1972)	Item Number On Process Data Sheets
Black Liquor Feed Rate	GPM	128 - 132	10
Black Liquor Solids Content (a)	wt. %	62.0 - 63.9	14
Black Liquor Heat Content (b)	BTU/lb liquor	3697 - 3945	-
Steam Production (c)	1000 lb/hr	198 - 245	1
Reduction Ratio (d)	%	79.8 - 87.0	-
Sulfidity (e)	%	22	-

(a) Black liquor as fired.

(b) Black liquor as fired. Results of six composite samples. Wet basis.

(c) Total production including soot blowing steam.

(d) 100 (Na_2S)/(Na_2S + $Na_2 SO_4$). Results of seven samples.

(e) 100 (Na_2S)/(Na_2S + NaOH). Company reports.

As far as known from the process records and discussions with the operators, the furnace was operated normally during the tests.

C. Electrostatic Precipitator

The primary voltage and secondary current for each control section of the precipitator are displayed in the recovery furnace control room. Readings were taken on the half-hours during testing, and recorded with the furnace operating conditions on the process data sheets (Appendix). The readings are summarized in Table 7 for July 13, 14, and 15, the days on which particulate emissions were sampled.

As far as known from the records and from conversations with the operators, the precipitator was operating normally during the tests.

D. Smelt Dissolving Tank

Particulate emissions from the smelt dissolving tank were measured on July 12, 19 and 21, 1972. TRS and SO_2 emissions were measured July 21. During the tests records were kept on the recovery furnace, whose operation is closely related to the dissolving tank. These records are included with the other furnace operating data in the appendix.

Green liquor samples taken from the dissolving tank were analyzed for reduction ratio. The determinations for July 19 and 21 were 84.5 and 77.0 percent respectively. (No sample was taken on July 12.)

The records show that furnace operation during tests on the dissolving tank were approximately the same as on the other days. As far as known from these records, the smelt dissolving tank was operated normally during the tests.

Unit 2		
Secondary Current	Amps	0.7 - 1.5
Primary Voltage	Volts	320 - 360
Unit 3		
Secondary Current	Amps	1.3 - 1.8

/1992

[illegible]

[illegible]

[illegible]

SO_2 = 14.77 - 63.82 lb/hr @600 ADT/day
= 0.55 - 2.4 lb/hr

* N[illegible] [illegible] report in EMR's [illegible]

Halsey - 325 ADT/day or 13.5 ADT/hr

EPA tests at American Can Co., Halsey, Oregon
Recovery Boiler (no DCE) (1972)

CO ≈ 100 ppm =

$\frac{lb\,CO}{hr} = (4.3\times10^{-6})$ [illegible] $(85{,}000\ scfm) = 36\ \frac{lb}{hr}$

$36\ \frac{lb}{hr} \cdot \frac{hr}{13.5\ ADT} \approx 3\ lb/ton\ (1-5)$

NO_x - ppm ≈ 40 (8-63 ppm)

$\frac{lb\,NO_2}{hr} = (7\times10^{-6})(85000)(40\ ppm) = 24\ \frac{lb}{hr}$

$\frac{24}{13.5} \approx 2\ lb/ton$

SO_2 - neg. - 0.07 lb/hr → 0.0052 lb/ton

- per p. 17 of test report, low sulfidity levels (22%) account in part for low SO_2 levels
- no auxilliary fuel except when black liquor supply is temporarily interrupted

Ref 6*
Sec 10.1
5/74

[illegible]: 653 ADT/day
≈ 27 ADT/hr

EPA tests at U.S. Plywood - Pasadena, Texas (1972)

Recovery Boiler:

CO: 100 ppm, avg over 6 days

$\frac{lb\ CO}{hr} = (4.3 \times 10^{-6})(100\,ppm)(145{,}000\,scfm) = 61\ \frac{lb}{hr}$

$\frac{61}{27} \approx 2.3\ \frac{lb}{ADT}$

NOx: 20-25 ppm, avg.

$\frac{lb\ NO_2}{hr} = (7 \times 10^{-6})(23\,ppm)(145{,}000\,scfm) = 23.4\ \frac{lb}{hr}$

$\approx \frac{23.4}{27} = 0.9\ \frac{lb}{ton}$

SO_2: 14.77 - 63.82 lb/hr @600 ADT/day
= 0.55 - 2.4 lb/hr

* Note: test reports in EMB's test files