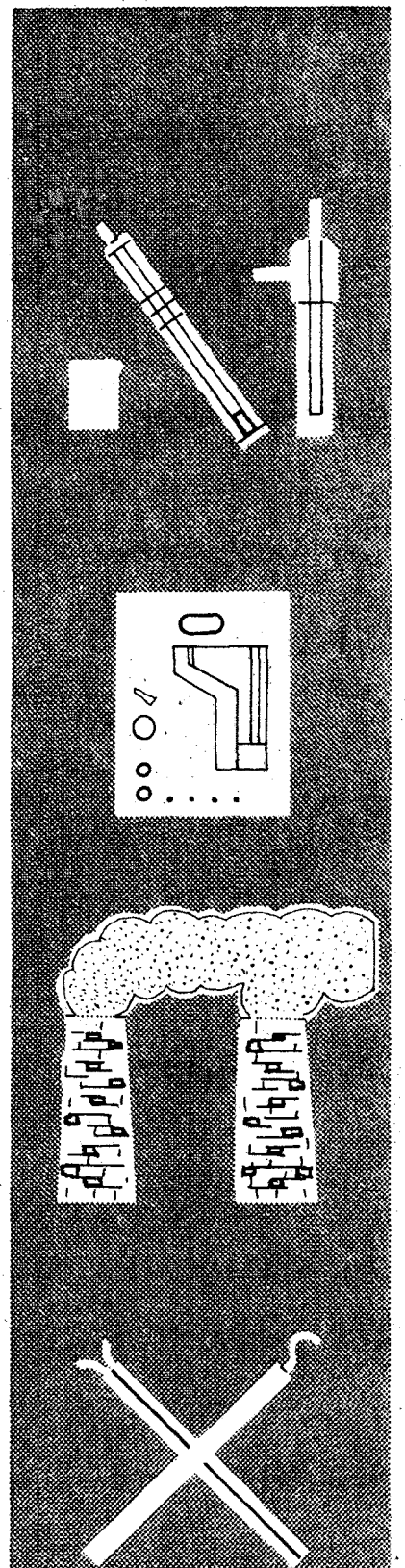

EPA PROJECT REPORT NO. 74-KPM-9

AIR POLLUTION EMISSION TEST

CROWN ZELLERBACH CORPORATION

Camas, Washington

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Emission Measurement Branch
Research Triangle Park, North Carolina

PARTICULATE EMISSION MEASUREMENTS FROM KRAFT PULP MILLS

EMB Project Report No.
74-KPM-9

Plant Tested

Crown Zellerbach Corporation
Camas, Washington

October 15-20, 1973

Prepared for

Environmental Protection Agency
Office of Air Quality Planning and Standards
Emission Measurement Branch
Research Triangle Park,
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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

I. INTRODUCTION

Under the Clean Air Act of 1970, the Environmental Protection Agency is given the responsibility of establishing performance standards for new installations or modifications to existing installations in stationary source categories. As a contractor, Monsanto Research Corporation (MRC), under the Environmental Protection Agency's "Field Sampling of Atmospheric Emissions" program, was asked to provide emission data from the Crown Zellerbach Corporation of Camas, Washington.

The field test work was directed by John Synder, Field Testing Section, Emission Measurement Branch. The sampling was performed by Monsanto Research Corporation with Darrell L. Harris as Team Leader.

This report tabulates the data collected at the inlet and outlet of the wet scrubber system controlling the exhaust of the smelt tank. The smelt tank is part of the overall recovery system of the kraft pulp mill. Spent digestion chemicals (black liquor) are burned in a recovery furnace and smelt is formed in the bottom. This smelt is continuously removed from the furnace and fed into the smelt dissolving tank where it is dissolved in scrubbing liquor or makeup water to make the uncausticized green liquor. Gaseous emissions from the smelt dissolving tank are scrubbed in a packed tower scrubber and emitted to the atmosphere.

Sampling was performed on the inlet and outlet of the packed tower scrubber. Particulate loadings were determined by Method 5, "Determination of Particulate Emissions from Stationary Sources." Other procedures that were required for the Method 5 tests were: Method 1, "Sample and Velocity Traverses for Stationary Sources;" Method 2, "Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube);" Method 3, "Gas Analysis for Carbon Dioxide, Excess Air and Dry Molecular Weight;" and Method 4, "Determination of Moisture in Stack Gases." All of the above methods are given in the Federal Register, Vol. 36, No. 247, December 23, 1971.

The only modifications required at each sampling location consisted of correcting the port location and providing a support surface for the sampling equipment.

This report presents a summary and discussion of sampling results, a description of the process, the location of sampling points, and a description of the sampling and analytical procedures. Appendices include all field and analytical data generated from this project.

II. SUMMARY AND DISCUSSION OF RESULTS

The inlet and outlet gases from the scrubber system at the Crown Zellerbach plant were sampled for particulate loading. The four runs on the outlet are identified by numbers 1 through 4 prefixed by "A". The one run completed on the inlet is identified by a "B" prefix. The five particulate runs were performed over a six-day period.

The inlet was sampled with a flexible heated probe because the horizontal duct required a vertical traverse. Figure 1 shows the setup of the Method 5 train and the modifications used to sample the inlet. The six-foot probe was supported in the vertical port by a bracket attached to the port and a clamp assembly to hold the probe in the proper location for each sampling point. On the horizontal traverse, the probe was supported in the correct position in the port by a board. The heated flexible line connected the probe to the sample train. The rest of the sampling train was exactly as specified in Method 5.

Two 20-point traverses were used on the inlet duct, but the last two points on the vertical traverse (those on the bottom side of the duct) were not sampled because of a backflow of water in the bottom of the duct. Run B-1 was ruined when water from the bottom of the duct was sucked into the cyclone, cyclone catch flask, and filter. Subsequent runs

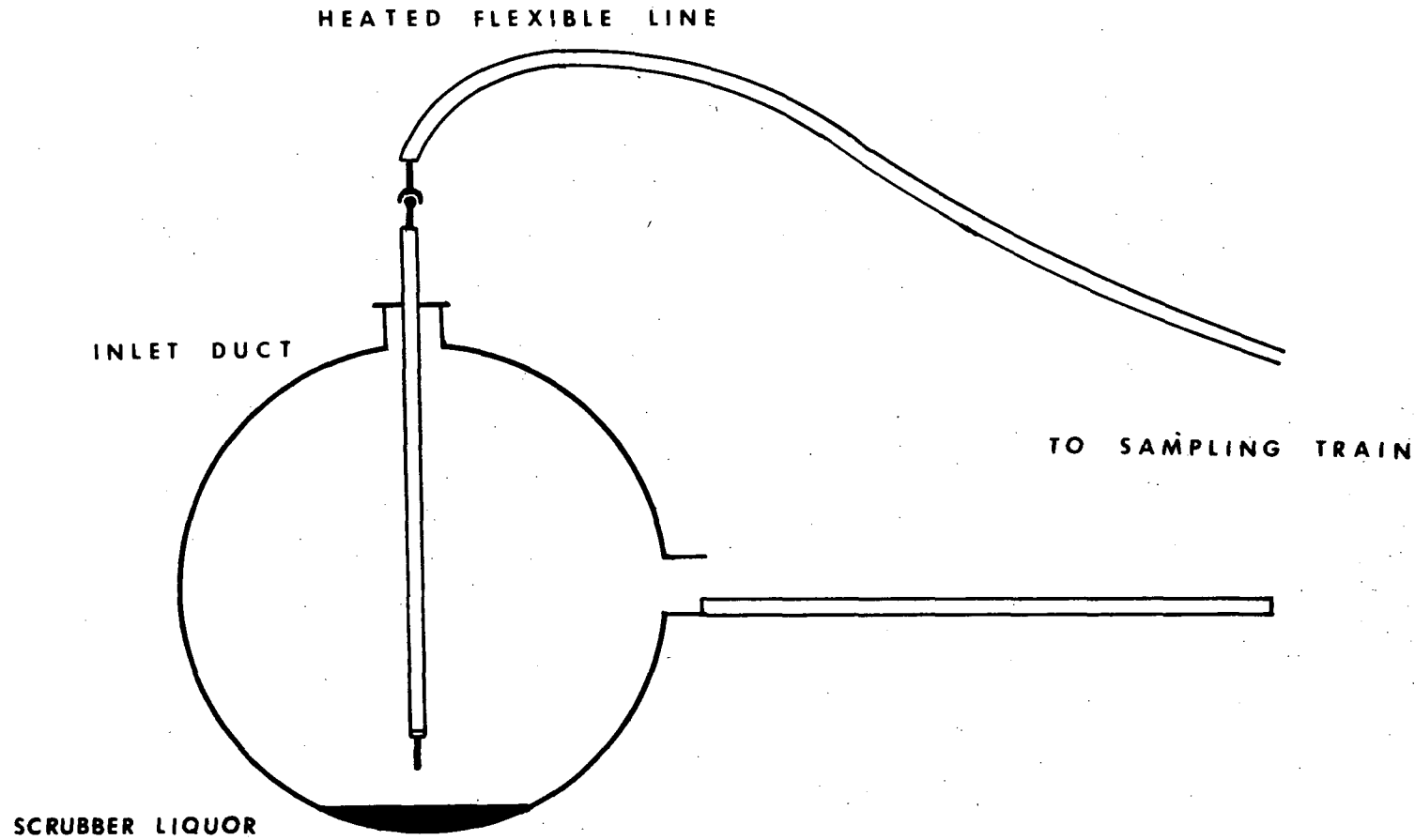


Figure 1. Setup of Method 5 probe and heated flexible line at the inlet

(B-2 and B-4) were made avoiding these last two points. Run B-3, to be run simultaneous with run A-3, was deleted from the program due to a cracked glass probe liner. The 38 points were sampled for 5 minutes each for a total run time of 190 minutes. At the outlet duct, all runs used two 18-point traverses, for a total of 36 points. Each point was sampled for 5 minutes for a total run time of 180 minutes.

Several problems were encountered during the sampling program involving both sampling equipment failure and plant process upsets. One entire day was lost (October 17, 1973) due to a "black out" or "black area" condition developing in the recovery furnace. This is caused when a portion of the buildup (dried black liquor) on the furnace's walls collapses and falls onto the smelt bed and blocks the primary air ports located near the bottom of the furnace. These ports produce a zone where reduction and smelting take place. If the air ports are blocked, a black zone occurs, and the fuel flow must be reduced until the condition is corrected.

As mentioned before, the first run on the inlet of the scrubber was lost due to dipping the probe tip into a scrubbing liquor backflow at the bottom of the duct. The third run at the inlet was not performed due to breakage of the probe used at this location. A spare probe was air shipped to Portland, but during the fourth run the new probe's heater shorted out and heat could not be applied to the probe gases. It was also discovered after the run that the cyclone in the oven had been broken; however, it was not known when the breakage occurred. It was noted that the collected volume of water was much lower than in the previous run for approximately equal volumes of gas sampled. This was due either to the lack of heat in the probe permitting condensation and run-back of stack moisture, or to the broken cyclone allowing ambient

air to enter the train. In any event, the run is not considered to be representative and has been deleted from the results.

No equipment failure occurred during the runs performed at the outlet of the scrubber. All four of these runs are considered to be representative.

A summary of the results of particulate sampling is given in Table 1. Particulate loadings from the probe, cyclone and filter are indicated as "front half," and the total catch includes the front half and the impinger residues.

Emission factors are calculated based on the rate of pulp produced. This rate can be calculated by knowing the amount of black liquor burned and the percent solids contained in the liquor. Normal production is calculated on a value of 0.0004 M tons of pulp produced per liter of black liquor at 61.4% solids content base average. The production for the individual runs is then found by the following equation:

$$[EPP] = [BLF]\,[PLR]\left[\frac{S_t}{S_b}\right]$$

where:

EPP = Equivalent pulp production rate, M ton/hr

BLF = Black liquor feed charged, liter/hr

PLR = Pulp to liquor ratio at average % solids, M tons/liter

S_t = % solids, test average

S_b = % solids, base average

and the emission factor is calculated by

$$F = \frac{E}{EPP}$$

Table 1. SUMMARY OF PARTICULATE RESULTS

Run Number:	A 1	A 2	A 3	A 4	B 2
Date:	10-16-73	10-18-73	10-19-73	10-20-73	10-18-73
Method Type	EPA - 5	EPA - 5	EPA - 5	EPA - 5	EPA - 5
Volume of gas sampled - (Nm^3)[4] - (DSCF)[1]	2.79 (98.6)	2.92 (103)	3.11 (110)	2.62 (92.6)	2.83 (100)
Percent Moisture by Volume	35.1	35.1	37.7	34.2	43.5
Average Stack Temperature - °C - (°F)	71.1 (160)	75.6 (168)	75.0 (167)	73.9 (165)	77.8 (172)
Stack Volumetric Flow Rate - Nm^3/sec - (DSCFM)[2]	8780 (5170)	8970 (5280)	9290 (5470)	8220 (4840)	7590 (4470)
Stack Volumetric Flow Rate - m^3/sec - (ACFM)[3]	15500 (9140)	16200 (9540)	17500 (10300)	14700 (8680)	15900 (9340)
Percent Isokinetic	100.0	103.1	105.3	100.3	108.9
Feed Rate - M tons/hr of Equivalent Pulp Production - (tons/hr)	11.2 (12.3)	9.5 (10.5)	9.4 (10.4)	11.2 (12.4)	9.5 (10.5)
Duration of Run - Minutes	180	180	180	180	190
Particulates					
Probe, Cyclone, and Filter Catch, mg	276.5	443.2	669.3	368.0	3034.8
mg/Nm^3 - (grains/DSCF)[6]	98.9 (0.0432)	152 (0.0663)	214 (0.0937)	140 (0.0612)	1070 (0.467)
Kg/hr - (lb/hr)	0.866 (1.91)	1.36 (3.00)	1.99 (4.39)	1.15 (2.54)	8.12 (17.9)
Kg/M ton of Equivalent Pulp Production - (lb/ton)	0.077 (0.155)	0.143 (0.286)	0.212 (0.422)	0.103 (0.205)	0.855 (1.70)
Total Catch - mg	314.4	477.6	685.0	401.5	3196.4
mg/Nm^3 - (grains/DSCF)[6]	112 (0.0491)	163 (0.0714)	219 (0.0959)	153 (0.0668)	1130 (0.4920)
Kg/hr - (lb/hr)	0.989 (2.18)	1.47 (3.23)	2.04 (4.50)	1.26 (2.77)	8.53 (18.80)
Kg/M ton of Equivalent Pulp Production - (lb/ton)	0.088 (0.177)	0.155 (0.308)	0.217 (0.433)	0.113 (0.223)	0.898 (1.79)
Percent Impinger Catch	12.1	7.2	2.3	8.3	5.1

[1]Dry Standard Cubic Feet @ 70°F, 29.92 in Hg
[2]Dry Standard Cubic Feet per Minute @ 70°F, 29.92 in Hg
[3]Actual Cubic Feet per Minute - Stack Conditions
[4]Normal Cubic Meters at 21.1°C, 760 mm Hg
[5]Metric Tons per Hour (1 metric ton - 1000 Kg)
[6]Grains per Dry Standard Cubic Feet

where:

F = Emission factor, kg/M ton
E = Emission rate kg/hr
EPP = Equivalent pulp production rate, M ton/hr

A summary of calculations of equivalent pulp production rates for all runs is given in Table 2.

Table 2. SUMMARY OF CALCULATIONS OF EQUIVALENT PULP PRODUCTION RATE

Date	Run No.	Average black liquor flow rate during test		Test time, min	Avg % solids	Black liquor charged		Equivalent pulp production		Equivalent pulp production rate	
		lpm	gpm			liters	gallons	M tons	tons	M tons/hr	tons/hr
10/16	A-1	485	128	180	58.9	87210	23040	33.5	36.9	11.2	12.3
10/18	A-2	413	109	180	59.2	74270	19620	28.6	31.6	9.5	10.5
10/19	A-3	413	109	180	58.4	74270	19620	28.3	31.1	9.4	10.4
10/20	A-4	485	128	180	59.2	87210	23040	33.6	37.1	11.2	12.4
10/18	B-2	413	109	190	59.2	78390	20710	30.2	33.3	9.5	10.5

III. PROCESS DESCRIPTION AND OPERATION

Kraft pulp is produced from wood as shown in Figure 2. The wood used at Camas is mostly fir and hemlock. In the pulping process 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 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 black liquor receives its final concentration in direct contact evaporators. Liquor leaving the evaporators, containing about 37% 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 sulfide. 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

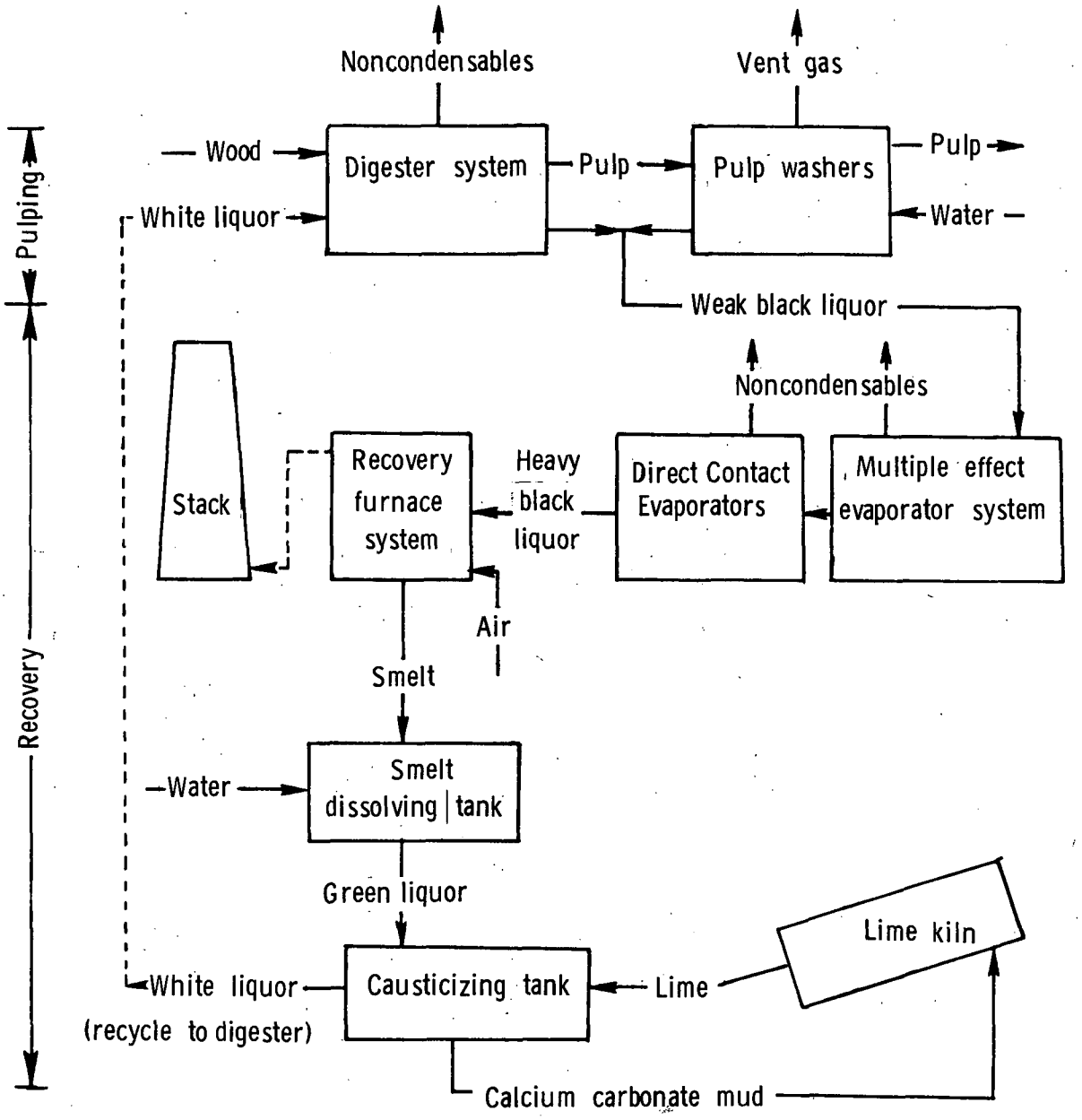


Figure 2. Kraft pulping process

for recycle to the digesters. A calcium carbonate mud precipitates from the causticizing tank, and is recycled to a kiln to regenerate lime.

Only one of the above process facilities was tested by EPA. This facility was the smelt dissolving tank. However, both the smelt dissolving tank and the recovery furnace system are described below.

The smelt dissolving tank receives a stream of molten smelt which is continuously tapped from the recovery furnace. The molten smelt is subsequently dissolved in the smelt dissolving tank to form "green liquor." The green liquor is then sent to the causticizing department for further processing. Weak wash is used as the dissolving liquid in the smelt tank. This is the liquid stream that results from washing the lime mud.

The recovery furnace in which the smelt is formed was manufactured by the Babcock and Wilcox Company. This furnace is designed to operate at an equivalent pulp production of 360 air-dried tons per day, but Crown Zellerbach operates this furnace slightly above design capacity. Hot black liquor is sprayed into the furnace through a nozzle 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.

The smelt dissolving tank system consists of a smelt spout, a dissolving tank, agitators, circulating pumps, and a system of pumps and piping for transferring the dissolving tank green liquor to the causticizing department. The smelt dissolving tank is normally supplied with a closed top, a vent pipe, and steel housings which enclose the smelt spouts

projecting from the front of the furnace hearth.

A smelt spout is basically a water cooled trough which is used to disperse or otherwise break up the stream of smelt before it hits the surface of the liquor in the tank. This is accomplished by discharging a heavy stream of recirculated green liquor into the stream of molten smelt through nozzles located behind and slightly below the smelt spout.

Breaking up of the smelt stream before it hits the liquor surface in the tank prevents serious explosions which might be caused by the reaction between the hot smelt and the green liquor in which it is to be dissolved. In effect, there is a continual series of small explosions taking place at the contact point of the molten smelt and the recirculated green liquor. This 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 packed tower scrubber which removes particulates.

The scrubber is packed with 7.6 cm (3 inch) polypropylene intalox saddles. The gases move up through the packing where they are scrubbed countercurrently with fresh water. Two streams of water leave the scrubber. One is the overflow which is ducted to the smelt dissolving tank. The other is recycled and blended with the incoming makeup water (fresh water). The scrubbed exhaust gases pass through an entrainment separator prior to leaving the packed tower. This entrainment separator is a 0.45 meter (1.5 foot) section packed with 5 cm (2 inch) polypropylene intalox saddles.

IV. LOCATION OF SAMPLING POINTS

Sampling was conducted at the inlet and outlet of the wet scrubber. The system, shown in Figure 3, has 1.22 m (48 in.) diameter stack extending from the top of the smelt dissolving tank through the roof of the building. A 0.91 m (36 in.) diameter line transfers gas to the inlet of the scrubber. It extends from the top of the smelt tank at approximately an 80° angle (10° from horizontal) to the bottom of the scrubber. Inlet samples were taken from ports located in this line 2.18 m (86 in.) downstream from a normally open damper and 0.91 m (36 in.) upstream of an inspection manhole. This constituted a 2.39 diameter distance from the nearest upstream disturbance and a 1.0 diameter distance from the nearest downstream disturbance. There were two 10.2 cm (4 in.) ports at this location, positioned 90° from each other.

The outlet line of the scrubber rejoined the original stack at a distance of approximately 9 m (29 ft) from the top of the stack. A normally closed damper was located in the stack between the scrubber inlet and outlet lines that could be opened if necessary to bypass the scrubber.

The scrubber outlet was sampled at two 10.2 cm (4 in.) diameter ports positioned 90° from each other on the original stack. They were located 4.27 m (14 ft) from the junction of the stack and scrubber outlet and 4.57 m (15 ft) from the

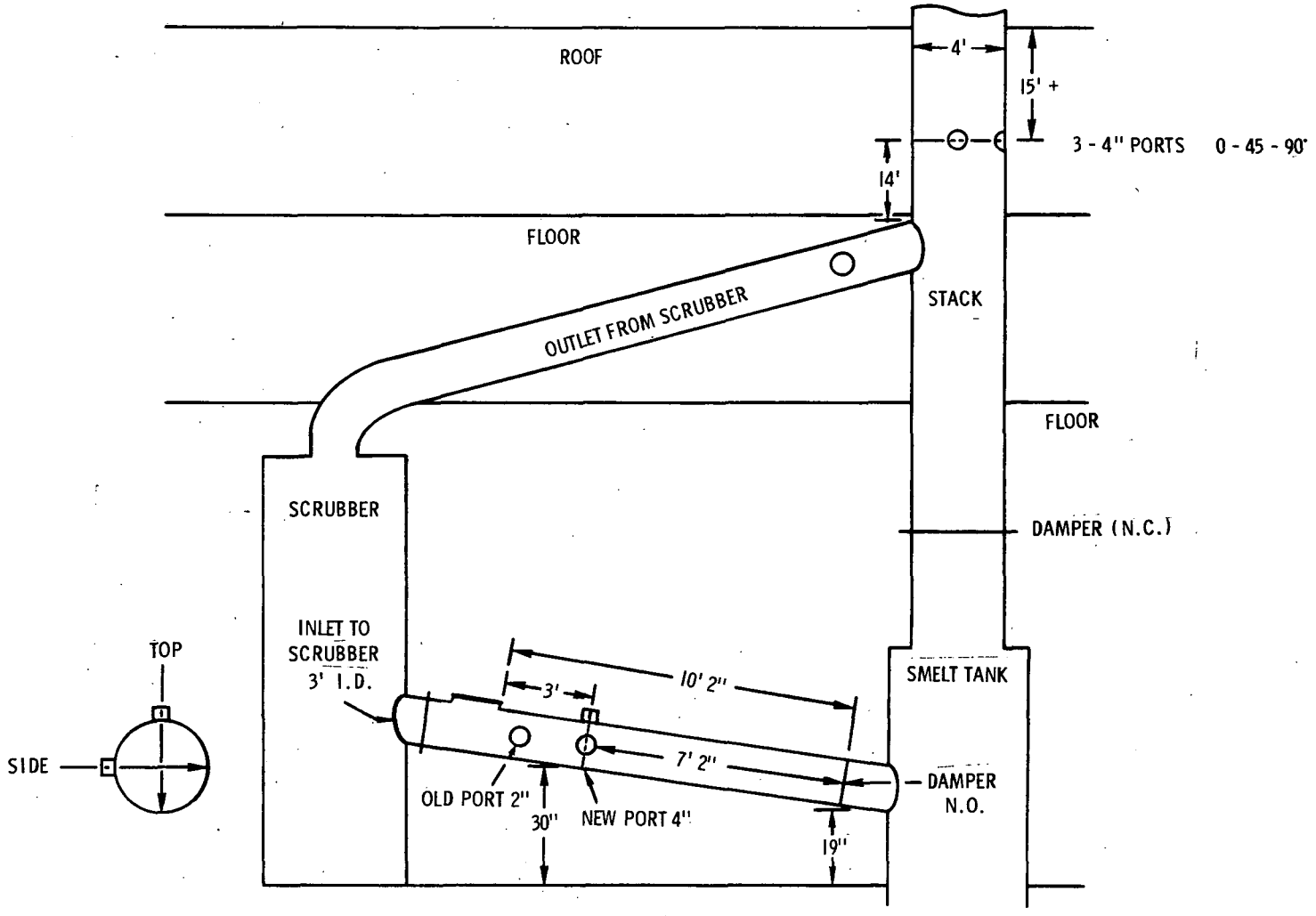


Figure 3. Inlet and outlet of scrubber sampled at Crown Zellerbach Corporation

atmosphere outlet of the stack. This constituted a sampling location 3.5 diameters from the nearest upstream disturbance and 3.75 diameters from the nearest downstream disturbance.

Figures 4 and 5 show the traverse point locations for the inlet and outlet sampling positions.

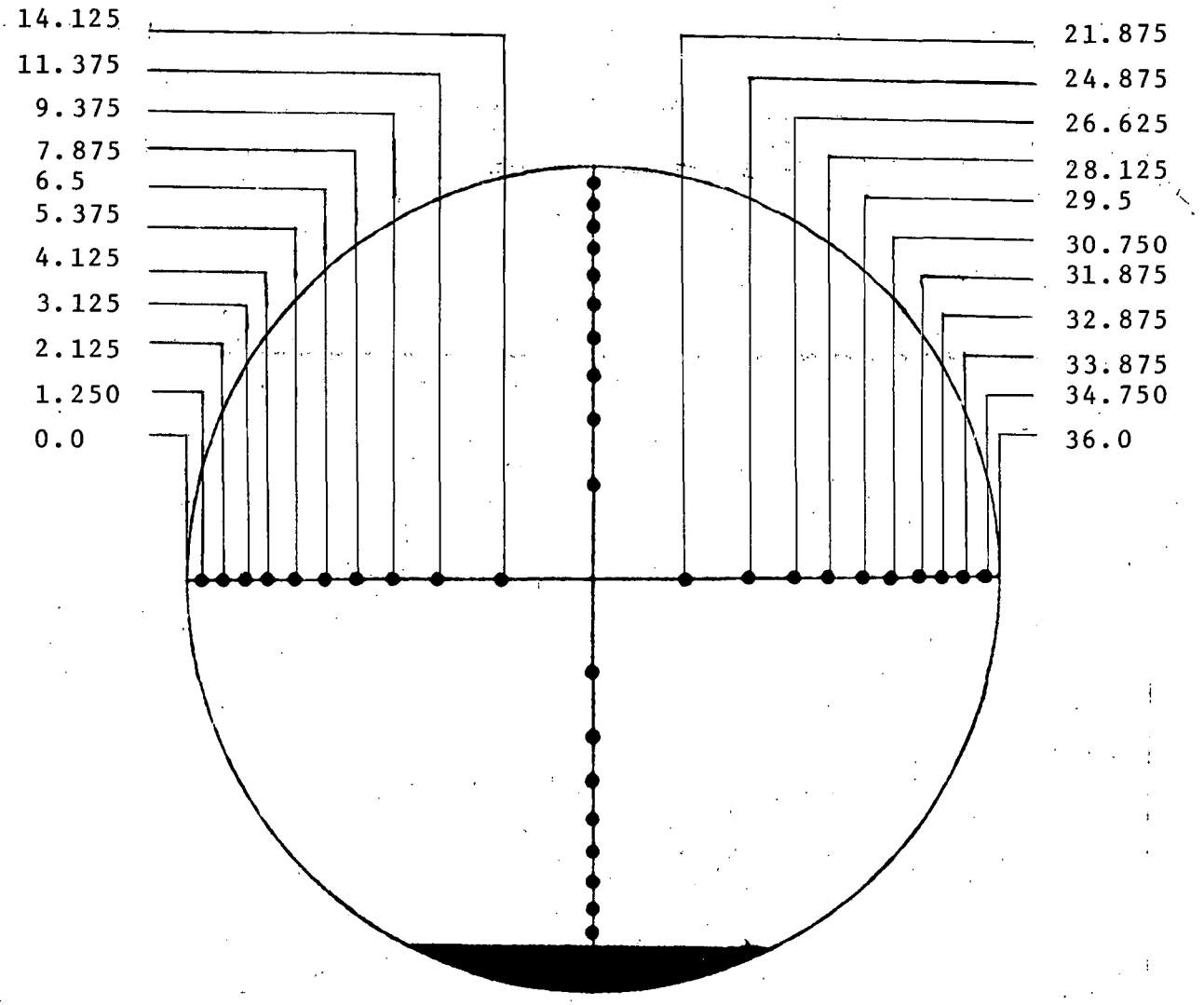


Figure 4. Traverse point locations (inlet)

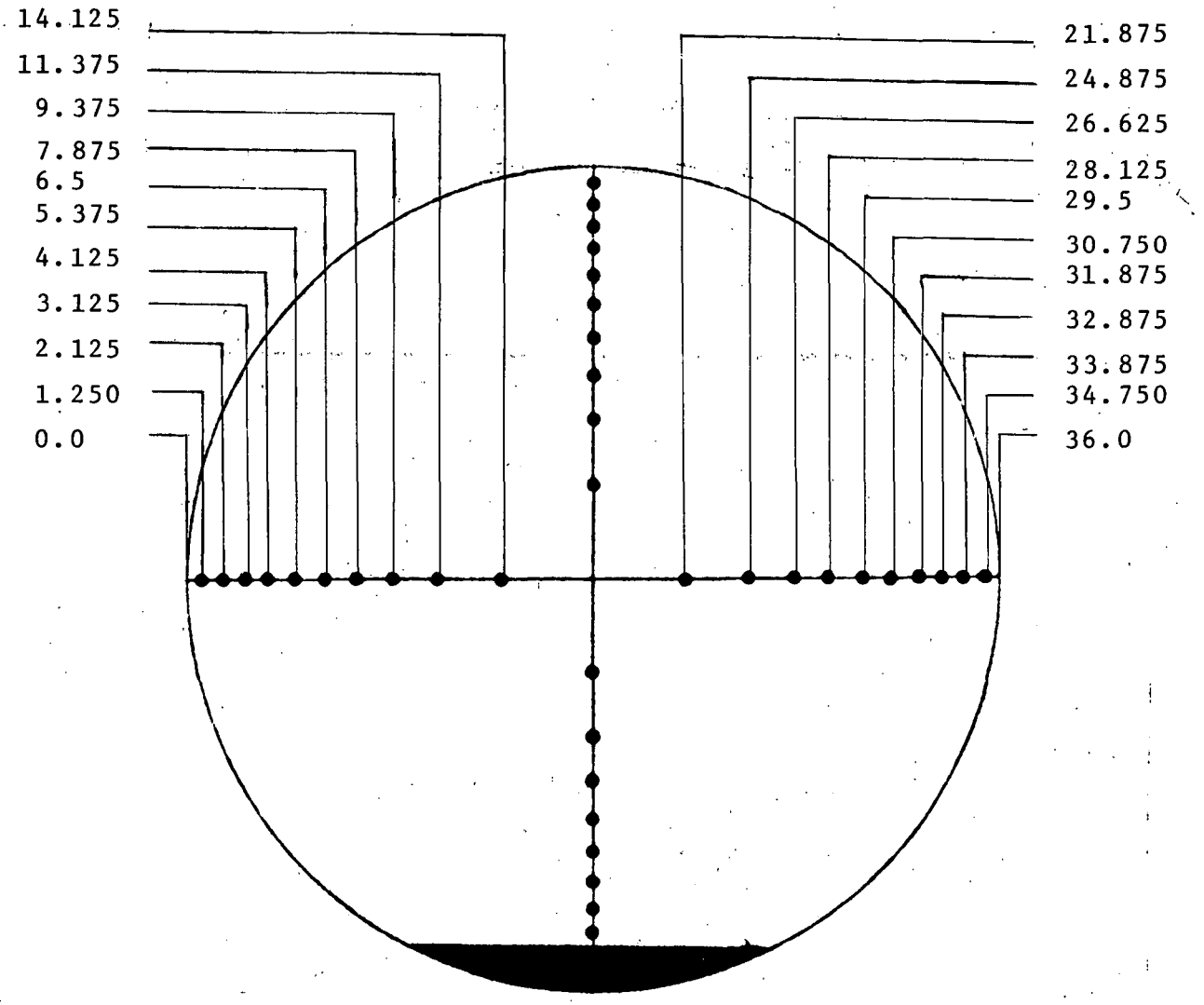
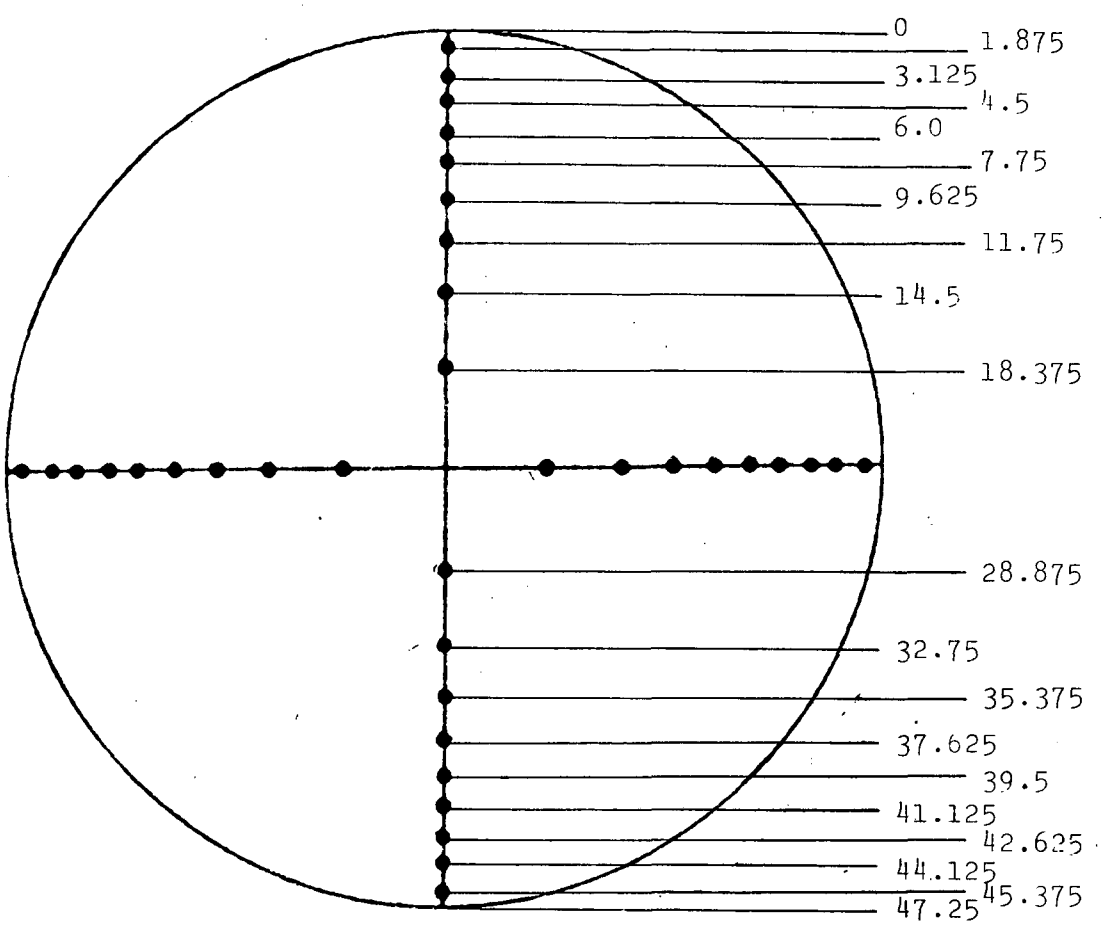


Figure 4. Traverse point locations (inlet)



47.25 inch I.D.

Figure 5. Traverse point locations (outlet)

V. SAMPLING AND ANALYTICAL PROCEDURES

SAMPLING PROCEDURES

The wet scrubber inlet and outlet were sampled generally in accordance with the Federal Register methods. The exceptions to these methods are listed below.

1. On the inlet, a special flexible line was used so that the vertical port could be sampled. As can be seen in Figure 1, a conventional 1.82 m (6 ft) stainless steel glass lined probe was used to traverse. It was held in the duct by a bracket. A heated flexible sample line was run from the probe to the sample box connecting it to the cyclone in the heated oven in the same manner in which the conventional probe is connected to the sample box. The heat in the flexible line was controlled by a variac and kept above 100°C (212°F).

   The horizontal port was traversed in the same manner as the vertical port except that a board was used to support the stainless steel glass-lined probe, as can be seen in Figure 1.

2. Method 4 tests were run to determine the moisture in the stacks. On the inlet the moisture was 33% and unsaturated, and on the outlet, 37% and saturated. There were droplets of water in the gas stream of the inlet, so this stack was treated as a saturated or super-saturated gas stream at 77°C (170°F).

   Halfway through each run on both the inlet and outlet the water in the impingers was measured and the moisture calculated. If the moisture for the first half of the run was different from that used in the nomograph calculation, the nomograph was readjusted to compensate for this difference in moisture.

ANALYTICAL PROCEDURES

Analytical procedures used on the collected samples generally followed the methods outlined in the Federal Register.

Samples from the Method 5 sampling trains were recovered as outlined in the August 17, 1971, Federal Register. After removal of the filters, all sample exposed surfaces were washed with distilled water or reagent grade acetone as specified. All sample bottles for liquid samples were obtained from Wheaton Scientific, Catalogue No. 219630. Each of these bottles was acid soaked with 1:1 HNO_3 for one day, rinsed with distilled water, and soaked with distilled water for one day prior to use.

Analytical procedure for the Method 5 samples followed the Federal Register guidelines with one exception. Container No. 3 as indicated in the method contains water from the impingers and washing of the glassware of the train. The solution was extracted with chloroform and ether, and then the extracted portion was dried to constant weight, as specified. In addition, the water remaining after extraction was evaporated to dryness at 100°C (212°F) to constant weight.[1] Both weights were included in the total mass of particulate.

Sample weights from the Method 5 samplers were reported as "front half" (probe washings and filter collection weights) and "total" (front half plus water, chloroform-ether extract and impinger acetone washing weights).

[1]See "Specifications for Incinerator Testing At Federal Facilities," U. S. Department of Health, Education, and Welfare publication, October 1967, page 31.