JSC/CCA

Container Division
8209 C. R. 131
WILDWOOD, FL 34785
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JEFFERSON SMURFIT CORPORATION & CONTAINER CORPORATION OF AMERICA

February 2, 1995

RECEIVED
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Bureau of
Air Regulation

Florida Dept. Environmental Reg
2600 Blair Stone Rd
Tallahassee, FL 32399-2400

Air Permitting & Standards Section

Subject: Container Corporation Of America
Name Change

Dear Sir,

This is to inform you that on December 31, 1994 the name of Container Corporation of America was changed to Jefferson Smurfit Corporation (U.S.). The company will continue to do business under the names Container Corporation of America and Jefferson Smurfit Corporation.

If you need any more information or require any further submissions concerning this matter, please contact me at 904-748-2900.

Sincerely,

Dave Riddell

Dave Riddell
General Manager
Jefferson Smurfit Corporation U.S.
8209 C.R. 131
Wildwood, FL 34785

cc: NE District
EPA

C5740002 1/94

Made from recycled paper

Deposition of Richard B. Jett, Mill Controller
(also, batch digester production - protected)

A The Phoenix Project in general terms is the restarting or rebuilding of Container Corporation of America of Fernandina Beaches' No. 2 paper machine which is currently idle.

The project involves rebuilding that paper machine together with other equipment additions with the intent to increase the capacity of this complex.

Q Okay. But you're not aware of any currently operating facilities or equipment being retired or placed out of commission as a result of new sources being permitted or new equipment being permitted?

A No, I'm not aware of that.

Q Okay. So essentially the Phoenix Project is designed to increase production quantity at the mill; is that correct?

A That is one of its three major objectives, yes.

Q And what are the other two major objectives?

A The second objective of that machine is to begin manufacturing recycle medium at the mill. Right now we make linerboard.

And the third major objective of the machine is to increase our availability of lightweight linerboard which we are restricted right now on our two paper machines to produce.

Q Okay. Have you made plans to be available for

CONTAINER CORPORATION OF AMERICA, INC.
ENFORCEMENT HISTORY

On September 30, 1986 Jefferson Smurfit Corporation (JSC) acquired a majority interest in Container Corporation of America, Inc. (CCA). While CCA's history of noncompliance prior to the acquisition by JSC would be irrelevant to a permitting decision for a JSC permit, the entire history of noncompliance of CCA and JSC is relevant to permitting decisions for CCA permits.

1. OGC Case No. 90-0346: DER issued an NOV on April 24, 1990 alleging that CCA's mill in Fernandina Beach discharged 200,000 gallons of untreated industrial wastewater to the Amelia River, in violation of the mill's permit conditions for biological oxygen demand (BOD) and total suspended solids (TSS). OGC has reviewed a draft consent order seeking corrective actions and a monetary settlement of $20,000, of which $516.04 represents DER costs. The draft consent order was returned to the N.E. District on September 10, 1990, and verbal agreement between the parties has been reached.

2. OGC Case No. 89-1625: A Consent Order was entered on August 2, 1990 alleging that JSC's paper mill in Jacksonville exceeded its industrial wastewater permit limits for BOD and TSS. JSC agreed to pay a settlement of $5,015.43, of which $165.43 represents DER costs.

3. OGC Case No. 89-0617: A Civil Complaint was filed with the Nassau County Circuit Court alleging that CCA burned tires on 5 days at its Fernandina Beach mill in violation of fuel restrictions for one of its power boilers. The Complaint further alleges that CCA emitted black liquor, an unpermitted pollutant, on 22 occasions, violated permit limits for particulate matter 19 times, failed to notify DER of malfunctions 15 times, and emitted noxious gases on 27 occasions. DER has made a settlement offer of $297,000 plus corrective action, which has not been accepted. No hearing has yet been set.

4. OGC Case No. 87-1145: A Consent Order was entered on May 25, 1988 alleging that CCA discharged shredded plastic material into the Amelia River without a solid waste permit. CCA agreed to pay a $3,200 settlement.

5. OGC Case No. 87-1124: A Consent Order was entered on June 21, 1988 alleging that CCA of Fernandina Beach disposed of coal ash and sludge (lime mud from causticizing green liquor from recovery boiler) in several creeks without a solid waste permit. CCA agreed to pay a settlement of $1,600 and to submit a plan for disposal of coal ash and sludge.

6. OGC Case No. 87-0885: On September 17, 1987, DER sent to CCA of Fernandina Beach a draft consent order alleging that it failed to submit continuous emission monitoring reports on time and seeking a settlement of $3,845.78, of which $95.78 represents DER costs. On June 21, 1988, the N.E. District rescinded the draft consent order.

7. OGC Case No. 87-0565: OGC received a draft consent order on May 1, 1987 alleging that CCA violated air permit conditions. No draft or final consent order has been located - being investigated.

8. OGC Case No. 86-1220: A Consent Order was entered on July 27, 1987 alleging that hazardous waste (sludge and condensate from tanks and process vessels) may have discharged into the groundwater when CCA demolished or dismantled coal gasification equipment in order to build CCA's paper recycling center in Jacksonville. The Consent Order alleged violations of groundwater and drinking water standards and for causing pollution without a permit. Corrective actions were agreed upon, but not a monetary settlement.

9. OGC Case No. 86-0573: EPA issued a letter of violation to JSC for various alleged violations of its Jacksonville paper mill's No. 10 Power Boiler, including. EPA alleged that JSC conducted initial performance tests for PM, SO_2, and NO_x four months late; did not install CEM equipment for opacity prior to performance testing; conducted CEM performance evaluations for SO_2, NO_x, CO_2, and opacity a month late; did not maintain strip charts for SO_2 and NO_x from CEM for nearly one year; did not submit quarterly reports of excess emissions for SO_2, NO_x and opacity on time; and did not report excess emissions for SO_2 and NO_x on several occasions.

OGC received a draft consent order on May 14, 1986 requiring certain remedial actions such as internal audits of CEM equipment and improved recordkeeping procedures, and a monetary settlement of $10,000. No consent order has yet been executed. The status of this case is being investigated.

10. OGC Case No. 85-0501: A Consent Order was entered on February 24, 1986 alleging that Austille Packaging Company (JSC) violated hazardous waste requirements for accumulation time, recordkeeping, exception reporting, personnel training, maintenance and operation of the facility, arrangements with local authorities, contingency plans, and emergency procedures. JSC agreed to a monetary settlement of $5,6[illegible]7.64, of which $90.98 represents DER costs.

11. OGC Case No. 85-0324: A Consent Order was entered on February 24, 1986 alleging that Austille Packaging Company (JSC) violated hazardous waste requirements for accumulation time, recordkeeping, exception reporting, personnel training,

maintenance and operation of the facility, arrangements with local authorities, contingency plans, and emergency procedures. JSC agreed to a monetary settlement of $9,495.78, of which $45.78 represents DER costs. The violations alleged in this case are not duplicative of those in OGC Case No. 85-0501, which arose from a separate NOV.

12. OGC Case No. 84-0984: A Consent Order was entered on April 3, 1986 alleging that CCA of Fernandina Beach violated hazardous waste requirements for general inspections and sampling and analysis. CCA agreed to corrective actions and a $7,350 monetary settlement, of which $74.24 represents DER costs.

13. OGC Case No. 83-0459: A Consent Final Judgment was entered on April 13, 1984 alleging that CCA of Fernandina Beach exceeded its VE limit on 9 occasions, failed to notify DER of excess emissions 6 times, circumvented pollution control devices 51 times, violated industrial wastewater permit conditions 2 times, and failed to notify DER of malfunctions 2 times. CCA agreed to pay $64,000 in DER costs and a monetary settlement of $36,000.

14. OGC Case No. 83-0395: On March 7, 1984 EPA issued an Administrative Order finding the following industrial wastewater violations: 4 exceedances of the daily maximum for BOD, 1 violation of the daily average for BOD, 6 violations of the daily maximum for TSS, 2 violations of the daily maximum for temperature, and 1 violation of the daily maximum for pH. The violations occurred on 12 days during July of 1982 through February of 1984. Two days worth of violations were the subject of OGC Case No. 83-0459. However, EPA and Department records apparently do not indicate any resolution of the remaining violations. The legal case tracking system shows the case as still being open.

15. OGC Case No. 83-0374: A Consent Final Judgment was entered on February 28, 1985 whereby Austille Packaging (JSC) agreed that it violated VOC limits in a nonattainment area and failed to use required control technology. JSC agreed to install control equipment and to pay a $62,000 settlement plus $38,130.34 in DER costs. Further, JSC agreed to demonstrate compliance by December 31, 1985, or risk penalties up to $5,000 a day (doubled if enforced by a court).

On December 18, 1987 DER filed a Motion for Penalties for failure to demonstrate compliance as agreed to in the Consent Final Judgment. DER is seeking double the stipulated penalties plus interest, costs, and attorney fees. The Motion is still the subject of litigation.

OGC#	PROGRAM1	E-CO-DATE	E-NOV-DATE	E-FO-DATE	STYLE
861510	AP				AUSTILL PACKAGING COMPANY (PRESS #2) VS. DER
861509	AP				AUSTILL PACKAGING COMPANY (PRESS #4) VS. DER
861508	AP				AUSTILL PACKAGING COMPANY (PRESS #5) VS. DER
850501	HW	860224	850723	000000	AUSTILL PACKAGING (JEFFERSON SMURFIT CORPORATION); DER VS.
850324	HW	860224	850605	000000	AUSTILL PACKAGING, INC.; DER VS.
830374	AP	831201	000000	000000	AUSTILL PACKAGING, INC.; DER VS.
830792	AP				CONTAINER CORPORATION OF AMERICA
900346	IW	000000	900424	000000	CONTAINER CORPORATION OF AMERICA DER VS.
890549	IW	000000	000000	000000	CONTAINER CORPORATION OF AMERICA VS. DER
891148	AP				CONTAINER CORPORATION OF AMERICA VS. DER
891501	AP				CONTAINER CORPORATION OF AMERICA VS. DER
871700	AP				CONTAINER CORPORATION OF AMERICA (#141871) VS. DER
871701	AP				CONTAINER CORPORATION OF AMERICA (#141872) VS. DER
871702	AP				CONTAINER CORPORATION OF AMERICA (#141873) VS. DER
871703	AP				CONTAINER CORPORATION OF AMERICA (#141874) VS. DER
871704	AP				CONTAINER CORPORATION OF AMERICA (#141875) VS. DER
871705	AP				CONTAINER CORPORATION OF AMERICA (#141877) VS. DER
871706	AP				CONTAINER CORPORATION OF AMERICA (#141878) VS. DER
881126	AP	000000	000000	000000	CONTAINER CORPORATION OF AMERICA (FERNANDINA BEACH); DER VS.
861220	GW	000000	000000	000000	CONTAINER CORPORATION OF AMERICA (JACKSONVILLE); DER VS.
870565	AP	000000	000000	000000	CONTAINER CORPORATION OF AMERICA (JEFFERSON SMURFIT); DER VS
840984	HW	860403	850116	000000	CONTAINER CORPORATION OF AMERICA, DER VS.
830459	AP	000000	000000	000000	CONTAINER CORPORATION OF AMERICA; DER VS.
830395	IW				CONTAINER CORPORATION OF AMERICA; DER VS.
871124	SW	880621	000000	000000	CONTAINER CORPORATION OF AMERICA; DER VS.
840011	IW				CONTAINER CORPORATION OF AM. VS DER
830154	AP				CONTAINER CORPORATION - FERNANDINA
820551	PP				CONTAINER CORP. OF AMERICA VS DER
800036	AP				CONTAINER CORP. OF AMERICA VS. DER
870885	AP	000000	000000	000000	CONTAINER CORP. OF AMERICA (JEFFERSON SMURFIT CORP)DER VS.
901183	AP				CONTAINER CORP. OF AMERICA (RULE CHALLENGE 17-4)
871145	SW	880525	000000	000000	CONTAINER CORP. OF AMERICA(SUBS. OF JEFFERSON SMURFIT)DER VS
890617	AP	000000	000000	000000	CONTAINER CORP. OF AMERICA, INC., FERNANDINA; DER VS.
841018	AP				CONTAINER CORP. VS. DER
891625	IW	900802	000000	000000	JEFFERSON SMURFIT CORPORATION DER VS.
861538	IW				JEFFERSON SMURFIT CORPORATION VS. DER
890971	AP				JEFFERSON SMURFIT CORPORATION VS. DER
871688	AP				JEFFERSON SMURFIT CORPORATION (#141868) VS. DER
871689	AP				JEFFERSON SMURFIT CORPORATION (#141869) VS. DER
871690	AP				JEFFERSON SMURFIT CORPORATION (#141870) VS. DER
890261	AP				JEFFERSON SMURFIT CORPORATION (144609) VS. DER
860573	AP	000000	000000	000000	JEFFERSON SMURFITT; U.S. EPA, DER, & JACKSONVILLE BESD VS.

INSPECTION REPORT

CONTAINER CORPORATION OF AMERICA
PULP AND PAPER MILL
FERNANDINA BEACH, FLORIDA

by

PEI Associates, Inc.
11499 Chester Road
Post Office Box 46100
Cincinnati, Ohio 45246-0100

Contract No. 68-02-3963
Work Assignment No. 40
PN 3630-40

Project Officer

Mr. John Busik

Project Manager

Mr. William Voshell

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV
ATLANTA, GEORGIA 30365

March 1985

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SECTION 1

INTRODUCTION

Under the terms of a consent decree between Container Corporation of America (CCA) and the State of Florida Department of Environmental Regulation (DER), PEI Associates, Inc. (PEI) conducted an inspection of emissions sources at Container Corporation's Fernandina Beach Mill. Sources to be covered during the inspection included the No. 5 Recovery Boiler and electrostatic precipitator (ESP), No. 4 Recovery Boiler and ESP, No. 4 Power Boiler and mechanical collector (Bahco) and No. 5 Power Boiler and mechanical collector (Bahco).

Under terms of the work assignment issued by the U.S. Environmental Protection Agency (EPA), PEI was directed to complete the following tasks:

1. Inspect and determine the physical condition of the ESP serving the No. 4 and No. 5 Recovery Boilers.
2. Inspect and determine the physical condition of mechanical collectors on the No. 4 and 5 Power Boilers.
3. Review the preventive maintenance and emergency maintenance procedures and determine the adequacy of these programs to maintain compliance with applicable opacity and emission limitations.

This report presents the results of the inspection and the conclusions drawn by the authors as a result of reviewing and evaluating the data obtained from Container Corporation during and subsequent to the inspection. Based on these conclusions, recommendations are presented concerning possible corrective action or the need for further study and evaluation. These recommendations are not to be interpreted as absolute or mandatory but are included for consideration by Container Corporation in its response to DER. Any recommendation should be investigated by Container Corporation for specific applicability to the individual units.

A copy of the Complaint for Civil Penalties and Injunctive Relief and Stipulation and Motion for Entry of Consent Final Judgment (Case No. 84-127CA) is provided in Appendix A.

SECTION 2

PROCESS DESCRIPTION

2.1 RECOVERY BOILERS

Container Corporation operates two black liquor-fired recovery boilers to generate steam and electricity. As part of the combustion process, the inorganic portion of the black liquor is reduced and drained from the boiler hearth as a molten smelt.

Black liquor is concentrated in both boilers from 50 percent solids to 67 percent solids by noncontact evaporators. Because the flue gases from the recovery boiler are not placed in contact with the liquor, hydrogen sulfide (H_2S) is not stripped from the liquor.

There are three areas of combustion in the recovery boiler furnace: the secondary air zone, primary air zone, and the tertiary air zone (upper secondary air zone). Specific combustion processes occur in each zone that determine the areas of heat release and the volume of combustion air required.

Liquor is fired through steam atomizing nozzles producing a pop-corn size droplet. The droplets dehydrate as they fall through the combustion zone. Volatile hydrocarbons are evaporated and oxidized. Long chain hydrocarbons are reduced to a char that forms a char bed on the hearth of the boiler. On the hearth, char is burned with primary air and sodium is reduced to sodium carbonate and sodium sulfide. The molten smelt drains through the char bed matrix and out through smelt spouts.

Char is partially oxidized to carbon monoxide (CO) that oxidizes to carbon dioxide (CO_2) in the upper portion of the primary air zone. Sodium in the smelt is oxidized and a portion is removed by the combustion air, which is combined with CO to form sodium carbonate (Na_2CO_2). Sulfur in the vapor phase is oxidized to sulfur dioxide (SO_2) above the char bed.

In low odor design boilers, the char bed temperature is maintained high enough to increase the rate of sodium loss. Under oxidizing conditions and high temperature, sulfur and total reduced sulfur (TRS) compounds react with sodium and form sodium sulfate (Na_2SO_4). Typical char bed temperatures range from 1800° to 2000°F with high primary air temperatures (≥400°F).

Because sulfur in the fired liquor is converted to Na_2SO_4 instead of being released as SO_2, the uncontrolled particulate matter emission rate is higher than from a conventional boiler. Because of elevated char bed temperature, the particulate matter is also finer than from a conventional boiler.

2.1.1 No. 5 Recovery Boiler

The original design of the No. 5 Recovery Boiler is a Babcock and Wilcox (B&W) cross recovery low odor boiler. The design liquor firing rate is 125,000 lb black liquor solids (BLS) per hour with a maximum peak rating of 125,000 lb BLS/h (1000 ton air dried pulp) at 3000 lb BLS/ADT and and 6600 Btu/lb BLS. Actual DER permit limits are 157,000 lb/h of BLS. Total heat input rate is 750 x 10^6 Btu/h.

The boiler is equipped to fire both black liquor and residual oil. The amount of residual oil fired is minimized to prevent formation of sticky salt cake.

The uncontrolled particulate matter emission rate from the boiler is estimated to be 6.0 gr/dscf (∿ 11,520 lb/h). Total design flue gas volume is 500,000 acfm at 400°F and 27 percent moisture. Based on the liquor fired, approximately 46.7 dscf of flue gas is produced per pound of BLS fired. At low excess oxygen levels (≤4.0% oxygen), the volume of flue gas produced is less than design. Under current operating conditions the boiler produces approximately 348,500 acfm when fired at 151,000 lb BLS/h (∿ 4.0% oxygen in the flue gases).

2.1.2 No. 5 ESP

The ESP serving the No. 5 Recovery Boiler was installed in 1979 as part of the original construction of the source. The unit was manufactured by Environmental Elements Corporation (Kopper's) and contains two chambers with six electrical fields in series in the direction of gas flow (Table 1).

Dust removal from the unit is by five drag conveyors in each chamber. The drags move perpendicular to the gas stream discharging to screw conveyors and ribbon mixer located under the center wall between the chambers. Positive gas baffles are used between the three mechanical fields to prevent gas sneakage under the electrical zone. Baffles are also used between the inlet

TABLE 1. DESIGN SPECIFICATIONS FOR NO. 5 ESP

Manufacturer	Environmental Elements
Number of chambers	2
Number of fields	6
Mechanical fields in direction of gas flow	3
Number of bus section/field	2
Gas volume	500,000 acfm
Gas temperature	400°F
Gas moisture	27% (volume)
Superficial velocity	2.68 ft/s
Treatment time	13.4 s
Gas passages	124 (62/chamber)
Plate spacing	10 in.
Plate width	12.125 ft.
Plate height	30.0 ft
Number of plates	378
Effective surface area	270,630 ft^2
Specific collection area	541.26 ft^2/1000 acfm
Number of electrodes	5,952
Electrode length	31.3 ft
Total electrode length	192,246 ft
Plate rappers	144
Electrode rappers	48
Distribution plate rappers	8
Turning vane rappers	8
T-R set number	12
T-R set size	1500 ma 55 kV
Drag hoppers	4
Drag direction	Perpendicular
Inlet dust loading	6.0 gr/dscf (11,520 lb/h)
Outlet dust loading	0.015 gr/dscf (28.8 lb/h)
Design efficiency	99.75%

plenum drag bottom and inlet field and between outlet field and outlet plenum.

The inlet to the unit is from the bottom with gas turning vanes and gas distribution plate to control inlet velocity distribution. Gas is emitted through two stacks (one per chamber).

Design gas volume of the unit is 500,000 acfm ($400^{\circ}F$) with a superficial velocity of 2.68 ft/s. Total plate area is 270,630 ft^2 for the three mechanical fields each containing 124 gas lanes (62/chamber). At the design gas volume, the specific collection area is 541.26 ft^2/1000 acfm.

Electrode design is weighted wire with six electrical fields in the direction of gas flow. Each electrical field is sectionalized into two bus sections in each chamber (H1 and H2).

Electrical voltage is supplied by 12 transformer-rectifiers (T-R) sets rated at 1500 milliamp (ma) and 55 kilovolts (kV). Electrical control is by digital automatic control circuits. Power input is recorded by primary and secondary meters (current and voltage).

The design inlet dust loading is 6.0 gr/dscf or approximately 11,520 lb/h at design gas volume. Outlet design grain loading is 0.015 gr/dscf or 28.8 lb/h.

2.1.3 No. 4 Recovery Boiler

The No. 4 Recovery Boiler is a B&W kraft recovery boiler. The boiler was installed prior to promulgation of the New Source Performance Standard (NSPS) for kraft recovery boilers and is subject to State of Florida DER emission standards for kraft pulp mills (i.e., 3 lb/3000 lb BLS fired).

The boiler is a low odor design with a noncontact liquor evaporator. The design steam flow is 492,000 lb/h. Design boiler process rate is 1000 tons air-dried pulp per day or 125,000 lb BLS/h.

2.1.4 No. 4 ESP

The No. 4 ESP (sometimes referred to as 3A ESP) is a weighted wire ESP manufactured by Environmental Elements (Table 2). The unit contains two chambers with six electrical fields in series in the direction of the gas flow. The outlet field in each chamber is divided into four bus sections (2 T-R sets) and the remaining fields in each chamber are divided into two bus sections.

Salt cake is removed by drag conveyors that discharge at the inlet end of each chamber. Original design was for four drags (2 per chamber) in the

TABLE 2. DESIGN SPECIFICATIONS FOR NO. 4 ESP

Manufacturer	Environmental Elements
Number of chambers	2
Number of fields	6
Mechanical fields in direction of gas flow	3
Number of bus sections/chamber	2 field 1-4 4 field 5-6
Gas volume	420,000 acfm
Gas temperature	$400^{o}F$
Gas moisture	27% (volume)
Superficial velocity	2.97 ft/s
Treatment time	10.6 s
Gas passages	94 (47/chamber)
Plate spacing	10 in.
Pate width	10.625 ft
Plate height	30 ft
Number of plates	280
Effective surface area	179,775 ft^2
Specific collection area	428.0 ft^2/1000 acfm
Number of electrodes	3,948
Electrode length	32.3 ft
Total electrode length	127,530 ft
Plate rappers	48
Electrode rappers	72
Distribution plate rappers	8
T-R set number	14
T-R set size	1250 ma 55 kV
Drag hopper	2
Drags	4
Drag direction	Parallel
Inlet dust loading	3 gr/acfm (10,800 lb/h)
Outlet dust loading	0.012 gr/acfm (43.20 lb/h)
Design efficiency	99.6%

direction of gas flow. A recent rebuild modified the unit to three drags per chamber. Because of an inlet design change to the top inlet, drags have been extended into the inlet plenum. Moveable gas baffles are used between mechanical fields to prevent gas sneakage and dust reentrainment.

The gas inlet originally was from the bottom with top gas outlet, but the inlet was converted to top inlet in 1983. The new inlet is equipped with an inclined baffle plate and perforated distribution plate to aid in gas velocity distribution. Outlet from the unit is through a single stack located above the ESP roof.

Design gas volume for the ESP is 420,000 acfm (400^{o}F) with a superficial velocity of 2.97 ft/s. The total effective collection plate area is 179,775 ft^2 at design gas volume. The specific collection area is 428 ft^2/1000 acfm. There are three mechanical fields in each chamber with 94 gas lanes (47/chamber). Electrical current is supplied by 14 T-R sets rated at 1250 ma and 55 kV. The T-R sets are controlled by digital automatic control circuits.

2.2 POWER BOILERS

2.2.1 No. 4 Power Boiler

No. 4 power boiler is a B&W combination-fired continuous water tube boiler firing residual oil and/or bark. The boiler is a spreader stoker with overfire and underfire combustion air, three air-swept wood spouts, and four oil burners. The boiler is rated at 200,000 lb/h of steam at 875 psig and 890^{o}F at a firing rate of 47,500 lb/h unhogged Southern Pine bark and 3,500 lb/h No. 6 fuel oil, or 13,500 lb/h No. 6 fuel oil alone (Table 3).

The particulate matter emissions are controlled by a mechanical collector system manufactured by Bahco (JCD Multicyclone) and purchased by Container Corporation from Combustion Equipment Associates, Inc. (CEA) of New York City, New York. The Bahco JCD Multicyclone, manufactured in Sweden, is a dynamic dust collector consisting of a number of horizontal cyclone tubes operating in parallel and arranged perpendicular to gas flow. Each cyclone tube has a nominal capacity of 350 to 600 acfm. The JCD is built in modules that are connected in parallel. As originally designed, incoming flue gas is split by a divergent plenum into two primary dust collectors, one upper and one lower.

TABLE 3. NO. 4 POWER BOILER DESIGN DATA

Boiler manufacturer	B&W	
Type	Continuous tube	
Fuel burners		
Bark	3 air-swept wood spouts	
Oil	4 circular burners	
Spreader stoker		
Dimensions	12' 1¼" x 22' 8"	
Grate surface area	254.5 ft^2 net	
Total heating surface	79,114 ft^2	
Total furnace volume	11,440 ft^3	
Steam, actual, 10^3 lb/h	200	200
Type fuel	Oil	Oil and bark
Rate and load duration, h	Continuous	Continuous
Excess air leaving boiler, %	14	22
Burners in use	4	4
Fuel consumption, 10^3 lb/h	13.5	3.5/47.5
Flue gas leaving boiler, 10^3 lb/h	234	298
Steam pressure at superheater outlet, psig	875	875
Temp. of superheated steam, ^oF	822	890
Temp. of flue gas leaving air heater, ^oF	376	430
Furnace draft, in. of water	0.1	0.1
Boiler and superheater draft, in. of water	0.8	1.4
Air heater draft, in. of water	1.3	2.[illegible]
Dust collector draft, in. of water	1.7	2.8
Unit efficiency, %	85.7	73.5

Each collector consists of a first and second stage. Gas passes through the first stage of the primary collector into the second stage and clean gas is then discharged to the stack. Particulate matter from the first and second stages of the primary collectors is withdrawn by secondary fans into two secondary collectors. These collectors are smaller than the primary collectors and serve to concentrate the particulate matter for removal. Clean gas from the secondary collectors is then reinjected into the primary collectors and passed through to the stack. Particulate matter from the secondary collectors is withdrawn by tertiary fans to four tertiary cyclones for dust removal. A fifth hopper cyclone is used to collect large particulate matter that is collected by settling in the inlet of the secondary collectors. Clean gas from these cyclones is then discharged back to the inlet of the primary collectors.

2.2.2 No. 5 Power Boiler

No. 5 power boiler is a B&W combination-fired continuous water tube boiler firing residual oil and/or bark. The boiler is a travelling grate rated at 160,000 lb/h of steam at 875^{o} psig and 825^{o}F firing 60,000 lb/h hogged Southern Pine and hardwood bark. The boiler is also rated at 500,000 lb/h of steam at 875^{o} psig and 838^{o}F firing 60,000 lb/h of bark and 20,200 lb/h of No. 6 fuel oil (Table 4).

The particulate matter emissions are controlled with a Bahco mechanical collector similar to that employed on No. 4 Power Boiler. The Bahco collector on No. 5 Power Boiler, however, was originally designed with four primary collectors, two secondary collectors, four tertiary cyclones, and a hopper cyclone.

2.2.3 Operating Principles of the Bahco JCD Multicyclone

As described previously, the Bahco collector consists of modularized banks of tubular collectors arranged in parallel (Figure 1). Flue gas enters each individual cyclone tube via a distribution plenum. The gas is given a cyclonic spiralling motion by adjustable turning vanes on the inlet cap (Figure 2). The coarse dust is separated from the gas stream by centrifugal force and is discharged to a vertical dust plenum. As the gas stream swirls down the length of the cyclone, higher pressure differential in the center

TABLE 4. NO. 5 POWER BOILER DESIGN DATA

Boiler manufacturer	B&W	
Type	Continuous tube, travelling grate	
Fuel burners		
Bark	5 air-swept wood spouts	
Oil	6 circular burners	
Travelling grate		
Dimensions	22' 8" x 17' 1½"	
Total heating surface	79,922 ft^2	
Total furnace volume	27,100 ft^3	
Steam, actual, 10^3 lb/h	160	500
Type fuel	Bark	Oil and bark
Rate and load duration, h	Continuous	Continuous
Excess air leaving boiler, %	34	23
Oil burners in use	0	6
Fuel consumption, 10^3 lb/h	60	20.2/60
Flue gas leaving boiler, 10^3 lb/h	310	645
Steam pressure at superheater outlet, psig	875	875
Temp. of superheated steam, °F	825	838
Temp. of flue gas leaving oil heater, °F	360	398
Furnace draft, in. of water	0.5	1.7
Boiler and superheater draft, in. of water	0.6	2.2
Dust collector draft, in. of water	0.6	2.2
Unit efficiency, %	68.5	79.0

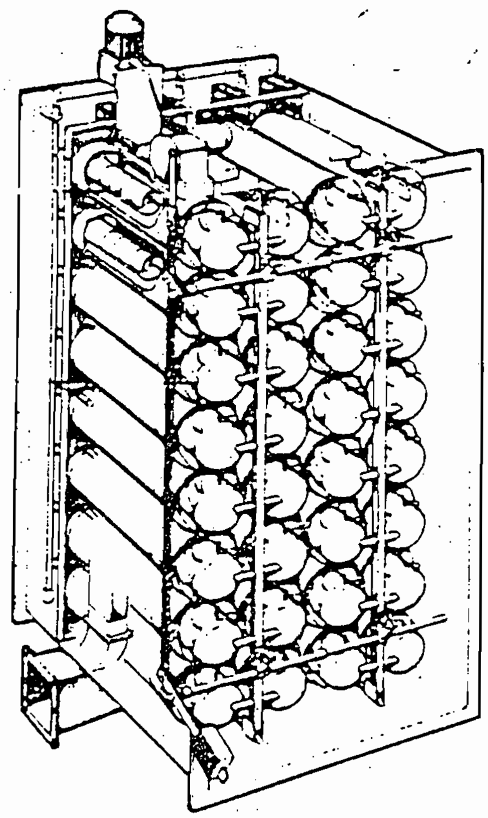

Figure 1. Bahco collection tube bank.

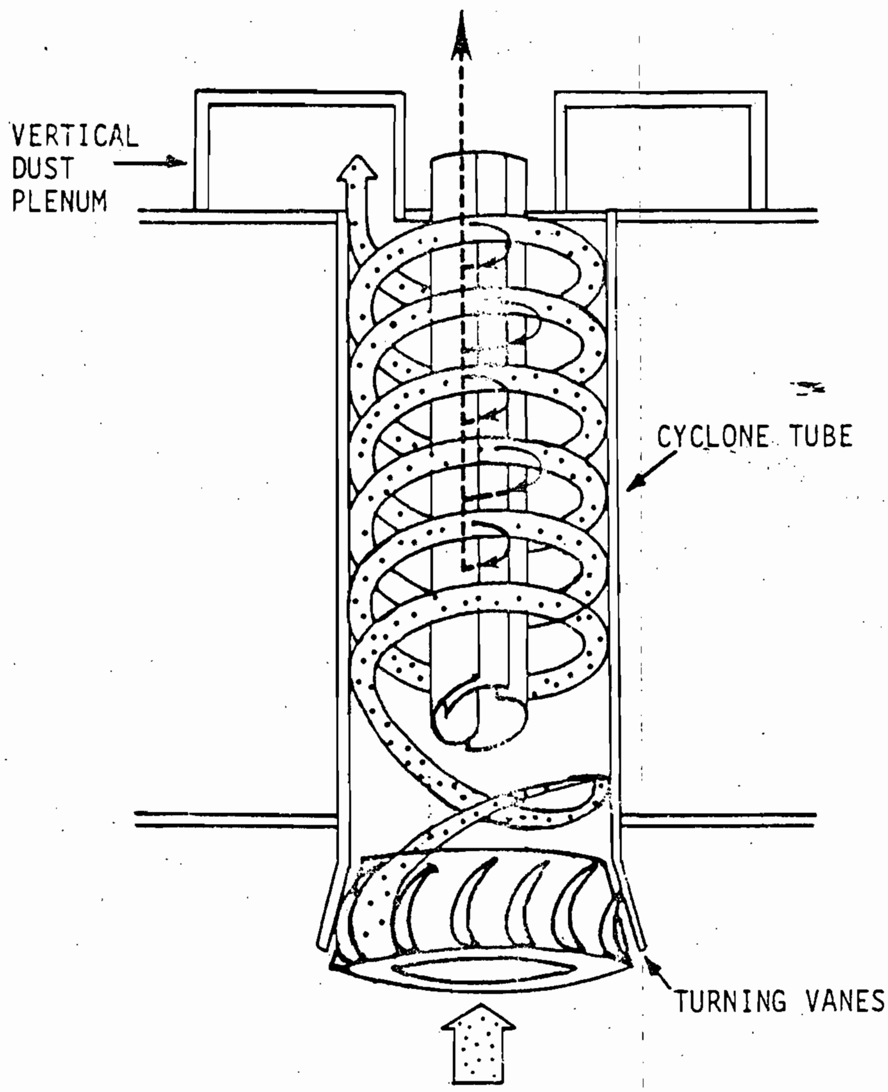

Figure 2. Bahco collection tube.

tube directs approximately 92 percent of the gas stream over the three slots of the tube. When the gas makes the 180° turn into the center tube, the gas stream rids itself of finer particles because the cyclonic inertia already imparted to these particles prevents them from making this turn (Figure 3). The cyclonic or "scalping" stream set up by the turning vanes captures these particles and carries them along with the coarse particles to the dust outlet. Clean gas is discharged from the center tube.

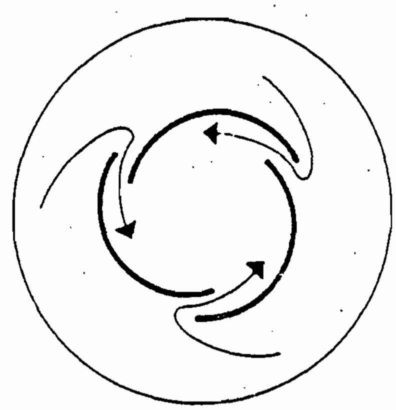

Figure 3. Gas stream flow into center tube.

This gas now enters the second stage of the primary collector. The gas stream passes through a second stage of cyclone tubes where further dust separation is accomplished. The second stage of the primary collector is identical to the first stage with both stages incorporated in the same enclosure. Clean gas from the second stage of the primary collector is passed to the stack.

Final separation of dust takes place in the secondary collectors. The dirty gas stream from the first stage of the primary collector is transported by secondary fans through a smaller secondary collector. The dirty gas stream from the second stage of the primary collector is similarly transported to another secondary collector. Clean gas from the secondary collectors is re-injected into the flue gas inlet of the primary collectors. Dirty gas from the secondary collectors is transported by tertiary fans to respective banks of tertiary cyclones. The dust is concentrated and final dust removal is accomplished. Clean gas from these cyclones is returned to the inlet of the primary collectors.

Because this collection mechanism relies heavily on the cleanliness of the three slots of the center tube, each cyclonic tube is equipped with a self-cleaning device (Figure 4). This arrangement uses an electrically driven "reamer" for each collection tube. Approximately every 5 minutes, an electric motor rotates a reamer shaft in each vertical row of tubes within the collector. As the shaft rotates, the reamer assembly within the center tube of each cyclone is partially withdrawn and then replaced. This reamer assembly includes four rings that drag through the length of the center tube scrapping away any accumulated dust.

Approximately 8 percent of the total gas flow that does not enter the center tube carries the separated dust to the vertical dust plenum. This plenum connects all the tubes in each vertical row to the collection duct underneath the collector.

The Bahco multicyclone is a typical multicellular straight-through cyclone in that the turning vane ring located at the inlet of each cyclone tube is adjustable. The adjustment is made during boiler operation to accommodate changes in gas flow (boiler load) and to keep the pressure drop constant across the multicyclone. When the gas flow decreases, the pressure drop is kept constant by inserting the vanes. This increases the path length of gas across the turning vanes creating a cyclonic flow with stronger centrifugal force.

The unit is designed to maintain collection efficiency as boiler load decreases down to 30 percent. This is accomplished by incremently inserting the turning vanes in response to decreasing gas flow to maintain design pressure drop. A constant pressure drop on a reduced gas flow maintains centrifugal force and thereby collection efficiency will tend to increase (Figure 5).

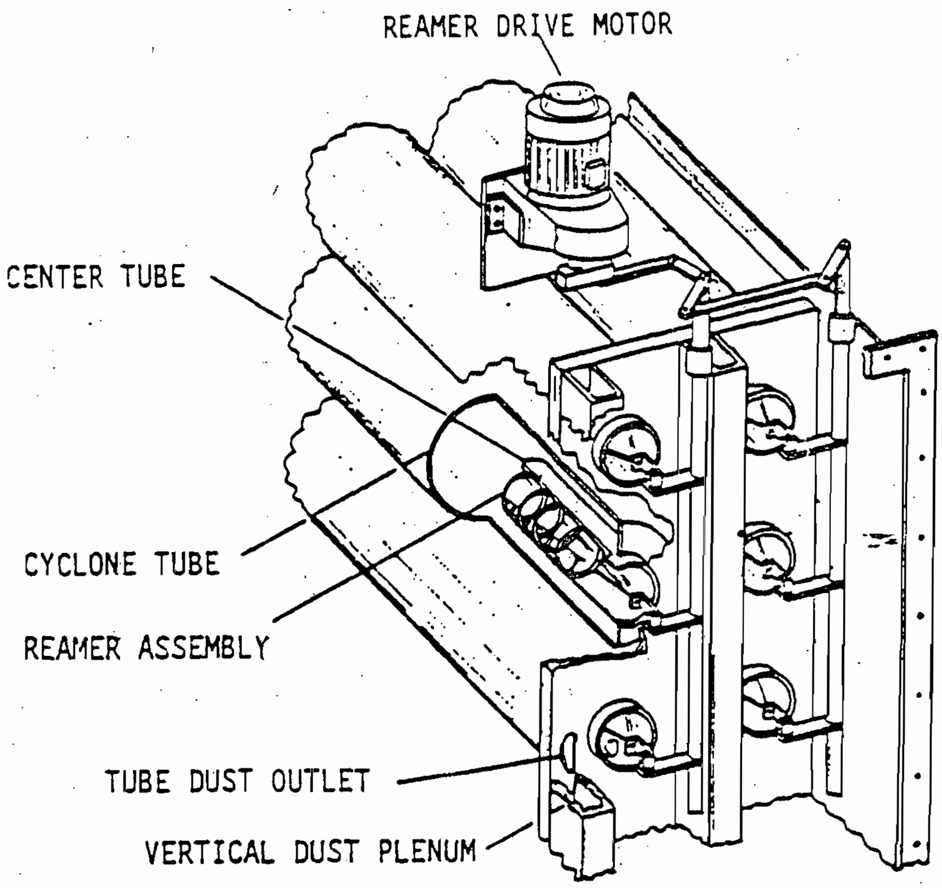

Figure 4. Bahco self-cleaning device.

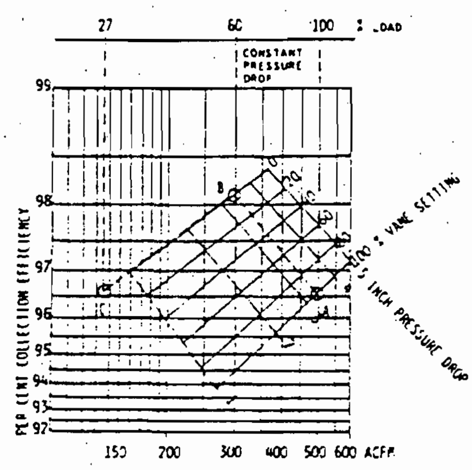

Figure 5. Relationships among gas volume and collection efficiency, and guide vane adjustment.

Automatic adjustment of the turning vanes is accomplished by differential pressure sensors in the collectors. These sensors transmit data to controllers that activate pneumatic cylinders on each collector. The pneumatic cylinders engage the guide vane activating levers. The levers, in turn, mechanically insert and withdraw the vane rings of each tube (Figure 6). The guide vane activating lever may also be engaged manually.

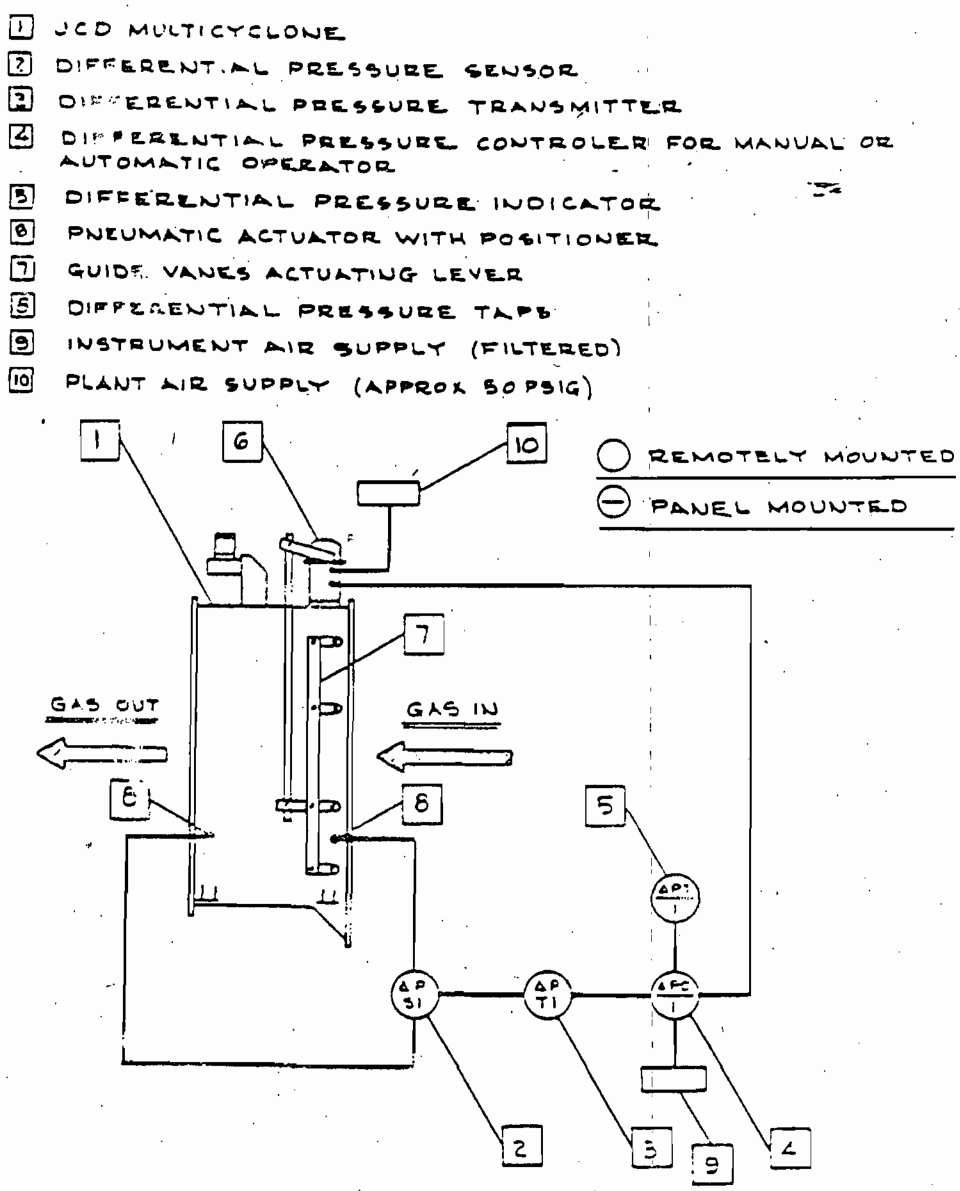

Figure 6. Bahco guide vane adjustment system.

2.2.4 Bahco JCD Multicyclone Design Specifications for No. 4 Power Boiler

Figure 7 illustrates the general layout and gas flow of the Bahco dust collector serving the No. 4 Power Boiler as originally installed. The first and second stages of the two primary collectors each contain 192 tubes. The diameter of each tube is 9 3/4 in. with a length of 34 3/4 in. and a center tube length of 20 in. At a design gas flow of 85,000 acfm per collector, the gas flow across each tube is 443 acfm.

The two secondary collectors each contain 32 tubes with dimensions identical to the primary tubes. At a design gas flow of 14,600 acfm per collector, the gas flow across each tube is 456 acfm. Table 5 gives a more complete description of the technical specifications for each component as originally designed.

As constructed under these specifications, Bahco guaranteed a maximum of 0.05 g/scfm of dry gas, at 170,000 acfm of 400^{O}F flue gas with a moisture content of 7 percent to 18 percent. Assuming minimum moisture (maximum scfmd), this amounts to 41.786 pounds of particulate matter per hour.

2.2.5 Bahco JCD Multicyclone Design Specification for Power Boiler No. 5

Figure 8 illustrates the general layout and gas flow of the collector serving the No. 5 Power Boiler. As can be seen, the Bahco collector for the No. 5 Power Boiler is larger than the one for No. 4 Power Boiler. The collection system for the No. 5 Power Boiler consists of four primary collectors, two secondary collectors, and five tertiary cyclones. The first and second stages of the four primary collectors each consist of 160 tubes. The two secondary collectors each contain 60 tubes. The dimensions of all the tubes are identical to the tubes found in the Bahco collector serving the No. 4 Power Boiler (i.e., 9 3/4 in. diameter, 34 3/4 in. length, and a center tube length of 20 in.).

At a design gas flow of 75,000 acfm per primary collector, the gas flow across each tube is 469 acfm. Similarly, at a design gas flow of 24,400 acfm per secondary collector, the gas flow across each tube is 407 acfm. Table 6 gives a more complete description of the technical specifications for each component as originally designed.

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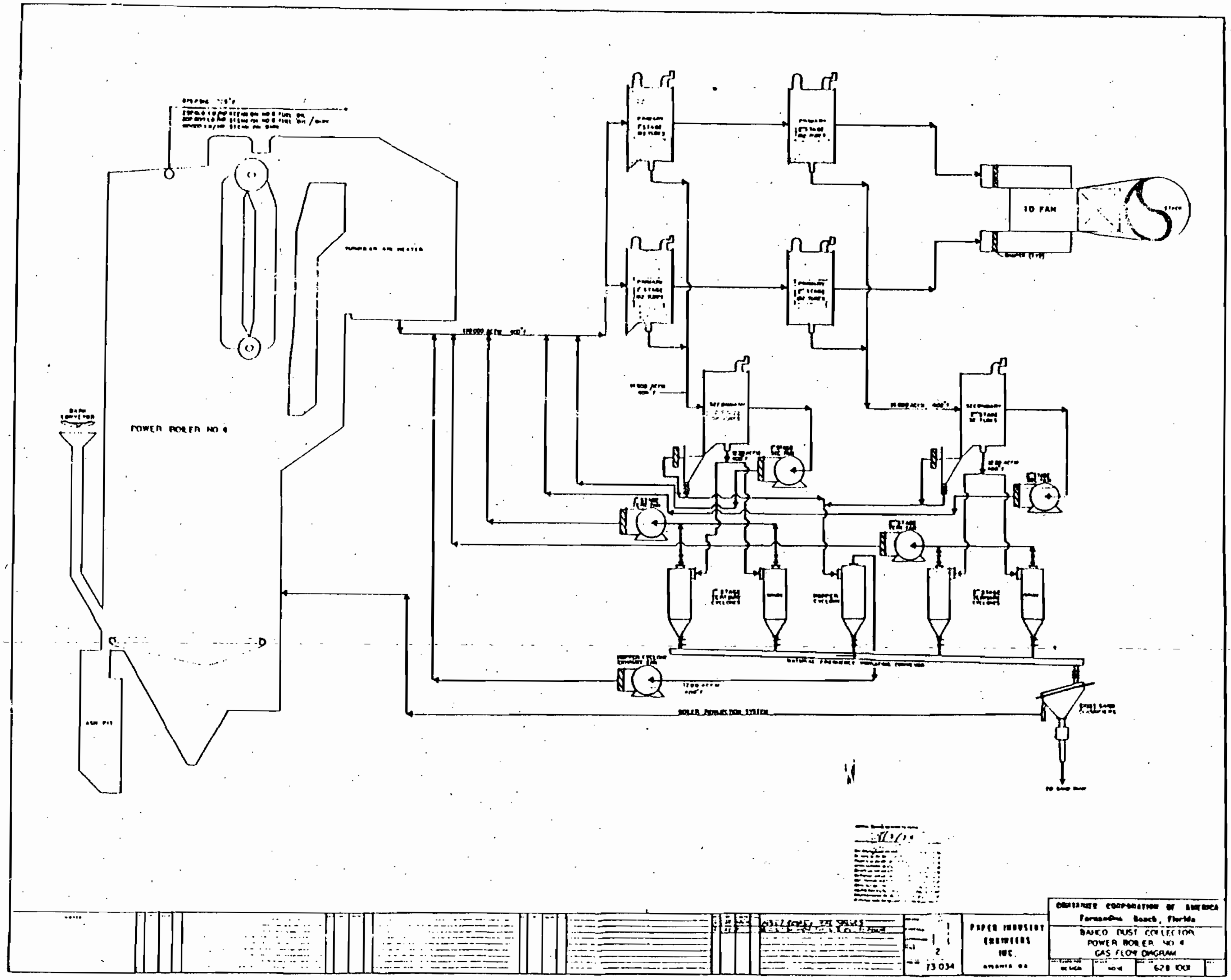

Figure 7. Original layout of Bahco dust collector No. 4 Power Boiler.

TABLE 5. NO. 4 POWER BOILER BAHCO DESIGN SPECIFICATIONS

Steam production, lb/h	200,000
Type of fuel	Bark and oil
Make of boiler	B&W
Reinjection capability	Yes
Primary Collector:	
Gas volume - inlet, acfm	170,000
Gas temperature, °F	400
Moisture content (by volume), %	7-18
Dust load - inlet, gr/scfd	1.0
Specific gravity of dust	Sand - 2.65, Bark - 0.3
Pressure drop, in. water	2.6 x 2
Collector type, JCD	12-1610
Total number of tubes, No.	2 x 384
Arrangement	4 (12 x 16)
Cleaning device	Yes
Secondary Collector:	
Gas volume - inlet, acfm	14,600 x 2
Gas temperature, °F	400
Pressure drop, in. water	3.14
Collector type, JCD	04.0810
Total number of tubes	2 x 32
Arrangement	2 (4 x 8)
Cleaning device	Yes

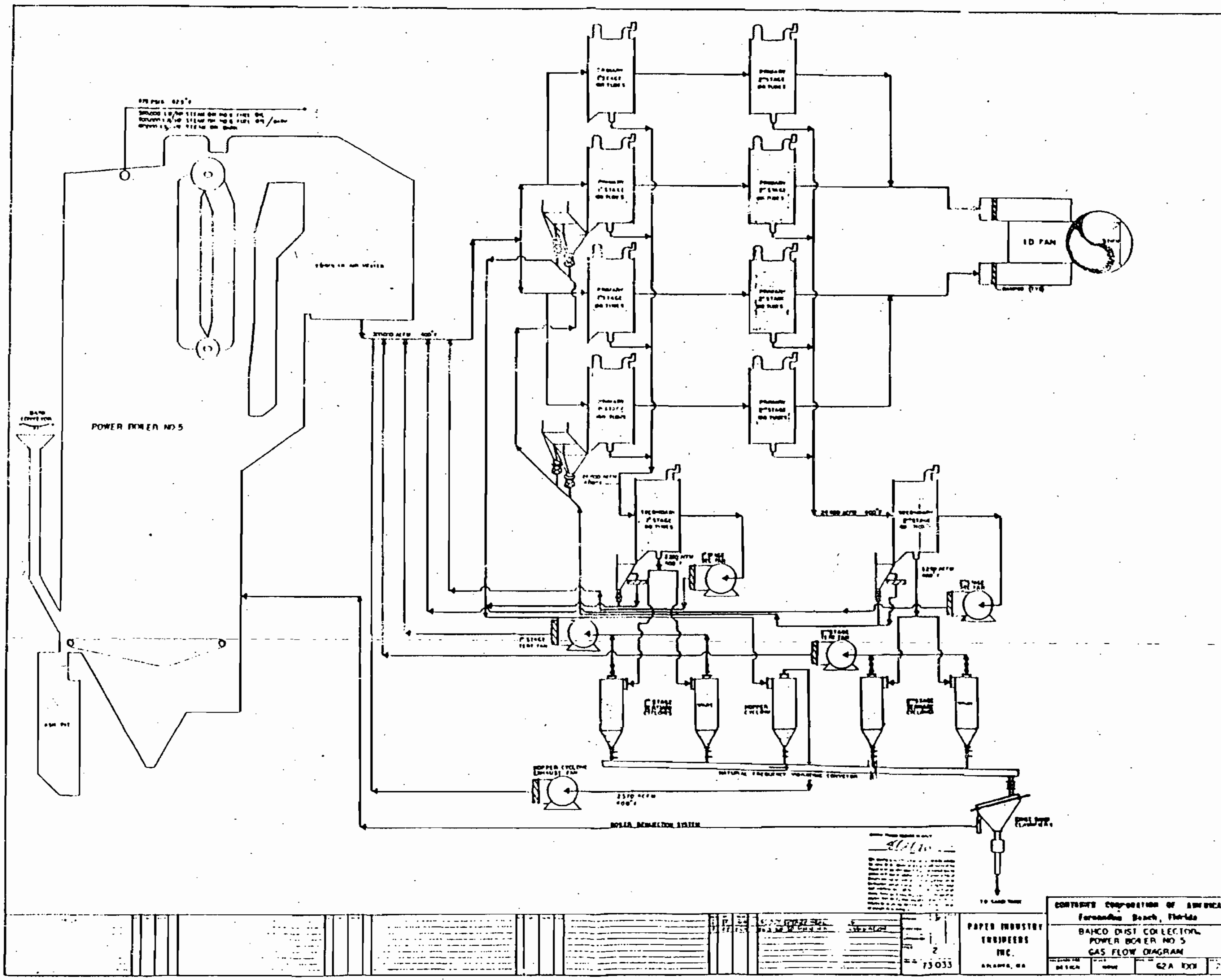

Figure 8. Original layout of Bahco dust collector No. 5 Power Boiler.

TABLE 6. NO. 5 POWER BOILER BAHCO DESIGN SPECIFICATION

Steam production, lb/h	500,000
Type of fuel	No. 6 oil and bark
Make of boiler	B&W
Type of grate or stoker	Detroit travelling grate
Reinjection capability	Yes
Primary Collector:	
Gas volume - inlet, acfm	300,000
Gas temperature, ^{o}F	400
Moisture content (by volume), %	7-18
Dust load inlet, gr/scfd	1.0
Specific gravity of dust	Sand - 2.65, Bark - 0.3
Pressure drop, in. water	2 x 3.14
Collector type, JCD	10.1610
Total number of tubes	2 x 640
Arrangement	2 x 4 (10 x 16)
Cleaning device	Yes
Secondary Collector:	
Gas volume - inlet, acfm	2 x 24,400
Gas temperature, ^{o}F	400
Pressure drop, in. water	2.53 each
Collector type, JCD	06.1010
Total number of tubes	2 x 60
Arrangement	2 (6 x 10)
Cleaning device	Yes

As constructed under these specifications, Bahco guaranteed a maximum of 0.05 g/scfm of dry gas, 300,000 acfm of 400^{o}F flue gas with a moisture content of 7 percent to 18 percent. Assuming minimum moisture (maximum scfmd), this amounts to 73.689 pounds of particulate per hour.

SECTION 3

RESULTS OF THE INSPECTION

3.1 FIELD EVALUATION OF THE RECOVERY BOILERS AND ASSOCIATED ESP'S

The inspection of the recovery boiler operation consisted of an analysis of power distribution in the ESP, status of rapper systems, condition of the shell, and an internal inspection of the ESP for salt cake buildup, deposits, plate alignment and warpage, and corrosion.

Because the boilers could not be brought down for internal inspection, one chamber was selected for internal inspection. The chamber was isolated from the flue gas stream by guillotine dampers. The lower and upper (penthouse) doors were opened and the ESP cooled by natural draft.

In order to evaluate the salt cake deposit patterns and the effectiveness of rappers, the rappers were not used during the cool down period. After an initial internal inspection, the rappers were activated and a second internal inspection was conducted to determine the structural conditions of the unit (i.e., warpage, alignment, corrosion) and the condition of salt cake deposits.

All internal entries were conducted in accordance with confined area entry procedures as specified by the Occupational Safety and Health Administration (OSHA) and Container Corporation. These procedures include gas analysis and lock out provisions.

3.1.1 No. 5 ESP

The No. 5 ESP was observed on Monday, June 25, 1984, and power levels recorded on each T-R set and electrical bus section. There are two chambers in the ESP each containing three mechanical and six electrical fields in series. Each electrical field is divided into two parallel bus sections (No. 1 and No. 2).

The outlet field transformer in the north chamber had been removed from service because of fluid contamination and the E and F fields were being serviced by the E field transformer.

Tables 7 and 8 present the power levels that were recorded on each chamber. It should be noted that the secondary current increased in a normal manner from inlet to outlet in each field. A check of chamber and bus section secondary current, however, indicated the possibility of a close clearance or buildup in the No. 2 bus section of field C south chamber. This can occur as a result of misalignment in the electrical field or instrument error caused by improper gate opening in SCR circuits. Figures 9 through 14 are graphic representations of power distribution in the unit.

TABLE 7. NUMBER 5 RECOVERY BOILER CORONA POWER LEVELS (SOUTH CHAMBER)

Parameter	A	B	C	D	E	F
Primary current, amperes	85	115	145	210	175	220
Primary voltage, volts	270	225	285	325	340	360
Primary corona power, volts	22,950	25,875	41,325	68,250	59,500	79,200
Secondary current, mA	400	600	960	1,190	1,020	1,250
bus H1, mA	200	300	610	600	540	660
bus H2, mA	200	300	360	590	500	620
Secondary voltage, kV	38	28	33	42	44	45
bus H1, kV	38	28	33	42	44	45
bus H2, kV	37	28	33	42	44	46
Secondary corona power, watts	15,200	16,800	31,680	49,980	44,880	56,250
T-R conversion, %	66.2	64.9	76.7	72.2	75.4	71.0

TABLE 8. NUMBER 5 RECOVERY BOILER CORONA POWER LEVELS (NORTH CHAMBER)

Parameter	A	B	C	D	E/F
Primary current, amperes	85	185	180	210	180
Primary voltage, volts	305	325	315	300	250
Primary corona power, volts	25,925	60,125	58,275	63,000	45,000
Secondary current, mA	340	1,100	1,060	1,200	1,020
bus H1, mA	270	580	570	600	510
bus H2, mA	200	520	530	600	510
Secondary voltage, kV	40	38	38	35	32
bus H1, kV	42	38	38	36	32
bus H2, kV	42	38	38	36	32
Secondary corona power, watts	13,600	41,800	40,280	42,000	32,640
T-R conversion, %	52.4	69.5	69.1	66.7	72.5

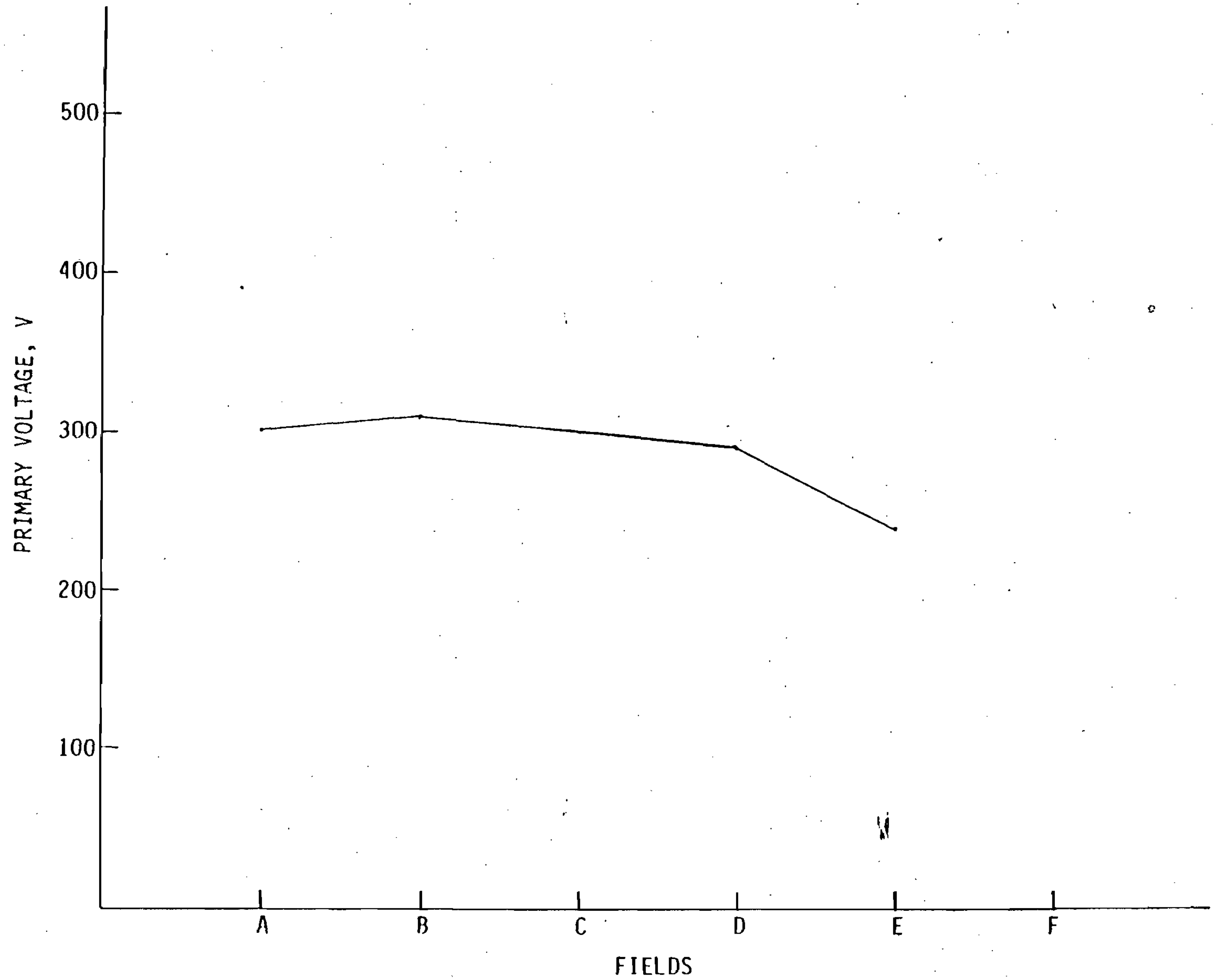

Figure 9. Primary voltage north chamber, No. 5 ESP (6/25/84).

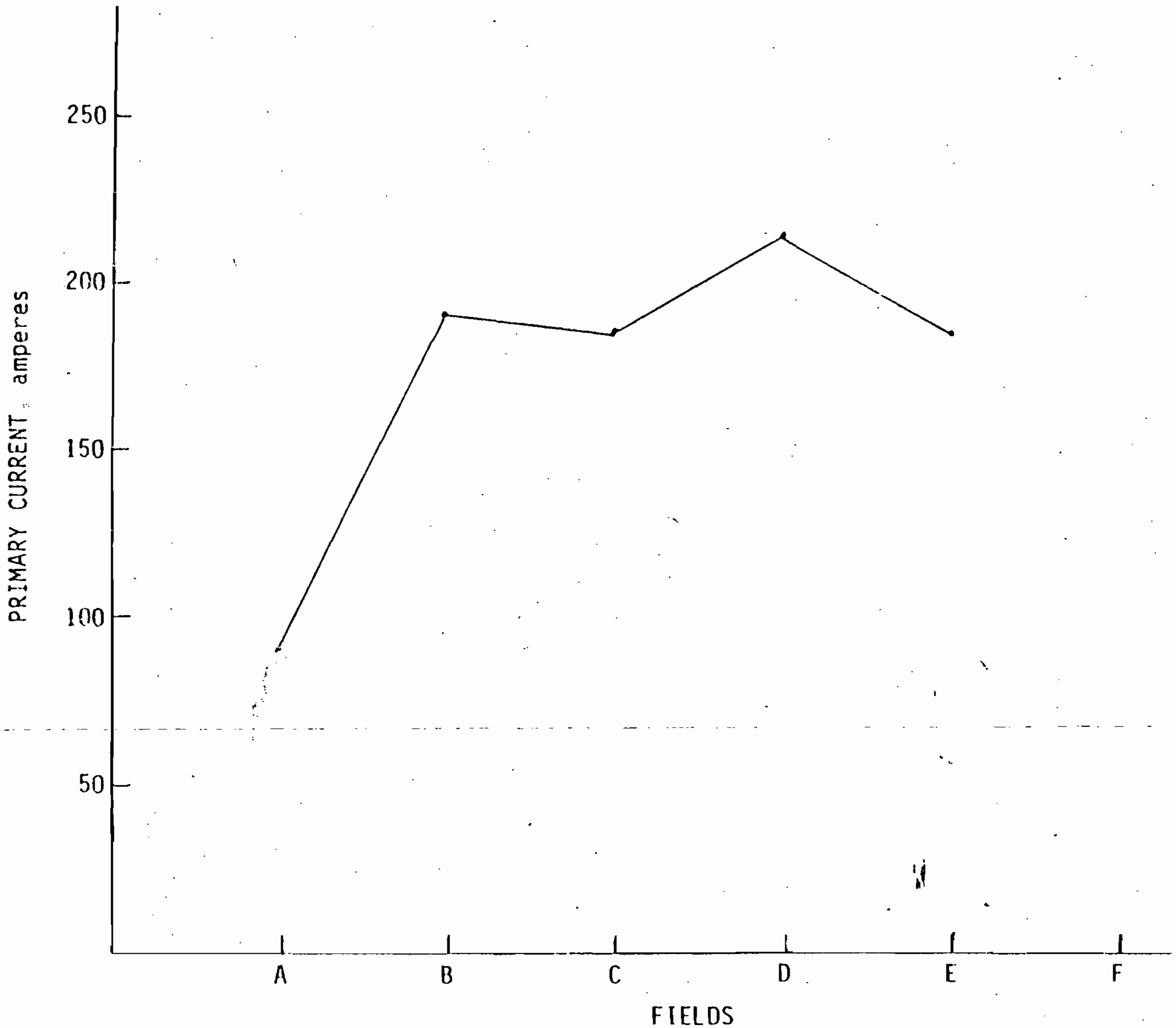

Figure 10. Primary current north chamber, No. 5 ESP (6/25/84).

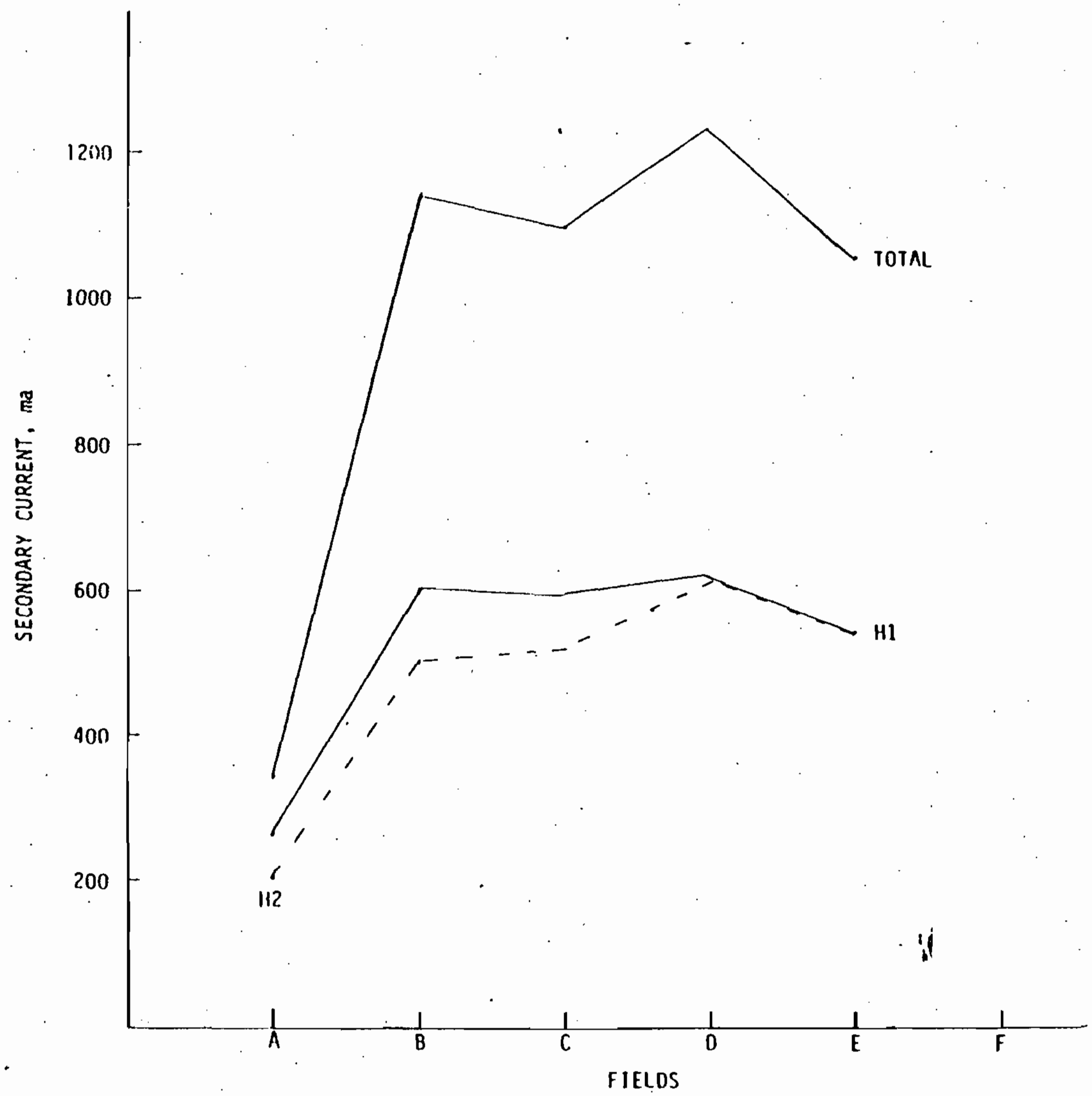

Figure 11. Secondary current north chamber, No. 5 ESP (6/25/84).

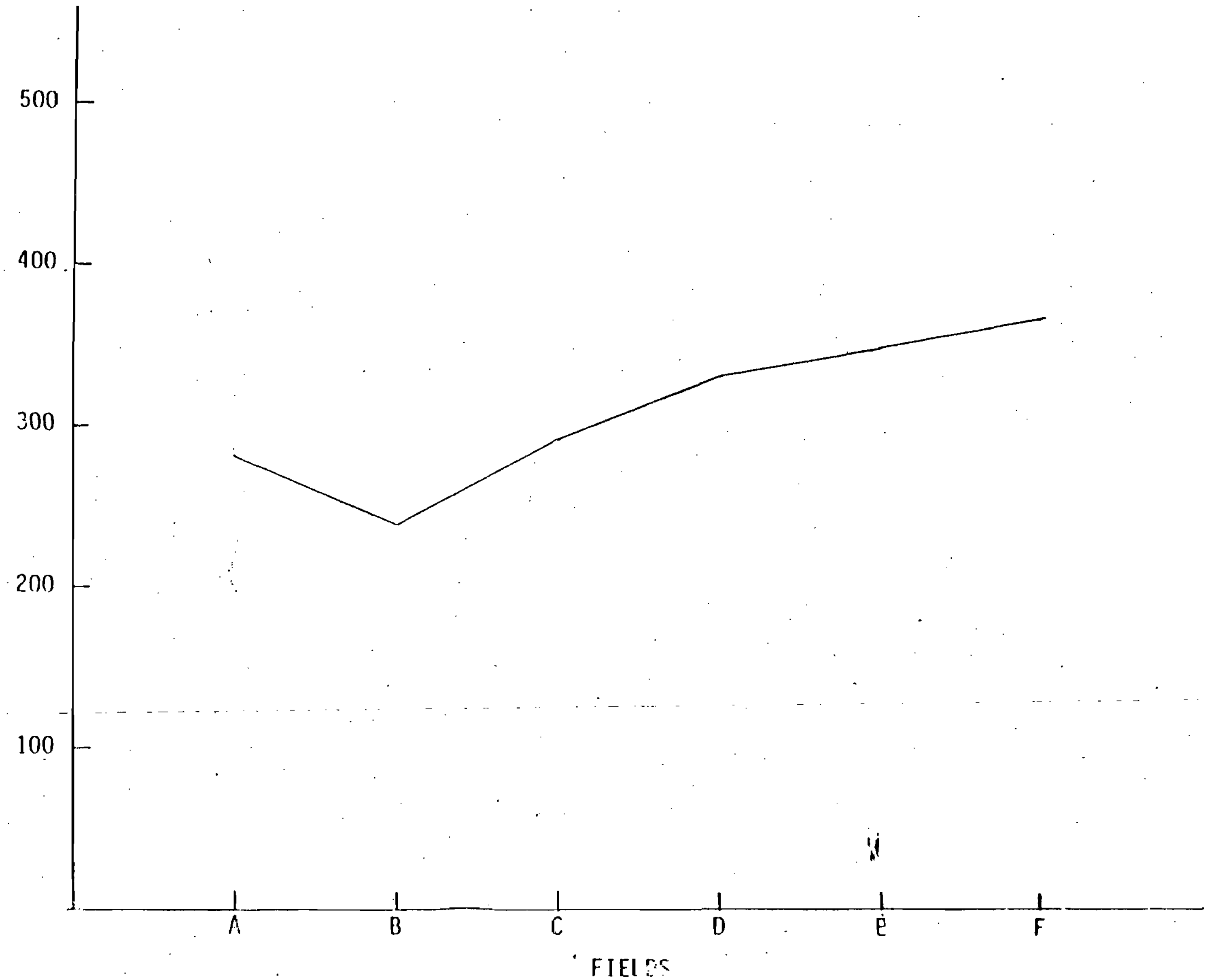

Figure 12. Primary voltage south chamber, No. 5 ESP (6/25/84).

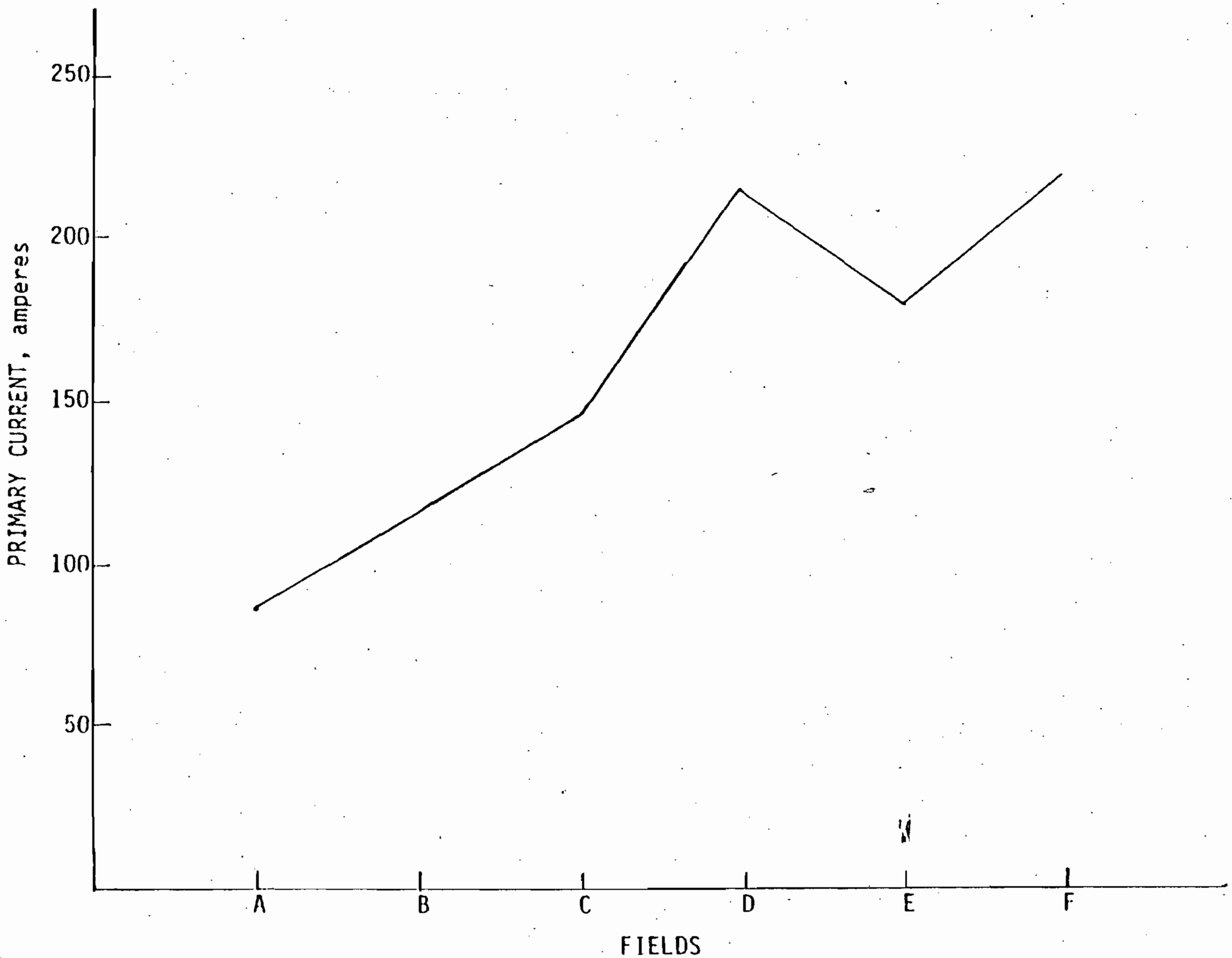

Figure 13. Primary current north chamber, No. 5 ESP (6/25/84).

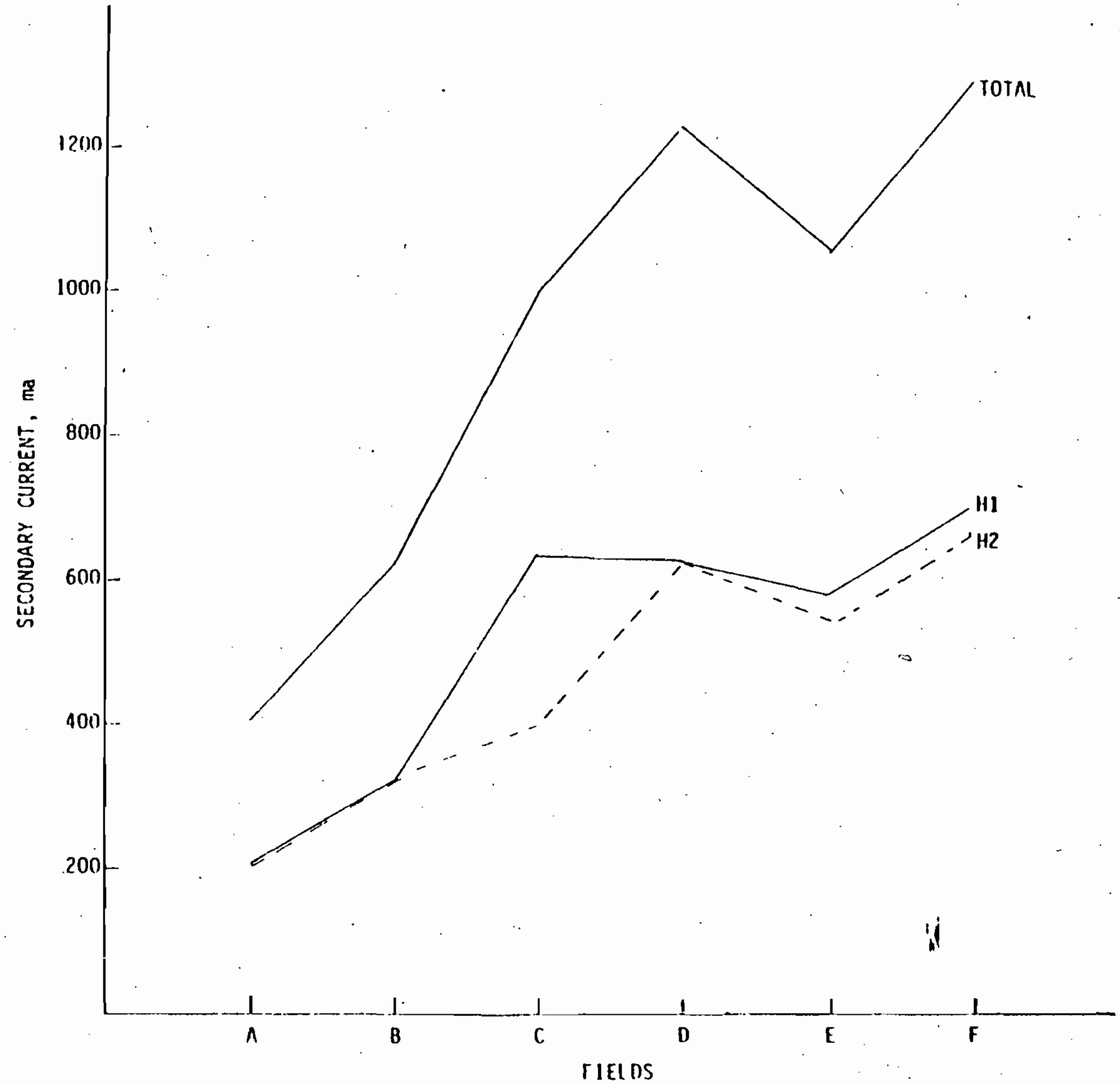

Figure 14. South chamber secondary current (6/25/84).

Overall corona power input to each chamber was high, 214,790 watts in the south chamber and 170,320 watts in the north chamber. The lower power consumption in the north chamber was partially the result of the loss of the outlet field transformer and the possible imbalance in gas volume through the chambers. The north chamber may be carrying approximately 12 percent more volume than the south chamber.

Discussion with plant personnel since the inspection indicated that turning vanes used in the duct upstream of the ESP inlet were fouled at the time of the inspection which resulted in an imbalance in gas flow. Removal of this material and subsequent stack testing indicates that equal flow to each chamber has been achieved. V-I curves were produced on the north and south chambers to evaluate internal conditions within the electrical field (Figures 15 and 16). Corona initiation voltage in all fields appears to be low (12 to 18 kV) indicating low salt cake retention on the wires and effective rapping.

The gas load V-I curve pattern in the north chamber is typical except for the low current and voltage in the C field. This may indicate salt cake buildup on bottle weights and wire frame or a clearance problem.

V-I curves in the south chamber were not typical and were similar to air-load curves especially in the outlet fields. High current readings indicate a low dust loading and dust suppression of the corona.

Comparison of the general pattern between north and south chambers implies that the north chamber may be receiving a substantially higher gas flow and mass loading than the south chamber. No indication of insulator tracking was observed in either chamber.

3.1.2 Rapper Function

Salt cake is removed from wires and collection and gas distribution plates with pneumatic rappers. There are 144 collection plates, 48 discharge wire frames, and 8 distribution plate rappers. Rapper function is variable and rapping time is controlled by solid state control circuits and solenoids that are enclosed in a metal cabinet for weather protection. Manual activation triggers are included on the valves for maintenance checks. Total system troubleshooting can be conducted by replacement of printed circuit boards with constant run cards.

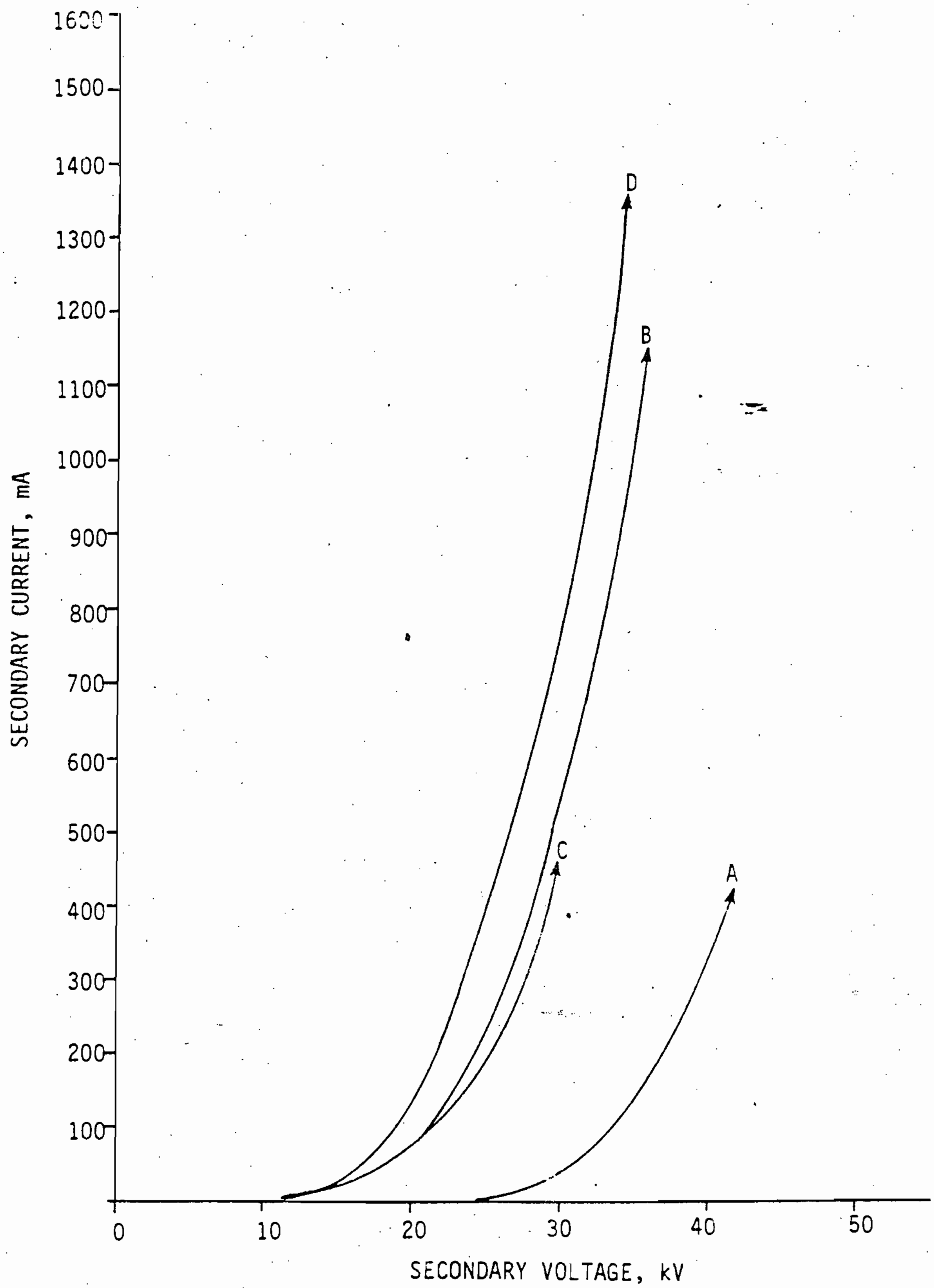

Figure 15. North chamber, No. 5 ESP gas load V-I curves.

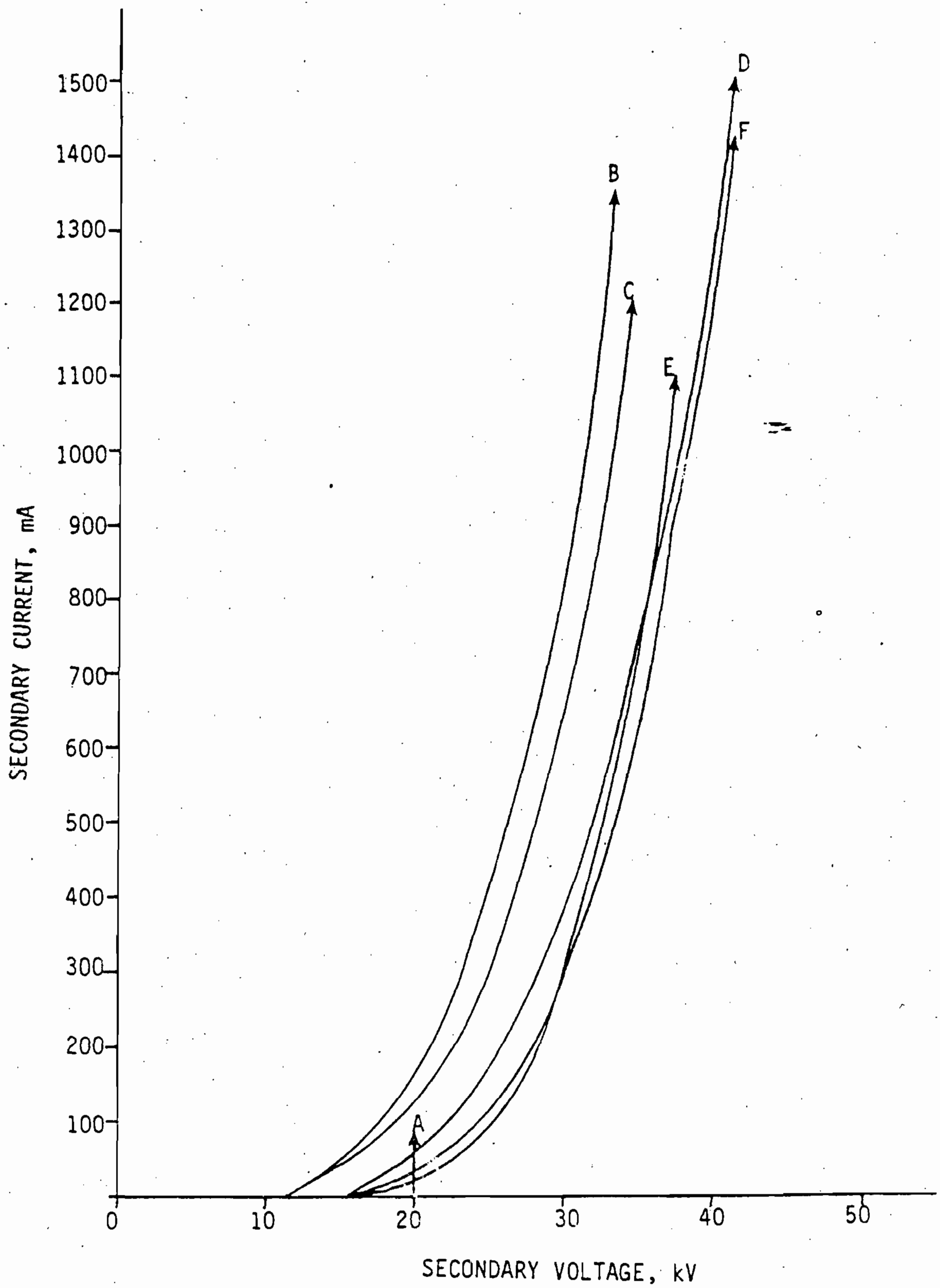

Figure 16. South chamber, No. 5 ESP gas load V-I curves.

On previous inspections, rapper function was poor and many of the rappers were not operating effectively because of condensed water in the compressed air system. Container Corporation has installed an effective compressed air drying system to improve rapper reliability. No water was observed at the compressed air point of the rappers. A long-term problem, however, has resulted from dry compressed air. Rust that existed as a wet sludge previously is now becoming entrained and fouling solenoid valves. Air line filters have been installed to remove rust prior to the solenoid valves. A rapper-by-rapper inspection indicated 15 of 128 rappers either were not functioning or were weak, or the rapper shafts were broken (6 on the south side and 9 on the north side).

Turning vane rappers were not available for use because the solenoids had been removed. One rapper shaft was broken and the plates were not rapped. Wire frame rappers are isolated from the wire frame by synthetic polymer rods. The rapper shaft is connected to the insulator by a block clamp. The insulator is housed in a tappered seat in the block and clamped using a spilt block and bolt (Figure 17). Over periods of continued operation, the tappered shaft loosens and rapping energy is not effectively transferred to the wire frame. This problem is aggravated if the rapper shaft is not vertical and side stress is placed on the connection. Shifts in the wire frame alignment can move the support insulator latterally causing the shaft to be stressed when penetrating the penthouse roof. A visual inspection indicated only two shafts in the south chamber operating at a detectable angle.

3.1.3 Penthouse Insulators

Barrel insulators are used in the penthouse to support wire frames and discharge electrodes and isolate the high voltage system from the ESP shell. Moisture, dirt, or coatings on the insulator can result in electrical tracking to ground and ultimate failure of the insulator. An inspection of all insulators in the south chamber penthouse was conducted and no evidence of electrical tracking was observed (i.e., cracks, chips, etc.). The insulators appeared clean and no accumulation of dust was observed in the penthouse.

3.1.4 Purge Air Fans and Heaters

Purge air fans are used on the penthouse to prevent dust from entering the penthouse area. The ESP is operated at positive pressure and salt cake

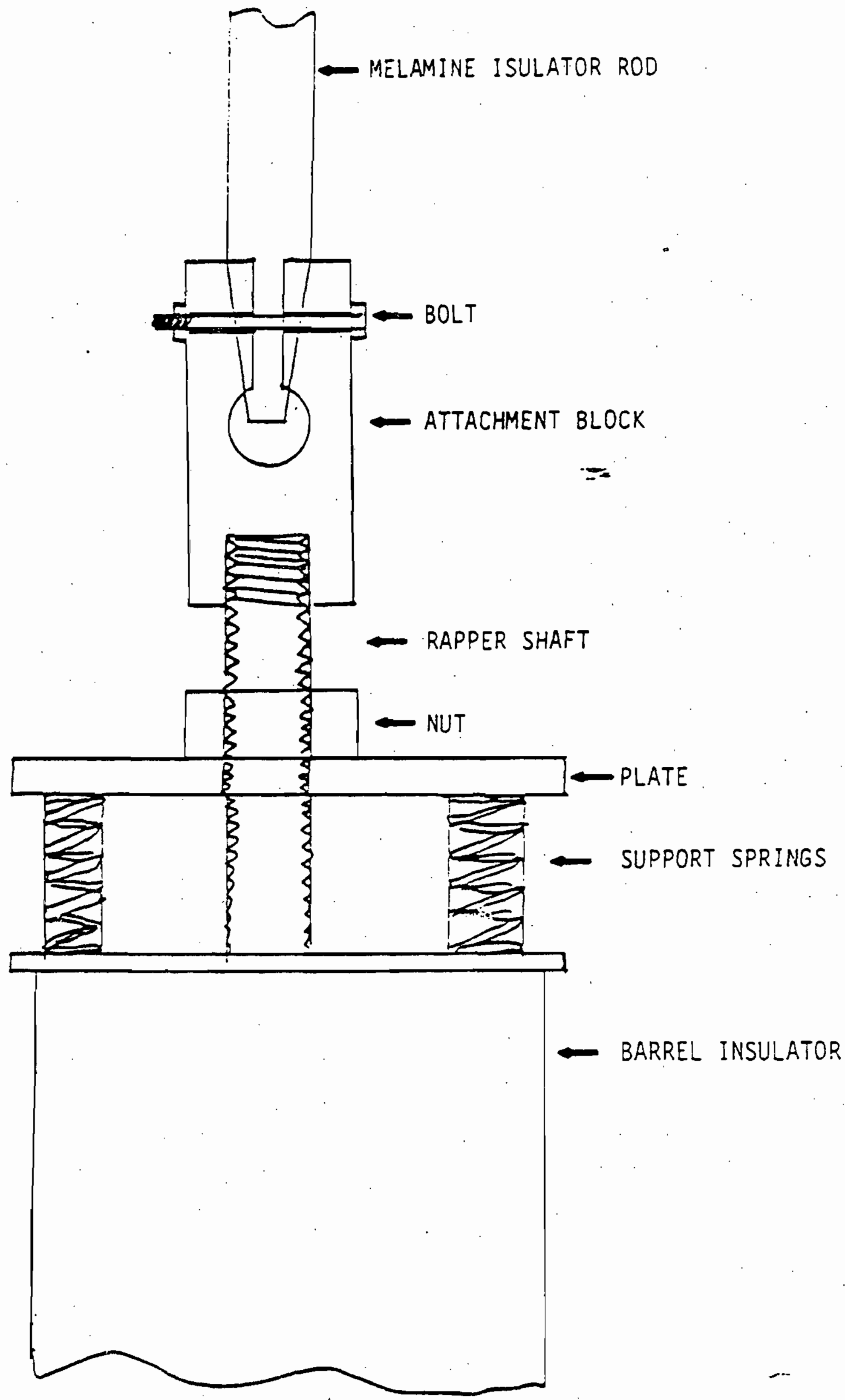

Figure 17. Wire frame rapper rod attachment block.

can penetrate through the rapper shaft insulator support openings into the penthouse. The area is pressurized to force gas flow into the ESP and prevent dust penetration. Normally, the purge air is heated to prevent condensation on the insulators and ESP shell. In this unit, even with the moderate Florida climate, condensation does not appear to present a problem. Penthouse heaters and air filters are not used. No evidence of insulator failure, dust buildup, or corrosion was observed.

A previous corrosion/erosion problem was observed on the ESP roof under the purge air inlet opening. This failure was corrected by patching the roof and installing a deflector plate under the purge air opening.

3.1.5 Gas Inlet and Distribution

The gas inlet to the ESP is from the bottom up into the ESP box (bottom entry). The inlet plenum is rectangular and the gas is turned by an inclined set of turning vanes containing 16 individual vanes. Each vane is a "L" shape with the long side toward the ESP inlet (Figure 18).

During the inspection, it was observed that a buildup of salt cake was present on the horizontal face of the turning vanes, which was partially obstructing the flow of gas on the south chamber inlet (the north chamber could not be observed because of ESP operation). Discussion with plant personnel indicated that chronic fouling had occured and that all efforts to maintain clean turning vanes were uneffective. In an effort to improve gas distribution (i.e., reduce pluggage), a portion of the horizontal vane had been removed.

It should be noted that both the gas distribution plate and turning vanes are rapped by the same two rappers. As noted in the previous sections, the turning vane rappers were not functioning.

A visual inspection of the distribution plate from the top looking into the inlet plenum indicated substantial pluggage of the perforated distribution plate (Figure 19). The fouling was sufficient to seriously affect the gas distribution within the chamber and affect collection efficiency. It is suspected that the pluggage is directing gas flow to the north chamber as implied by the V-I curves and corona power levels. An inspection of the north chamber inlet, however, could not be conducted to verify this suspicion. It is also possible that the north chamber distribution plate was also fouled.

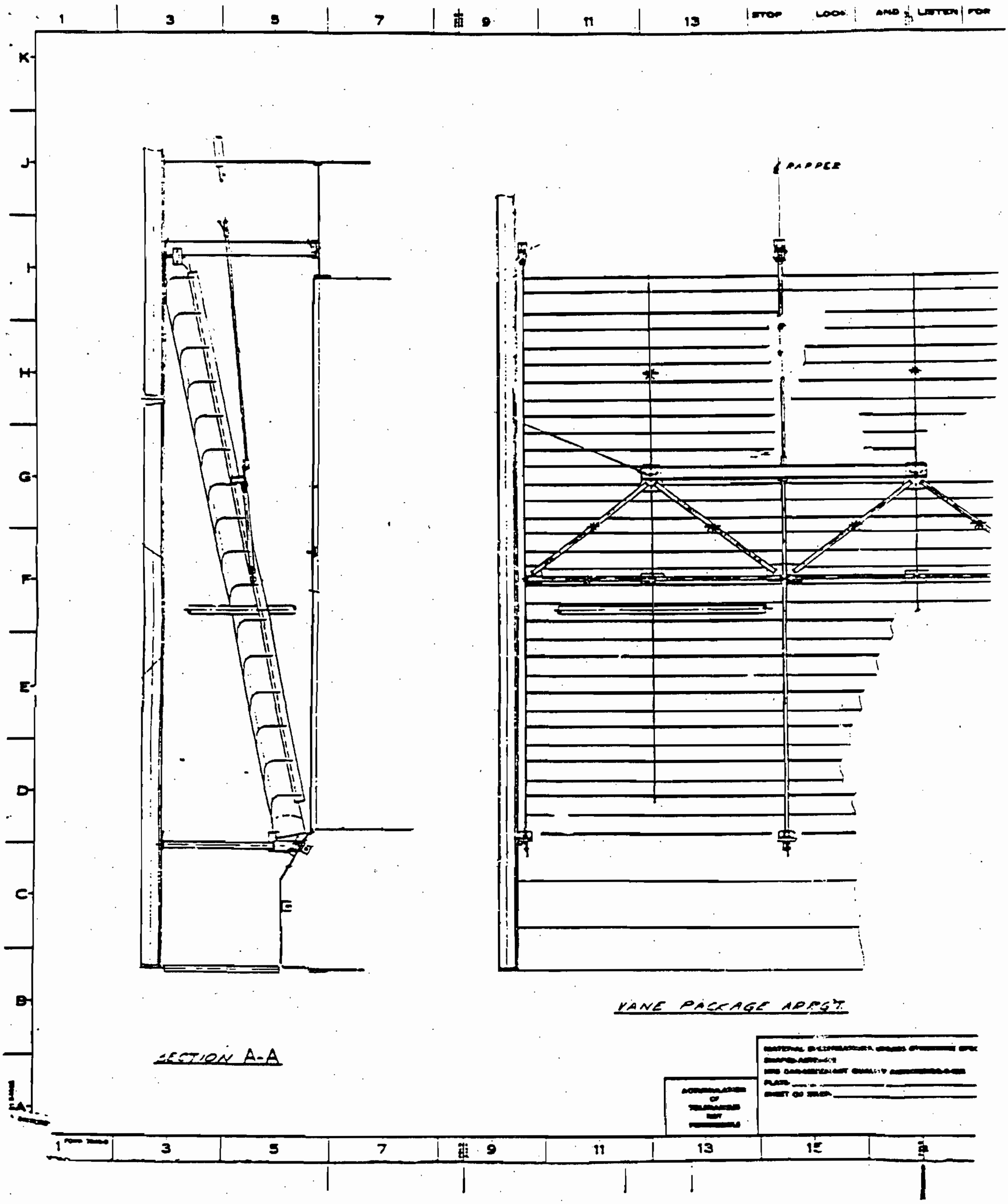

Figure 18. Turning vane configuration.

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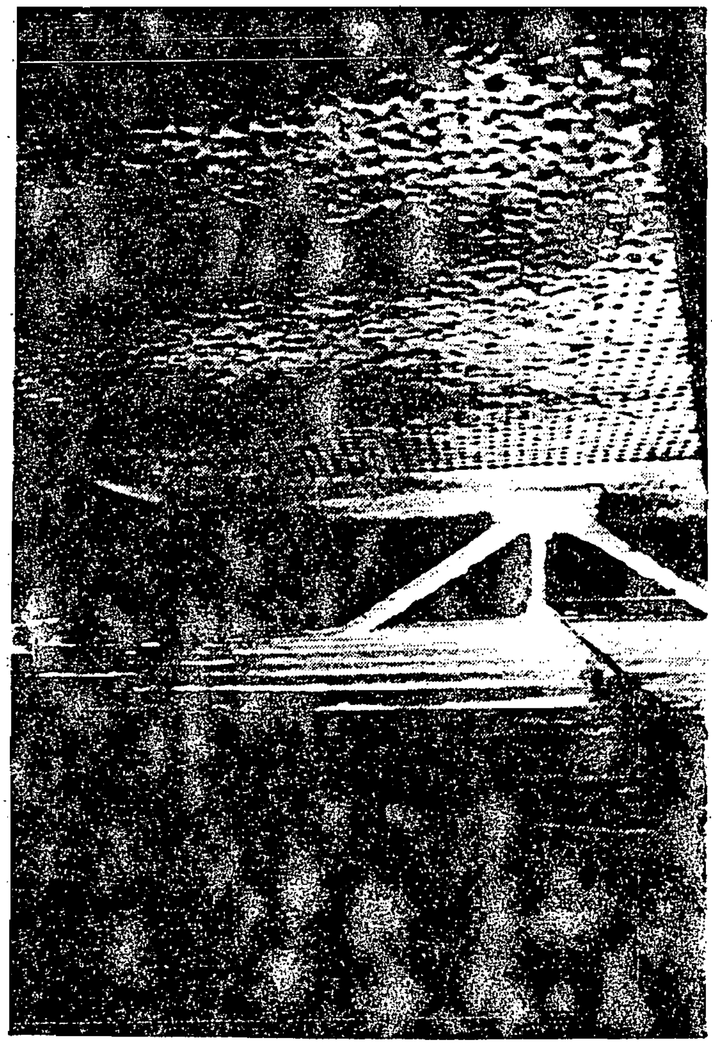

Figure 19. South chamber turning vanes and gas distribution plate showing pluggage (looking down into inlet plenum, vane lower portion of photograph).

Chronic fouling of the inlet vanes and distribution plate usually occurs because the plates are structurally rigid and rappers cannot impart sufficient vibration to dislodge the salt cake. In many cases, this is initiated and aggravated by sticky salt cake caused by low temperature (i.e., direct contact evaporation) or sulfur trioxide (SO_3) adsorption (i.e., low salt cake pH). Neither of these key elements in the formation of sticky salt cake were apparent in this application.

Improvements in turning vane and distribution plate rapping have been made since erection of this unit. Current turning vane installation (Environmental Elements) allows the vane system to be partially free floated and rapped from the lower edge by a horizontally located rapper (Figures 20 and 21). This allows a typical vane to horizontally travel up to 1.75 in. in an oscillating motion. This provides sufficient vibration to maintain clean vanes.

Distribution plates normally are rapped in a vertical rapper arrangement. Improved plate vibration can be generated by using free floating plates with rapping in a horizontal motion perpendicular to the plate face (Figure 22).

3.1.6 Drag Chains and Antisneakage Baffles

Drags in the ESP are located in the three mechanical fields and the outlet plenum (5 sets). The drags are installed perpendicular to the gas flow allowing minimum chain length and drag width.

Because the drags are moving across the gas stream, positive baffles can be used between the mechanical fields. An inspection of the baffles indicated minimum corrosion and no points of visual penetration. In several areas a salt cake buildup was observed on the structural beams between the mechanical fields above the baffle plates. The buildup, however, was not judged sufficient to disturb the gas flow distribution. The deposits are in locations that cannot be efficiently removed by normal methods (no access at structural level). Removal can be accomplished by high pressure water from the top but this practice should be avoided. Use of water at this location would result in the need to completely wash the unit. Repeated washing will result in corrosion in the drag and shell areas.

Historic problems with drag chain alignment and shaft failure have been noted. The plant has installed shear pins in the drive shaft couplings and changed the shaft lubrication from external lubrication to graphite.

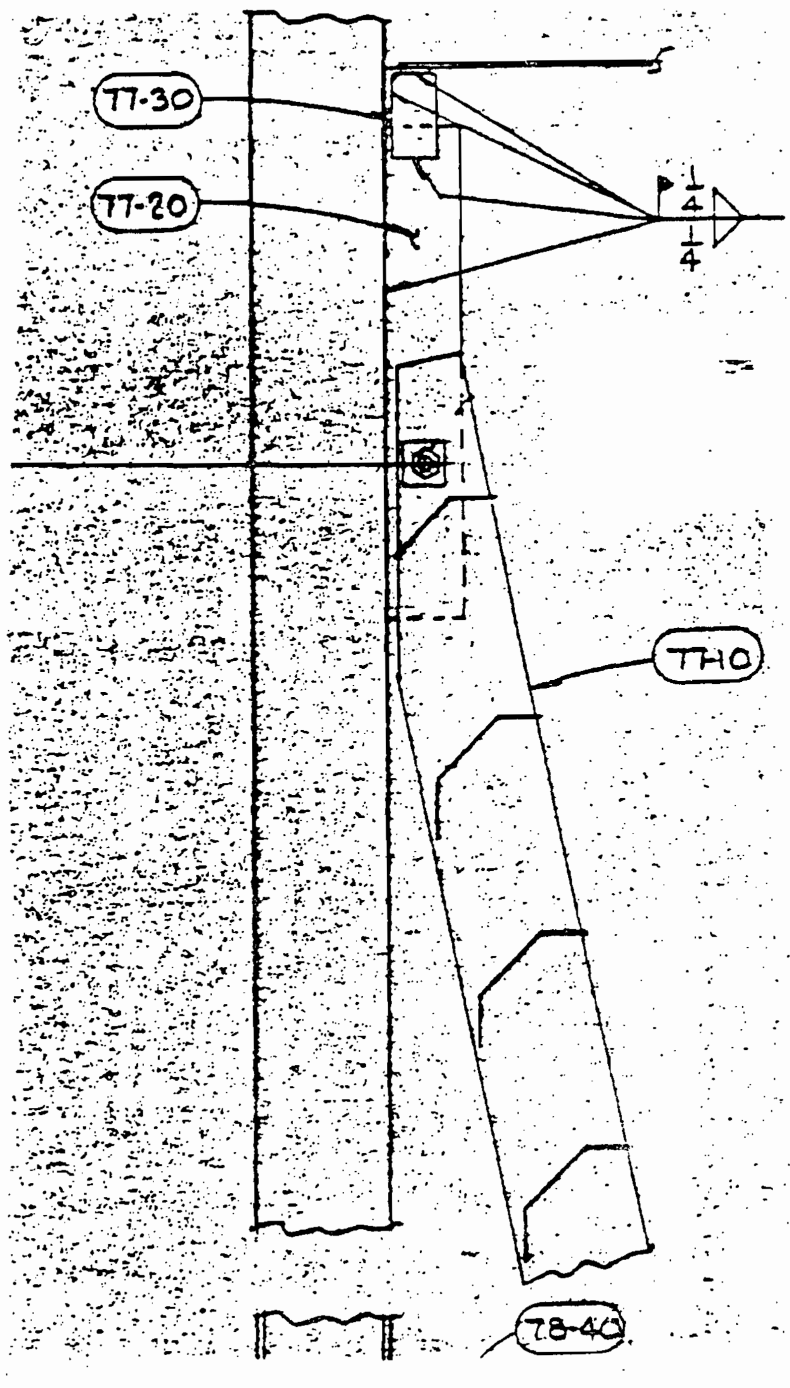

Figure 20. Possible modification to turning vanes to improve rapping (upper attachment).
(Courtesy of Environmental Elements Corporation)

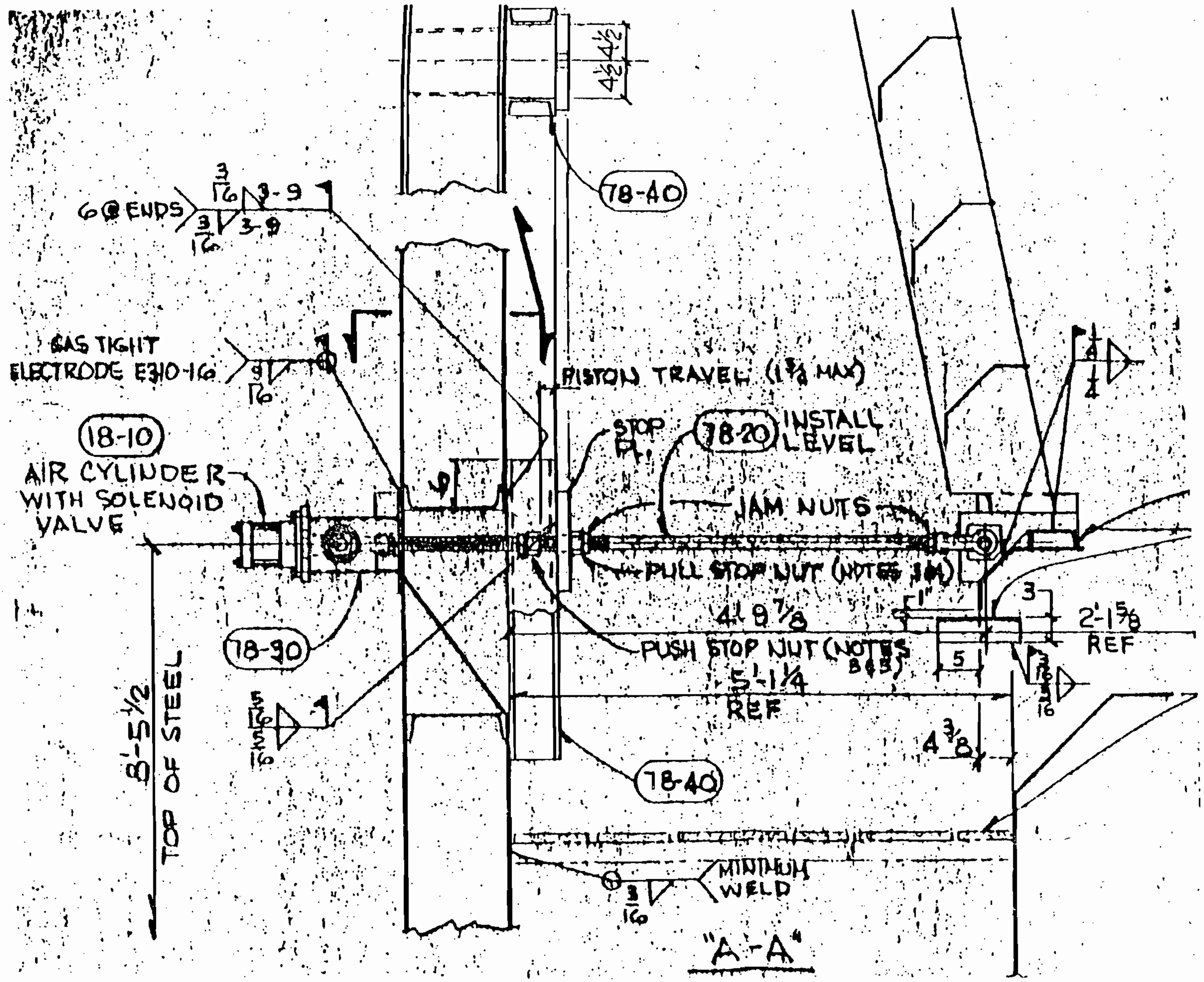

Figure 21. Possible modification to turning vanes to improve rapping (lower attachment with rapper).
(Courtsey of Environmental Elements Corporation)

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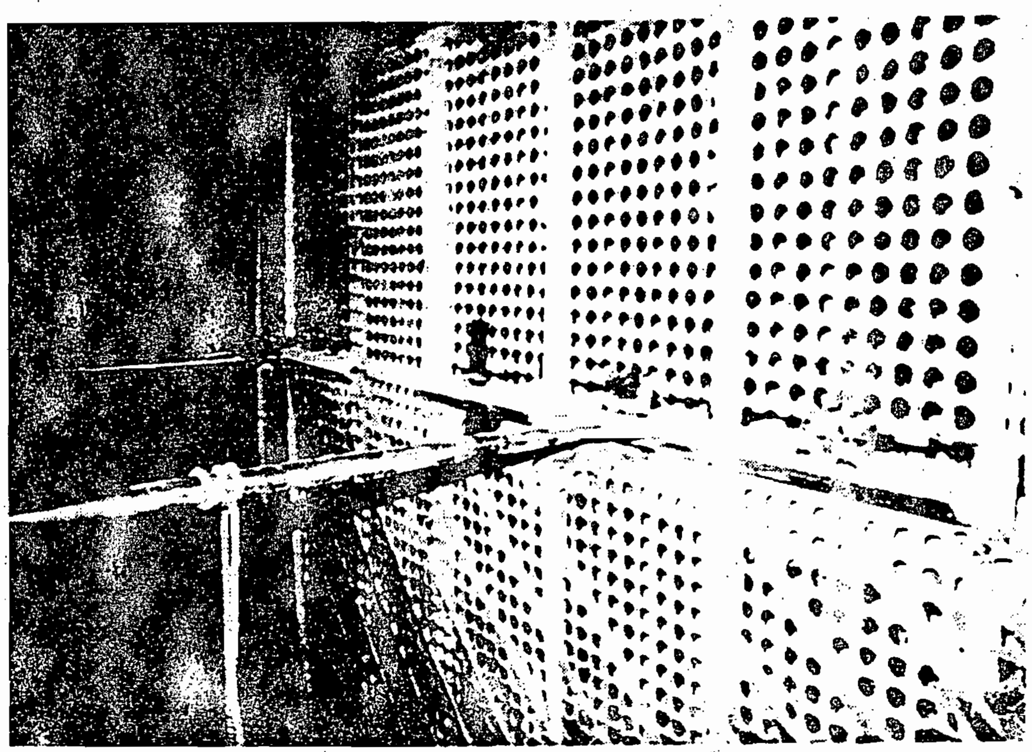

Figure 22. Inlet distribution plate showing horizontal rapper.

Drag chain alignment has been improved and drag chain wrecks eliminated. The drag plates (scraper blades) have been lengthened to improve salt cake removal at baffle corners. A normal buildup of salt cake was observed on drag structural members but appears to be self limiting in that the blades pass over the deposits on their return path.

Collected dust rate is highest in the inlet field drag area and lowest in the outlet field as expected because the inlet field collects approximately 10 to 90 percent of the particulate matter.

All drag scrapers appeared to be in place and visually straight. Observation of the drags during their operation indicated even removal of the salt cake.

3.1.7 Salt Cake Deposits

A visual inspection was made of plates, wire frame (upper and lower), and discharge wires in each section to judge the effectiveness of the rapping process. An inspection was conducted after shutdown and a second inspection was conducted after operation of the rappers.

Upper Wire Frame--

An inspection of the upper wire frame indicated minimum salt cake deposits in Fields C, D, E, and F. A major area of buildup was observed in Fields A and B and particularly in Field A. The deposit was massive covering several square feet of area. The deposit was approximately 12 to 14 in. above the wire frame (Figure 23).

Shape and location of the deposits indicate that the cause of the buildup is vertical gas flow from the inlet plenum into the area above the electrical field. The gas, prevented from continuing into the second mechanical field by antisneakage baffles, passes into the electrical zone.

Presence of these deposits can result in electrical shorts that either trip the T-R set or severely limit power input. The deposits, because of their nature, usually do not result in complete grounds, but because of the high resistivity (dry dust) allow a current to flow to ground (soft ground).

The gas flow into this area is possibly caused by a buildup of deposits and pluggage of turning vanes. In fact, the gas flow may have been increased as a result of modification to the turning vanes (i.e., shortening of the vane horizontal length). Periodic removal of deposits is necessary for continued operation. The rate of deposition is not known and the interval between

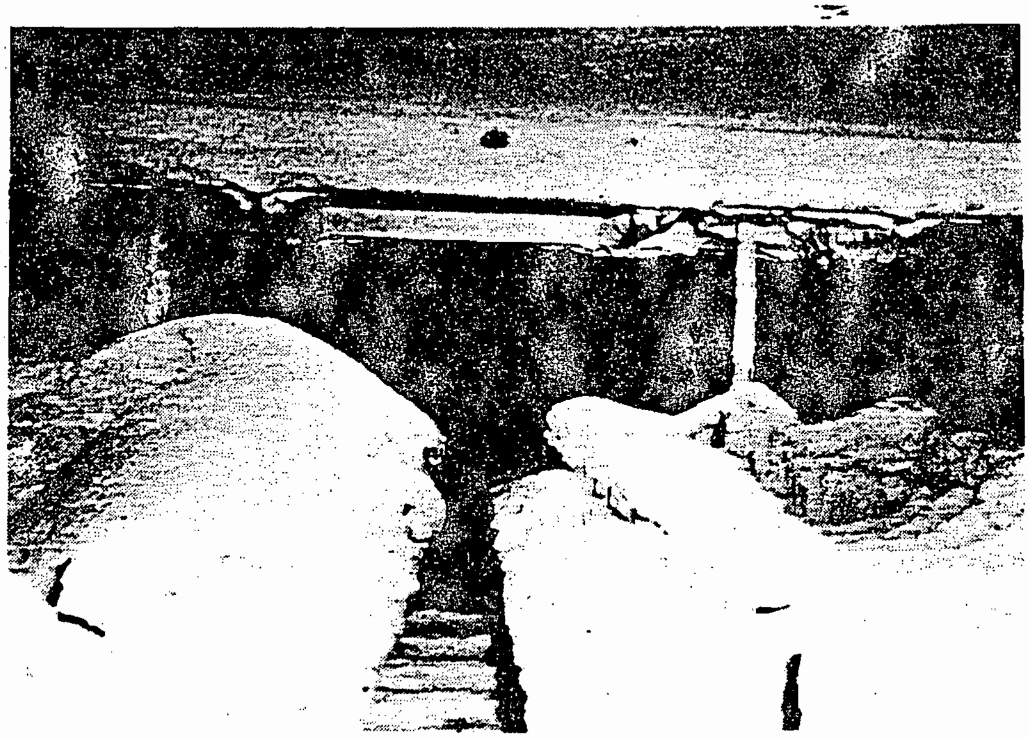

Figure 23. Upper wire frame inlet field No. 5 ESP showing salt cake deposits.

preventive maintenance is not defined. If these intervals can be confined to periods of normal outages, the deposits would not require forced outages or operation with only a single chamber. With changes in inlet gas distribution, improved rapping, and modification to the gas turning vanes, the buildup may be eliminated.

Plates--

An evaluation of salt cake buildup was made in all mechanical fields from the drag bottom to the upper wire frame area. No area of abnormal buildup was observed prior to rapping. As expected, a heavier deposit was observed in the inlet field with almost no deposits in the outlet field. After rapping, the plate deposits were uniformly light.

The salt cake had a white, nonagglomerating appearance and was not sticky or crustal. Salt cake had the normal appearance of a low odor boiler operated at low excess air.

Lower Wire Frame and Bottle Weights--

In the inlet mechanical field (A/B) and second mechanical field (C/D), the bottle weights had large masses of salt cake in several locations (Figure 24). The number of deposits was low (<20) and the deposits were randomly distributed in the field. The accumulations were both hard and crusty and in some cases discolored (yellow/white). The size of the deposits was large enough to reduce clearances and produce soft grounds between plates and wires.

The deposits could be dislodged manually but were not able to be removed by rapping. Plant personnel indicated that the presence of deposits can be confirmed by evaluating the power readings. In some cases the deposits can be removed by constant rapping in the affected field. When this is not successful, entry must be made into the unit for manual removal.

Soft deposits on the wire frame were easily removed by rapping and in many cases appeared to be self limited by electrical sparking between the mass and ground. The sparks dislodged the soft flaky salt cake preventing further accumulation and establishment of a complete ground. Sparking as a result of reduced clearance reduces the ability to achieve full corona power in the affected field.

The presence of soft grounds composed of hard crusty material is characteristic of salt cake being wet and drying out. These deposits are commonly

Figure 24. Buildup of salt cake on bottle weights C field south chamber.

found in low temperature direct contact applications. Also these deposits are not uniform as would be expected from condensation on low temperature areas (i.e., near walls). Discussion with plant personnel indicated that when drag repairs are made, the ESP bottom may be washed to aid in maintenance. Water could have splashed up on the wire frame initiating the growth of the deposits in a random manner.

A routine internal inspection program is necessary to eliminate or control deposits of this type. After the internal inspection, maintenance personnel must remove the deposits by lightly hitting the bottle weights with hammers. This can be accomplished during routine outages or on scheduled inspections depending on the frequency of outages.

3.1.8 Wires

A random inspection did not indicate any areas where wires had been removed from the collector in a manner that would affect performance. No lanes were observed in any electrical field with less than four wires. It should be noted that at the corners of the wire frame one wire must be eliminated to allow the support pipe to be attached to the lower wire frame. In these lanes, removal of wires can be more critical than in the other lanes in the field.

All wires are equipped with shrouds to prevent wire burn off and sparking at the top and bottom of the electrical field. An inspection of the wires did not indicate incomplete rapping and no deposits were observed except as noted in the area of the bottle weights.

3.1.9 Plate Warpage and Alignment

A random inspection of each field from the bottom and top did not indicate any area of plate warpage. An inspection of the bottom wire frame however, did indicate a shift in the frame in the direction of gas flow and a rotation of the frame. This alignment was correlated with the difference in secondary current in the C field bus sections No. 1 and No. 2 (610 mA and 360 mA). At the maximum point, the alignment was shifted approximately 1 in. (Figure 25).

The movement of the wire frame indicated that one corner of the frame had moved vertically approximately 1/8 to 3/16 inches downward. This allowed the lower frame to move in the direction of gas flow and to twist.

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Figure 25. Frame alignment between C and D electrical fields south chamber.

Plant personnel repositioned the frame by tightening the frame support nut on the barrel insulator, which raised the frame (Figure 26). Alignment was achieved without lateral adjustment of the jack screws positioning the insulator.

An air-load test was conducted on the south chamber prior to startup and the deviation in C field secondary current was corrected. A check of C field during gas-load conditions after the outage indicated bus sections balance had been restored (i.e., H1 was 700 mA and H2 was 630 mA).

After the outage, corona power was recorded in each chamber. Tables 9 and 10 present the power levels for the south and north chambers, respectively. An increase in secondary power is noted in each chamber. This was a result of boiler load changes between the two periods. The air-load test conducted prior to startup of the south chamber, continued to indicate internal clearance problems specifically in fields A and D (Figure 27). These were suspected to be caused by residual salt cake deposits in the unit during manual attempts to dislodge and remove the large mass of salt cake above the upper wire frame in the A field. No explanation can be offered for the low clearance indicated in the D field.

3.1.10 T-R Set Controls

The T-R set control cabinets were installed in an air conditioned dust-free room. Inspection ofthe T-R control panels did not indicate accumulated dust or deposits. Air circulation and temperature were adequate for protection of circuits (heat removal).

During the inspection one T-R set main breaker malfunctioned as a result of a loose wire (3 phase feed). During the outage of the south chamber for internal inspection, the breaker was repaired. Discussion with plant personnel indicated that H_2S corrosion of electrical components (i.e., breakers, printed circuit boards, etc.) was a chronic problem. Filter elements in the air supply to the T-R set control room are designed to remove particulate matter but not gaseous contaminants such as H_2S, SO_2, and SO_3.

3.2 NUMBER FOUR ESP

No. 4 ESP was observed on Tuesday, June 26, 1984, and corona power input levels recorded for each T-R set. The ESP is divided into two chambers,

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Primary
Primary
Primary
Seconda

Seconda

Seconda

Primary
Primary
Primary
Secondar

Secondar

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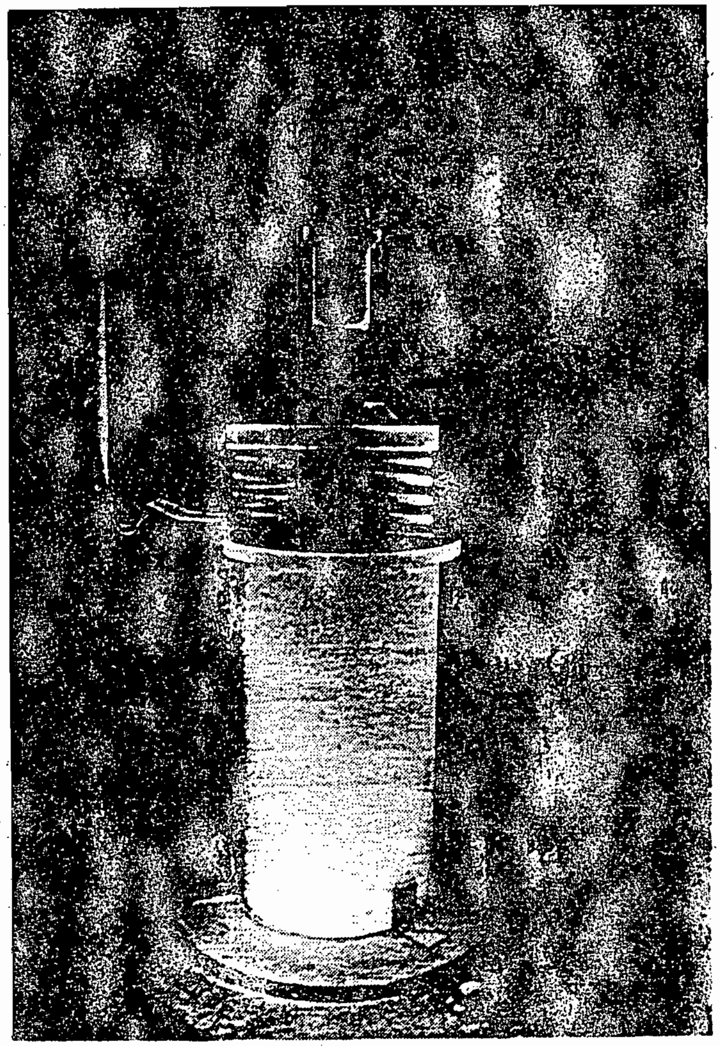

Figure 26. Support insulator showing alignment jacks and frame vertical adjustment.

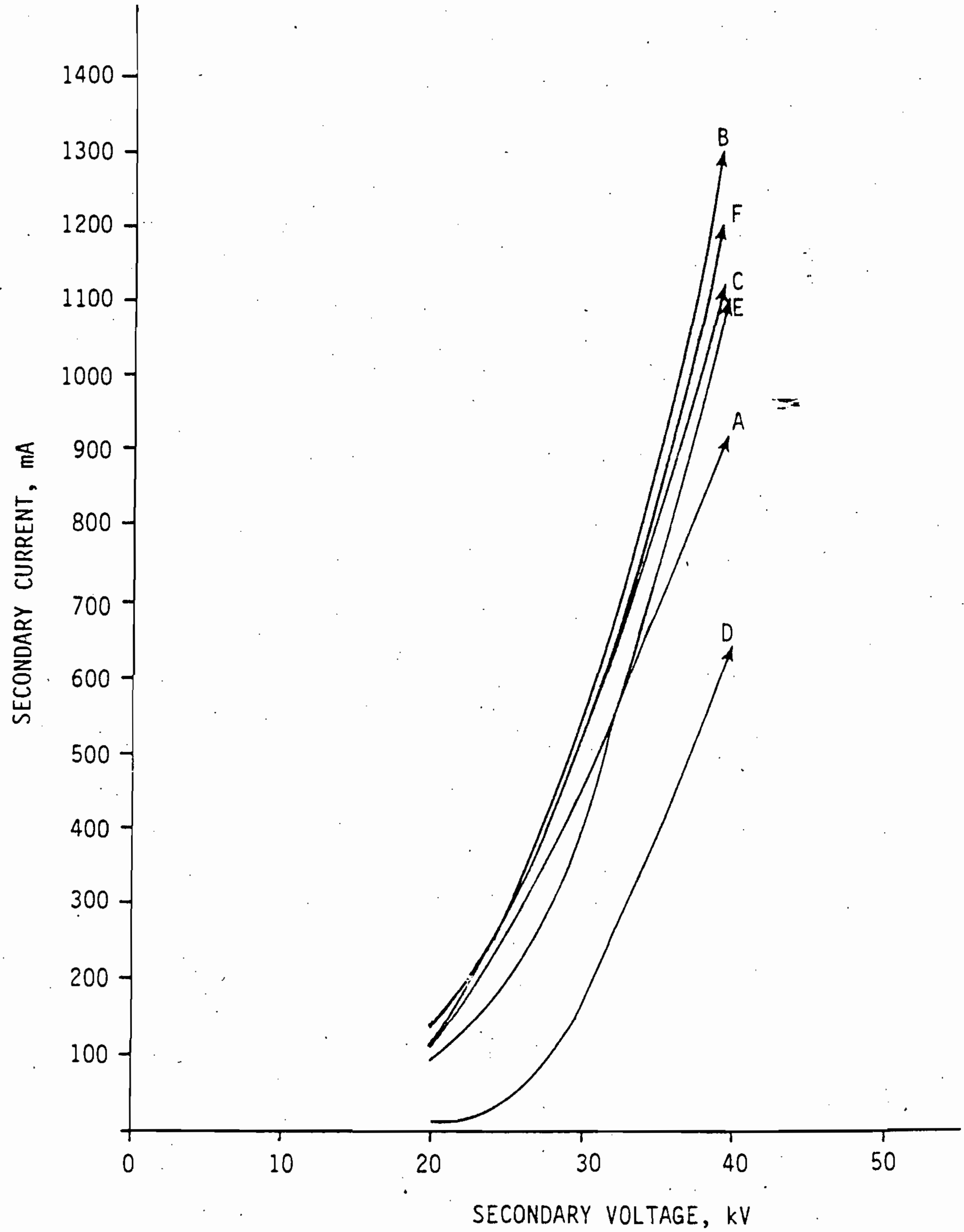

Figure 27. Air-load test south chamber No. 5 ESP (after alignment change).

each containing six electrical fields in series. The fifth and sixth fields are divided into two electrical sections each containing one T-R set. Each section served by a T-R is divided into two bus sections identified as H1 and H2.

Table 11 presents the power levels from the T-R set control panels. The calculated power input to the unit was 345,180 watts on the primary side and 241,625 watts on the secondary side (assuming a conversion efficiency of 0.70).

TABLE 11. RECOVERY BOILER NUMBER 4 CORONA POWER LEVELS

Parameter	Fields							
	A (1)	B (2)	C (3)	D (4)	E N(5)	F N(6)	E S(7)	F N(8)
Primary current, amperes	162	158	168	175	185	230	205	177
Primary voltage, volts	210	190	180	190	250	330	250	250
Primary corona power, watts	34,020	30,020	30,240	33,250	46,250	75,900	51,250	44,250
Secondary current, mA	650	625	575	700	730	1,300	870	740
bus H1, mA	360	400	300	300	460	610	475	410
bus H2, mA	360	400	350	450	490	660	550	460
Secondary corona power, watts (calculated)	23,814	21,014	21,168	23,275	32,375	53,130	35,875	30,975

The secondary current pattern in the unit increased from inlet to outlet as dust was removed from the gas stream (Figure 28). A plot of chamber current (Figure 29) from inlet to outlet, however, indicated that the north chamber had a suppression in the last field (F). All other fields appeared reasonably balanced (north to south).

The sum of the current drawn by each bus section Fields A, B, C and D was significantly higher than that indicated by the meters when measuring total current from the T-R set. This was also observed in E(N), E(S), F(N), and F(S). Because of this deviation, chamber balance may not be indicative

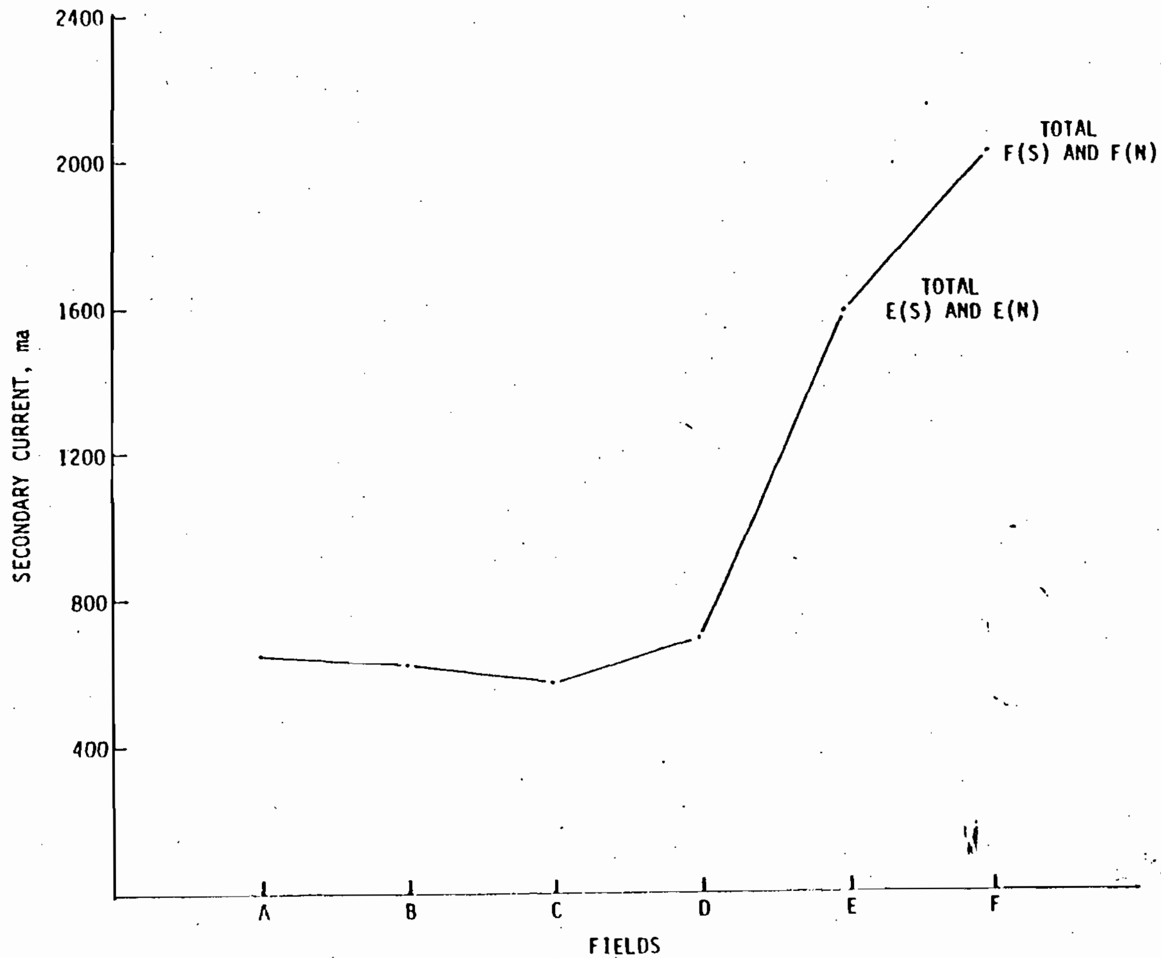

Figure 28. Secondary current No. 4 ESP.

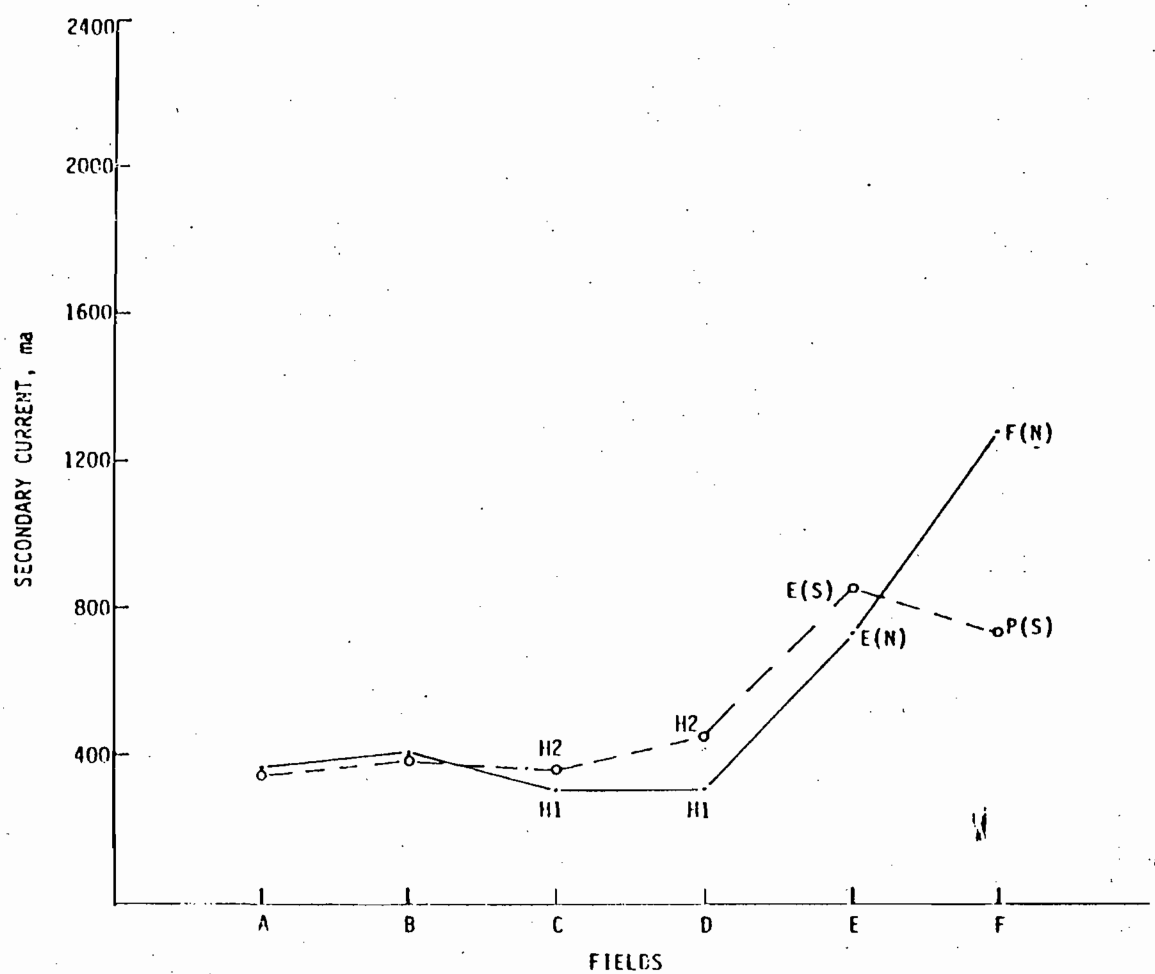

Figure 29. Secondary current by chamber No. 4 ESP.

of internal differences between sections. V-I curves could not be produced because the No. 4 ESP is not equipped with secondary voltage meters.

3.2.1 Rapper Function

The No. 4 unit is equipped with pneumatic rappers to remove salt cake from the wires and plates. There are 72 plate rappers, 48 wire frame rappers, and 8 distribution plate rappers. A check of rapper function indicated only two rappers were not functioning at the time of the inspection and one rapper boot was leaking. Several rapper rods were loose on the shaft of wire frame rappers. This was caused by the failure of the clamp connecting the insulator shaft to the discharge frame shaft. (See discussion concerning No. 5 Recovery Boiler rappers.) No evidence of water in the compressed air was noted. Filters were used in the air lines to trap rust.

3.2.2 Penthouse Insulators

A visual check of penthouse barrel insulators did not indicate cracks, chips, or other evidence of electrical tracking. The insulators also appear clean with no dust accumulation. During the rebuild of the No. 4 ESP, the plant replaced ceramic barrel insulators with alumina. This has eliminated insulator failure from heat stress.

3.2.3 Purge Air Fans and Heaters

The purge air fans on the penthouse were operating but the plant does not use the heaters. No failure of the insulators has occured because of the cold purge air. The use of cold purge air does not appear to affect performance of the unit.

3.2.4 Gas Inlet and Distribution

The original design of the ESP was a bottom inlet, top outlet gas flow. Over time, the plant has experienced chronic fouling of the inlet duct, turning vanes, and gas distribution plate. In an attempt to solve this problem, the inlet was redesigned to allow top inlet. The drag was lengthened to allow salt cake removal from the inlet and outlet plenums. The inlet has a baffle to assist in gas distribution. An inspection of the gas distribution plate from the north chamber inlet field (between lanes) did not indicate pluggage of the plate openings.

The top inlet may be a concern in that the gas vector is down and may result in gas sneakage under the inlet field baffles as the drag chain operates. Gas sneakage in this area would severely affect ESP performance because the total collected weight of salt cake passes under the baffles at this location. Confirmation of gas sneakage must be made using a full flow gas velocity distribution test (i.e., hot wire anamometer). Analysis should also be conducted to define the direction of gas flow in the area behind the gas distribution plate to determine if there is a downward flow into the drag area.

3.2.5 Gas Baffles

Gas baffles are used to prevent gas sneakage under the electrical fields in the drag bottom. Because the drags move longitudinally parallel to the gas flow, positive sealing of fields cannot be accomplished because openings for passage of drag blades and chains must be provided. Gas baffles are constructed of 1/8 in. steel plate suspended from a permanent plate above the drags. The baffle is free to swing in either direction pivoting on a length of chain or ring. Slots are cut in each baffle to allow passage of drag chains. When a scrapper blade reaches the baffle, the plate rotates out of the path and then falls to the vertical position after the blade has passed.

The unit is divided into three mechanical fields with six electrical fields in series. A baffle is used between the inlet plenum and inlet field (A), between fields B and C, between fields D and E, and between the outlet field (F) and the outlet plenum.

3.2.6 Drag Scrapers

Three drag scrapers are used in each chamber running in parallel from the outlet plenum to the inlet plenum. Collected salt cake is discharged into a transverse screw conveyor and discharged to a ribbon mixer. The drive or head block shaft is located in the inlet plenum and is connected to the drive through the ESP shell. On each drive shaft two gear sprockets are mounted on which a chain is placed. The tail block for each drag is located in the outlet plenum. Two chains between the head and tail shaft must be aligned and tensioned to prevent the drag from running off the sprockets and weakening. Angle iron scraper blades are mounted between the chains.

As the chain pair is rotated over the drive sprockets, the scraper blades are dragged along the ESP bottom pushing salt cake ahead of the blades. Chain tension must be maintained to prevent the drags from lifting over the salt cake. Guides are also provided to maintain the chains in line with the shaft sprockets.

The No. 4 ESP bottom is not flat, but contains a crown of approximately 1-1/2 inches at the wall between the two chambers. Guide rails are used in the bottom of the ESP to level the shell bottom and allow the drag blades to move freely over the shell. An inspection of the drags did not indicate that any blades were missing (i.e., abnormal spaces on chains) or that the chains were out of the guides.

Baffles are used between the inlet and A field, between B and C fields, between D and E fields, and between F field and the outlet plenum. The baffle at the inlet plenum consists of two plates for each drag chain that extends down to the top of the bottom drag blades (approximately 6 inches from floor). The baffle has slots that allow the passage of chains without movement of the baffle (Figure 30). In order for the blades to complete the rotation, the baffle must be moved out of position by the scraper blade. Free movement of the baffle is allowed by suspending the plate by a short length of chain. When each scraper blade passes, the flue gas seal is broken providing an opening under the gas treatment zone.

The baffles between the remaining fields are constructed of two movable baffle plates with a rigid structural member between them. One baffle is provided for passage of the upper drag chain scraper blades, and the other is provided for passage of the lower blade in the opposite direction (Figures 31 and 32). Each moveable baffle is suspended by a chain that allows it to swing freely in either direction. These baffles are shorter in length than those used in the inlet field. Also, the plates fit closer providing a more positive seal. When scraper blades on all three drags are in line across the chamber, a large opening is presented between the fields. If the blades are spaced at regular distances, two successive baffles may be opened between the fields, which provides a gas sneakage path. During the inspection, the blades appeared to be staggered across the chamber. Staggered placement of blades across the chamber presents the minimum open baffle area at any period of time (Figure 33). The number of blades per chain (distance between blades) should be checked to prevent simultaneous opening of successive baffles on each drag.

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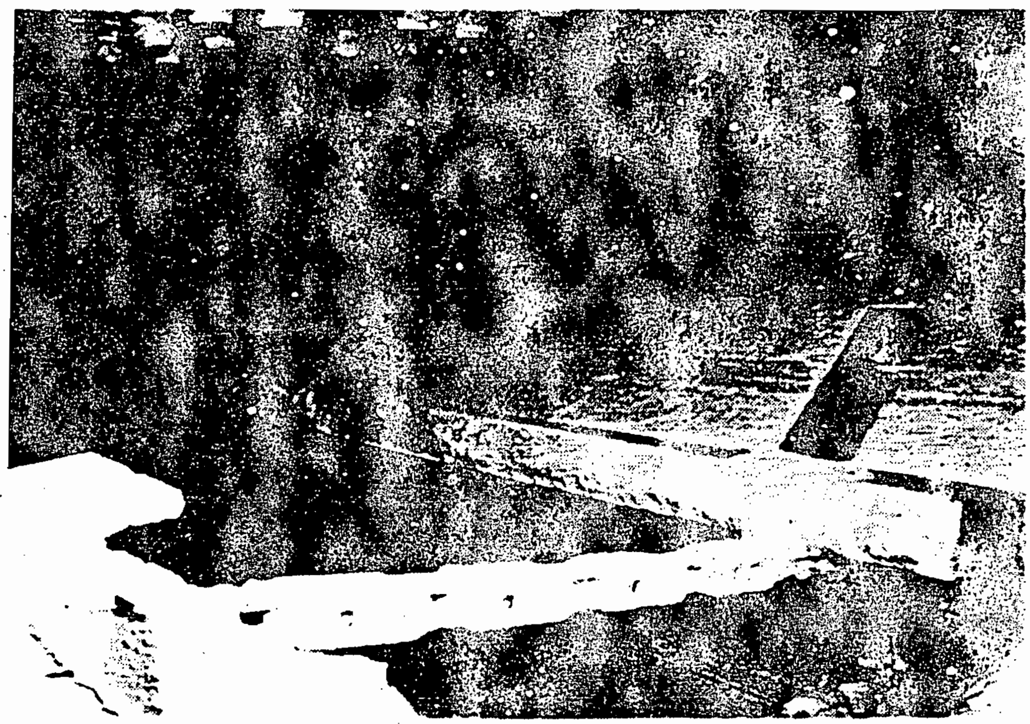

Figure 30. Antisneakage baffle between inlet field and inlet plenum No. 4 ESP.

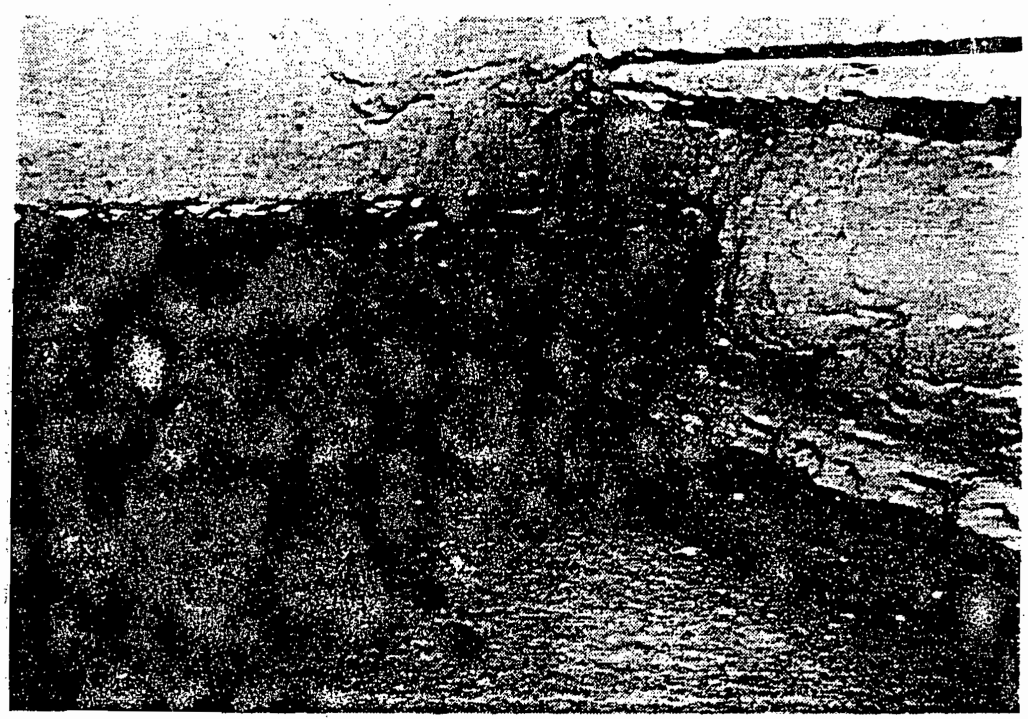

Figure 31. Lower antisneakage baffle allowing passage of lower drag scraper blade between fields B and C No. 4 ESP.

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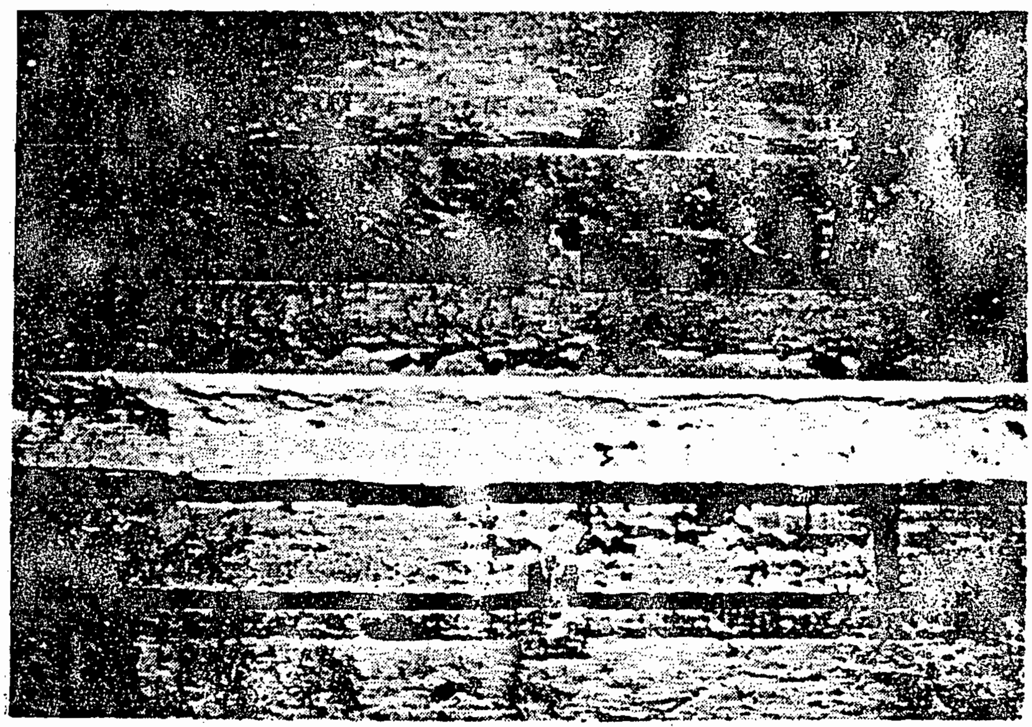

Figure 32. Upper antisneakage baffle.

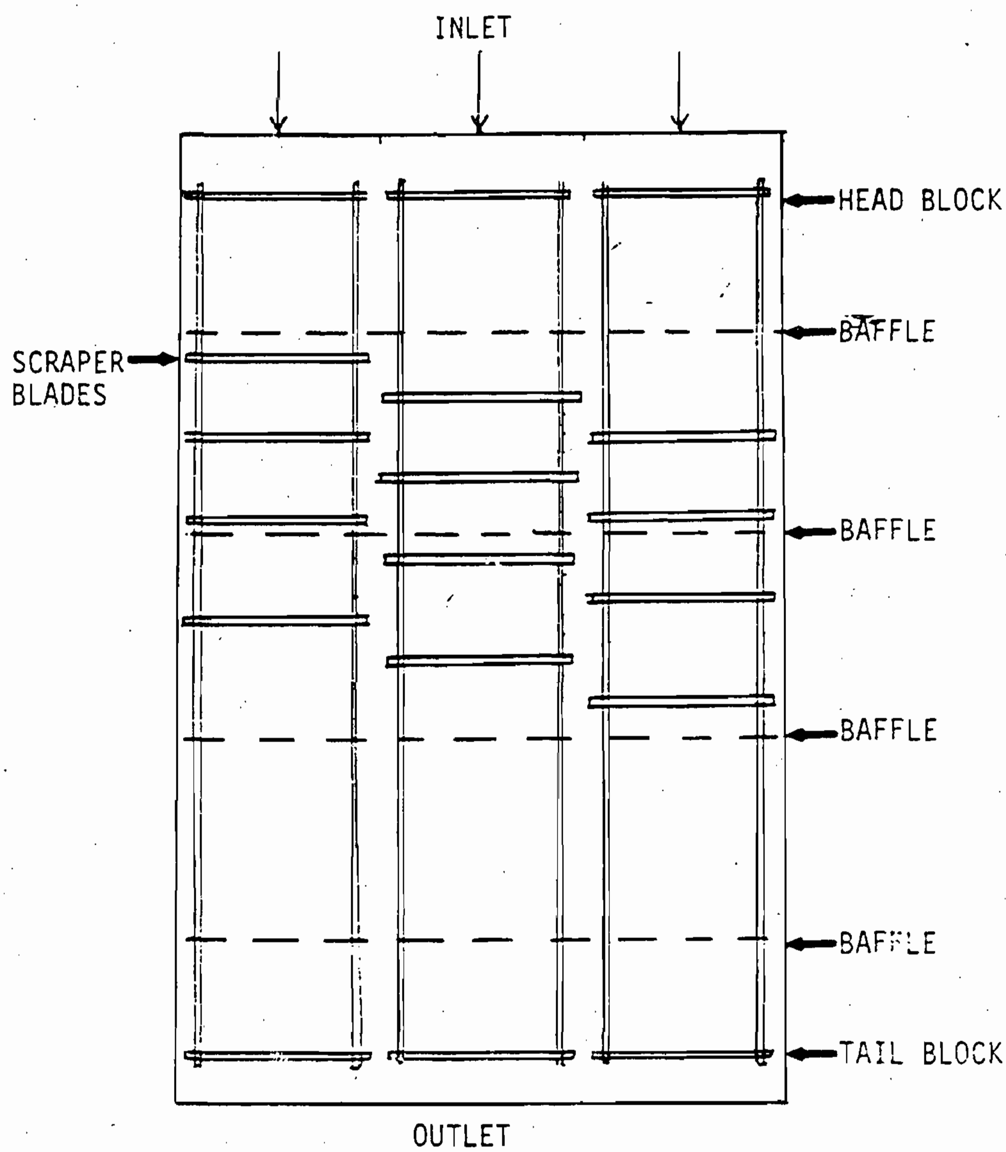

Figure 33. Possible drag scraper blade positions to prevent gas sneakage.

The plant has experienced several problems with the drag system that have resulted in down time requiring extensive maintenance. The most serious problems occured when the drag chains kink in the guides and become entangled in the baffles or when the scraper blades become dislodged from the chain. When the chain stops, the drive continues to move until the motor overheats, the gears are stripped, or the chains break. The additional stress on the head and tail block results in movement and misalignment of the drag chains. In an effort to prevent chain wrecks, the plant has installed shear pins in the drive shaft couplings. These pins are designed to break and allow the drags to stop before major damage occurs.

In order to prevent massive dust accumulation when the drags stop, the plant has designed a motion indicator that senses the movement of the drag chain scraper blades. A swinging weight that is attached to a shaft extending outside of the shell is placed in the path of each drag chain. When a blade passes, the arm rotates and falls back to a vertical position (Figure 34). On the outside, a switch is positioned that indicates movement of the shaft at regular intervals. Loss of regular switch activities sounds an alarm indicating drag malfunction. This design is more reliable than conventional methods that sense drive shaft motion or motor current.

During the rebuild, the plant increased the drag head shaft, installed stronger chains, changed scraper plates, and improved alignment. In an effort to reduce dust weight in the drag bottom, the drag speed was increased. After the rebuild, a period of drag problems occured when scraper blades on the inside wall of the south chamber caught and removed nine swinging baffles The loss of baffles resulted in wrecks of the chains, drive shafts, and screw conveyor. This problem was unforeseen and not expected after the rebuild. A third drag on each chamber was installed to reduce the width. The drag length was extended into the inlet plenum. Also, to reduce bearing failure on head and tail blocks, each iron block was replaced with permanently lubricating graphite bearings.

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Figure 34. Drag scraper motion indicator interior paddle.

3.2.7 Salt Cake Deposits

Plates--

A visual inspection of the collection plates was conducted prior to rapping to evaluate rapper effectiveness. A uniform thickness of salt cake was observed in each field. The heaviest deposits were observed in the inlet field with the least deposits in the outlet field. A thicker deposit was noted in the outlet field of the No. 4 ESP than in No. 5 ESP. Even after rapping, the deposits in the outlet field were still present. It appears that a significant particulate matter loading is entering the last field.

Upper Wire Frame--

An inspection of the upper wire frame did not indicate any salt cake deposits. There was no indication of gas flow in the area above the gas treatment zone.

Lower Wire Frame and Bottle Weights--

Hard deposits of salt cake were observed on the bottle weights (Figure 35) in the A, C, and D fields north chamber. The deposits were 8 to 10 inches in diameter and were in contact with the plates. Almost all the deposits involved a pair of bottle weights in the gas lane. In both the second and third mechanical fields, the bottle weights were frozen and wire tension was not being maintained. This is not, however, considered to be the cause of the crusty deposits. As discussed in Section 3.1.8, these deposits were probably caused by water introduced during drag chain repair.

3.2.8 Plate Repair

Deterioration of the lower portion of the plates occured from impaction of the plates on the alignment pins, corrosion, and erosion. As part of a partial rebuild, Container Corporation removed the lower portion of affected plates and designed a metal sandwich to extend the plates to the design length. The repair material is approximately 24 inches long and extends the full width of the plate. Slots are cut in the repair plate to allow clearance for stiffners. No stiffner is used in the new plate material. Figure 36 is a simplified drawing of the system. Because of the clearance between plates and thinness of metal, the extensions could not be welded in place. Instead, short blocks were used with nuts to close the sandwich at the lower portion of the collection plate. To prevent reduction in clearance from projection of bolts

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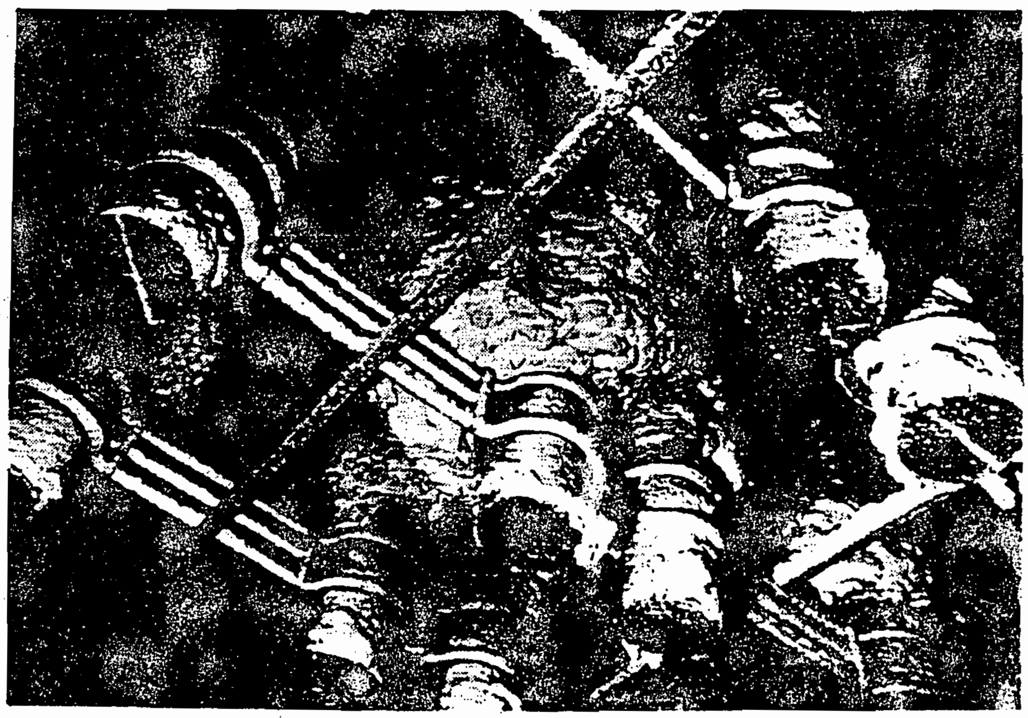

Figure 35. Buildup on bottle weights and wire south chamber No. 4 recovery boiler, inlet field.

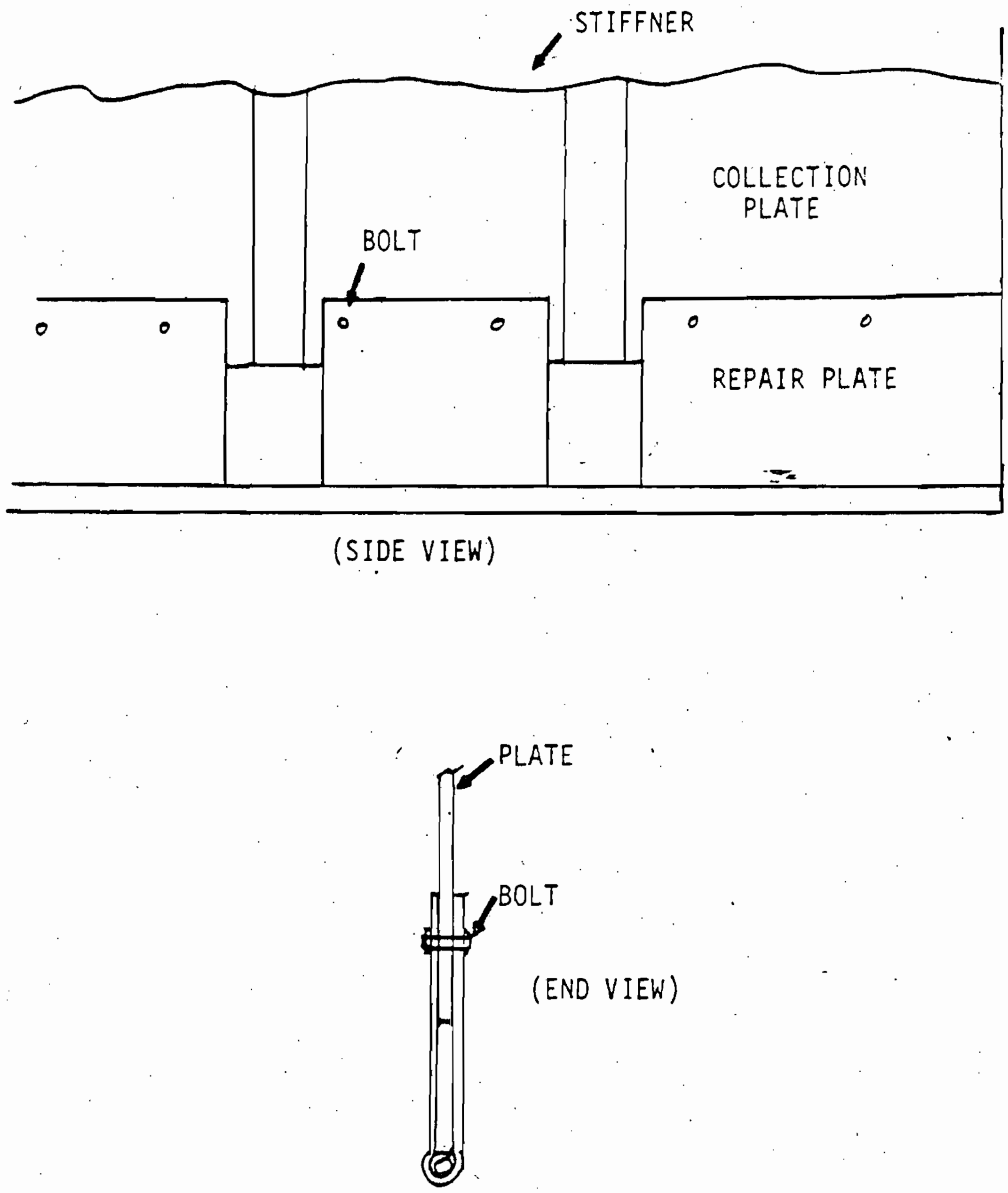

Figure 36. Plate repair method No. 4 ESP.

through the plate, the ends were cut off flush with the nut. This reduced the number of screw threads available for attachment.

Approximately 48 plates were repaired in the south side and 60 in the north side. Since the rebuild, four plate sandwiches have opened resulting in electrical clearance reductions and/or grounds. This has occured as bolts and nuts have separated under rapping action. When this occurs, a new bolt is installed and the nut tackwelded in position to prevent loss. It is not considered practical to reinspect and tackweld all of the remaining bolts. It appears, however, that this has ceased to be a problem. Figure 37 shows the completed repair in the north chamber of the ESP. Splits in the plates were observed at the lower edge that are thought to be the result of impact of the plates on the alignment rakes. Figure 38 shows the upper portion of a split not covered by the plate repair.

3.3 RECOVERY BOILER OPERATION

The operation of the recovery boiler determines the weight of salt cake entering the ESP, the particle size distribution, temperature and moisture content of the gas stream, and the total gas volume. Both recovery boilers are equipped with noncontact liquor evaporators. The use of noncontact evaporators increases inlet loading over conventional designs and reduces gas stream moisture content. Normally, 50 percent of the boiler particulate matter loss is recovered in the cascade evaporators.

The boilers are also low odor design which forces the conversion of SO_2 and TRS to sodium complexes (Na_2SO_3 and Na_2SO_4). This also increases the amount of particulate matter lost from the furnace. To operate at low odor conditions, the char bed temperature and air must be controlled within narrow limits. A decrease in char bed temperatue will result in higher SO_2 and TRS emissions. The formation of SO_3 from the SO_2 can result in serious particulate matter modification in the ESP, which causes loss of corona power and reduced efficiency.

In reviewing the operation of the ESP, it is necessary to analyze boiler operation to determine if operating practices can have an impact on ESP performance. Normal areas of review include but are not limited to: boiler excess air, firing rate, residual oil-firing, and collected salt cake pH.

Figure 37. Plate repair No. 4 ESP, between electrical fields A and B.

Figure 38. Close-up plate repair No. 4 ESP showing plate split.

The flue gas volume treated by the ESP is defined by the volume of combustion products produced by black liquor combustion and the excess air contained in the flue gas entering the ESP. The volume of gases produced by burning black liquor at a specific mill varies with wood species, season, cut time, and pulp yield. The volume, however, is reasonably constant over long periods of time. Moisture in the flue gas is introduced by hydrogen conversion in the liquor, water fired with liquor, and steam used in soot blowing. Given the black liquor solids fired and the normal soot blowing rates, the total volume of gases produced is proportional to firing rate.

An increase in volume can occur if boiler excess air is increased resulting in an increase in superficial velocity through the ESP. A significant increase in volume can reduce ESP efficiency. Recent stack tests were reviewed to compare the measured flue gas volumes to the design volumes of each ESP. Also, one year of boiler logs was reviewed to determine the range of boiler excess air.

3.3.1 Recovery Boiler Number 5

A stack test was conducted on No. 5 Recovery Boiler on November 8-9, 1983. The total gas volume measured was 348,584 acfm at a temperature of 434^{o}F. The firing rate was 151,055 lb BLS/h and the excess oxygen in the flue gas was 4.0 percent (24% excess air). At stoicometric conditions, approximately 45.87 dscf of flue gas was produced per pound of black liquor solids burned. The flue gas velocity was 1.98 ft/s through the north chamber and 1.76 ft/s through the south chamber. These are lower than the design velocity of 2.68 ft/s and increases the potential efficiency of the unit by increasing residence time (Table 12).

Design specific collection area (SCA) of the ESP is 541.26 ft^2/1000 acfm of treated gas. The actual SCA under stack test conditions is 776.4 ft^2/1000 acfm. The design removal efficiency is 99.75 percent at a gas volume of 500,000 acfm and at an inlet loading of 6.0 gr/dscf. Assuming a proper gas distribution through the unit and normal power input levels, operation at both higher SCA and lower velocity should result in a higher collection efficiency.

A review of one year of boiler logs indicated that the boiler had not been fired at rates in excess of those documented during the stack test and that boiler excess air was consistent with operation of a low odor design

TABLE 12. COMPARISON OF STACK TEST OPERATING CONDITIONS TO ESP DESIGN CONDITIONS - NO. 5 RECOVERY BOILER

Parameter	Test 11/09/83	Design
Flue gas volume, acfm	348,584	500,000
Flue gas volume, dscfm	143,358	224,093
Flue gas temperature, ^oF	434	400
Flue gas oxygen, %	4.0	
Flue gas moisture, %	26.7	27 (vol.)
Superficial velocity, ft/s	1.87	2.68
Specific collection area, ft/1000 acfm	776.4	541.26
Treatment time, s	19.22	13.4
Actual emission rate, gr/dscf	0.0101	0.015
lb/h	12.42	28.8
Allowable emission rate, lb/h	41.5	

boiler. The average flue gas oxygen at the boiler outlet was typically 1.5 to 3.0 percent oxygen and the average value was 2.01 percent. During startup, shutdown, or upset conditions, the flue gas oxygen was observed to be 8.0 to 9.0 percent for short periods of time. These periods also corresponded to the firing of residual oil for increased heat input and boiler stability.

At a normal firing rate of 150,000 lb BLS/h and at an excess oxygen of 9.0 percent, the flue gas volume would still be below the design gas volume of the ESP.

Salt Cake pH--

The pH of salt cake collected by the ESP is an indirect indication of the agglomeration characteristics of the salt cake. As the pH of salt cake is reduced by adsorption of SO_3 from the gas stream, the particles agglomerate and become sticky. These particles are hard to remove from the ESP plate by rapping and can accumulate to a significant thickness. As the thickness increases, the resistivity of the dust layer increases. This results in a voltage drop across the layer.

If a heavy salt cake layer develops, the ESP corona power input decreases, which results in low collection efficiency. Typical power input is characterized by low secondary voltage ($\geq$50 kV), and increased sparking at low current. The formation of SO_3 from SO_2 is increased as boiler excess air increases or when residual oil is fired in the boiler. When firing residual oil, boiler excess air is typically increased to ensure complete combustion. Also, residual oil used on the east coast contains higher levels of vanadium ($\geq$200 ppm). Vanadium is an efficient catalyst for converting SO_2 to SO_3. Firing of residual oil has been shown to increase corrosion in direct contact evaporation systems and to form acidic salt cake.

Container Corporation collects salt cake from the transverse screw conveyor discharge from the ESP and analyzes the salt cake pH on two-hour intervals. Normal pH is $\geq$9.5 but at high excess air or during residual oil-firing the pH may be as low as 6.2.

The plant has observed that the salt cake becomes sticky at pH's below 9.0 and therefore the practical limit for operation has been established at 9.5. The average value for one year of log entries was 10.09 with a high of 12.82 and a low of 5.47. The low values corresponded with periods of high excess air and/or residual oil firing. Because of the delay between gas stream SO_3 increase and salt cake discharge from the ESP, a 2 to 4 hour delay was observed between operating parameter changes and pH changes. A total consumption of oil was not obtained but based on the review of 300 days of boiler logs, 178 days were recorded when oil was being fired in the boiler. The periods of oil usage are not continuous and may last from 1/2 to 4 hours depending on need. A summary of average, low and high excess oxygen and salt cake values for each operating day reviewed is provided in Table 13. Also a graphical plot of salt cake pH, excess oxygen, and number of oil guns firing is provided in Appendix B.

3.3.2 Recovery Boiler Number 4

A stack test was conducted on recovery boiler number 4 on May 18, 1984. The measured gas volume was 310,506 acfm (406°F). Boiler firing rate was 134,507 lb BLS/h and the average flue gas excess oxygen was 5.0 percent. At stoichiometric conditions, approximately 47.58 dscf of flue gas was produced per lb of BLS fired. Average flue gas velocity through the ESP was 2.19 ft/s,

TABLE 13. SUMMARY OF BOILER FLUE GAS EXCESS OXYGEN AND SALT CAKE pH ON NUMBER 5 RECOVERY BOILER (6/1/83 to 4/26/84)

Salt cake pH			Boiler flue gas oxygen		
Average	High	Low	Average	High	Low
10.09	12.82	5.47	2.01	10.0	0.0

which is lower than the design velocity of 2.97 ft/s. The decrease in velocity should increase the potential collection efficiency of the ESP. The residence time is increased from 10.6 to 14.3 seconds (Table 14). Design SCA of the ESP is 428.0 ft^2/1000 acfm and the actual calculated value during the test was 578.9 ft^2/1000 acfm.

TABLE 14. COMPARISON OF STACK TEST OPERATING CONDITIONS TO ESP DESIGN CONDITIONS - NO. 4 RECOVERY BOILER

Parameter	Test 05/18/84	Design
Flue gas volume, acfm	310,506	420,000
Flue gas volume, dscfm	140,223	188,238
Flue gas temperature, °F	406	400
Flue gas oxygen, %	5.0	
Flue gas moisture, %	27.3	27.0
Superficial velocity, ft/s	2.19	2.97
Specific collection area, ft/1000 acfm	578.9	428.0
Treatment time, s	14.3	10.6
Actual emission rate, gr/dscf	0.044	0.026
lb/h	52.87	43.20
Allowable emission rate, lb/h	134.51	

A review of one year of boiler logs indicated that the test firing rate and flue gas oxygen were normal for operation of the boiler. There are periods, however, when flue gas oxygen (excess air) is high, which increases flue gas volume. A sensitivity analysis indicates that a flue gas oxygen of 9.0 percent at maximum firing rate would be necessary to achieve design gas volume. The average flue gas oxygen for the review period at boiler outlet was 2.87 percent. Values of 7 to $\geq$10 percent were observed during periods when residual oil was fired. Of the 300 days reviewed, residual oil was fired on 107 days.

Salt Cake pH--

The pH of salt cake collected by the ESP is checked every two hours and recorded on the boiler log. The average value for boiler logs that were reviewed (6/1/83 to 4/26/84) was 10.0. The minimum value recorded was 4.56, which is below the trigger point for sticky salt cake defined by Container Corporation (i.e., 9.5). Lower pH periods corresponded to high residual oil firing periods with corresponding high excess air. It was also observed that during periods of boiler upset or oil firing the normal two hour pH data are not recorded. Table 15 provides a summary of pH and excess oxygen levels. These data are graphically presented in Appendix C.

TABLE 15. SUMMARY OF BOILER FLUE GAS EXCESS OXYGEN AND SALT CAKE pH ON NUMBER 4 RECOVERY BOILER (6/1/83 to 4/26/84)

Salt cake pH			Boiler flue gas oxygen		
Average	High	Low	Average	High	Low
10.00	12.04	4.56	2.87	10.0	0.0

Rebuild of Number 4 ESP--

Number 4 ESP was rebuilt to correct corrosion or erosion of collection plates during a scheduled outage beginning in January 1984. During the rebuild, approximately 108 plates were repaired and several electrodes were replaced. Alignment was corrected and corrosion in the shell repaired. Wire frame, bottle weights, and support rods (pipes) were sandblasted and cleaned. A change in inlet design (bottom to top) was made to reduce distribution plate pluggage, and drags were extended into the new inlet plenum. To reduce drag alignment problems, a third drag was installed in each chamber.

Drag head shafts, chains, and tail shafts were strengthened and permanent lubrication installed (graphite) to eliminate the need for external lubrication. The drag hopper bottom was leveled by installing rails for the drag scrapers. After the rebuild, bolts securing 4 out of 108 plates repaired (48 south, 60 north) released, resulting in grounds. These were repaired and further problems have not occurred.

A large number of wires broke after startup resulting in grounds. Inspection of the wires by Container Corporation indicated that wires were breaking at the crimp (shroud). All wires were not pull tested and as a result improper crimps were responsible for the high failure rate. Wires were removed and pull tested (100%) to eliminate the failure.

Original failure of plates was suspected to be the result of corrosion, but plate splits were a complication. Splits appear to be caused by an alignment shift that placed the plate on the lower alignment rods (pins). A change in the lower plate alignment system was made to prevent rapping of the plates onto the grid. Wire frame support insulators were changed from porcelain to alumina during the rebuild. The unit had experienced chronic insulator tracking and the alumina eliminated the problem.

3.4 BAHCO COLLECTORS

3.4.1 Modifications to Bahco Collectors

In August of 1981 a major modification was completed on the Bahco collection system serving the No. 4 Power Boiler. This modification consisted of removing the secondary collector serving the first stages of the two primary collectors. In place of this secondary collector, a settling chamber was installed (Figure 39). The purpose of the settling chamber is to collect coarse particulate matter from the discharge of the primary collectors. Finer particulate matter escaping the settling chamber is routed to a newly installed bank of four tertiary cyclones. Clean gas from the tertiary cyclones is reinjected into the inlet plenum of the primary collectors.

The rationale behind this modification was to reduce maintenance on the secondary and tertiary dust handling systems. Because the secondary collector reduced gas flow, elimination of this unit would maintain gas flow to the tertiary systems and thus reduce grain loading. Reduced grain loading would ease maintenance of the tertiary system due to abrasion.

Additional modifications to No. 4 Bahco included removal of the hopper cyclone serving the dropout chambers in the inlets of the secondary collectors

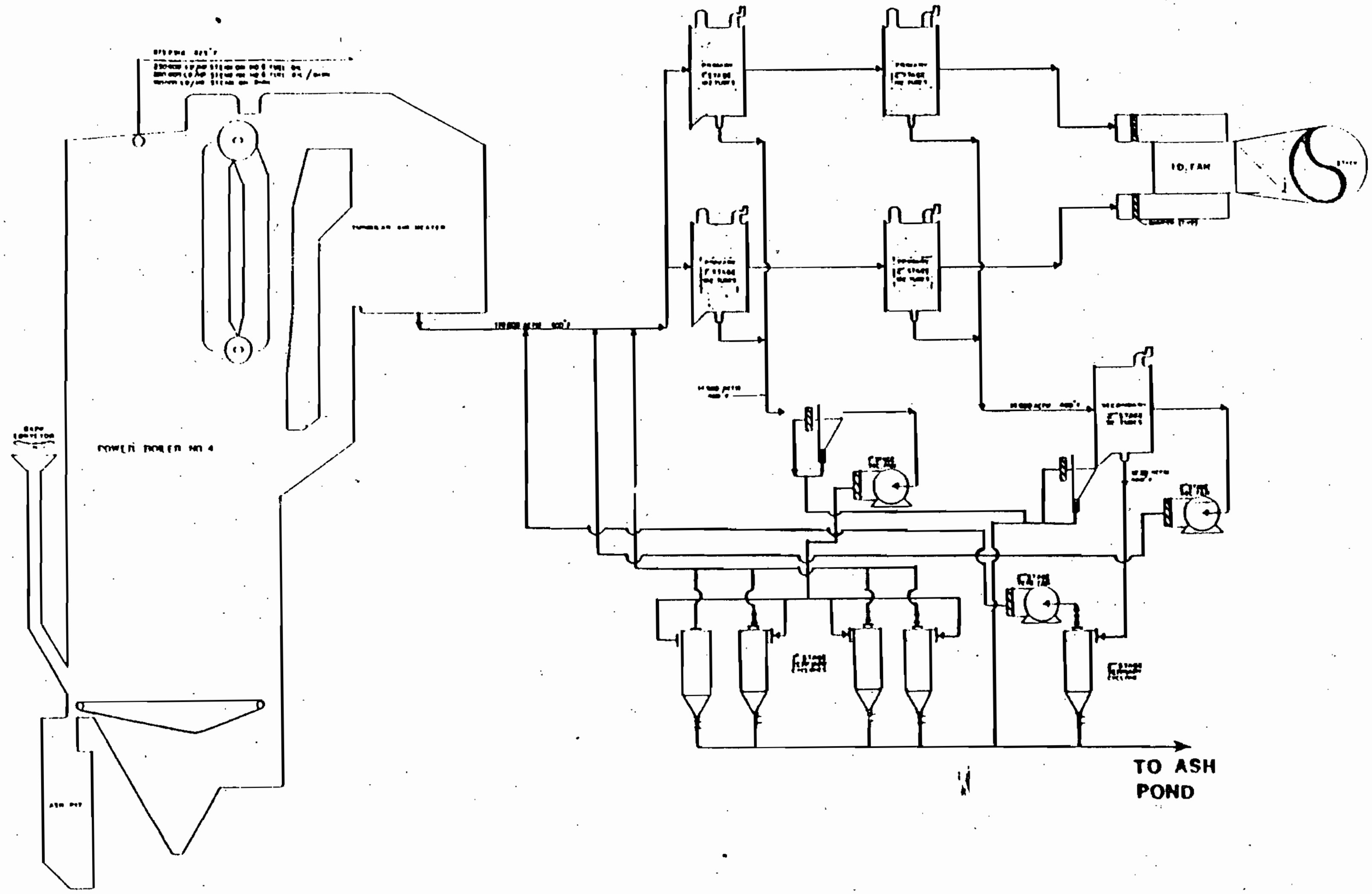

Figure 39. General layout of Bahco collection system for No. 4 Power Boiler after August 1981 modifications.

and removal of the spare tertiary cyclone serving the second stage secondary collector. It should also be noted that the boiler reinjection system is not operated and that collected dust from all components of the system is discharged to an ash pond for waste water treatment.

The Bahco system serving the Number 5 Power Boiler remains essentially the same as originally installed. One system modification has been made in that dust collected from all system components is routed to an ash pond for waste water treatment. Currently, the boiler reinjection system is not used.

Finally, the design of these Bahco systems and their associated emissions guarantees assumed inclusion of existing multicyclones ahead of the Bahco collection systems. These multicyclones, however, were removed when the Bahco systems were originally installed.

3.4.2 Evaluation of Bahco Collection Systems

During the course of PEI's field evaluation, the Number 4 Power Boiler was operating and the Number 5 Power Boiler was not. A complete internal and external inspection was conducted of the Bahco system serving the Number 5 Power Boiler and an external inspection was performed on the Bahco system serving the Number 4 Power Boiler.

Internal Inspection of No. 5 Bahco--

All collectors were entered via manways in the inlets. In addition, the space between the outlet of the first stage and the inlet of the second stage in each collector was inspected. The first stage inlets of all collectors were found to be clean except for some minor vane buildup on the eastern most tubes of the western primary collector on the lower level. Sonic horns have been installed on three of the four primary collector inlets.

Inspection of the spaces between the first and second stages of each collector afforded the opportunity to inspect the reamer assemblies serving the first stages of all collectors. Entry was not possible in the outlets of the two upper primary collectors nor in the outlets of the two secondary collectors. A minor number of inoperable reamers were found in most cases except in the outlet of the first stage of the east primary collector on the lower level. In this case, 19 out of 192 reamer assemblies, or approximately 10 percent, were inoperable. In all cases, reamer assembly failures occurred in the same place. Figure 40 is a photograph of the reamer assemblies in one

Figure 40. Cyclone tube gas outlets showing reamer assemblies and activation shaft.

vertical row of tubes. On either side of the tube outlets are the vertical dust plenums. In the case of a reamer assembly failure, the pin attaching the reamer assembly to the reamer activating arm had either broken or fallen out.

In addition to the 19 reamers found inoperable, deposits of dust on the floor between the first and second stages were found to be in excess of all the other collectors. Further, the inlet of the second stage of this collector showed partial pluggage of the tube vanes.

The abnormal deposits of dust in the lower two primary collectors seem to be the result of maldistribution of incoming flue gas. Figure 41 illustrates the inlet plenum layout for all four primary collectors. Flue gas from the boiler air heater is routed parallel and above the collectors, makes a 90° turn to vertical, and splits between east and west plenums. Four 90° branch ducts from these two plenums feed the upper and lower collectors. Dropout chambers ahead of each inlet collect large particulate matter as the flue gas makes the final turn into the collector. Because each set of upper and lower collectors are fed by the same vertical plenum, heavier grain loading can be expected in the lower collectors due to the added inertia imparted to the particulate matter by gravity.

Abnormal dust deposits on the floor between the first and second stages of the lower level eastern collector and the eastern end of the lower level western collectors are indicated in Figure 41 by a series of "X's." This pattern also suggests a higher gas flow in the eastern vertical plenum or a left-to-right gas maldistribution. This left-to-right maldistribution may be caused by partial pluggage of the boiler air heater, stratification, or partial obstruction of the main plenum.

It was discovered upon entry that pneumatic vibrators were attached to the tube vane guide arms in some sections of each collector (Figure 42). These vibrators are designed to loosen dust accumulation on the guide vanes. During the inspection, several of these vibrators were still in service. It should be noted that when activated, little or no dust was dislodged from the adjoining guide vanes.

Information received from plant personnel that the guide vanes on all tubes are locked in the 0% position (fully inserted) was confirmed during the inspection. One exception was noted, however, in that the guide vanes on all

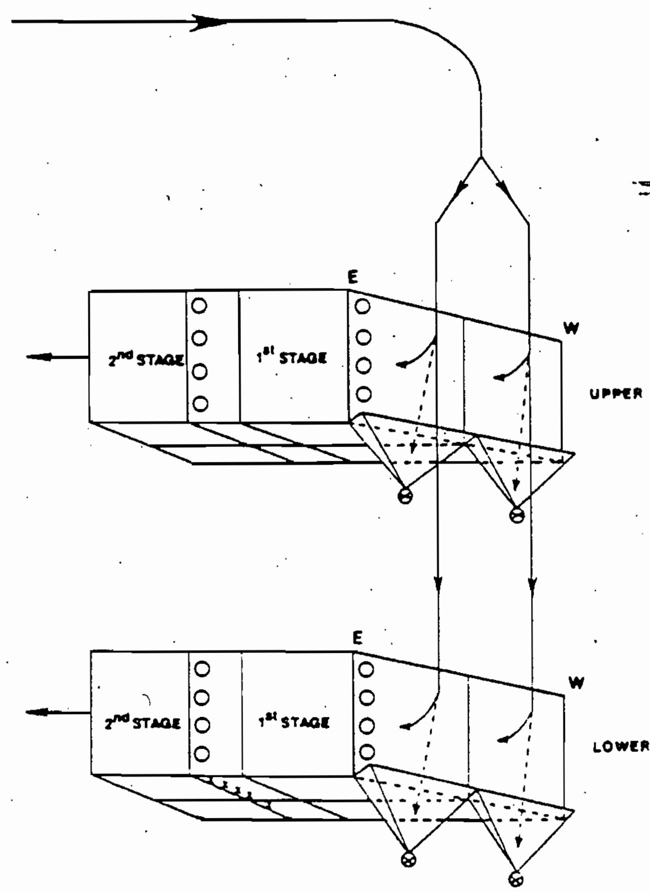

Figure 41. Inlet plenum arrangement of
No. 5 Bahco primary collectors.

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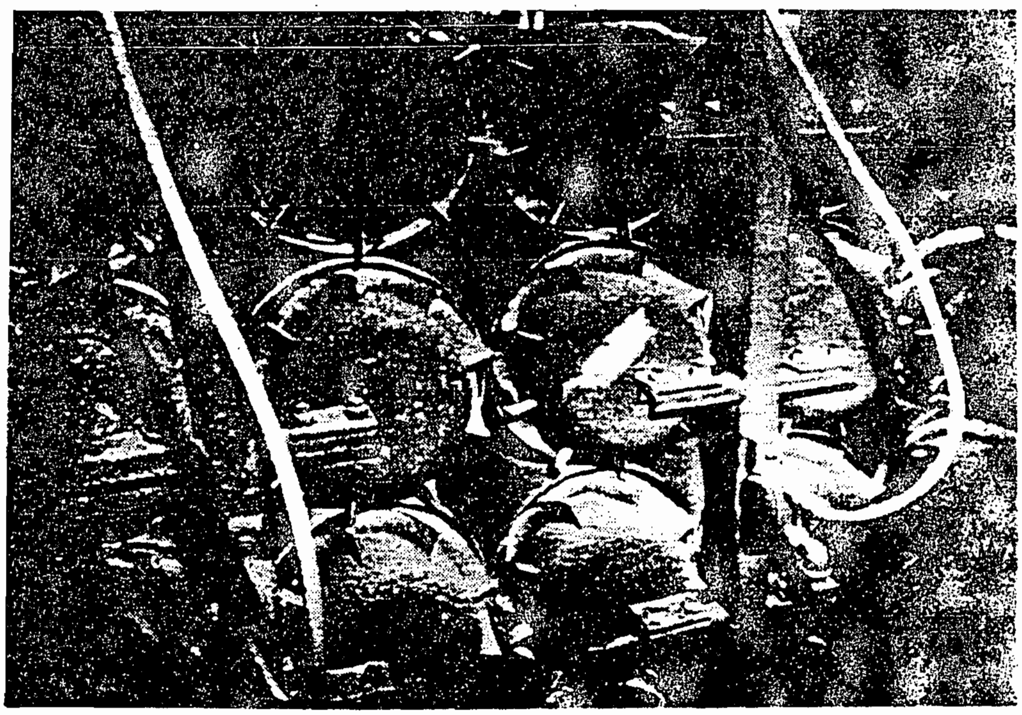

Figure 42. Pneumatic vibrators on inlet of cyclone tubes.

tubes in the second stage of the eastern collector on the lower level were found to be partially withdrawn.

During the inspection it was found that the guide vanes of all tubes, whether clean or partially plugged, showed no evidence of excessive abrasion. In addition, no evidence of breaches in structural integrity or signs of corrosion were evident.

External Inspection of No. 4 and No. 5 Bahco--

An external inspection of both collection systems revealed that the most severe maintenance problems on both units occur in the secondary and tertiary dust collection systems. Because of heavy grain loading of abrasive dust in these systems, secondary and tertiary ductwork must be reinforced using abrasive resistant plating (Figure 43). Reinforcement is critical at turns in the ductwork and on secondary and tertiary fans. Because these fans are not isolated and must carry the dust load, fan casings must be reinforced and fan blades replaced with abrasion resistant blades. In addition to ductwork and fans, the inlet of the tertiary cyclones had been reinforced. Reinforcement fabrication is accomplished on-site by welding overlapping plates across failed surfaces.

Inspection of the drop-out chamber hoppers on the primary and secondary collectors revealed evidence of hammer blows to the sides of the hoppers to dislodge pluggage (Figure 44). It should be noted that inleakage in or around these hoppers above the rotary valves allows oxygen to enter a confined space occupied by dust which may contain enough carbon from boiler carryover to initiate combustion resulting in excessive heat or fire.

Maintenance Practices and Collector Operation--

As noted previously, reinforcement of failed components in the secondary and tertiary systems is accomplished on-site. A team of plant maintenance personnel are enlisted in an ongoing preventive maintenance program on this problem.

In addition to the reinforcement efforts, original expansion joints throughout the system have been replaced with abrasion resistant material. This replacement effort has served to reduce inleakage due to abrasion effects on the joint material.

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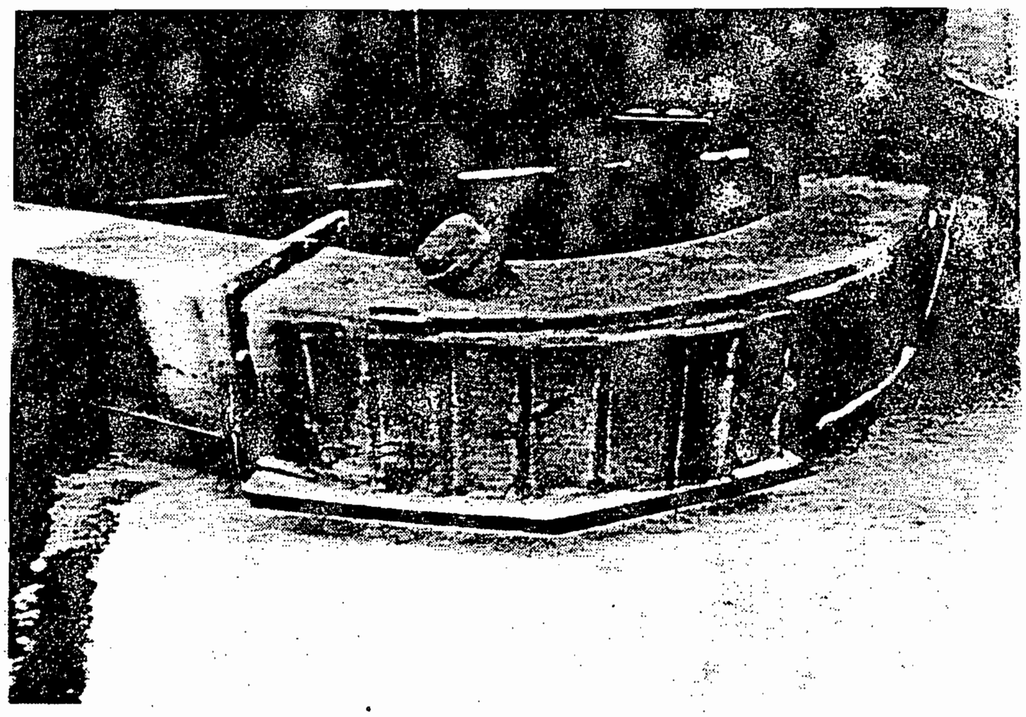

Figure 43. Secondary air ductwork reinforcement used to prevent abrasive failure.

Figure 44. Photograph of drop-out chamber hopper showing hammer blows.

All original rotary valves in the system have also been replaced with rotary valves incorporating adjustable seals. This has decreased inleakage around the rotary air locks. The original design proved inadequate when components experienced expansion and contraction under varying temperatures.

Internal inspection and maintenance of the collectors is performed during scheduled outages when all tubes are cleaned. Signs of vane wear prove to be the only external clue to the possibility of internal tube wear or tube integrity failure. Internal tube wear is most pronounced at the point where the gas stream leaves the guide vanes and initiates contact with the tube wall (Figure 45). As can be seen, the wear pattern follows the line of cyclonic action across the tube's inner wall. According to plant personnel replacement of a single tube requires approximately two hours.

Operation of the Bahco collection system on the Number 4 and 5 Power Boilers requires that the guide vanes in the primary and secondary collectors be set in the proper position to maintain design pressure drop across each collector given the boiler load. As was cited previously, Container Corporation has locked the guide vanes on all collectors in the 0% (fully inserted) position. This was done in an attempt to reduce maintenance on the guide vane activation system and/or to maintain the highest efficiency possible at all boiler loads. The guide vane adjustment system cannot, at the present time, be used in the automatic mode but can be activated manually from the top of each collector.

Proper operation of these units also requires that the volume of air removed by the secondary and tertiary systems approaches nominal design values. With the periodic assistance of consultants from Bacho, Container Corporation has made adjustments to fan damper settings and replaced defective components to correct abnormal operating conditions. In between these events, however, damper settings are locked while boiler loads vary. A history of fan failures and problems in balancing flows in the secondary and tertiary systems have been documented.

No. 4 Power Boiler Operation--

Table 16 gives actual boiler and collector parameters recorded during the inspection of the Number 4 Power Boiler as well as design parameters. It should be noted that no design data were available for the Number 4 Power

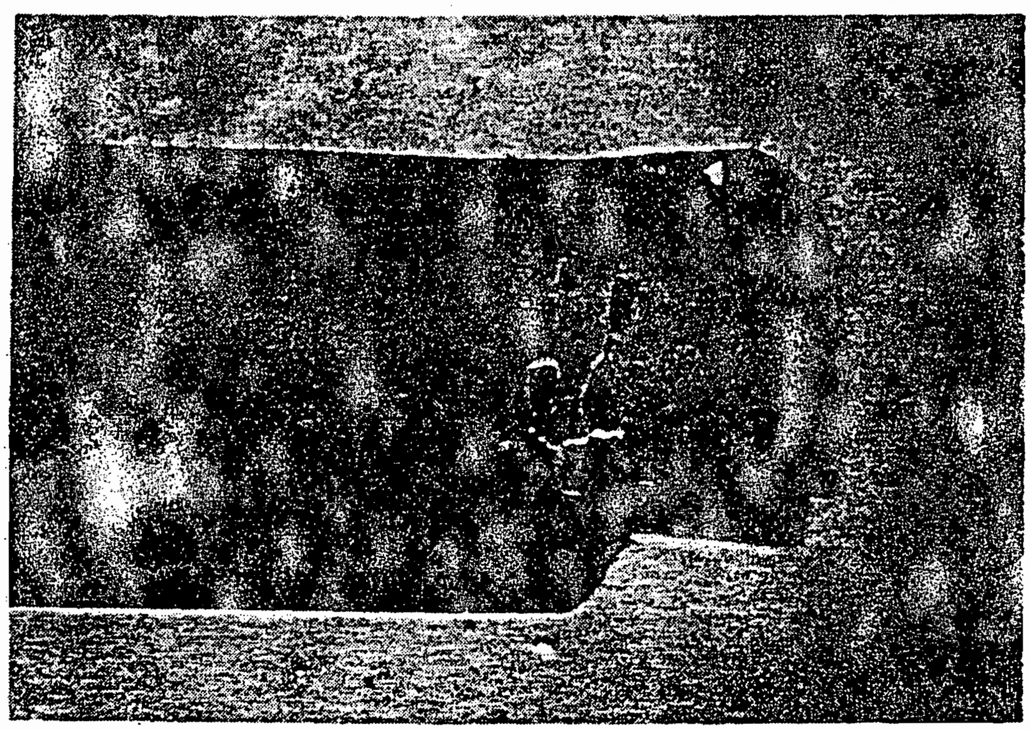

Figure 45. Removed cyclone tube showing tube wear.

TABLE 16. DESIGN AND ACTUAL PARAMETERS FOR NO. 4 POWER BOILER AND NO. 4 BAHCO

Parameter	Design	Actual
Steam flow, lb/h	200,000	59,000
Steam pressure, psig	875	834
Steam temperature, ^oF	890	778
Excess air, %		≥ 92
Feed water pressure, psig		1,228
Feed water temperature, ^oF		360
Fuel feed rate (bark only), ton/h	30	~ 8.5[a]
Flue gas temperature, ^oF	400	380
Moisture (fuel), %		45
ΔP Bahco 1st stage, in. H_2O	2.6	1.5
ΔP Bahco 2nd stage, in. H_2O	3.14	1.9
Flue gas volume per tube, acfm	443	185
Opacity, %		32[b]

[a] Calculated assuming 60 percent boiler efficiency.

[b] As measured by plant opacity monitor.

Boiler based on continuous load firing bark alone. Based solely on heat input into the boiler at a steam flow of 200,000 lb/h design and 59,000 lb/h actual, the load at the time of inspection was estimated to be 28 percent. Estimated boiler efficiency was 60 percent. Firing bark only, excess air was conservatively estimated to be 92 percent (10% oxygen).

Given the data in Table 16 and using the F-factor for dry bark of 9,640 dscf/10^6 Btu and the given percent moisture of the bark, the actual flue gas volume was calculated to be 71,000 acfm. With the two primary collectors containing a total of 384 cyclone tubes, the flow across each tube was calculated to be 185 acfm/tube with a recorded pressure drop across the first stages of the primary collectors of 1.5 in. of water and 1.9 across the second stages. It should also be noted that at the time these parameters were recorded, the plant opacity monitor was recording an opacity of 32 percent. At a load of 28 percent on a boiler firing bark alone at 50 percent fuel moisture, it is likely that the boiler flame temperature was decreased. Given that bark fuel is highly volatile and produces a high quantity of hydrocarbons during combustion, a low flame temperature sets up unfavorable conditions for complete combustion. This results in shifting the particle size distribution towards more production of fine particulate matter at a reduced flue gas volume.

Each cyclone tube of the Bahco collector serving the Number 4 Power Boiler is designed to operate at approximately 443 acfm per tube with an exceptable range between 350 to 600 acfm per tube. Below 350 acfm per tube, collection efficiency drops sharply. Below this flow rate the cyclonic action within the tube is severely hampered or does not occur. If the cyclonic action fails to generate or is severely distorted, flue gas will pass directly through the open orifice of the center tube. With a lack of cyclonic action in the tubes, only particles greater than approximately 200 µm are collected in the inlet drop-out chambers. If the cyclonic action is simply weakened, collection of finer particulate matter will be severely hampered. Reduced cyclonic action also reduces collection efficiency in the midrange of the particle size distribution. In either case, light scattering particles less than 2 µm are not collected regardless of collection efficiency.

Given a boiler load of 28 percent with a reduced gas flow across each primary tube of 185 acfm and pressure drop readings almost half of design, it is possible that this boiler did not meet the mass emission standards. It should be noted, however, that Container Corporation contends that emission testing has confirmed that the No. 4 Power Boiler meets the mass emission standards at reduced loads. Test results indicative of this condition were not available at the time that this report was prepared.

SECTION 4

MAINTENANCE PROCEDURES

Container Corporation conducts both preventive maintenance (PM) and routine maintenance of the ESP's. The procedures for scheduling and assigning personnel are the same as for the process equipment.

Normally, maintenance of the units is divided along craft lines (i.e., electrical and mechanical). The electrical department has responsibility for rappers, T-R set controls, and all internal components of the ESP except the drags. The mechanical department is responsible for drags, drag drives, and ribbon mixers.

Periodic PM inspections are conducted externally by the electrical department. All internal inspections of the units are conducted by the electrical department. Any internal condition that is determined to be the result of drag failure is assigned to the mechanical department for resolution.

An electrical foreman is assigned to each shift with two electricians. The foremen are periodically rotated into other process areas. Generally the rotation period is 6 months, but the rotated foreman is available for consultation.

Discussion and inspection of the ESP with the senior electrical foreman (Mr. Guthrie) indicated that the maintenance staff is experienced and well-versed in the operation, maintenance, and troubleshooting of ESP problems.

4.1 PM INSPECTIONS

PM inspections are conducted each day by the day shift electricians to verify proper function of major ESP components. Items checked include rappers, T-R set power levels, and drag function.

An annual PM inspection is conducted on each ESP to allow major maintenance to be conducted. Items covered during the annual outage include bolts and bearings, attachments, ribbon mixers, and alignment of plates and wires. The unit is also washed out to remove salt cake accumulation, aid in discovery of corrosion, and aid in the inspection.

4.2 SCHEDULING OF REPAIRS

Scheduling of repairs determined during routine inspections is necessary to provide for efficient use of personnel and maintenance resources, and to ensure that proper parts and materials are available.

As problems are diagnosed, personnel (maintenance, operators, environmental, etc.) complete a work order request for repair. Because all work cannot be completed immediately, a priority system is used to determine the timing of needed repairs. This system evaluates the need for crisis or emergency action versus delayed or scheduled repair.

All work order requests are evaluated by planners and placed into one of four categories. The highest priority is designated as A which requires immediate action. Second priority is designated as B^+, which requires action as soon as practical. The third category is designated as B, which means schedule repair within 3 days. Lower priorities repairs are delayed until a scheduled shut down (or when unscheduled outages occur for another reason).

Maintenance planning meetings are scheduled on Monday, Wednesday, and Friday. Maintenance staff pick up all A priority work orders prior to 8:00 a.m. each day and complete those before initiating lower priority items. This type of work order system is very similar to that used by many facilities and is quite effective and efficient in handling maintenance activities.

In an effort to determine the types of repair conducted on the ESP over the previous year, a copy of work orders was requested. Container Corporation unfortunately does not retain copies of work orders after completion of the repair. A computerized cost tracking system is used, however, to assign maintenance cost to process units and equipment (DOW). Review of these records does not adequately specify malfunctions or repairs for each unit because the records are intended to track man-hours (cost) for budget purposes.

Table 17 provides a summary of man-hours expended on the No. 4 and 5 Recovery Boilers. It is expected that the total man-hours expended exceeded

TABLE 17. SUMMARY OF MAN-HOURS EXPENDED FROM DOW[a]

Month	No. 4 Recovery Boiler	No. 5 Recovery Boiler
1/84	661.6	195
2/84	300	218
3/84	1042	319.5
4/84	297	185.5
5/84	256	160
3/1/83 to 2/29/84	1868.5 (LP) 54.75 (R)	--

[a]From interpretation of work order codes from DOW report.

those documented. For the purposes of ESP recordkeeping and diagnosis of chronic problems, a more specific work order recordkeeping system is required. There are several systems available for work order maintenance tracking. All computer systems generally have limitations in their ability to input detailed narrative information. Where practical, each piece of control equipment should be identified by a unique code. Components that typically require repair, inspection, or replacement should be further identified. Normally a 10 point 80 character narrative, the nature of the problem, component description, and repair model (i.e., adjustment, replacement, uncorrected) can be documented. An example computerized system used by a utility is provided in Appendix D. A system is only as effective as the reporting provided in the work order response. A two part work order is recommended. One describes the problem and the second describes the repair completed (i.e., findings, parts, etc.). Through the use of the computer, the types, frequency, and repetitiveness of the problems can be analyzed using key words and/or codes for specific problems.

Without an effective recordkeeping diagnosis system, failures are not correlated with causal factors. Through the use of diagnostic analysis, maintenance costs can be substantially reduced.

4.3 CONFINED ENTRY RECORDS

As a supplement to the work orders, PEI reviewed the confined entry reports completed by the electrical department. The procedure for confined entry requires a check of the entry area gas composition. A reason for entry is specified and occasionally specific problems are recorded. Between March 1, 1983, and February 28, 1984, 10 entries were made into the No. 4 ESP and 16 were made into the No. 5 ESP. Nineteen entries were made that could not be associated with a specific unit.

Tables 18 and 19 provide a summary of specific problems that were documented. Several events were not identified and therefore they could be associated with an individual unit.

TABLE 18. NUMBER OF CONFINED ENTRIES MADE FOR INSPECTION OR REPAIR[a]

Date	No. 4 Recovery Boiler ESP	No. 5 Recovery Boiler ESP	No. 7 Power Boiler ESP	Unit not specified
3/83	2		3	5
4/83	3	2		7
5/83	2	2		1
6/83			1	
7/83		2		1
8/83		5		1
9/83				
10/83	2			
11/83				2
12/83	1			2
1/84		3		
2/84		2		
Total	10	16	4	19

[a]Based on confined entry permits.

TABLE 19. PROBLEMS IDENTIFIED DURING CONFINED ENTRY[a]

Problem	No. 4 ESP	No. 5 ESP	No. 7 ESP	Unit not specified
Grounds	3	12	1	8
Broken wires	2	5	3	8
New wires	40			28
Alignment	1			1
Plate repair	1			
Transformer	2			1
Insulators				2
Miscellaneous	1		1	3

[a]Based on confined entry permits.

4.4 ON LINE MAINTENANCE

Container Corporation conducts on line maintenance of the recovery boiler ESP's, which allows the boiler to continue operation. When an internal problem develops (drag alignment or stoppage, wire break, ground, or insulation failure, etc.) an inspection must be conducted and repairs made. The normal procedure is to close the isolation guillotine at the inlet to the affected chamber, deenergize the ESP chamber, open lower and upper doors to cool the unit and purge the system, perform confined entry check, and enter the unit for inspection. Problems identified are corrected, or if extensive, scheduled for future repair.

During this period, the total flow of the boiler is treated by the remaining chamber. The removal efficiency of the one chamber is reduced because of higher superficial velocity and lower effective SCA. The SCA with both chambers on line is very high. It is possible that the ESP's could comply with the particulate matter and opacity standards using one chamber at reduced boiler load (i.e., $\sim$ 65%).

The need for on-line maintenance is recognized by the manufacturers and users of all modern ESP's. The requirement to shut down the boiler for routine preventive maintenance will eventually result in serious deterioration of the boiler and ESP because of increased corrosion during start-up and shut-down. The particulate matter emissions will also increase. Isolation of one chamber for maintenance should not be considered circumvention of control requirements.

Periods of one chamber operation should be recorded and archived, and isolation reported to the appropriate agency under the guidelines of the agency permit. To define the limits and potential emissions, a stack test should be conducted for one chamber operation at various boiler loads. A Method 9 observation should be conducted during testing to produce a baseline for future reference.

4.5 ESP SAFETY

ESP safety can be divided into two areas of concern: electrical hazard and confined area entry. The procedures for electrical hazard protection include the application of key interlock procedures and a tag-out system. Main breakers are thrown, T-R sets grounded, and doors opened. The key interlock system prevents entry with electrical power on the unit. As a redundant system, and to prevent accidental closure of the unit with personnel inside, a tag is placed on each breaker, switch, lock out, or door entry. The tag is placed on the device by each person entering the unit and cannot be removed by any one except the person tagging the unit out. This is an extremely safe procedure and if followed, provides for maximum safety. Grounds are also provided at each entry point, which are clipped to the wire frame, insulator, or T-R set conduit to ultimately ground the electrical system.

Confined area entry procedures are consistent with NIOSH requirements. Before any person can enter the ESP (penthouse, inlet, outlet, drags, etc.), the atmosphere in the enclosure must be evaluated and a entry permit completed. Gases confirmed are combustables, H_2S, oxygen, CO, CO_2, and SO_2. Permitted maximum levels for H_2S and SO_2 are less than that specified by NIOSH. Table 20 provides Container Corporation maximum permissible limits.

TABLE 20. CONFINED AREA ENTRY MAXIMUM VALUES

Gas	Maximum value allowed
Combustible gases (methane)	≤10% (volume)
H_2S	≤10 ppm (volume)
CO	≤25 ppm (volume)
CO_2	≤0.25% (volume)
SO_2	≤2 ppm (volume)
O_2	≥19.5% volume

SECTION 5

CONCLUSIONS

Based on the results of the internal inspection of control devices serving the recovery boilers and power boilers, and data provided by Container Corporation, the following conclusions are drawn.

5.1 NO. 5 RECOVERY BOILER

Operation of the No. 5 Recovery Boiler is reasonably steady with minimum swings in firing rate and changes in excess air. The firing rate and excess air are maintained within values that result in the total flue gas volume being less than the design gas volume of the ESP.

Both the design and actual area SCA and superficial velocity of the ESP exceed normal values necessary to achieve the NSPS for low odor boilers. Frequent monitoring of salt cake pH is accomplished to prevent the formation of sticky salt cake that would adversely affect ESP performance. The residual oil firing rate is kept to a minimum to prevent the formation of sticky salt cake.

Rapper system function was adequate with the exception of inlet turning vanes that were inoperative. As a result of changes in inlet gas turning vanes to prevent pluggage, the gas flow vector is above the treatment zone in the first field. This has resulted in salt cake accumulation and grounding of the electrical distribution system. The gas distribution through the box is also affected because of perforated plate pluggage.

Electrode to plate alignment was moved in one electrical section, but was immediately corrected. Overall power input was high with normal distribution (inlet and outlet) within the unit.

Random salt cake deposits were observed on the bottle weights and the wire frame that resulted in soft grounds. These were suspected to be caused by water being splashed on the bottle weights during drag maintenance. These deposits were removed by plant personnel during the inspection. Rapping effectiveness was judged to be good as no general deposits were observed on the plates or wires.

5.2 NO. 4 RECOVERY BOILERS

Operation of No. 4 boiler is similar to the No. 5 unit. It appears, however, that load swings and boiler upset periods are more frequent on the No. 4 unit. Based on the salt cake pH, it appears to be difficult to maintain good salt cake quality.

At operating firing rates and excess air levels, the flue gas volume is lower than the design volume for the ESP. The design SCA is lower than that for the No. 5 ESP but still within exceptable limits. An external inspection indicated that rapper function was adequate and previous problems with water in the air lines had been corrected.

An internal inspection also indicated that similar bottle weight and wire frame buildup was occurring on with the No. 5 unit. These were removed by plant personnel during the inspection.

Salt cake was being effectively removed by the rappers in all fields. A heavier accumulation than normal, however, was observed in the outlet field.

All antisneakage baffles were in place and functioning with free movement. The effectiveness of these baffles is not known, however, and there is some question concerning the gas flow in the treatment zone. The design change to top inlet has prevented distribution plate pluggage but may have resulted in gas sneakage.

5.3 OPERATION AND MAINTENANCE PRACTICES

The knowledge of personnel operating the ESP appears better than normal and the staff has superior experience in maintenance of the units. An effective PM program is used in identifying and correcting operating problems.

The only deficiency observed in the program concerns the maintenance records for the ESP. Work orders are not maintained after completion of the work and DOW are not completed in sufficient detail to adequately document repeating problems. The chronic failure or repeating of maintenance problems cannot be determined by management because diagnostic records are not maintained. Permanent maintenance records (i.e., work orders, computer summary reports, inspection reports, log books, malfunction reports, etc.) would aid in diagnosis and troubleshooting of repeat problems.

The practice of one chamber operation during maintenance is common in the industry and the unit can be operated at reduced load without violation of the emission standards. Container Corporation has used this technique during PM and normal maintenance periods. The use of this method, when mass and opacity standards are not violated, should not be considered as a bypass of the control device.

General maintenance of the ESP's is superior, but several chronic problems must be addressed and solved to reduce the frequency and duration of malfunctions. These areas include: turning vane and distribution plate pluggage on No. 5 ESP, gas sneakage above the inlet field No. 5 ESP and under the fields in No. 4 ESP, and formation of soft grounds.

5.4 BAHCO COLLECTORS

The Bahco collectors serving the No. 4 and No. 5 Power Boilers are experiencing heavy chronic abrasion damage. Abrasion has resulted in penetration of air into the secondary and tertiary air system. Inleakage reduces particulate matter removal from the primary separators and allows penetration through the system. Container Corporation has conducted and continues to conduct daily repair to the ducts.

The high abrasion results from a high grain loading and the presence of sand in the fuel. There is an indication that the systems were specified and designed at a much lower loading than the current operation. The difference is primarily based on the removal of a multicyclone originally installed on the boilers. Specific details concerning the removal of the multicyclone during Bahco installation are not known.

Changes in the No.4 unit have reduced significantly the rate of erosion, but abrasive damage continues to occur. Abrasion is not uniform throughout the system and is heaviest in the lower pair of primary collectors. Because of inlet plenum design, larger abrasive particulate matter is stratified in the lower primary collectors.

Removal efficiency of the collector is affected by the free passage of flue gas through slots in the inner tubes. Reamers are used in these tubes to maintain the openings. Continuous inspection and maintenance is necessary to maintain the desired efficiency. Currently an annual inspection is conducted to determine the status of the reaming devices. It should be noted that failure of individual tube reamers cannot be determined from outside the device during operation.

The Bahco has the unique ability to adjust pressure drop by changing inlet vane position. To maintain collection efficiency over a wide range of operating conditions and gas volume, the vane is moved in or out of the collection tube. Current operating rates and turn down of the boilers have resulted in the collectors operating below minimum recommended gas volume even considering inlet vane adjustment. At low boiler loads, the collector is not effective in removing fine particulate matter, which results in higher opacity levels. Considering the high maintenance to the collectors and the wide range of boiler operation, alternate control technology may be more applicable.

ESP's, fabric filters, or wet scrubbers are possible alternative technologies that could be used to control the particulate matter emissions from bark-fired boilers. Fabric filters, however, are not practical because of high residual carbon in the ash and the potential for bag blinding and fire. ESP's are applicable to wood-fired boilers, but do not treat carbon particulate matter with high efficiency. Therefore, in order to obtain high removal efficiencies and to limit ESP size, carbon must be reduced. A primary collector would be required to remove char, carbon, and sand before the gas stream is treated by an ESP.

A venturi scrubber would be effective in removing all particulate matter species. During oil firing, however, scrubber liquor would require pH control.

SECTION 6

RECOMMENDATIONS

As a result of the inspections at Container Corporation, the following areas warrant improvement or change to reduce malfunctions, and/or excess emissions.

1. Improvement in gas distribution at the inlet of No. 5 Recovery Boiler ESP, by rapping of turning vanes.

2. Improvement in rapping of perforated plate at the inlet of No. 5 Recovery Boiler ESP.

3. Development of a specific work order recordkeeping system for the recovery boiler ESP's. Computer or manual systems are equally effective if the records are maintained for diagnostic purposes.

4. Review of the inlet design and antisneakage baffle system of No. 4 Recovery Boiler ESP to determine if sneakage is occurring under the treatment zone.

5. Balance gas volume to both chambers of No. 5 Recovery Boiler ESP.

6. Institute PM inspection to remove wetted salt cake from bottle weights and lower wire frame, caused by drag washing during drag maintenance. Removal during the maintenance period may prevent a future outage caused by hardened deposits.

7. Consideration should be given to the installation of secondary voltage meter on No. 4 Recovery Boiler ESP, which would allow diagnosis through the use of V-I curves.

8. Conduct a Method 5 stack test to verify compliance of ESP No. 4 and No. 5 using one chamber at full boiler load or define maximum load under which one chamber operation ensures compliance.

9. An engineering study should be conducted to determine if a precollector can be installed to remove abrasive sand particulate matter from the flue gas entering the Bahco collector.

10. Reaming frequency should be increased to prevent buildup between tube cleaning of Bahco collectors.

11. If boiler loads or power levels are consistently below design values, collector tube removal should be considered to more closely match the collector to actual gas volume during turn down periods.

12. To reduce maintenance and malfunction of the Bahco collectors, alternate collection systems such as ESP's or venturi scrubbers should be considered.

13 All maintenance to the Bahco systems should be documented to address the areas of most serious abrasion, inleakage, and pluggage.

APPENDIX A

COMPLAINT FOR CIVIL PENALTIES AND INJUNCTIVE RELIEF

IN THE CIRCUIT COURT OF THE FOURTH JUDICIAL CIRUCIT, IN AND FOR NASSAU COUNTY, FLORIDA

STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION, Plaintiff, vs. CONTAINER CORPORATION OF AMERICA, a Delaware Corporation, Defendant.	CASE NO.:

COMPLAINT FOR CIVIL PENALTIES AND INJUNCTIVE RELIEF

Plaintiff, STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION (the Department), sues Defendant, CONTAINER CORPORATION OF AMERICA, and alleges as follows:

Jurisdiction and Venue

1. This is an action for injunctive relief, damages, cost recovery and civil penalties in excess of $5,000.00, exclusive of interests and costs.

2. This Court has jurisdiction in this cause pursuant to Sections 26.012, 403.121, and 403.131, Florida Statutes.

3. Venue in this cause lies in this county because the events and activities involved herein have taken place within this county and Defendant operates its business in this county.

Parties

4. The Department is the administrative agency of the State of Florida charged with the duty to protect Florida's air and water resources and to administer and enforce Chapter 403, Florida Statutes, and the rules promulgated thereunder, Florida Administrative Code Title 17. Concomitant with this duty is the authority to seek damages, civil penalties, and cost recovery for violations of Chapter 403 and Florida Administrative Code Title 17, and to seek injunctive relief to prevent further such violations. §§403.121, 403.131, Fla. Stat.

5. Defendant is a Delaware corporation registered with the Secretary of State to transact business in the State of Florida under the provisions of Sections 607.307 and 607.321, Florida Statutes.

6. Defendant owns and operates a pulp and paper mill located at North Eighth Street, Fernandina Beach, Nassau County, Florida. In conjunction with the operation of the mill, Defendant operates a wastewater treatment system that discharges effluent into the Amelia River.

7. Defendant has owned and operated this facility at all times relevant to this cause.

Allegations Applicable to Counts I through IV and VII

8. Defendant's pulp and paper mill includes two recovery boilers (referred to as Recovery Boiler #4 and Recovery Boiler #5) and three power boilers (referred to as Power Boiler #3, Power Boiler #4, and Power Boiler #5). All five boilers can reasonably be expected to cause visible emissions.

9. Visible emissions are emissions of air pollutants the opacity of which is greater than five percent. Fla. Admin. Code Rule 17-2.100(174).

10. Visible emissions are pollution within the meaning of Section 403.031(2), Fla. Stat.

11. Any source of air pollution must obtain a permit from the Department before such source can be operated, unless specifically exempted from permitting.

12. Defendant's recovery and power boilers are currently authorized to operate subject to the terms of the following permits issued by the Department:

a. Recovery Boiler #4 - DER Permit No. AO45-31745 (expires September 30, 1985)

b. Recovery Boiler #5 - DER Permit No. AO45-22774 (expires October 19, 1984)

c. Power Boiler #3 - DER Permit No. AO45-31746 (expires August 31, 1985)

d. Power Boiler #4 - DER Permit No. AO45-39806 (expires March 31, 1986)

e. Power Boiler #5 - DER Permit No. AO45-39807 (expires March 31, 1986)

13. Florida Adminstrative Code Rule 17-2.610(2)(a) prohibits the emission of air pollutants the opacity of which is equal to or greater than 20 percent unless a higher visible emission standard is specifically established for a source by the Department.

14. The Department has not established a higher visible emissions standard for Defendant's Recovery Boiler #4. In DER Permit No. AO45-22774, the Department established an alternative visible emissions standard of 35 percent opacity for Defendant's Recovery Boiler #5.

15. Defendant's Power Boiler #3 is an existing fossil fuel steam generator with a heat input rate of less than 250 million Btu per hour.

16. Florida Administrative Code Rule 17-2.600(6)(a) provides that existing fossil fuel steam generators with a heat input rate of less than 250 million Btu per hour may emit maximum visible emissions of 20 percent opacity except that visible emissions as dark as 40 percent opacity may be emitted for no more than two minutes in any hour.

17. DER Permit No. AO45-31746 requires that visible emissions from Power Boiler #3 not exceed 20 percent opacity except that a maximum of 40 percent opacity may be emitted for two minutes in any hour.

18. Power Boiler #4 and Power Boiler #5 are carbonaceous fuel burning equipment subject to the requirements of Florida Administrative Code Rule 17-2.600(10)(a).

19. Rule 17-2.600(10)(a) prohibits carbonaceous fuel burning equipment permitted prior to July 1, 1974, from having visible emissions in excess of 30 percent opacity. However, visible emissions may reach a maximum density of 40 percent opacity for no more than two minutes in any hour.

20. DER Permit No. AO45-39806 requires that visible emissions

from Power Boiler #4 not exceed 30 percent opacity except that a maximum of 40 percent opacity may be emitted for two minutes in any hour.

21. DER Permit No. AO45-39807 provides that Defendant's Power Boiler #5 may emit visible emissions not to exceed 30 to 40 percent opacity.

22. Violations of Chapter 403, Florida Statutes, and Florida Administrative Code Chapters 17-2 and 17-4 subject the violator to a maximum $10,000 penalty for each violation. Each day on which a violation occurs constitutes a separate violation. §403.141(1), Fla. Stat.

23. The Department incurred valid costs and expenses in investigating, tracing, and controlling the violations alleged above. Section 403.141(1) makes any person who violates Florida Administrative Code Chapter 17-2 or the provisions of any permit issued by the Department liable to the Department for reasonable costs and expenses of the state in tracing the source of the discharge and in controlling and abating the source and its pollutants.

COUNT I

24. On January 19, April 6, and April 22, 1983, visible emissions of greater than 20 percent were emitted from Recovery Boiler #4.

25. The visible emissions of Recovery Boiler #4 on January 19, April 6, and April 22, 1983, constitute violations of Florida Administrative Code Rule 17-2.610(2)(a) and Section 403.161(1)(b), Florida Statutes.

26. On March 2, March 4, March 11, and April 1, 1983, Recovery Boiler #5 emitted visible emissions in excess of 35 percent opacity.

27. The visible emissions from Recovery Boiler #5 on March 2, March 4, March 11, and April 1, 1983, constitute violations of DER Permit No AO45-22774 and Section 403.161(1)(b), Florida Statutes.

28. Power Boiler #3 and Power Boiler #4's visible emissions

on April 6, 1983, exceeded 40 percent opacity. Visible emissions from Power Boiler #4 on August 8, 1983, also exceeded 40 percent opacity.

29. The visible emissions from Power Boiler #3 and Power Boiler #4 on April 6, 1983, and the visible emissions from Power Boiler #4 on August 8, 1983, constitute violations of DER Permits No. AO45-31746 and No. AO45-39806, Florida Administrative Code Rule 17-2.600(5)(b)1, and Section 403.161(1)(b), Florida Statutes.

30. On March 2 and March 11, 1983, the visible emissions from Power Boiler #5 exceeded 40 percent opacity.

31. The March 2 and March 11, 1983, visible emissions from Power Boiler #5 constitute a violation of DER Permit No. AO45-39807, Florida Administrative Code Rule 17-2.600(5)(b)1 and Section 403.161(1)(b), Florida Statutes.

COUNT II

32. Excess emissions are emissions of pollutants in excess of those permitted by Florida Administrative Code Chapter 17-2 or any permit issued under the authority of Chapter 17-2. Fla. Admin. Code Rule 17-2.100(56).

33. Excess emissions which are caused entirely or in part by poor maintenance, poor operation, or any other equipment or process failure which may reasonably be prevented during malfunction are prohibited. Fla. Admin. Code Rule 17-2.250(4).

34. The Defendant's pulp and paper mill emitted excess emissions on January 15, January 19, March 2, March 4, March 11, April 1, April 6, April 22, and August 8, 1983. These excess emissions occurred during malfunction and were caused entirely or in part by poor maintenance, poor operation, or any other equipment or process failure which could reasonably have been prevented.

COUNT III

35. When excess emissions result from malfunctions or malfunction causes a source to operate in violation of permit

conditions, the owner or operator of the emitting facility is required to notify the Department immediately. Fla. Admin. Code Rules 17-2.250(6) and 17-4.13.

36. On January 15, 1983, Defendant's pulp and paper mill emitted excess emissions. Defendant did not notify the Department until May 2, 1983, that a malfunction had occurred on January 15, 1983, which resulted in excess emissions.

37. On March 4, 1983, Recovery Boiler #5 emitted excess visible emissions. Defendant did not notify the Department until May 2, 1983, of a malfunction resulting in the March 4, 1983, excess emissions.

38. On March 8, 1983, Recovery Boiler #5 emitted excess visible emissions. Defendant did not notify the Department of a malfunction resulting in the March 8, 1983, excess emissions.

49. On March 11, 1983, Defendant's Power Boiler #5 emitted excess visible emissions. Defendant did not notify the Department until May 2, 1983, of a malfunction resulting in the March 11, 1983, excess emissions.

40. On April 1, 1983, Recovery Boiler #5 emitted excess visible emissions. Defendant did not notify the Department until April 5, 1983, of a malfunction resulting in the April 1, 1983, excess emissions.

41. On April 22, 1983, Defendant's Recovery Boiler #4 emitted excess visible emissions. Defendant did not notify the Department until May 25, 1983, of a malfunction resulting in the April 22, 1983, excess emissions.

42. Defendant violated Florida Administrative Code Rules 17-2.250(6) and 17-4.13 and Section 403.161(1)(b), Florida Statutes, by not immediately reporting malfunctions occuring on January 15, March 2, March 4, March 11, April 1, and April 22, 1983, which resulted in excess emissions being emitted from Defendant's pulp and paper mill.

COUNT IV

43. Florida Administrative Code Rule 17-2.240 provides that no person shall circumvent any air pollution control device, or allow the emission of air pollutants, without the applicable air pollution control device operating properly.

44. Number 3A precipitator is an air pollution control device operated by the Defendant for the purpose of reducing the level of air pollutants emitted from Recovery Boiler #4.

45. Number 5 precipitator is an air pollution control device operated by the Defendant for the purpose of reducing the level of air pollutants emitted from Recovery Boiler #5.

46. On January 19, January 20, January 27, January 30, January 31, February 1, February 4, February 11, February 15, February 25, February 27, March 1, March 13, March 14, March 15, March 29, April 5, April 6, April 8, April 9, April 12, April 15, April 19, April 22, April 27, April 28, April 29, May 1, May 4, May 8, May 14, May 27, and June 14, 1983, Defendant circumvented #3A precipitator or allowed the emission of air pollutants from Recovery Boiler #4 while #3A precipitator was not operating properly.

47. On February 9, February 25, March 2, March 4, March 5, March 22, March 30, April 1, April 7, April 17, April 18, April 19, April 24, April 25, April 29, May 6, May 11, and May 30, Defendant circumvented #5 precipitator or allowed the emission of air pollutants from Recovery Boiler #5 while #5 precipitator was not operating properly.

<u>Allegations Applicable to Counts V through VII</u>

48. On May 2, 1979, the Department issued Permit No. IO45-17462 to Defendant to operate a 25 million gallons per day (MGD) industrial wastewater treatment system. Under certain conditions set forth in the permit, Defendant was authorized to discharge effluent from its treatment system into the waters of Amelia River.

49. The expiration date for Permit No. IO45-17462 (hereinafter the "permit") was March 31, 1981. Defendant was

granted a limited extension of this permit under the terms of a "Stipulation of Extension of Permit and Final Order," which authorized continued operation of Defendant's wastewater treatment system under the conditions of Permit No. IO45-17462 until December 1, 1983.

50. Under specific condition No. 3 of the permit, the discharge to the Amelia River must be "consistent at all times with the water quality standards set forth in Chapter 17-3, F.A.C. [Florida Adminstrative Code]."

51. The Amelia River is catagorized as Class III waters of the State pursuant to Fla. Admin. Code Rule 17-3.081.

52. Fla. Admin. Code Rule 17-3.121 sets forth the following water quality criteria which apply to all Class III surface waters except within zones of mixing:

> (13) Dissolved Oxygen - in predominantly fresh waters, the concentration shall not be less than 5 milligrams per liter. In predominantly marine waters, the concentration shall not average less than 5 milligrams per liter in a 24-hour period and shall never be less than 4 milligrams per liter. Normal daily and seasonal fluctuations above these levels shall be maintained in both predominantly fresh waters and predominantly marine waters.
>
> (28) Transparency - the depth of the compensation point for photosynthetic activity shall not be reduced by more than 10 percent compared to the natural background value.

Fla. Admin. Code Rule 17-3.061 sets forth the following additional applicable water quality criterion:

> (2)r. Turbidity - shall not exceed 29 Nephelometric Turbidity Units (NTU's) above natural background.

53. "Zone of mixing" or "mixing zone" means a volume of surface water containing the point or area of discharge and within which an opportunity for a mixture of wastes with receiving surface waters has been afforded. Fla. Admin. Code Rule 17-3.021(32). Defendant's permit does not authorize or specify a

mixing zone for discharge into the Amelia River.

54. Even if a mixing zone were authorized by the Department, Fla. Admin. Code Rule 17-4.244(1)(i) provides that the following additional standards apply within the mixing zone for Class III waters:

> 1. The Dissolved oxygen within a mixing zone shall not average less than 4.0 milligrams per liter in the mixing zone volume; and,
>
> 2. The turbidity within the mixing zone shall not average greater than 41 Nephelometric Turbidity Units in the mixing zone volume above natural background.

55. Regardless of the existence of a mixing zone, Fla. Admin. Code Rule 17-3.051(1) requires that all surface waters of the state at all places and at all times must be free from industrial discharges which, alone or in combination with other substances:

* * *

> (b) Float as debris, scum, oil, or other matter in such amounts as to form nuisances; or
> (c) Produce color, odor, taste, turbidity, or other conditions in such degree as to create a nuisance.

COUNT V

56. On or around May 2, 1983, defendant discharged effluent from its facility into the waters of the Amelia River.

57. Defendant's discharge of effluent into the Amelia River caused violations of special condition No. 3 of the permit in the following respects:

a. The discharge resulted in an unnaturally colored greenish-blue plume in violation of Fla. Admin. Code Rule 17-3.051(1)(c).

b. The discharge caused the dissolved oxygen levels in the Amelia River to be depressed to 0.0 milligrams per liter, in violation of the water quality criteria established in Fla. Admin. Code Rules 17-3.121(13) and 17-4.244(2)(i)1.

c. The discharge caused turbidity of approximately 190 NTUs over natural background for the Amelia River, in violation of the water quality criteria established in Fla. Admin. Code Rules 17-3.061(2)(r) and 17-4.244(2)(i)2.

d. The discharge caused the transparency in the Amelia River to decrease by approximately 90 percent, in violation of the water quality criteria established in Rule 17-3.121(28), F.A.C.

58. On or around June 9, 1983, Defendant discharged effluent from its facility into the waters of Amelia River.

59. Defendant's discharge of effluent into Amelia River caused violations of special condition No. 3 of the permit in the following respects.

a. The effluent discharge resulted in a plume in the Amelia River which had a dark oily film floating on the surface of the water, in violation of Fla. Admin. Code Rule 17-3.051(1)(b).

b. The discharge caused the dissolved oxygen levels in the Amelia River to be depressed to 0.0 milligrams per liter, in violation of the water quality criteria established in Fla. Admin. Code Rules 17-3.121(13) and 17-4.244(2)(i)1.

c. The discharge caused turbidity of approximately 190 NTUs over natural background for the Amelia River, in violation of the water quality criteria established in Fla. Admin. Code Rules 17-3.061(2)(r) and 17-4.244(2)(i)2.

d. The discharge caused the transparency in the Amelia River to decrease by approximately 90 percent, in violation of the water quality criteria established in Fla. Admin. Code Rule 17-3.121(28).

60. Defendant's discharges as described in paragraphs 56 through 59 are a violation of Section 403.161(1)(b), Fla. Stat., in that it is a violation of Chapter 403 to violate or fail to comply with any permit or rule issued or adopted by the Department pursuant to its lawful authority.

61. Defendant's discharges as described in paragraphs 56 through 59 are also a violation of Section 403.088(1), Fla. Stat., which prohibits any person, without written authorization from the

Department, from discharging into waters of the state any waste which reduces the quality of the receiving waters below the classification established for them. Defendant had no such written authorization.

COUNT VI

62. General Condition No. 3 of the permit requires that

> [i]f, for any reason, the permittee does not comply with or will be unable to comply with any condition or limitation specified in this permit, the permittee shall immediately notify and provide the department with the following information: (a) a description of and cause of non-compliance; and (b) the period of non-compliance, including exact dates and times; or, if not corrected, the anticipated time the non-compliance is expected to continue, and steps being taken to reduce, eliminate, and prevent recurrence of the non-compliance. The permittee shall be responsible for any and all damages which may result and may be subject to enforcement action by the department for penalties or revocation of this permit.

63. Defendant failed to notify the Department of the discharge described in paragraphs 56 through 59, in violation of its permit General Condition No. 3.

64. Defendant's failures to notify the Department of the discharges described in paragraphs 56 through 59 are violations of Section 403.161(1)(b), Fla. Stat., in that it is a violation of Chapter 403 to fail to comply with any permit issued by the Department pursuant to its lawful authority.

COUNT VII

65. The Department incurred reasonable costs and expenses in investigation, tracing, and controlling the violations alleged above. Section 403.141(1) makes any person who violates or fails to comply with any Department rule, order or permit liable to the Department for reasonable costs and expenses of the state in tracing the source of the dishcarge and in controlling and abating the source and its pollutants.

Prayer for Relief

WHEREFORE the Department requests that the Court enter the following relief to the Department and against the Defendant:

A. Impose upon Defendant a civil penalty not to exceed $10,000 for each violation, for each day that each violation has occurred;

B. Permanently enjoin Defendant from operating Recovery Boiler #4, Recovery Boiler #5, Power Boiler #3, Power Boiler #4, and Power Boiler #5, except in such a manner as to prevent the emission of visible emissions in excess of those allowed by Florida Administrative Code Chapter 17-2 and the applicable permits issued by the Department;

C. Direct Defendant to notify the Department by the end of next business day of any malfunction at its pulp and paper mill which results in excess emissions of air pollutants; and to file a complete written report within seven days of the occurrence of the malfunction on the causes of the malfunction and measures taken to correct it and to prevent it from reoccurring;

D. Permanently enjoin Defendant from circumventing pollution control equipment and from allowing air pollutants to be emitted from any source within its pulp and paper mill without the applicable pollution control device operating properly;

E. Direct the Defendant to file with the Department within 90 days a comprehensive description of all processes and sources of emissions where such circumvention could occur along with a program to prevent such from occurring;

F. Direct Defendant to maintain properly all facilities and equipment so as to prevent excess emissions of air pollutants; and to file with the Department within 90 days a comprehensive program for proper operation and maintenance of all facilities and equipment, including a training program for all persons responsible for the proper operation and maintenance;

G. Permanently enjoin Defendant from discharging effluent into the Amelia River in violation of its permit conditions and the water quality standards of the Department.

H. Direct Defendant to notify the Department by the end of the next business day of any discharge that results in a violation of its permit conditions or any applicable water quality standards of the Department; and to submit a complete written report within seven days of the occurrence on the causes of the occurrence and the measures taken to correct it and keep it from reoccurring.

I. Direct Defendant to file with the Department within 90 days a comprehensive program for proper maintenance and operation of all facilities and equipment, including a training program for all persons responsible for proper maintenance and operation, to prevent further discharges into the Amelia River in violation of its permit conditions and water quality standards.

J. Enter an award to the Department pursuant to Section 403.141, Fla. Stat., for damages caused to the air, waters and property of the state and for the Department's costs and expenses in tracing, controlling and abating the source of pollution.

K. Take such other action as the Court may deem necessary.

Respectfully submitted this 27th day of February, 1984.

Debra Swim

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(904)488-9730

IN THE CIRCUIT COURT, FOURTH JUDICIAL CIRCUIT, IN AND FOR NASSAU COUNTY, FLORIDA.

CASE NO. 84-127-CA

STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION,

Plaintiff,

vs.

CONTAINER CORPORATION OF AMERICA, a Delaware corporation,

Defendant.
______________________________/

STIPULATION AND MOTION FOR ENTRY OF CONSENT FINAL JUDGMENT

This Stipulation and Motion for Entry of Consent Final Judgment is entered into this 13th day of April, 1984, by the State of Florida Department of Environmental Regulation, Plaintiff, and Container Corporation of America, Defendant. Plaintiff and Defendant stipulate to the following facts and move the Court to accept the terms of settlement set forth herein and enter a consent final judgment as final disposition of this case:

1. This Court has jurisdiction in this cause pursuant to Sections 26.012, 403.121, and 403.131, Florida Statutes, and Section 5, Article V, of the Constitution of the State of Florida.

2. Plaintiff is the State agency empowered with the duty to enforce the provisions of Florida Air and Water Pollution Act and Sections 403.011 through 403.401, Florida Statutes (1981).

3. Defendant is a Delaware corporation registered with the Secretary of State to transact business in the State of Florida under the provisions of Sections 607.307 and 607.321, Florida Statutes. Defendant owns and operates a pulp and paper mill located at North Eighth Street, Fernandina Beach, Nassau County, Florida. In conjunction with the operation of the mill, Defendant operates a wastewater treatment system that discharges effluent into the Amelia River.

4. Plaintiff brought this complaint which was served on Defendant on March 8, 1984, and answered by Defendant on March 28, 1984. In resolution of the matters alleged in the complaint and responses thereto, the Plaintiff and Defendant agree to the following terms and conditions:

(1) An independent contractor to be funded by the United States Environmental Protection Agency shall perform a compliance audit on the air emissions of Defendant's mill located in Fernandina Beach, Florida. If that contractor is not PEDCO, then it will be a contractor mutually agreeable to both Plaintiff and Defendant.

(2) Defendant shall, within ninety (90) days of the completion of the audit, present a plan to Plaintiff to bring Defendant's mill into compliance with the air emissions audit where said audit determines there are violations of state and federal law. Within ninety (90) days of that submission Plaintiff shall approve that plan and any modifications to it. Within eighteen (18) months of receipt of Plaintiff's approval, Defendant shall satisfactorily bring the air emissions of the mill into compliance with all state laws and regulations pursuant to said plan. Verification of said compliance shall be in accordance with approved Department of Environmental Regulation and United States Environmental Protection Agency methods. During the interim, the facility is still required to meet existing state and federal rules and construction/operation permits currently on file with DER and U.S. EPA. Any disputes over matters contained in this paragraph shall be resolved by the Court unless the parties mutually agree to an alternative dispute resolution forum.

(3) Defendant agrees to contribute to the Nassau County School Board the sum of $18,000.00 per year for a period of two (2) years to fund an environmental science program at Fernandina Beach High School. Payments shall be made on or before June 1, 1984, and June 1, 1985.

(4) In reporting excess emissions, Container Corporation of America shall be required to notify the FDER by phone and in writing of any exceedance that requires reporting pursuant to Rule 17-2.250, Florida Administrative Code. Further, Container Corporation of America shall notify the FDER by phone within the first 30 minutes of any exceedance expected to continue beyond a two-hour period. If an obligation to notify by phone occurs outside of FDER regular business hours, such notification shall be made at the beginning of the next business day.

(5) In order to be more responsive to the concerns of the community and the FDER, Container Corporation of America shall be notified by FDER in a timely manner of any complaints or concerns expressed by either FDER or the community at large. In the case of any visual inspection by the FDER, the compliance officer who observes Container Corporation of America's operation will come onto the property and review his or her findings with a member of Container Corporation of America's environmental group at the time of the observance if a member is available for this consultation. If a non-compliance is observed, a copy of that report will be mailed to Defendant as soon as it is prepared. In the event the FDER is notified of a concern or complaint by a citizen or representative of the community, FDER shall notify Container Corporation of America of the nature of the complaint that same day, if possible.

(6) Defendant agrees to pay to the State of Florida Department of Environmental Regulation Pollution Recovery Trust Fund the sum of $64,000.00 as repayment to Plaintiff for costs and expenses of their investigative and regulatory activities in this matter. Payment shall be made on or before June 1, 1984.

(7) Defendant shall allow authorized representatives of the Department access to the property at reasonable times for purposes of determining compliance with this stipulation or the rules and regulations of the Department.

(8) Plaintiff expressly reserves the right to initiate appropriate legal action to prevent or prohibit the future violation of applicable statutes, or the rules promulgated thereunder.

(9) Nothing herein waives any right Defendant may have to seek modifications, variances, or other relief from any requirement imposed by state or federal laws, regulations, orders or permits from the appropriate regulatory agencies. Provided, however, that any such application shall not relieve Defendant from compliance with the terms of this agreement.

(10) Plaintiff expressly reserves the right to seek civil penalties under Sections 403.121 and 403.141, Florida Statutes, in the event Defendant fails to comply with the terms of this Stipulation and the Consent Final Judgment.

(11) Entry of the Consent Final Judgment does not relieve Defendant of the need to comply with applicable federal, state or local laws, regulations, or ordinances.

5. The Court shall retain jurisdiction to enforce the terms of this Stipulation and the Consent Final Judgment by contempt proceedings or by the entry of any other appropriate orders.

6. All notices in writing or by phone shall be directed to the Plaintiff at the Northeast Florida District Office located at 3426 Bills Road, Jacksonville, Florida 32207. All notices in writing or by phone shall be directed to the Defendant at the Container Corporation of America mill site located at North Eighth Street, Fernandina Beach, Florida 32034.

ARTHUR I. JACOBS
JACOBS & MULLIN
Post Office Drawer I
Fernandina Beach, FL 32034
(904) 261-3693 or 355-6070

DANIEL H. THOMPSON
State of Florida Department of Environmental Regulation
Twin Towers Office Building
2600 Blair Stone Road
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(904) 488-9730

IN THE CIRCUIT COURT, FOURTH JUDICIAL CIRCUIT, IN AND FOR NASSAU COUNTY, FLORIDA.

CASE NO. 84-127-CA

STATE OF FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION,

Plaintiff,

vs.

CONTAINER CORPORATION OF AMERICA, a Delaware corporation,

Defendant.

______________________________/

CONSENT FINAL JUDGMENT

THIS MATTER having come before this Court pursuant to a Stipulation and Motion for Consent Final Judgment between the parties previously filed with the Court, and the Court being fully advised in the premises and that the parties are in agreement as to the appropriate resolution of this matter as embodied in said Stipulation, it is therefore

ORDERED AND ADJUDGED that the terms of the Stipulation and Motion for Consent Final Judgment between the parties dated April 13, 1984, are adopted and incorporated herein and, accordingly, it is

FURTHER ORDERED AND ADJUDGED that the parties shall act in compliance with and shall be bound before this Court by the terms of said Stipulation and the Court shall retain jurisdiction to enforce the terms of this Consent Final Judgment by contempt proceedings or by entry of any other appropriate orders.

DONE AND ORDERED this 13th day of April, 1984, at Fernandina Beach, Florida.

/s/ John S. Cox
CIRCUIT JUDGE

Copies to:

DANIEL H. THOMPSON
State of Florida Department
of Environmental Regulation
2600 Blair Stone Road
Tallahassee, Florida 32301
Attorney for Plaintiff

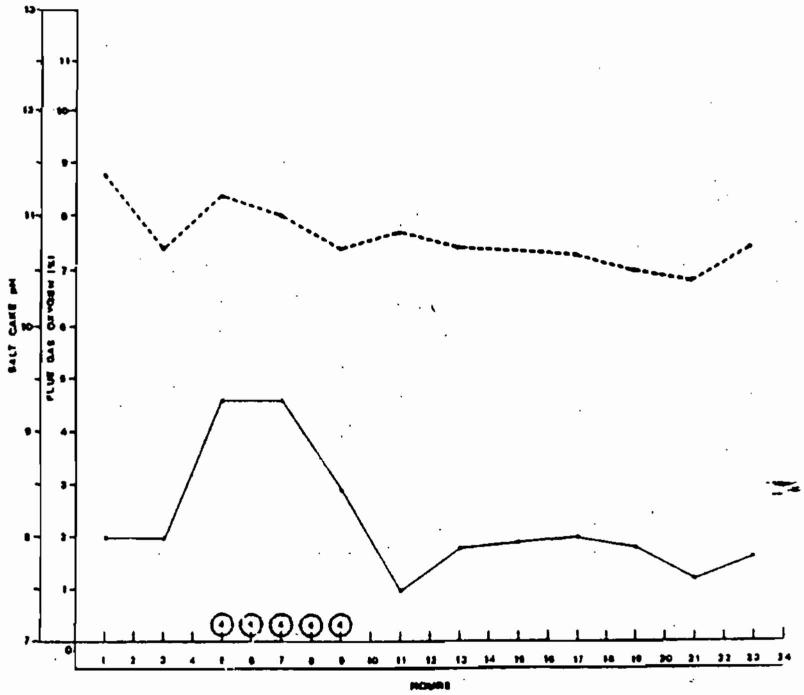
ARTHUR I. JACOBS
Jacobs & Mullin
Post Office Drawer I
Fernandina Beach, Florida 32034
Attorney for Defendant

APPENDIX B

SALT CAKE pH AND BOILER FLUE GAS
OXYGEN, RECOVERY BOILER NO. 5

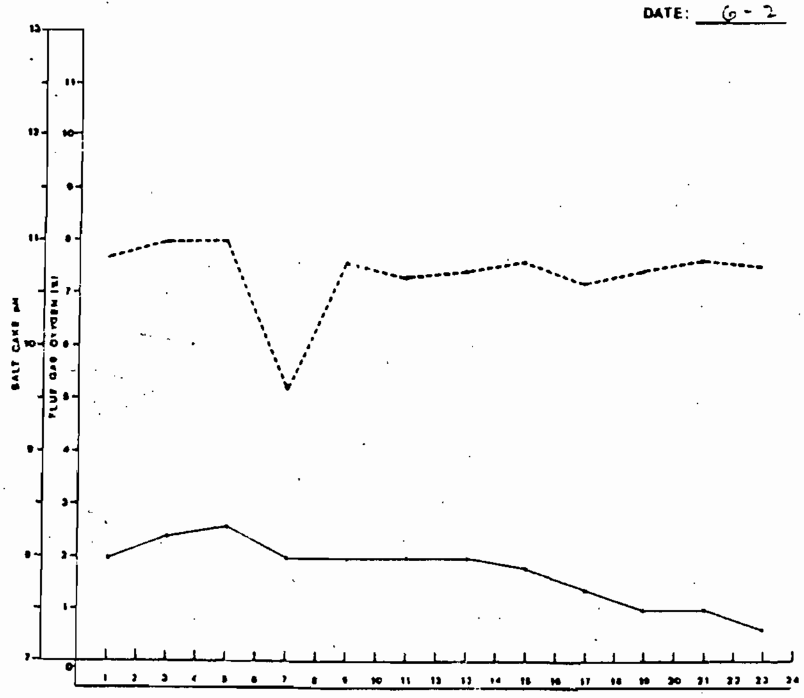
6/1/83 - 6/30/83

BOILER: 5
DATE: 6-1



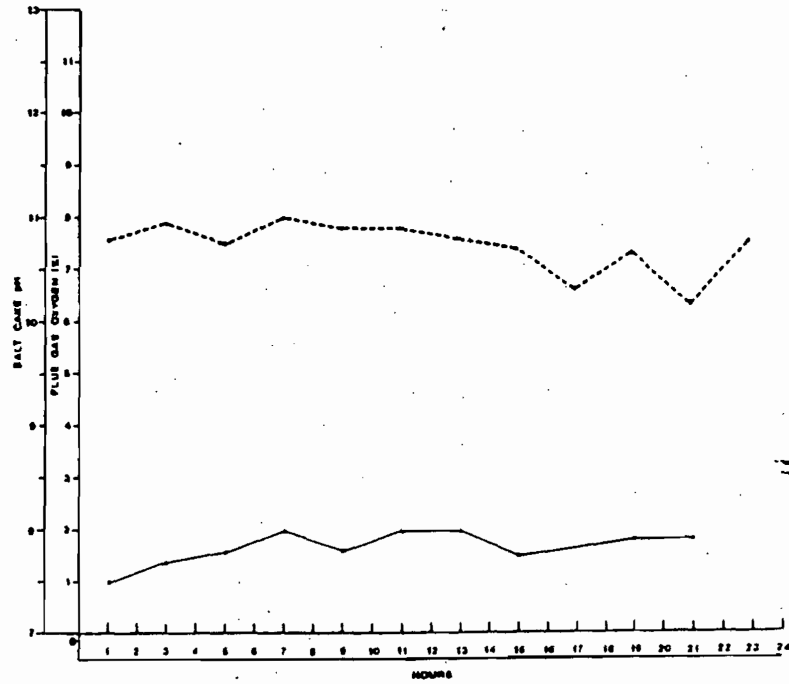
--- O_2
___ pH

BOILER: 5
DATE: 6-2



--- O_2
___ pH

BOILER: 5
DATE: 6-3



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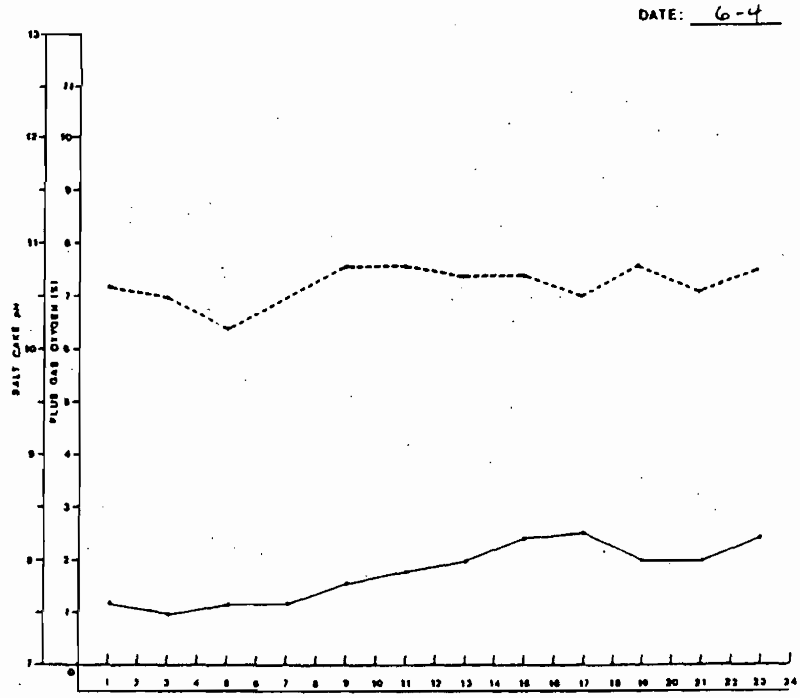

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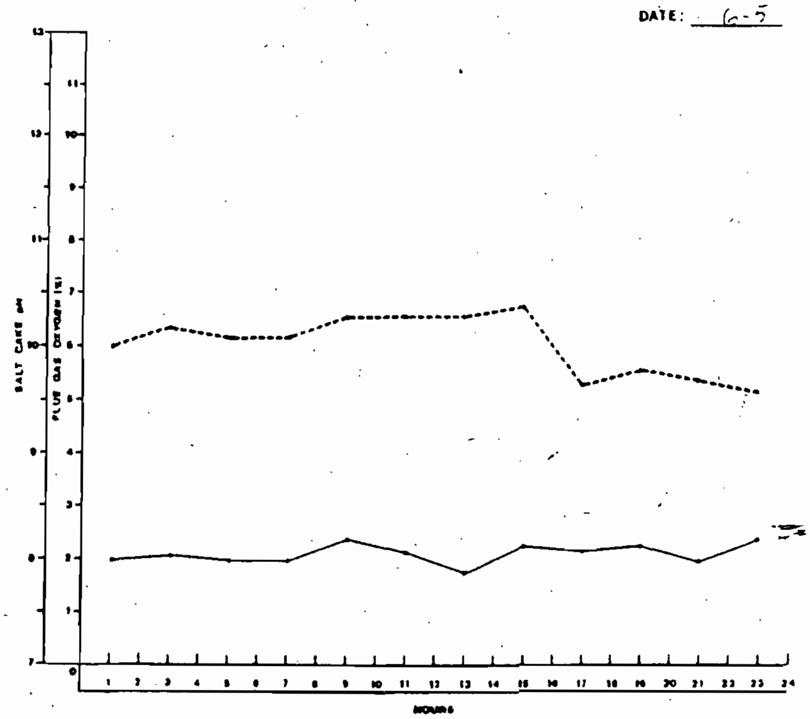

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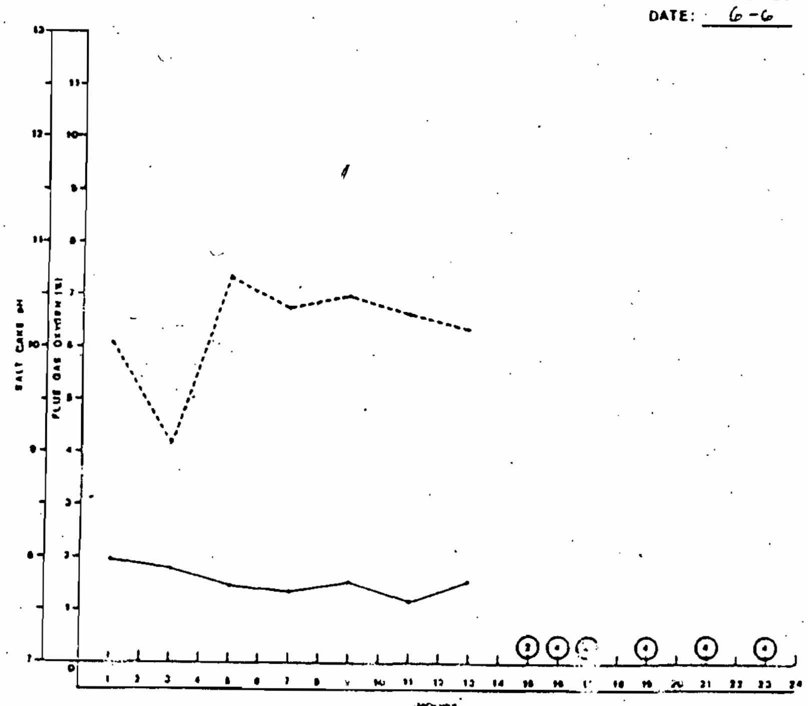

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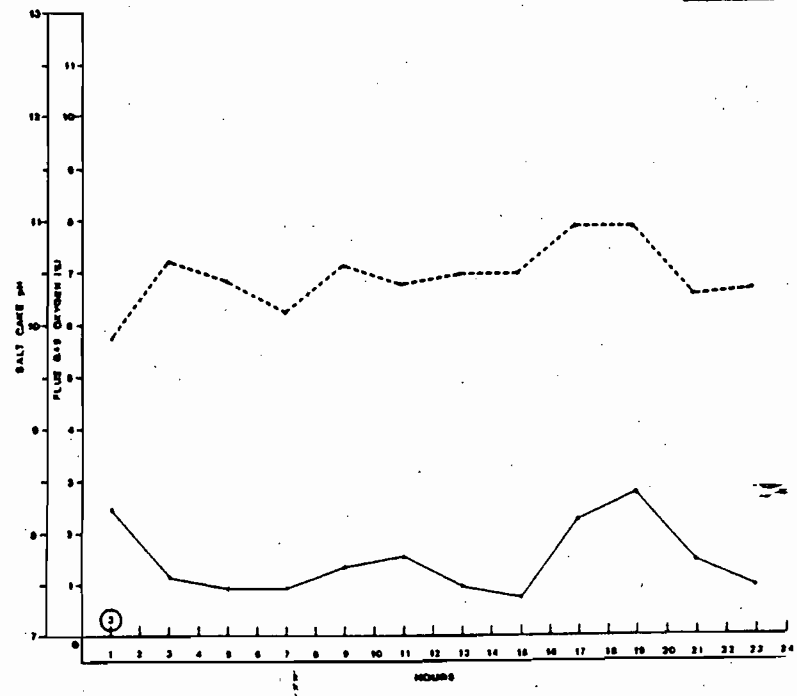
DATE: 6-7



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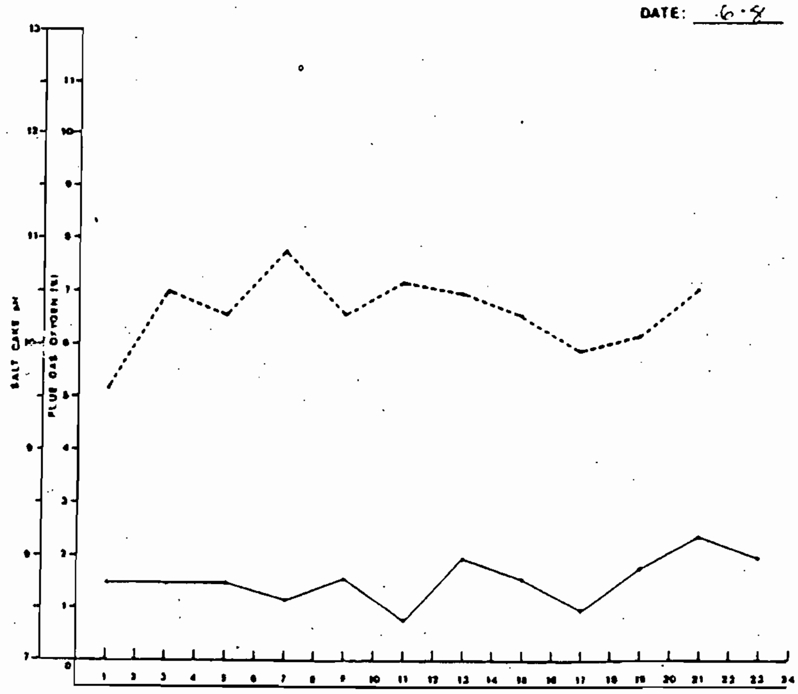

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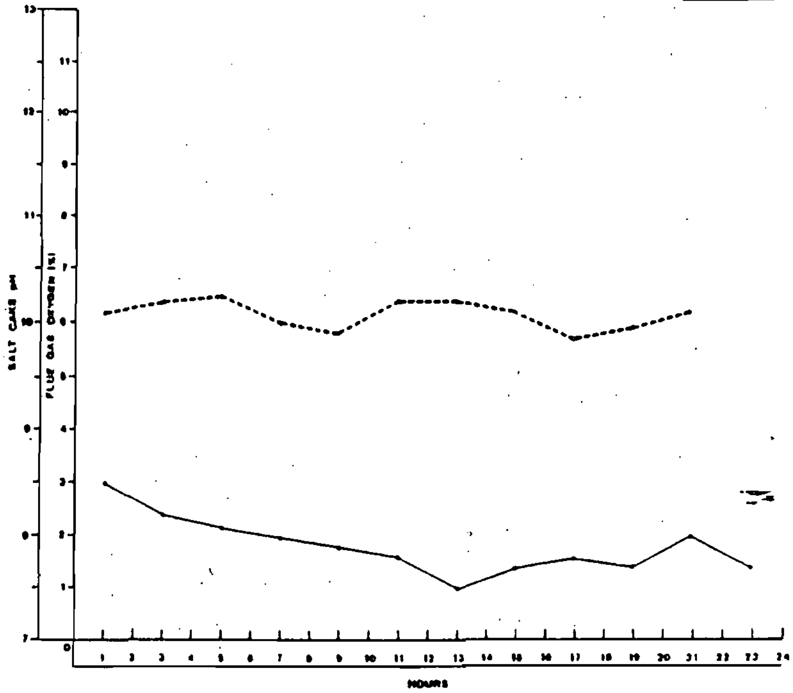
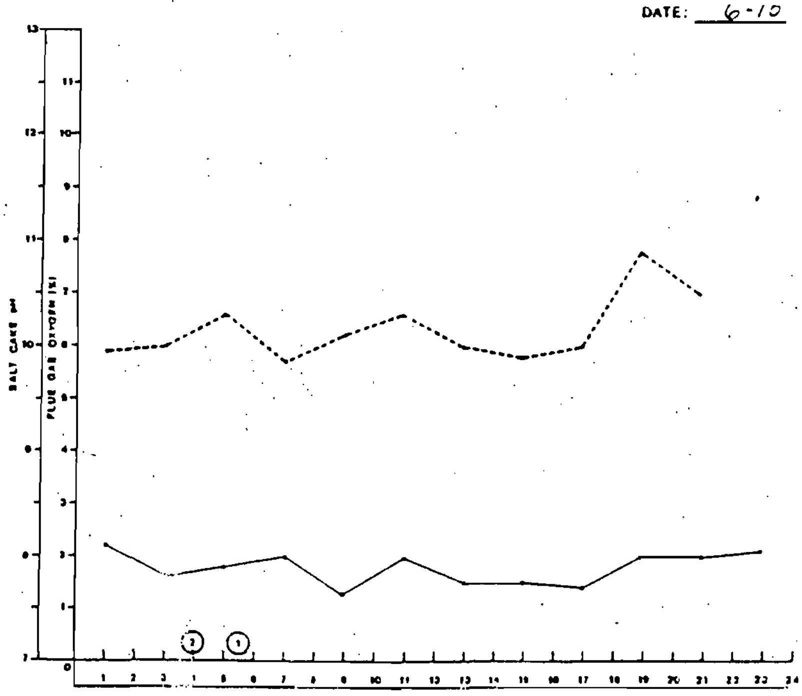
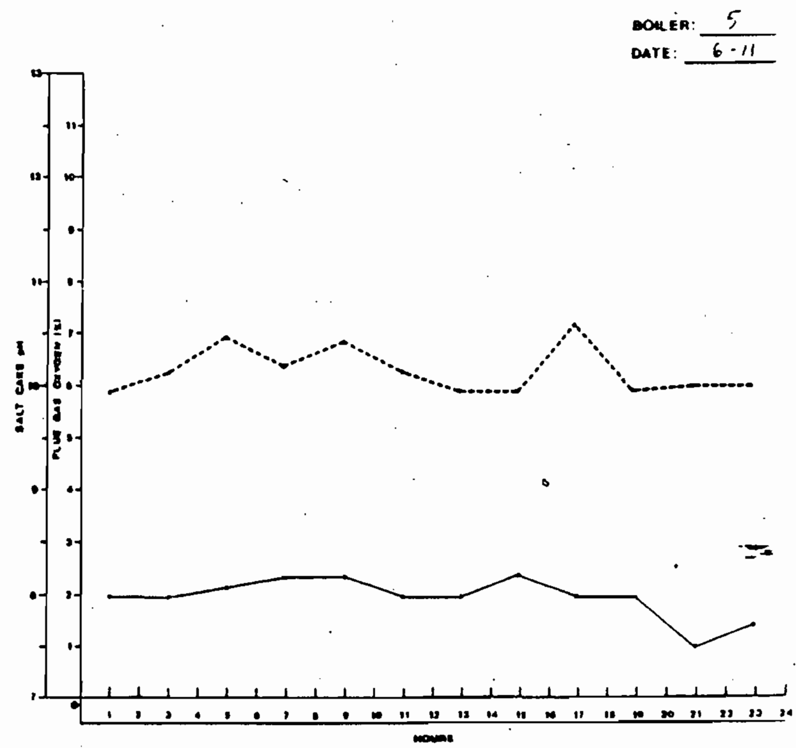


BOILER: 5
DATE: 6-10

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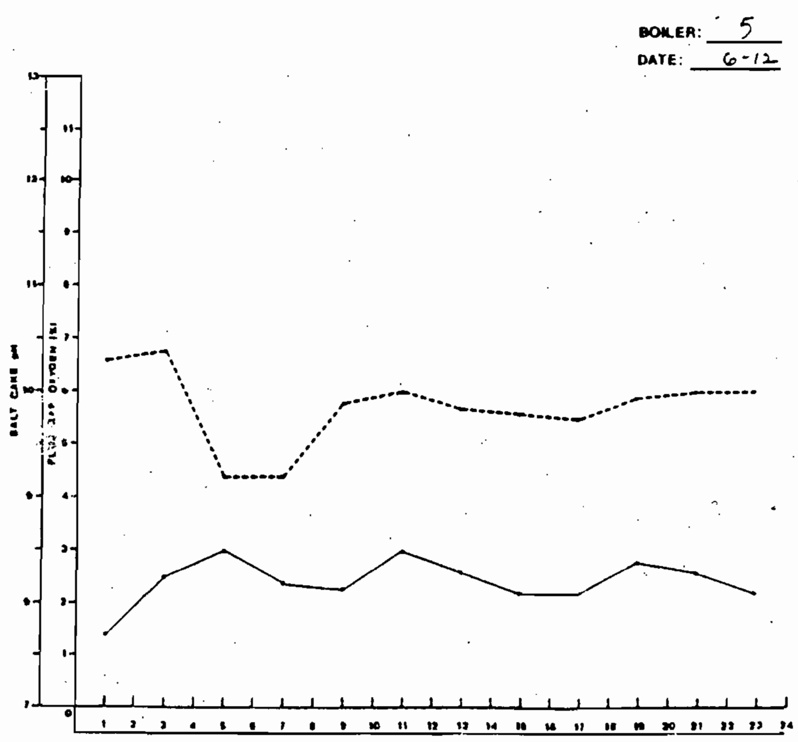
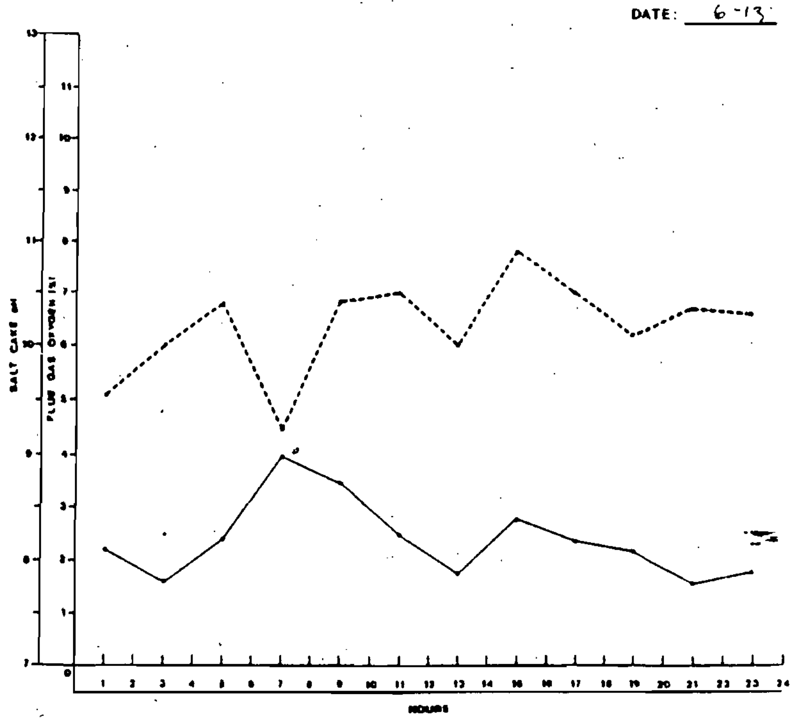
DATE: 6-11
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS


BOILER: 5
DATE: 6-12
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS

BOILER: 5
DATE: 6-13



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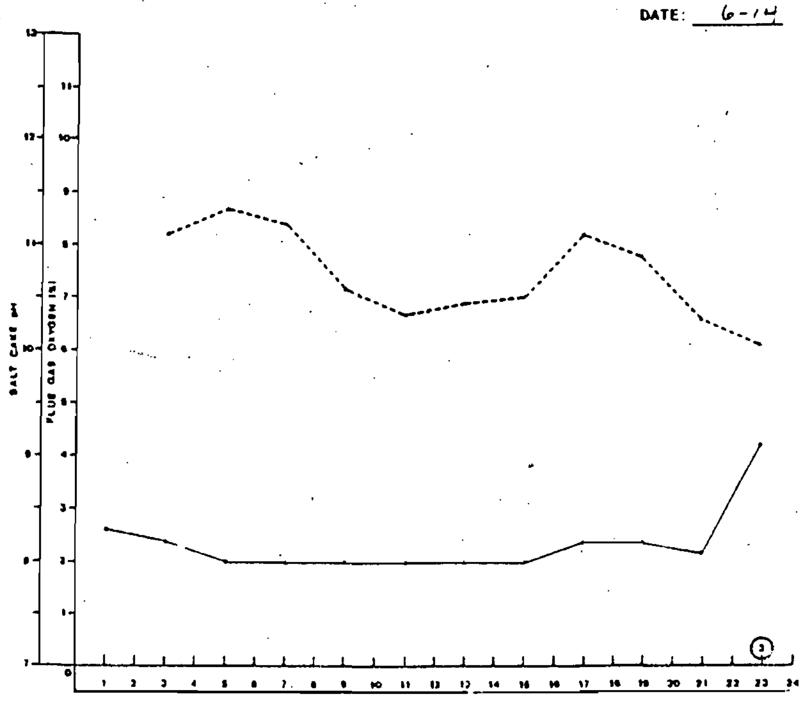

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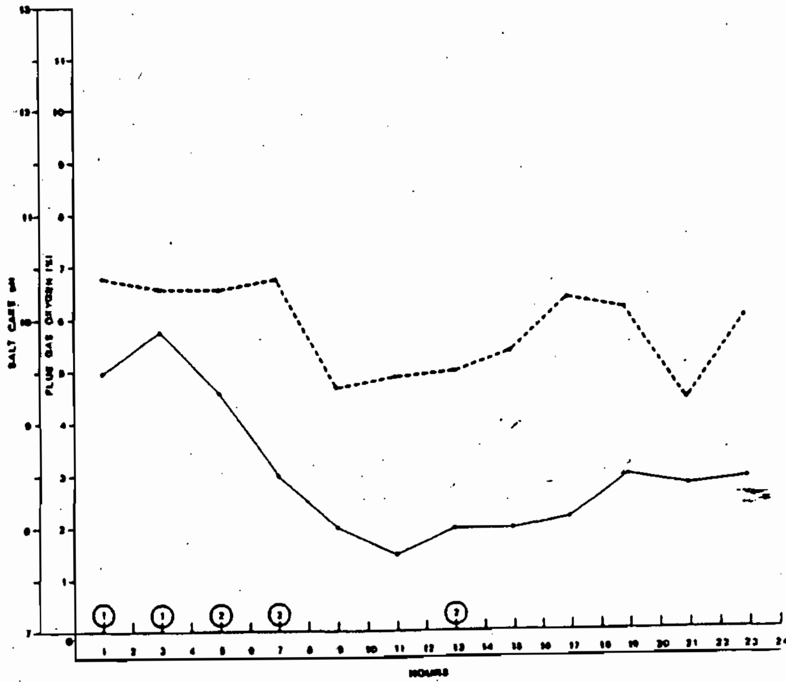

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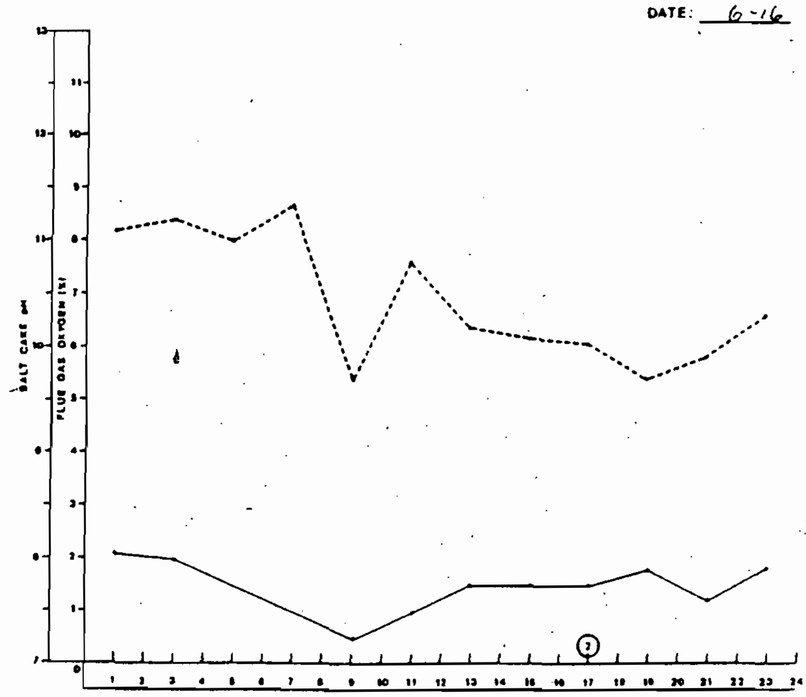
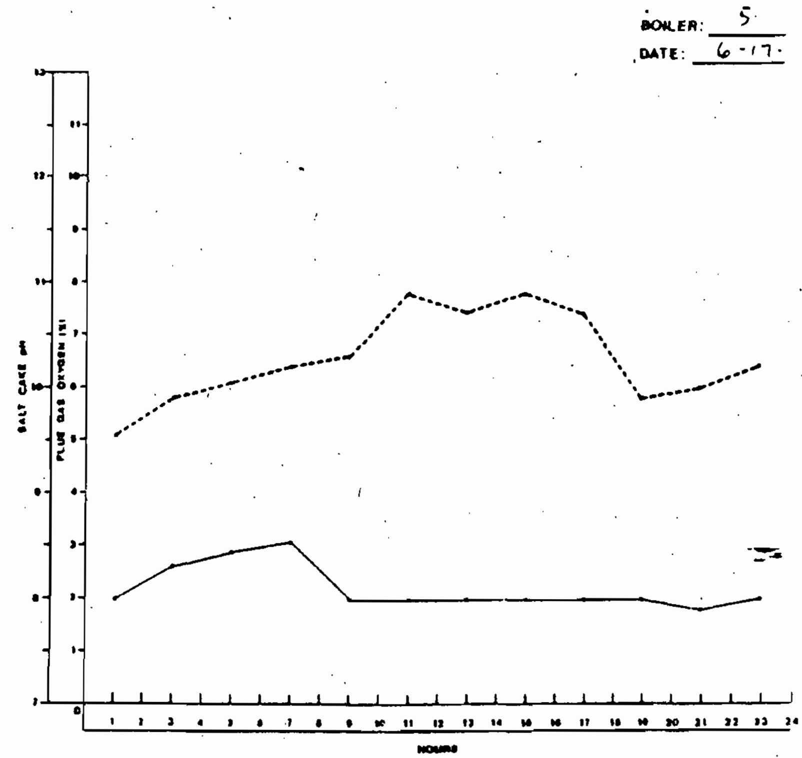
DATE: 6-16

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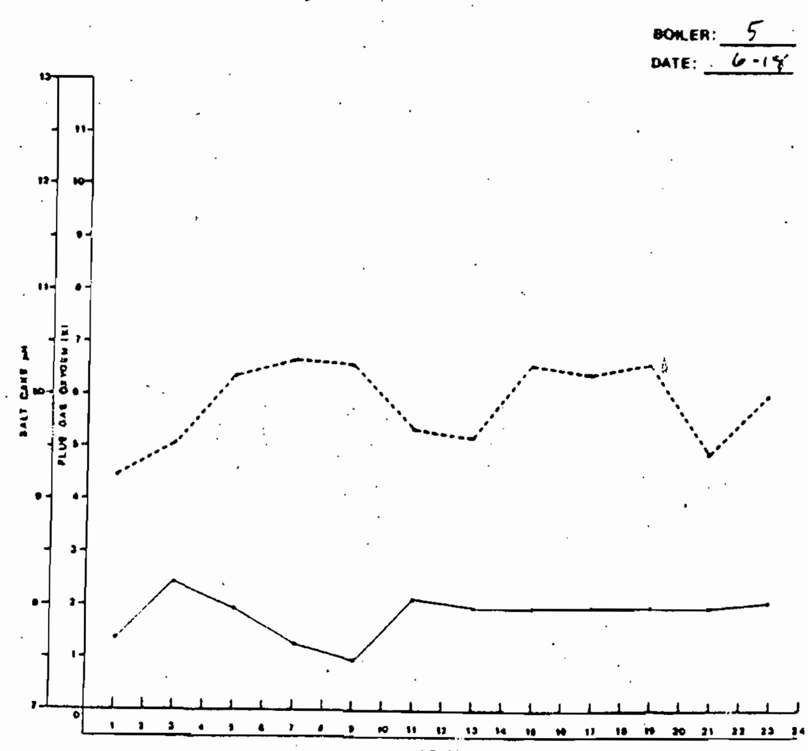
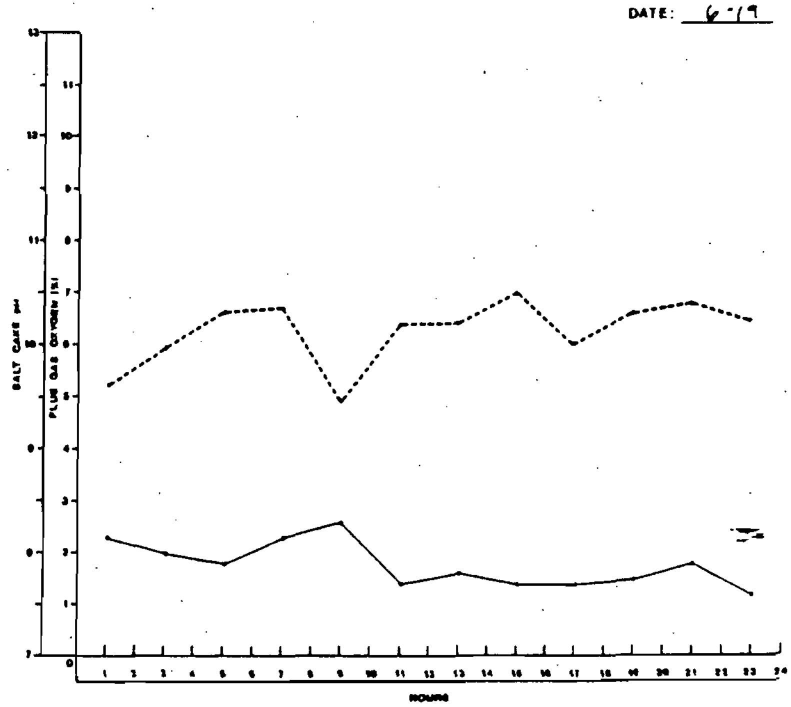
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS


BOILER: 5
DATE: 6-18
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS

BOILER: 5
DATE: 6-19



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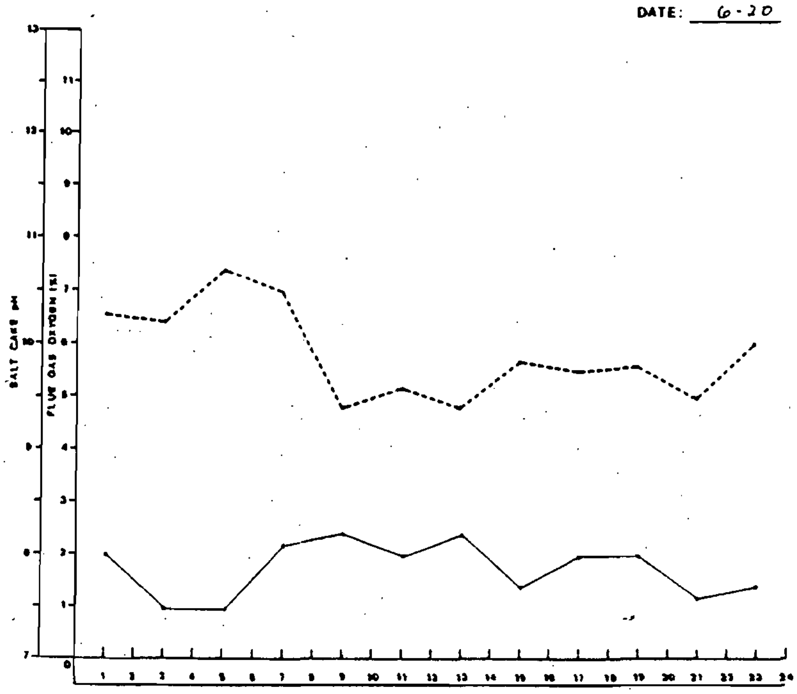
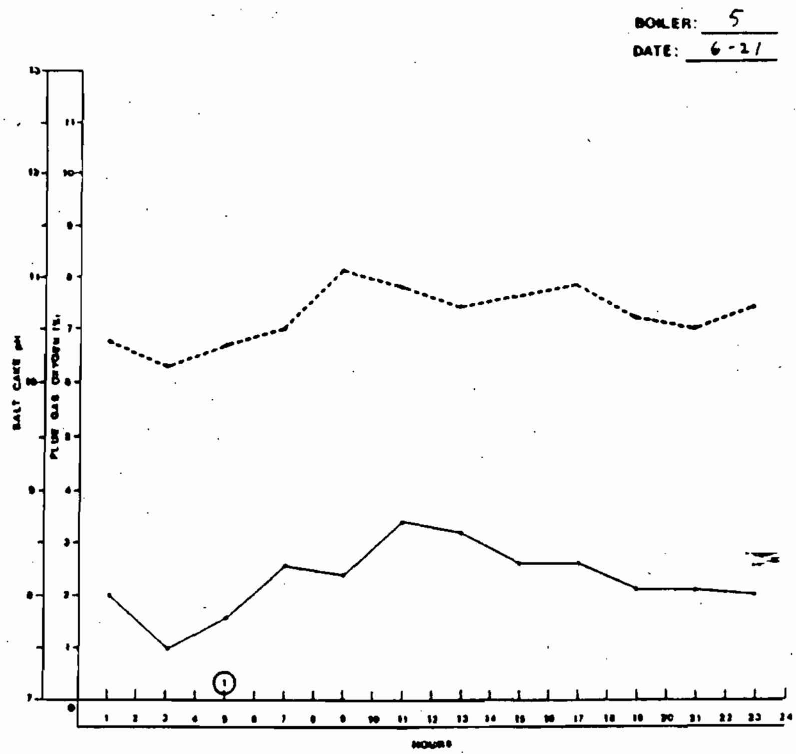
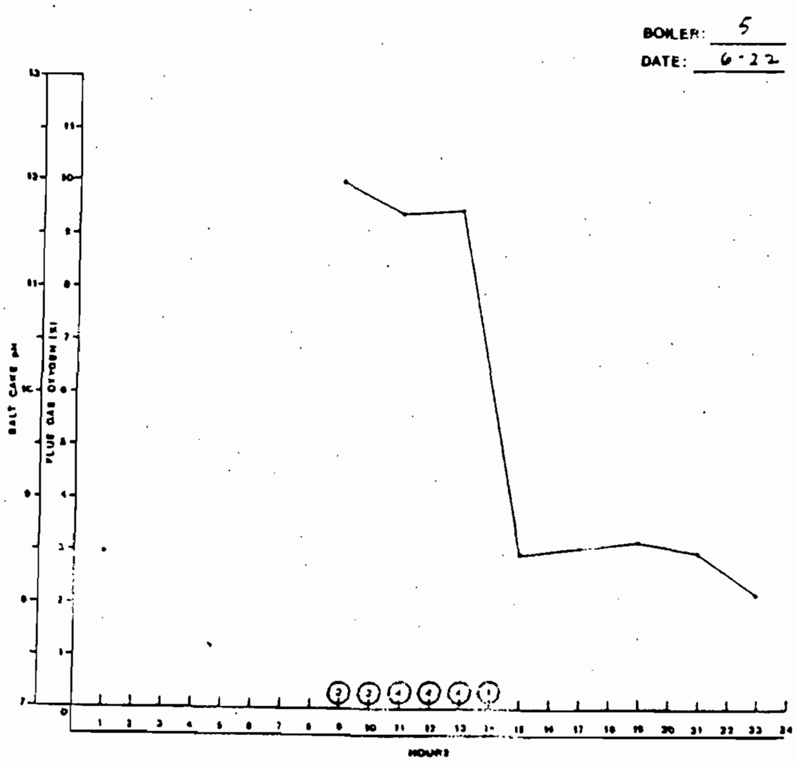
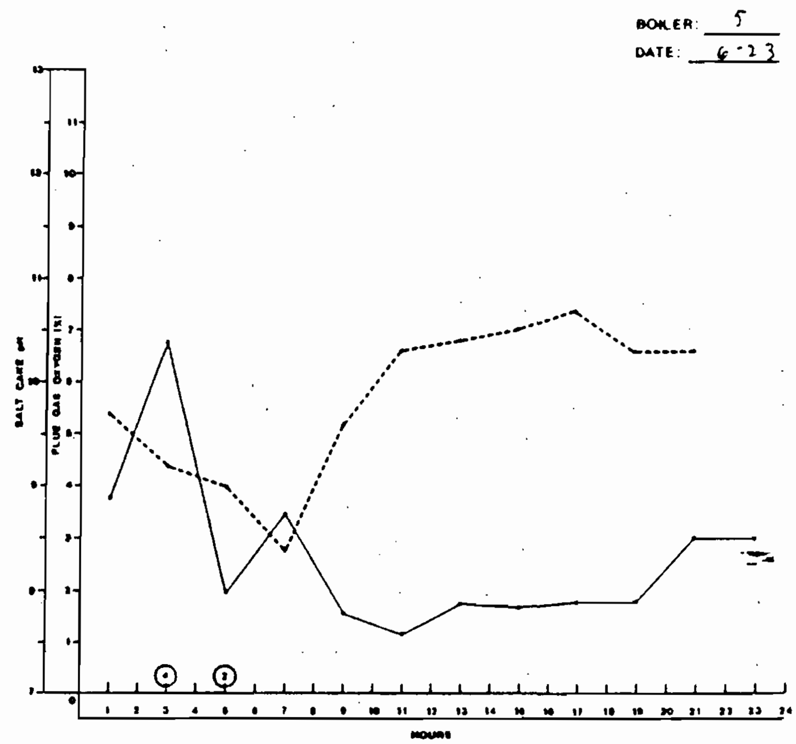
DATE: 6-20




BOILER: 5
DATE: 6-21
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS


BOILER: 5
DATE: 6-22
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS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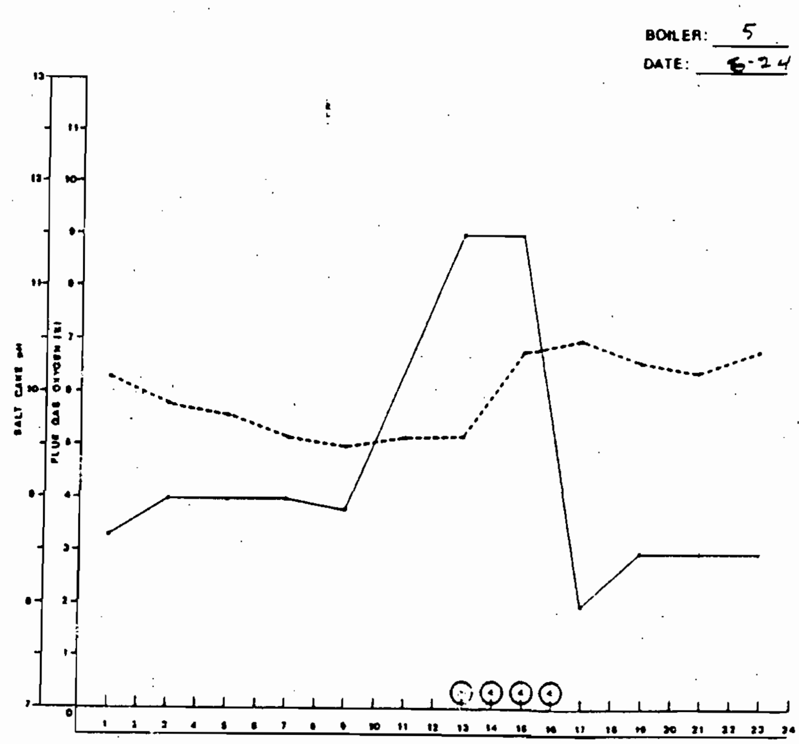
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS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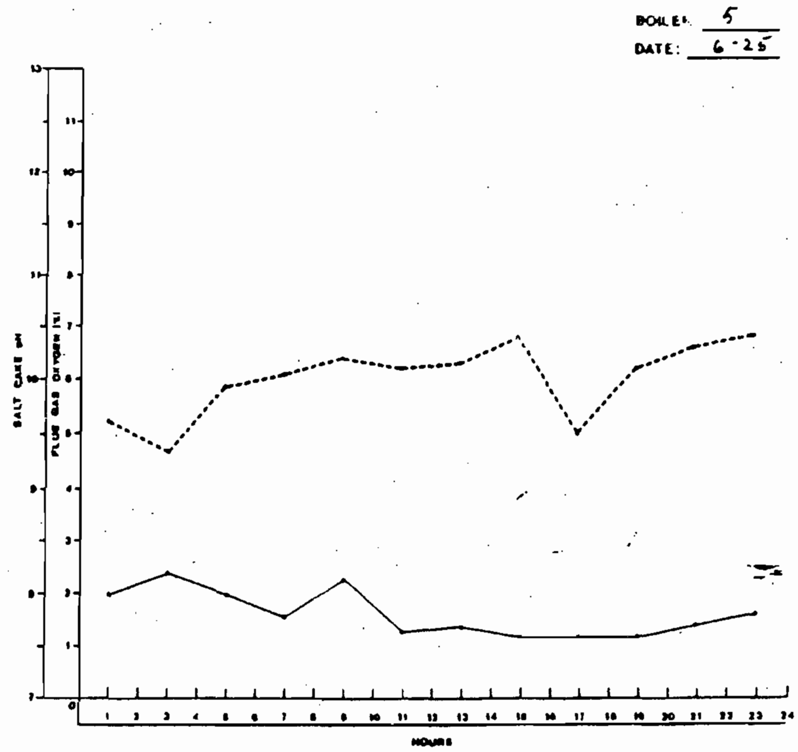
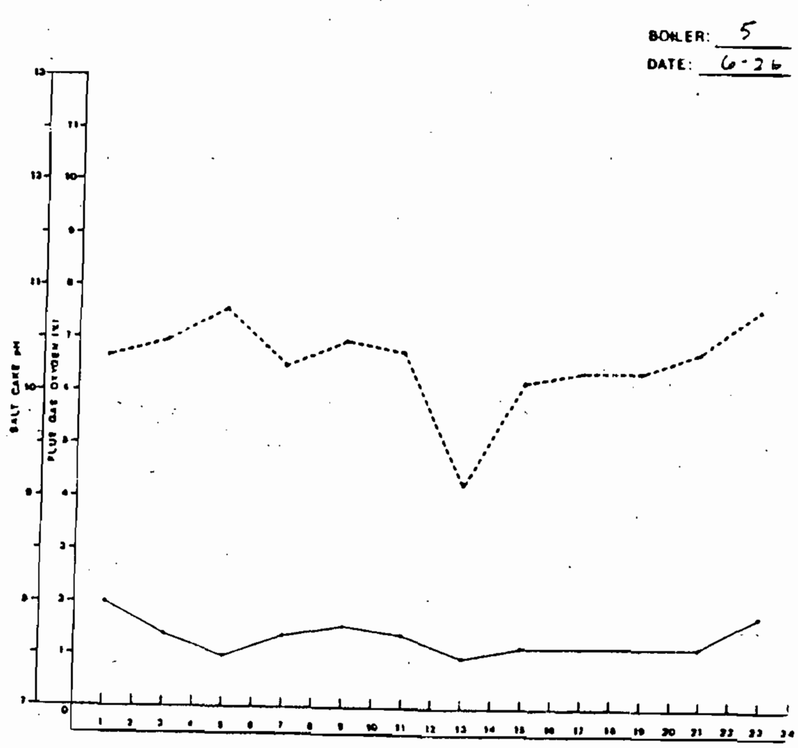
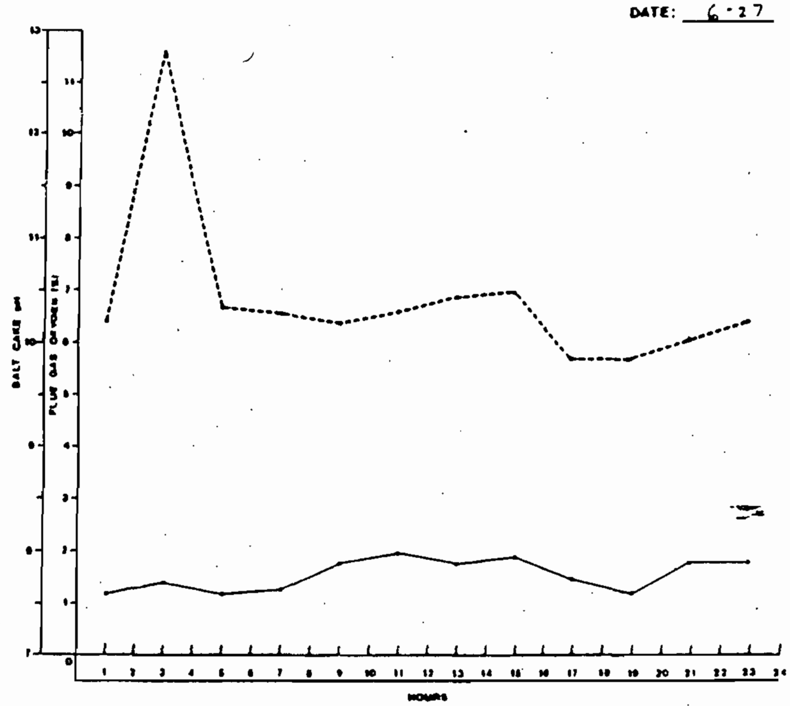
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS


BOILER: 5
DATE: 6-25
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS


BOILER: 5
DATE: 6-26
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS

BOILER: 5
DATE: 6-27



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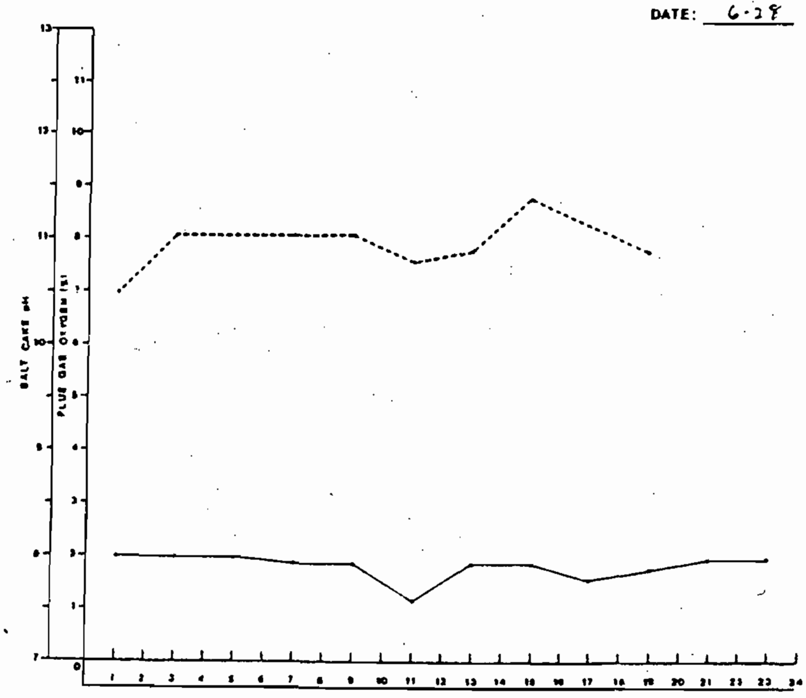
DATE: 6-28



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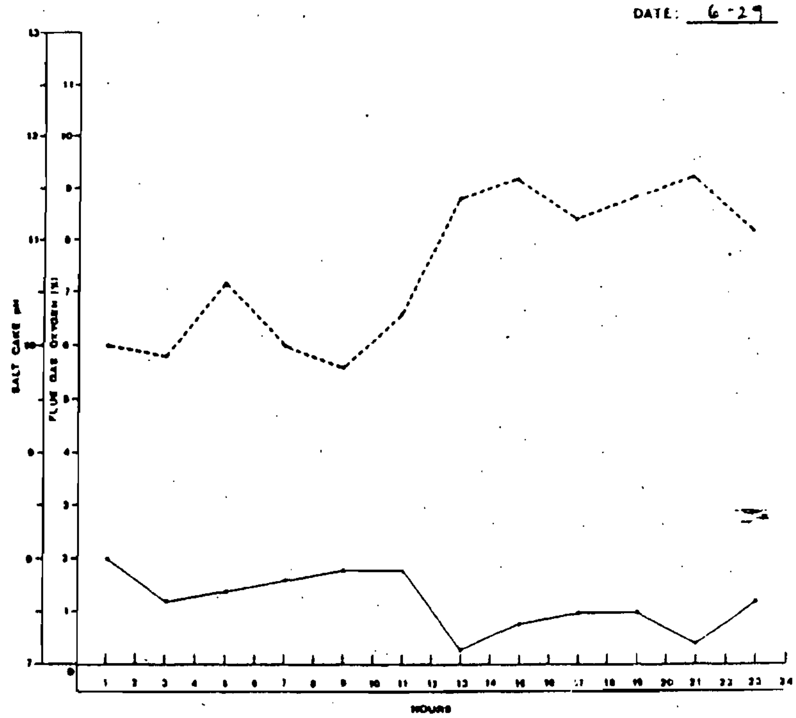

BOILER: 5
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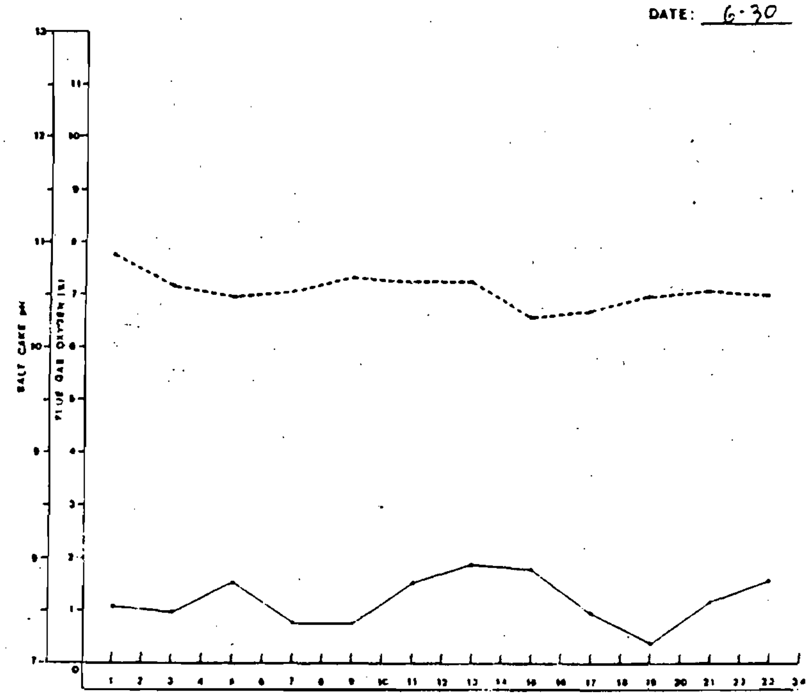
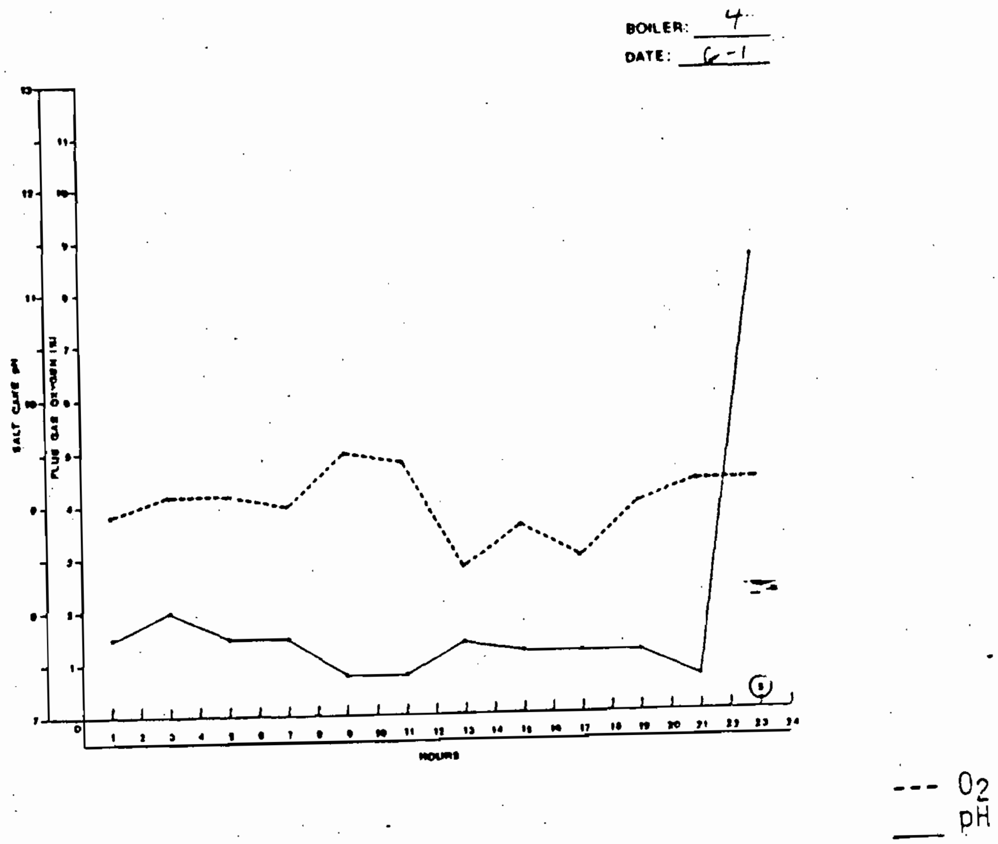
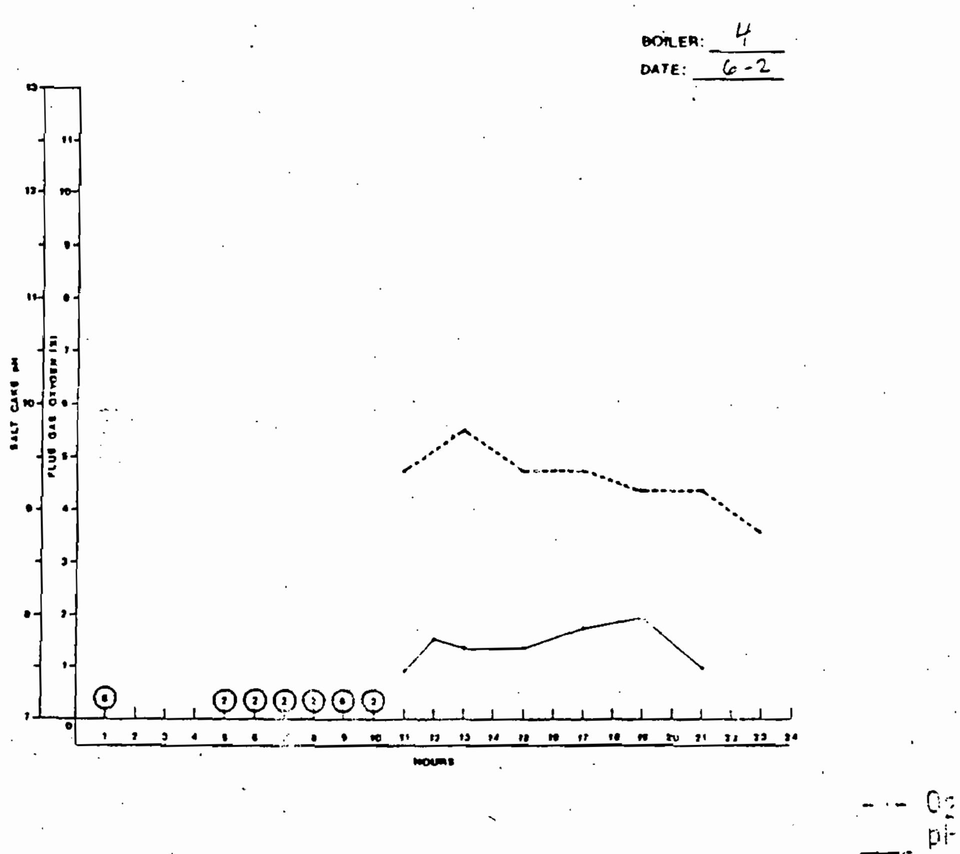


APPENDIX C

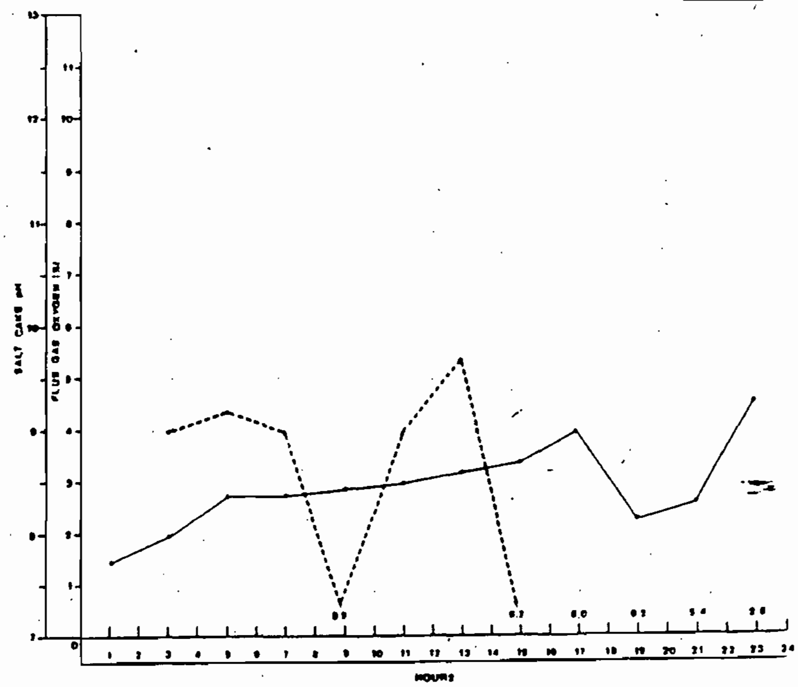
SALT CAKE pH AND BOILER FLUE GAS
OXYGEN, RECOVERY BOILER NO. 4

6/1/83 - 6/30/83


BOILER: 4
DATE: 6-1
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS
--- O_2
___ pH


BOILER: 4
DATE: 6-2
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS

BOILER: 4
DATE: 6-3



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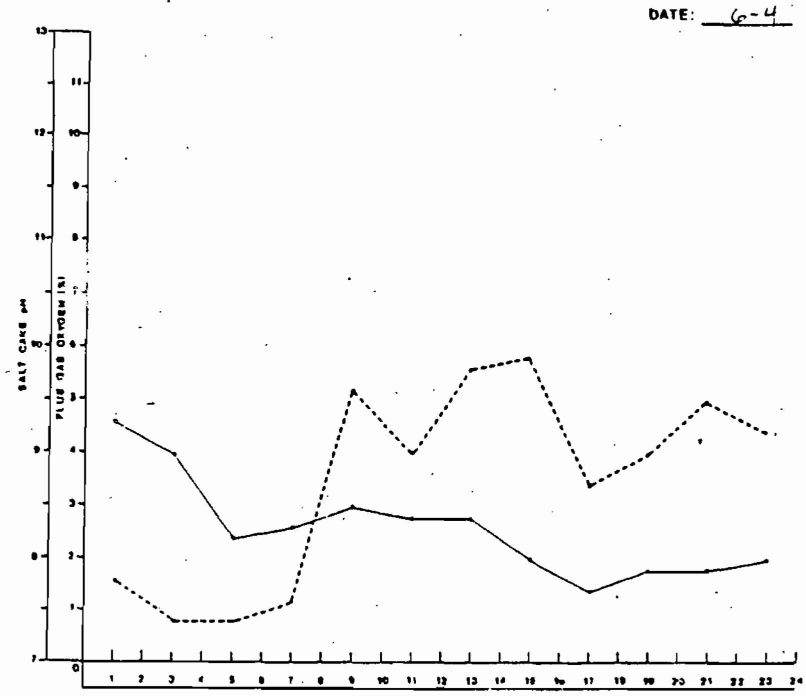
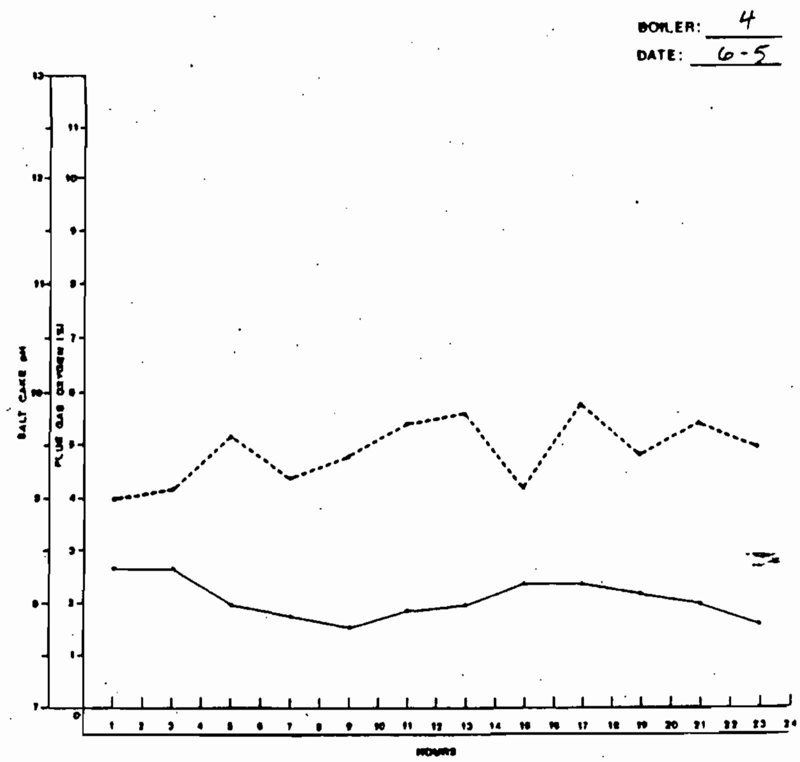
DATE: 6-4

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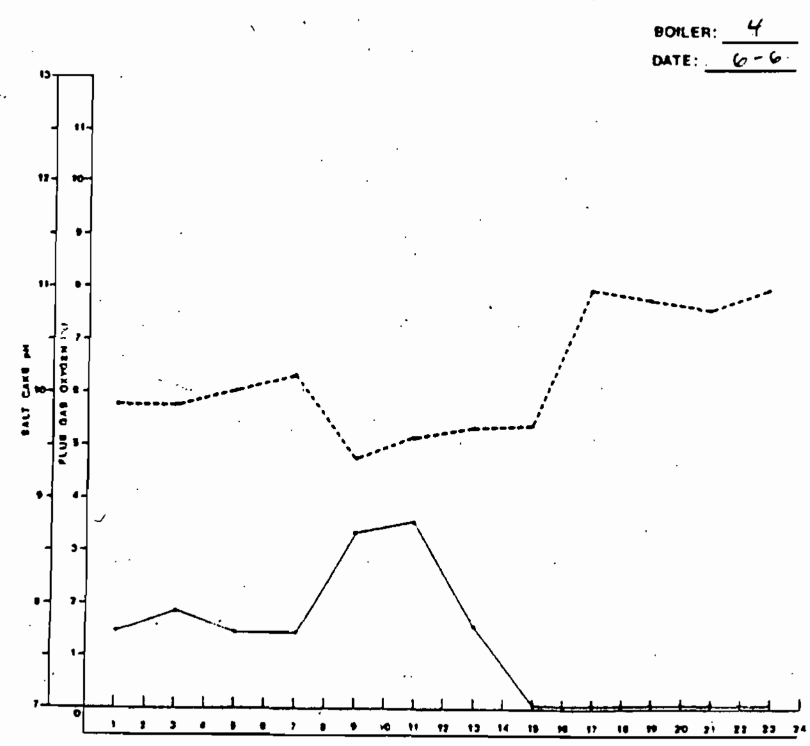
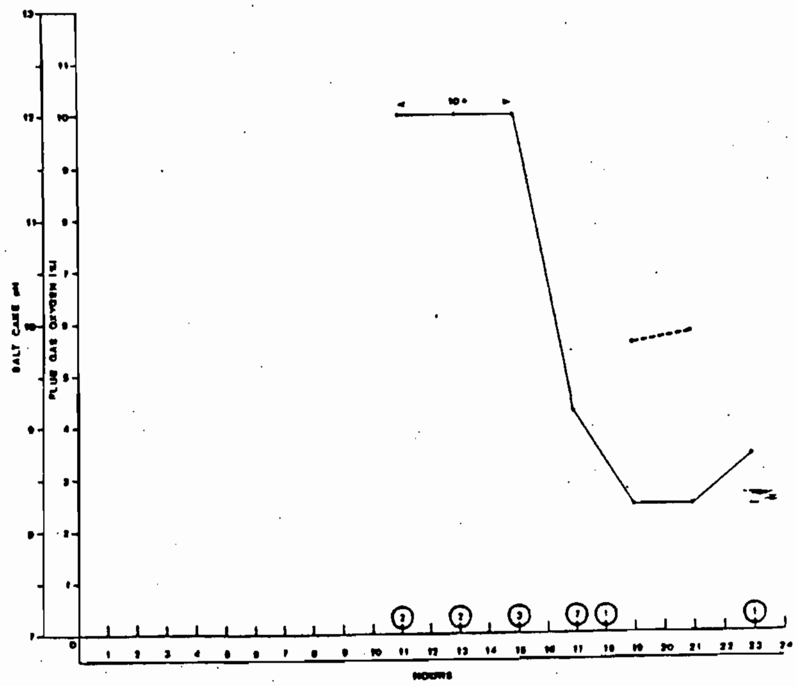
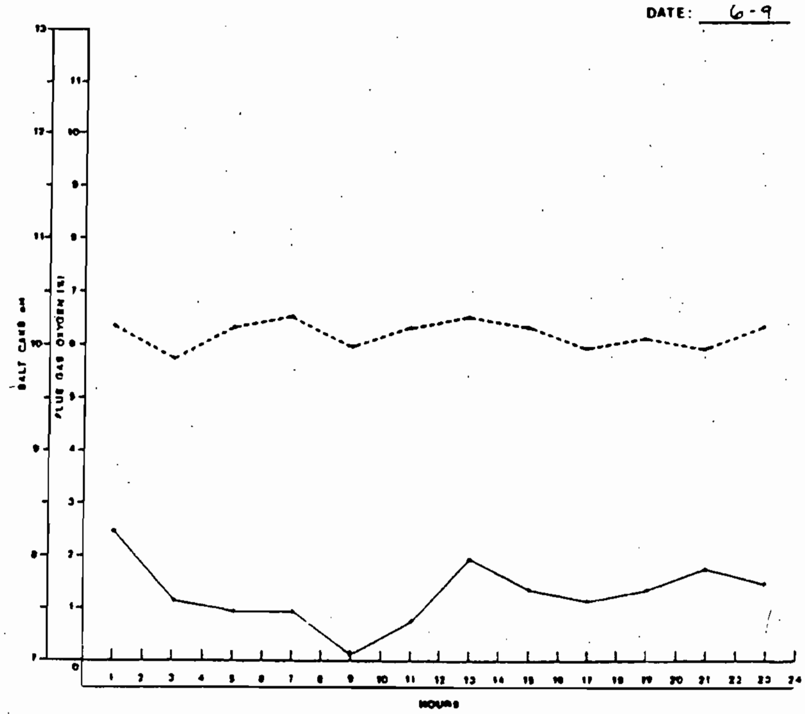
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS


BOILER: 4
DATE: 6-6
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS

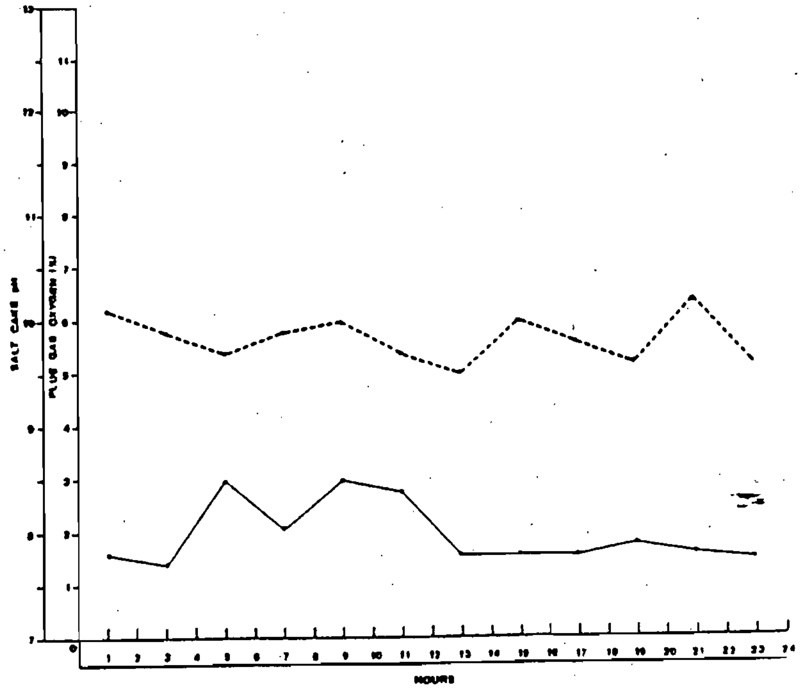
BOILER: 4
DATE: 6-8


SALT CAKE pH
FLUE GAS OXYGEN (%)
10+
HOURS

BOILER: 4
DATE: 6-9


SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS

BOILER: 4
DATE: 6-10



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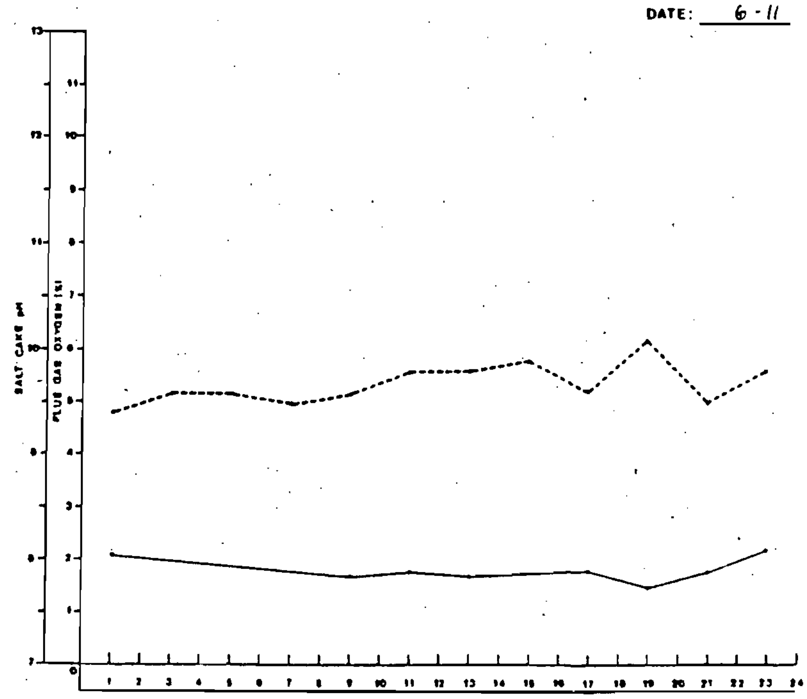

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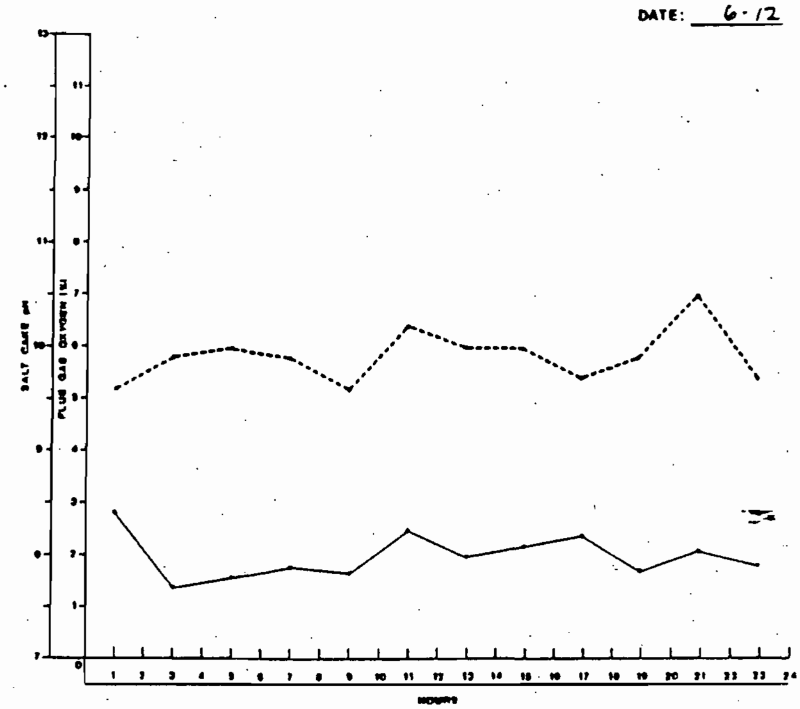

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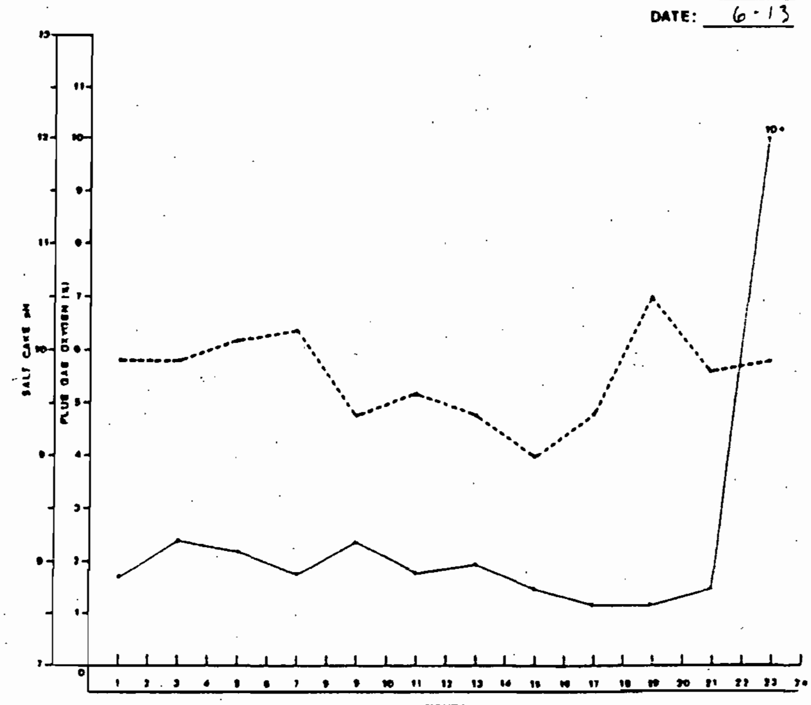

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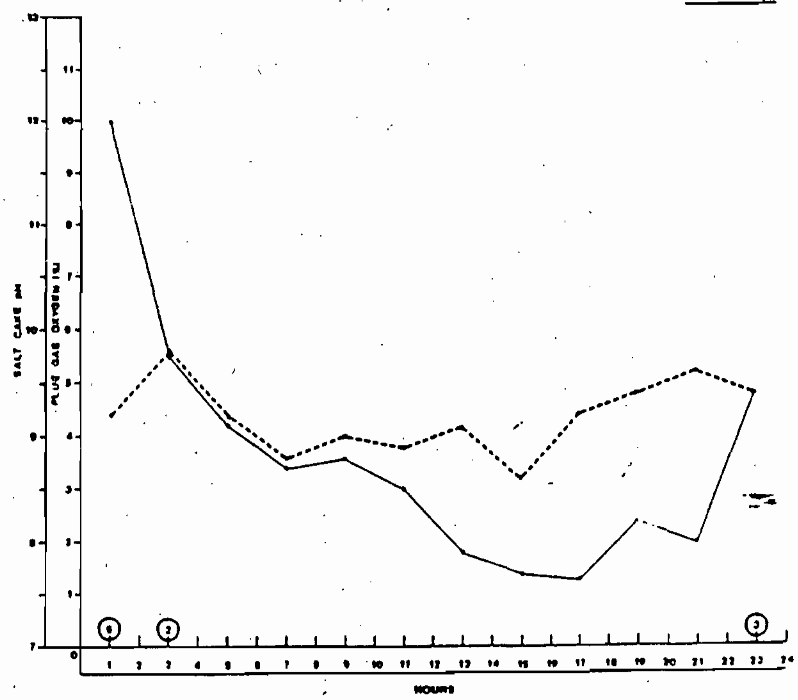

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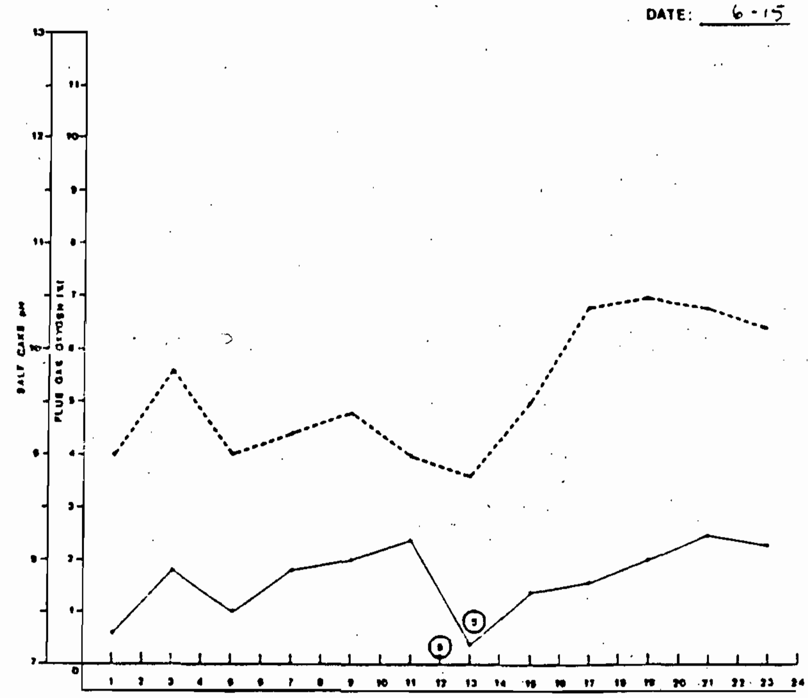

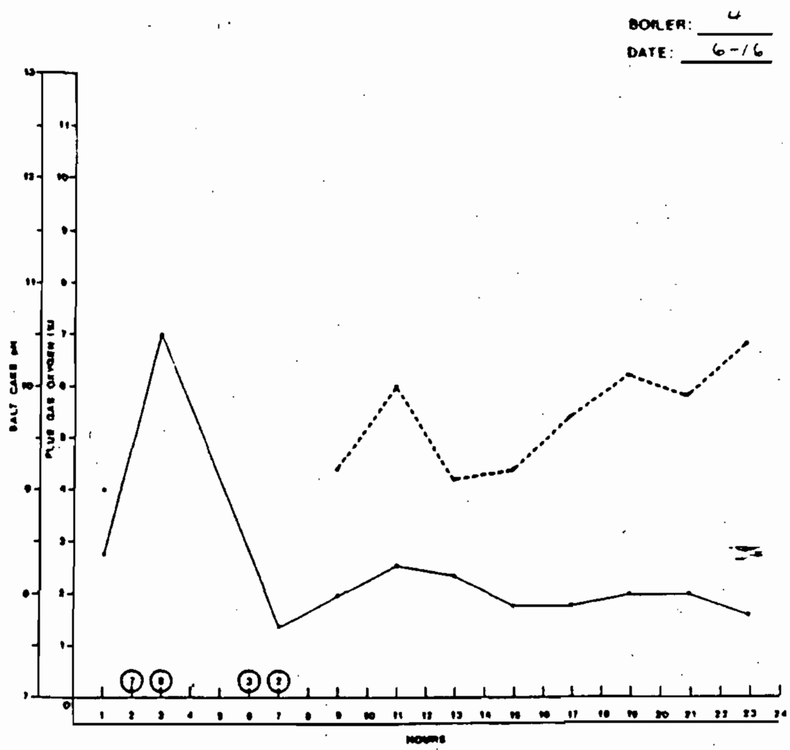
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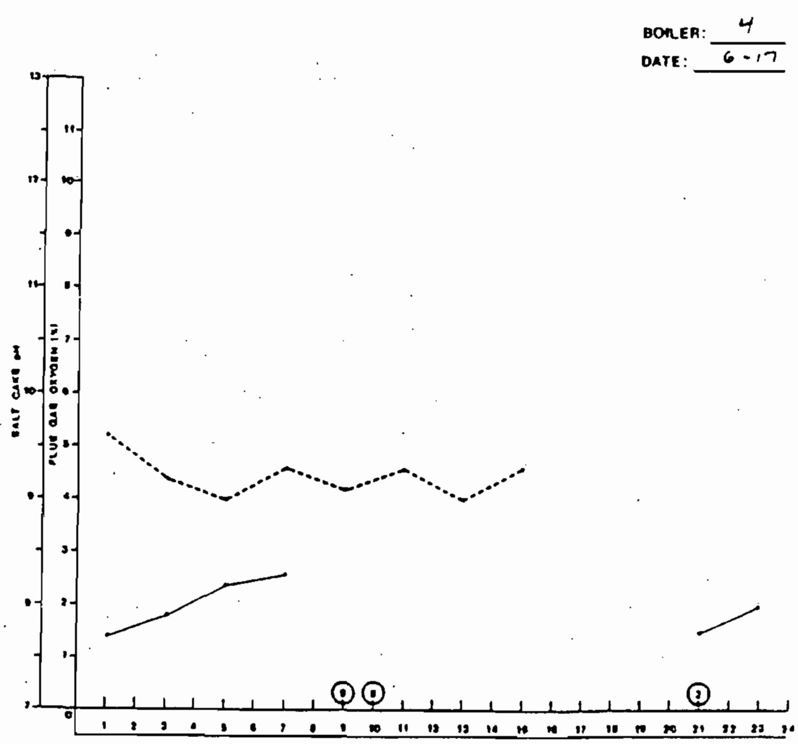
DATE: 6-16
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS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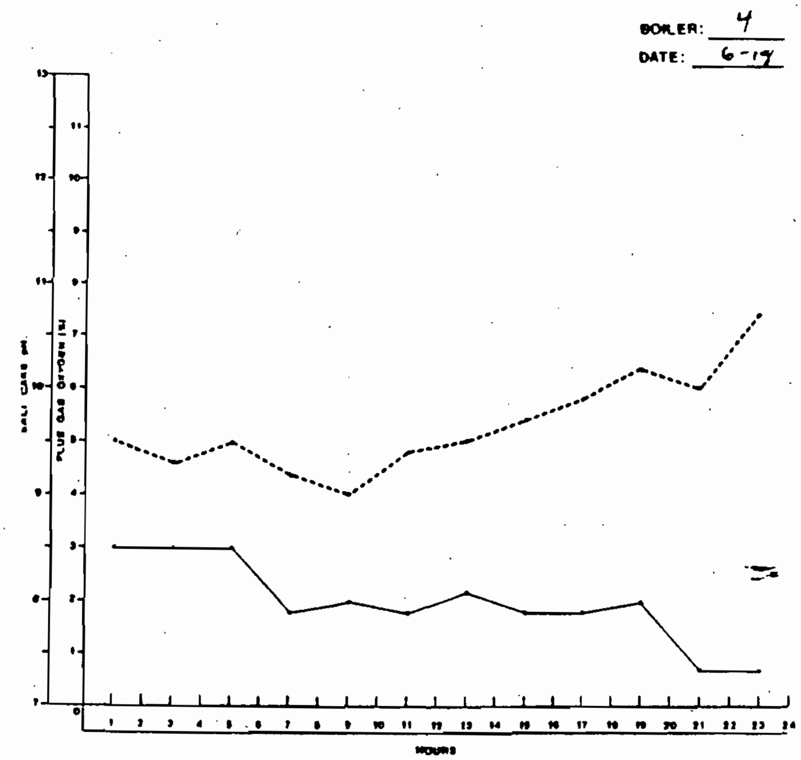
DATE: 6-17
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS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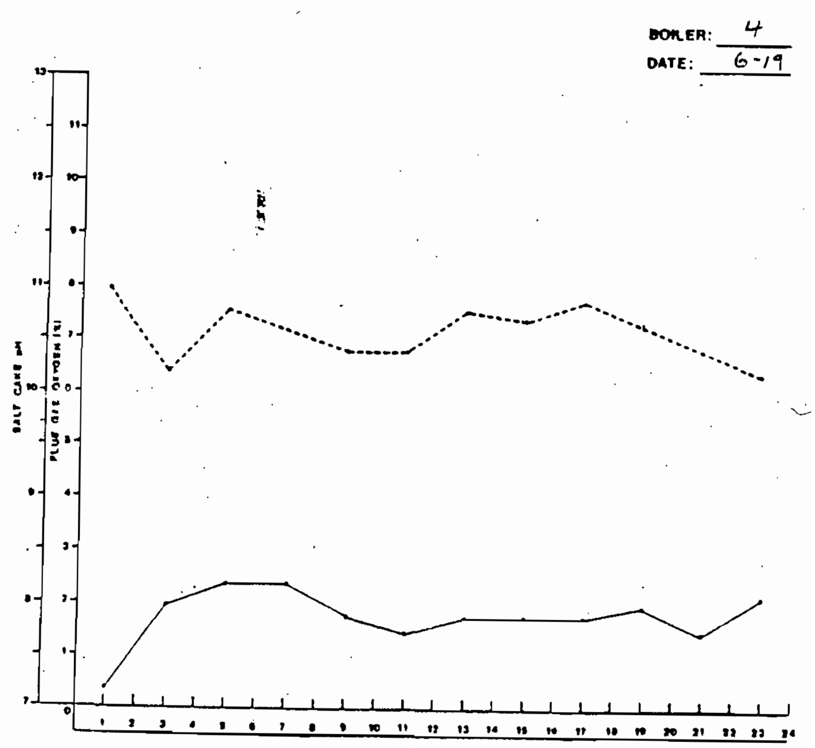
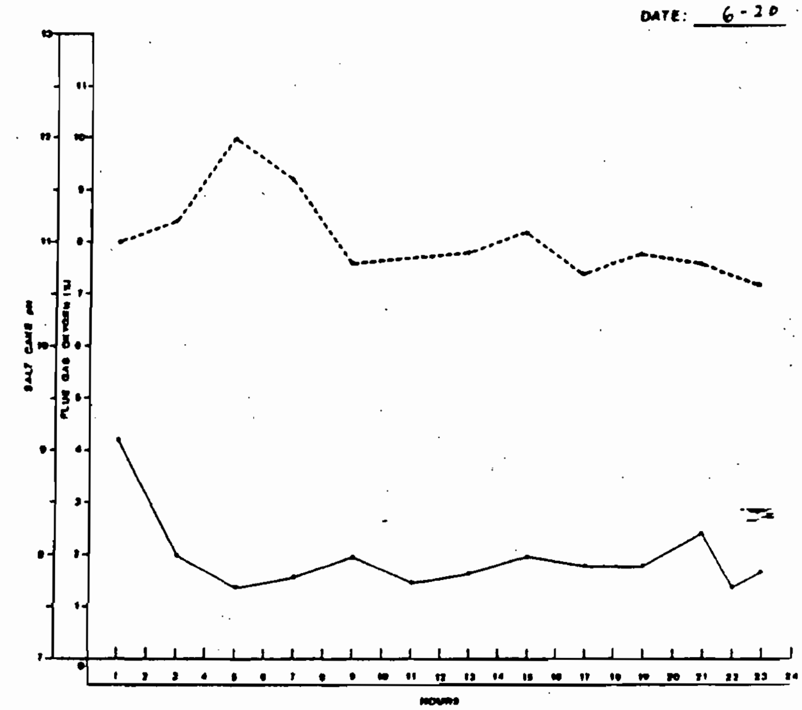
DATE: 6-19
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS


BOILER: 4
DATE: 6-19
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS

BOILER: 4
DATE: 6-20



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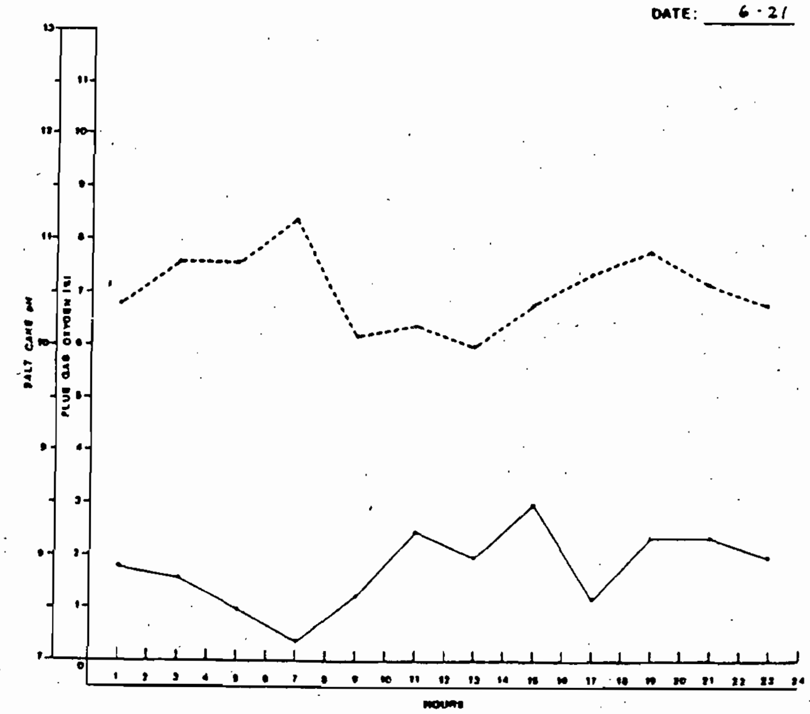

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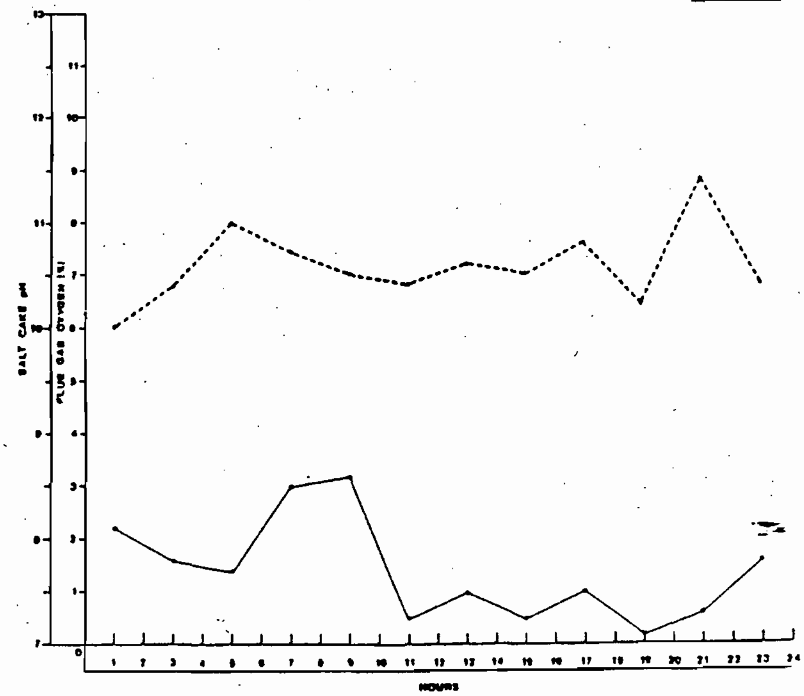

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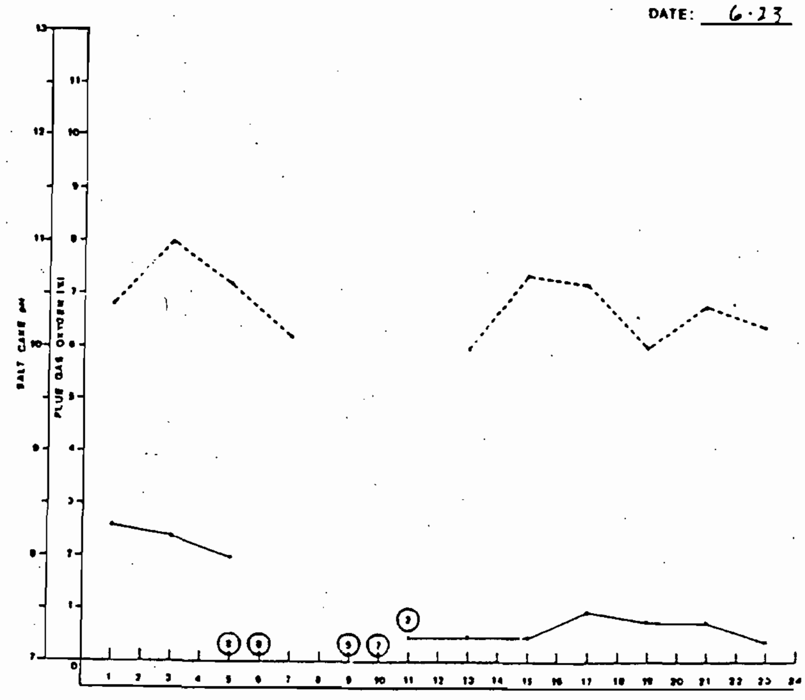
DATE: 6-23



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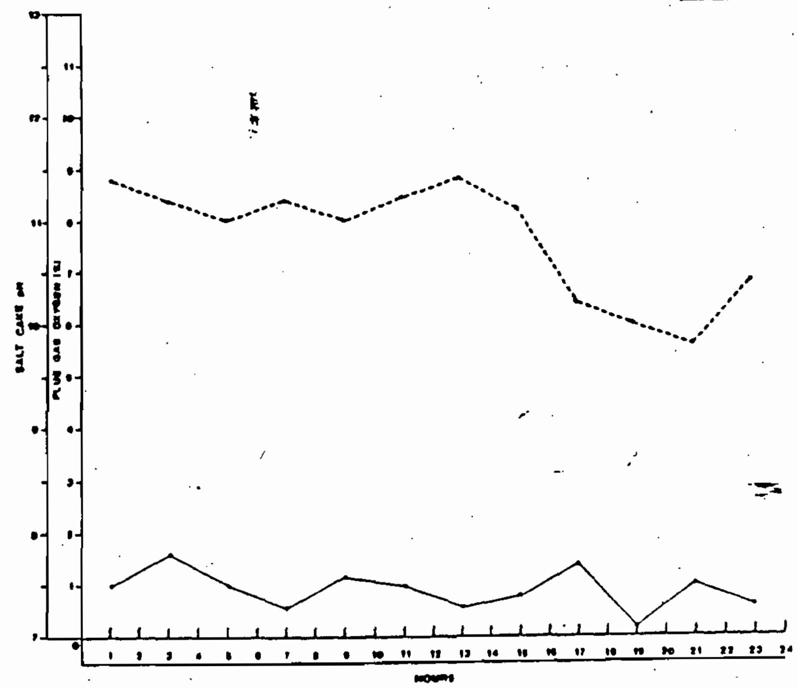
DATE: 6-24



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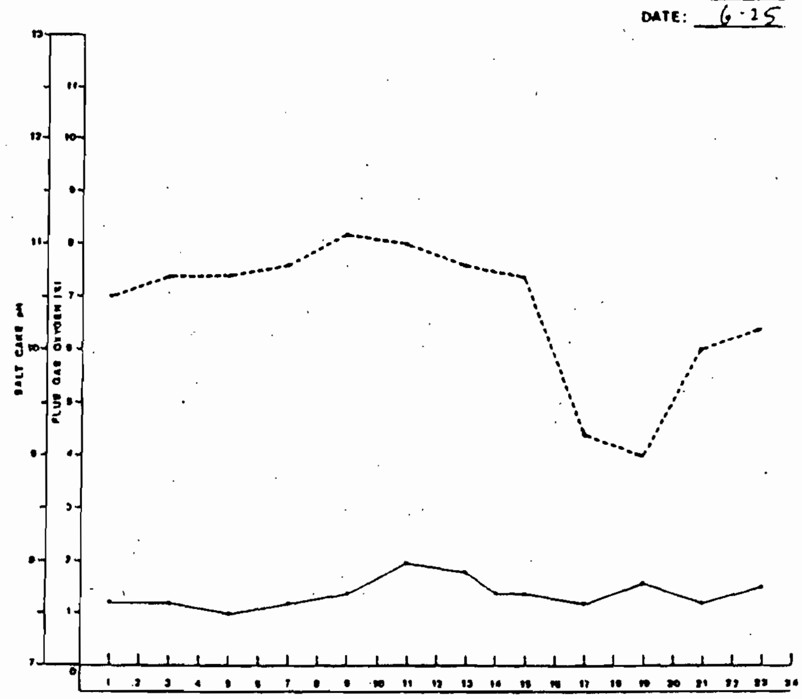
DATE: 6-25



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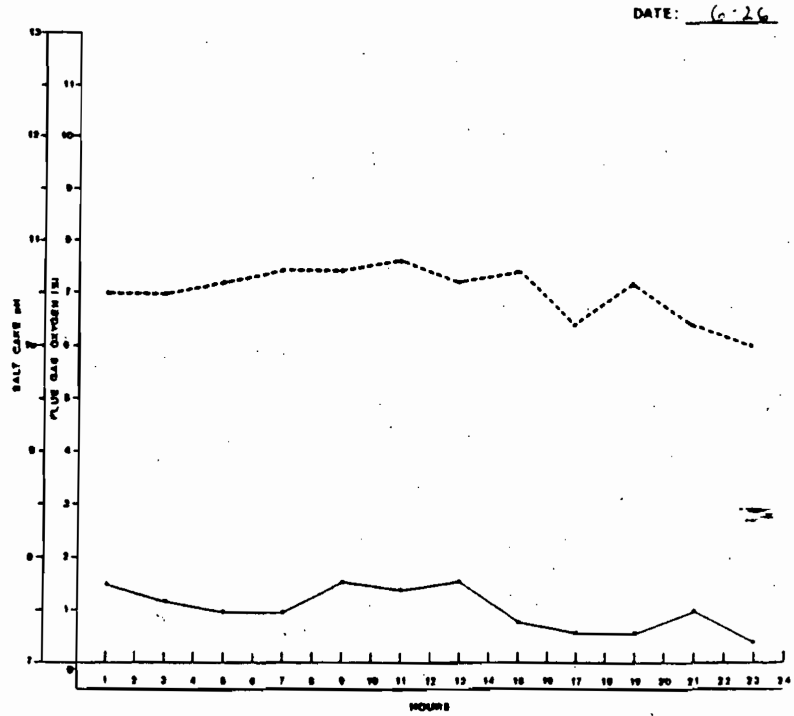
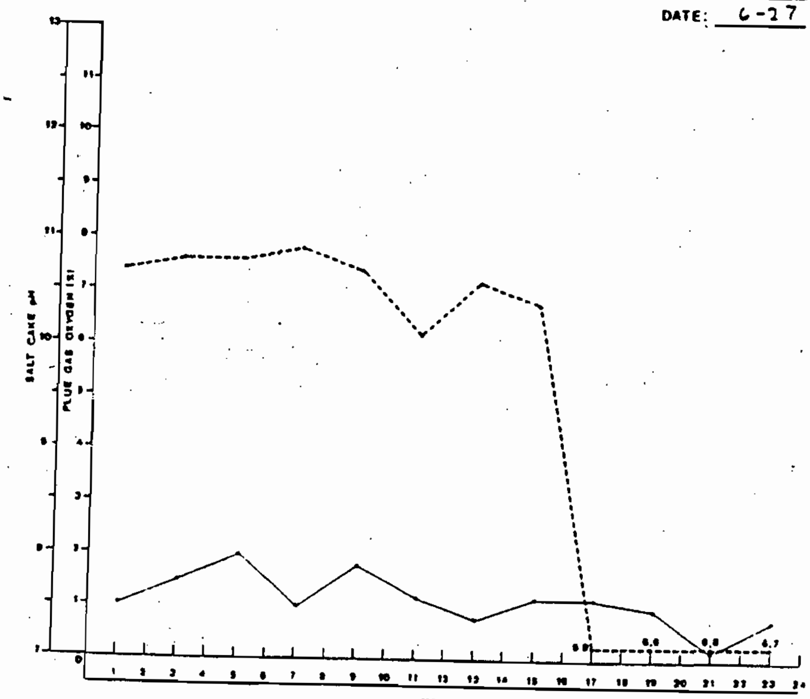
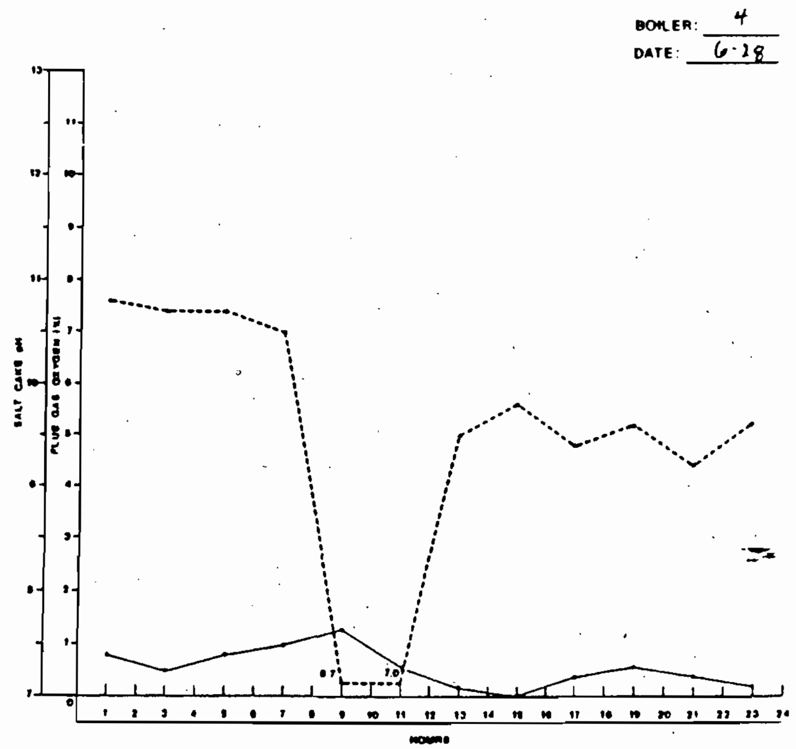
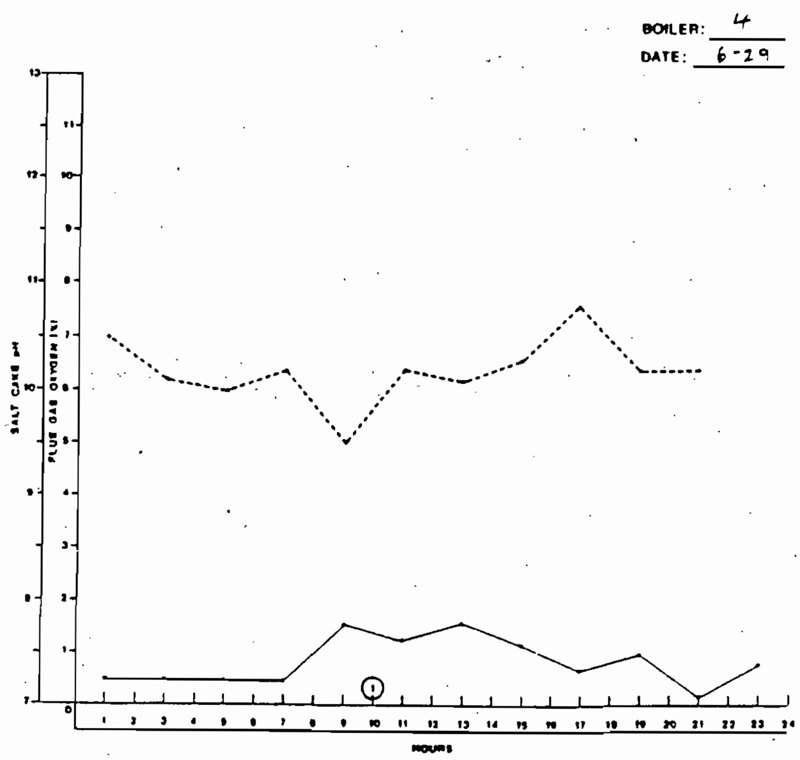
DATE: 6-26



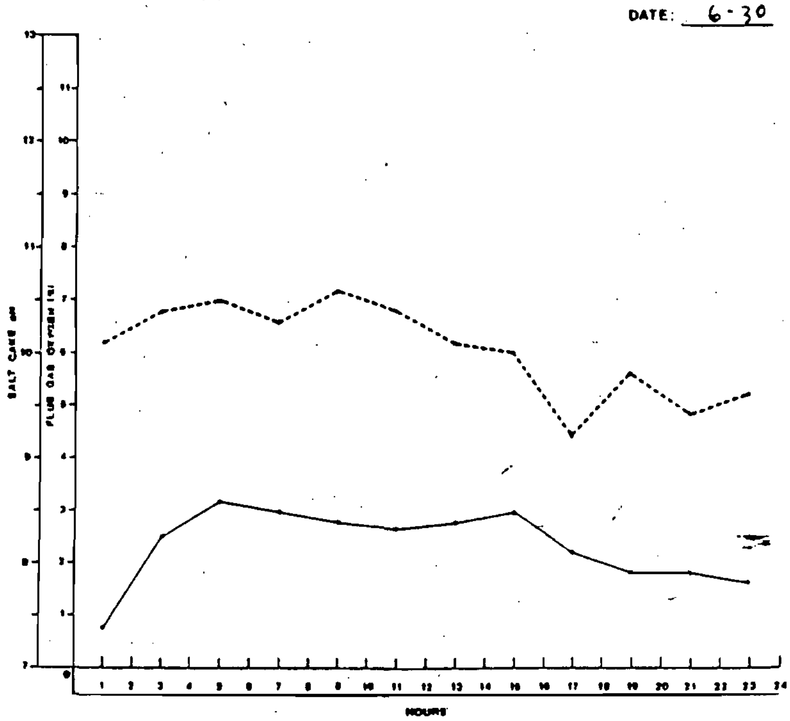
BOILER: 4
DATE: 6-27




BOILER: 4
DATE: 6-28
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS


BOILER: 4
DATE: 6-29
SALT CAKE pH
FLUE GAS OXYGEN (%)
HOURS

BOILER: 4
DATE: 6-30



APPENDIX D

PUBLISHED COMPUTERIZED MAINTENANCE PROGRAM[a]

[a] EPRI O&M Conference 1982.

COMPUTER COMPILATION OF PARTICULATE CONTROL EQUIPMENT MAINTENANCE RECORDS

By:

J. Lagomarsino
P. Goldbrunner
Burns and Roe Inc.
Oradell, New Jersey

ABSTRACT

This paper explains what can be expected from computerized maintenance record systems. Most systems currently in use are general record-keeping programs. As such, they are not very useful in providing a data base for managerial decisions. They store and retrieve but do not compile the large amounts of data involved in a typical set of maintenance records.

The price of small computers is dropping rapidly as their capabilities expand. A small computer, equipped with appropriate programs, can handle the records for a typical plant. Relatively inexpensive customized programs can enable the computer system to produce concise, understandable reports of maintenance costs and component failure frequencies. The results attainable by data compilation are illustrated with examples.

I. INTRODUCTION

The ability to learn from your experiences is especially important in the ever-evolving field of particulate removal systems. A utility should be able to use its experience to guide future equipment expenditures and to schedule maintenance of existing equipment in a timely fashion. For application in these ways, the utility maintenance data must be available in a reliable, concise, and quantitative form.

II. TYPICAL RECORD-KEEPING METHODS

Most plants use similar systems for keeping records of repair work. An operator or maintenance technician notes a problem and writes a maintenance request form describing it. The maintenance request is sent to the appropriate maintenance department which then schedules the work according to priority and available manpower. A maintenance staff leader describes the cause of the problem and the action taken on the maintenance request form.

If repairs are postponed because parts are unavailable or the problem cannot be corrected while the plant is in operation, the maintenance request form is filed as work waiting for parts or work waiting for an outage.

After the repair is complete, the maintenance request is filed according to the system involved. Most plant accounting departments also provide a way for recording manpower and equipment costs of repairs by system. However, the classifications used for accounting purposes are usually in terms of major pieces of equipment (e.g., boiler, coal handling system etc.) and make it impossible to identify specific problem components. Although some plants try to collate maintenance request forms by component and problem, few actually succeed. Information organized in this way would be useful because it points out recurring problems.

The record system at most plants is based on the maintenance request forms. These forms are usually adequate for their primary function of identifying and initiating maintenance work, however, most do not fulfill their secondary function as maintenance records because they are either too complex to be filled out, or too simple to provide adequate information. Additionally, outage work is often done without the use of maintenance request forms and causes incomplete records. In any case, the maintenance request forms themselves are not a good medium for long-term record keeping. After a relatively short time, so many forms accummulate that sorting through them to determine recurring problems is a burdensome task.

For the EPRI study "Reliability Assessment of Particulate Removal Systems" (EPRI-RP 1401-1), ESP and fly ash removal system maintenance request forms from several plants were collected and the information was compiled manually. This procedure was very time consuming. A record system which would automatically maintain a running total of failures and costs by component would provide an accurate quantitative profile of problem areas. A well-planned computer-based system can fulfill these requirements.

A good maintenance record system should fulfill both the communications requirements of the plant maintenance departments and the long-term record keeping requirements of the utility. The keys to a good maintenance record system are a maintenance request form that is simple yet complete, and an information file that permits easy retrieval.

III. THE MAINTENANCE REQUEST FORM

A good maintenance request form is important because the form is used frequently by many people. The form requirements must be self-explanatory to preclude the need for repeated instruction of personnel. Care must be taken to include only items necessary for the dual purpose of promptly executing repairs and providing relevant historical information.

Examination of nine plant maintenance record systems has indicated that a maintenance request form should include at least the information on the example printed in Figure 1. The format of the form must permit plant personnel to fill in the required data quickly and accurately. It must also place important data in prominent positions. Finally, the format should be adaptable to computerized organization of relevant data.

Figure 1 is an example of a maintenance request form that meets the requirements for comprehensive maintenance data collection. It is designed with four basic sections: the categorical breakdown section, originator's section, craftsman's section and maintenance foreman's section. The originator checks the assignment, priority, and unit status related to the problem and briefly describes the problem noted. He writes the date and time and signs the form.

The maintenance foreman determines the cause of the problem and when it can be corrected (immediately, when tools and/or parts are available, or during a scheduled outage). He signs and dates his entry. He describes the repair after it is completed.

The maintenance supervisor lists the materials, material costs, and manhours expended in making the repairs. He then signs and dates his entry.

UNIT	SYSTEM	SUBSYSTEM	COMPONENT	SUBCOMPONENT

MAINTENANCE REQUEST FORM 000000

ORIGINATOR: ______ DATE: ______ TIME: ______

ASSIGNED TO:

1	MECH.
2	ELECT.
3	INSTR.

PRIORITY:

1	EMERGENCY
2	SAME DAY
3	ROUTINE

UNIT STATUS:

1	NORMAL
2	DERATED
3	DOWN

PROBLEM DESCRIPTION: ______

FOREMAN: ______ DATE: ______ JOB STATUS:

1	REPAIRABLE
2	HOLD FOR: TOOLS
3	PARTS
4	OUTAGE

CAUSE OF PROBLEM: ______

WORK DONE: ______

SUPERVISOR: ______ COMPLETION DATE: ______

MATERIALS USED: ______

TOTAL MANHOURS	MATERIAL COST

Figure 1

The boxes at the top of the form are the keys to organizing the maintenance data in a form suitable for use in computer compilation. Short but clearly descriptive words must be selected to identify items requiring maintenance. The first box identifies the plant unit on which the problem has occurred. The next four boxes identify the problem component in relation to the system, subsystem, and major assembly in which it is located. For example, the bearings of a fly ash transport blower can be identified as follows:

System - pollution control

Subsystem - ash removal

Component - transport blower

Subcomponent - bearings

Such an identification system would make it easy to sort maintenance requests and thus keep track of equipment failure frequencies.

In implementing a maintenance record system, a utility should take action to encourage its proper use. The utility should also require plant personnel to use the maintenance request system to record outage work.

IV. THE RECORD FILING SYSTEM

A good filing system is essential for retrieving maintenance record information. The ability to compile and sort the files in a number of ways is desirable. For instance, a plant with several units would want maintenance records sorted by unit number. But to identify problem areas, the records should be sorted by equipment regardless of unit number. A sort useful in personnel administration to determine optimum department size would be by maintenance department handling the repairs. The desired methods of sorting the information will vary from plant to plant or even within the same plant over a period of time. For many reasons, it is important to organize the data base in a manner sufficiently flexible to accommodate future changes in the use of the information.

Many utility companies are converting maintenance requests into computerized data files, using commercially available general-purpose record-keeping programs. Such programs generally permit storing a short description of the problem, the action taken, and most other information from the maintenance request form. This stored information can be sorted and listed in several ways. However, these computer routines only list each maintenance request entry, and do not perform data compilation.

Other utilities use more sophisticated programs which permit storage of additional information such as maintenance labor costs and subcontractor material and labor costs. Again, these programs permit several different types of listings, and some also permit totaling of costs by system. However, most programs in use today list individual maintenance requests as principal output. This type of listing is usually too bulky to be of use to management personnel. A better approach would permit grouping of the data by component and indication of the number of maintenance requests in the component category. A graphical presentation of this data would make problem areas immediately visible and eliminate the need for searching through page after page of maintenance request listings.

The output from the computer program is probably the most important aspect of the entire system but it is often neglected. The output is the only part of the system that need be seen by utility management. The data must be presented clearly so that trends in equipment maintenance can be detected immediately in a quantitative way. With information organized in this way, the utility can make educated and well-justified decisions on equipment expenditure.

To point out trends direct comparisons must be presented in the output. For example, the maintenance costs of various plant systems over the same period of time could be compared. Alternatively, maintenance costs for one piece of equipment could be compared over time. The first type of comparison would point out high-maintenance equipment while the second would indicate equipment in deteriorating condition.

Figure 2 is an example of how data can be formatted to assist in staffing decisions. In this bar chart format, it is easy to compare how repairs and workload are distributed among the major maintenance departments. Similarly, Figure 3 compares the numbers of repairs delayed because of tool or parts outages, and could assist in determining how to allocate funds for inventory buildup.

Figure 4 presents a format for the display of repair information. It compares maintenance data in three categories for subsystems of the air pollution control system. The size of each bar section clearly indicates the magnitude of problems caused by that subsystem. This type of graph also allows ready comparison of whether a problem is labor, material or capital-intensive by comparing the size of a section from one bar to another.

As an example of the flexibility which is desirable in data compilation, the ash removal subsystem data from Figure 4 is broken down to the component level in Figure 5. Then, the information regarding the transport line component is further broken down to its subcomponent level in Figure 6. The data presented on these last two graphs is on too low a level to be

DEPARTMENT PROFILE

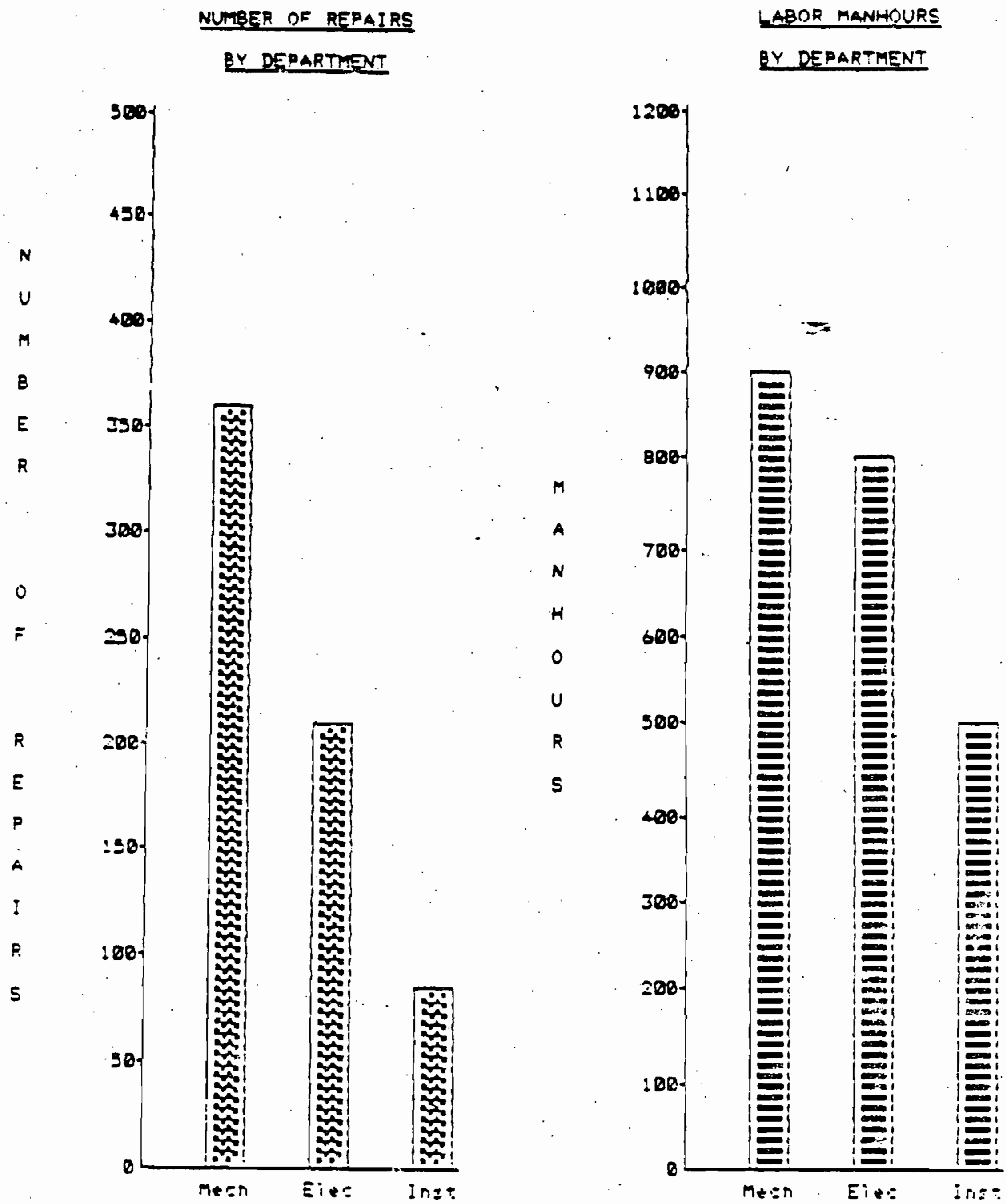


Figure 2

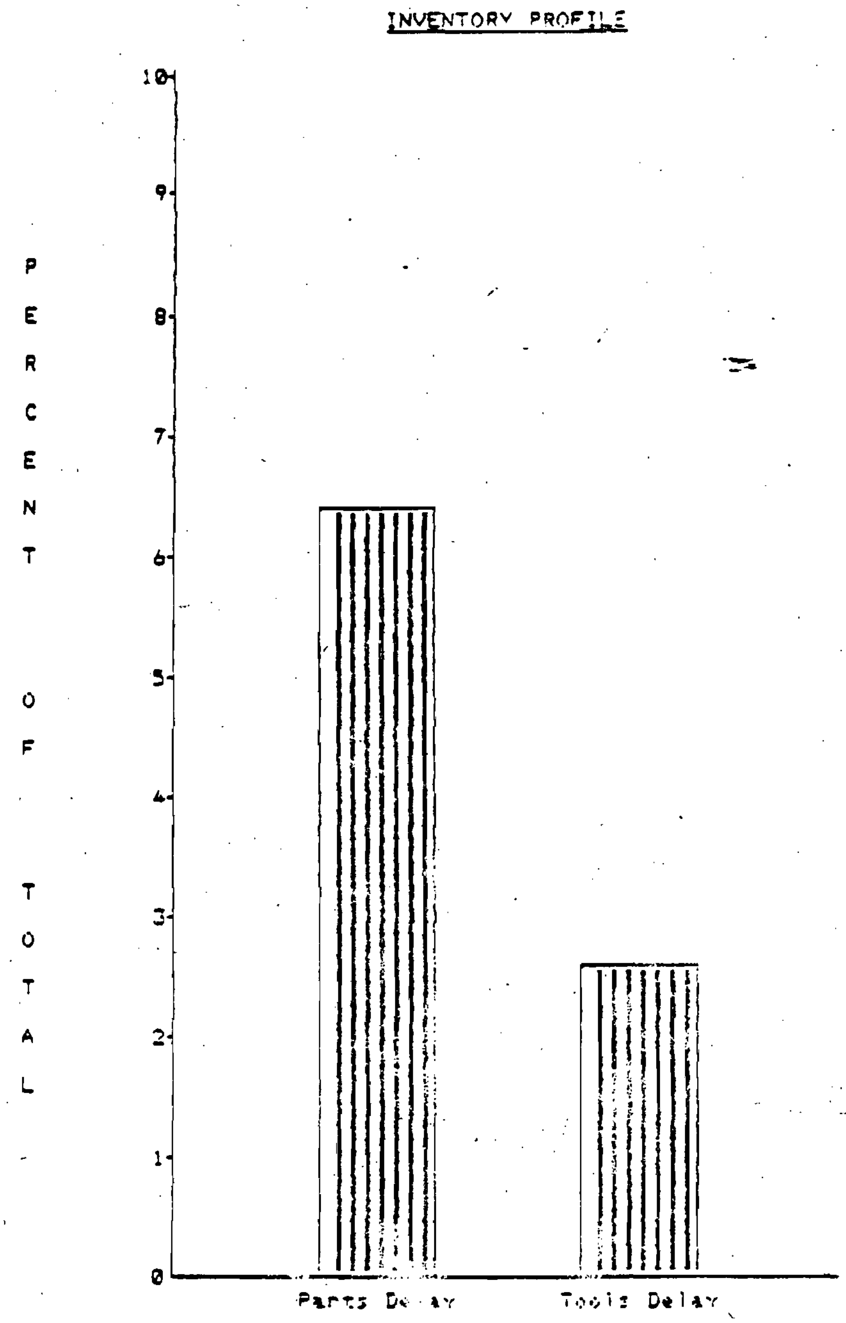

INVENTORY PROFILE
PERCENT OF TOTAL
10
9
8
7
6
5
4
3
2
1
0
Parts Delay
Tools Delay

Figure 3

MAINTENANCE SUMMARY

AIR POLLUTION CONTROL SYSTEM

JANUARY 1982

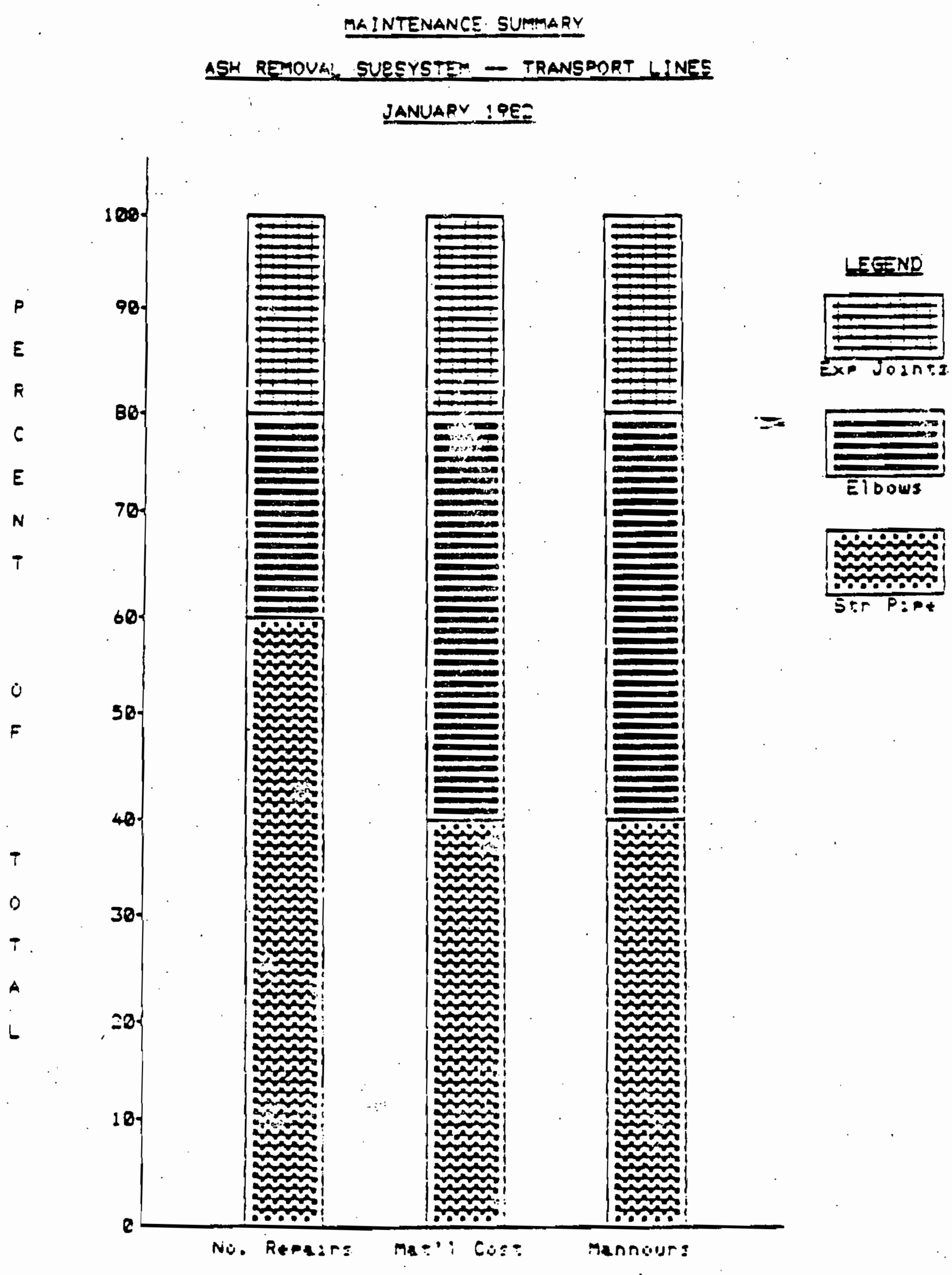
Figure 4

MAINTENANCE SUMMARY

AIR POLLUTION CONTROL SYSTEM — ASH REMOVAL SUBSYSTEM

JANUARY 1982

Figure 5



MAINTENANCE SUMMARY
ASH REMOVAL SUBSYSTEM — TRANSPORT LINES
JANUARY 1982
PERCENT OF TOTAL
100
90
80
70
60
50
40
30
20
10
0
No. Repairs
Mat'l Cost
Manhours
LEGEND
Exp Joints
Elbows
Str Pipe

Figure 6

part of the regular program output. However, detailed information should be available on request to permit exact identification of problem equipment.

V. SOFTWARE CONSIDERATIONS

The flexibility which is such an important part of this system, is largely dependent on the computer programs which direct the system. A program is a set of instructions which guide the computer through the functions which must be carried out and thereby, give the system its characteristics.

Functions accomplished by the software include data entry, data retrieval, editing, compilation and, finally, report preparation. The requirements for the software must be laid out carefully to ensure a successful system. The data entry software should be designed for efficient use with simple but specific equipment identification methods. The data compilation software should be designed to permit data breakdowns that are as flexible as possible. The report preparation software should be designed to produce reports which are simple and easy to understand.

VI. HARDWARE CONSIDERATIONS

The most important factors to consider in computer equipment selection are: program memory size, operating speed, data storage capacity and investment cost.

The size of program memory limits the sophistication of the programs and, therefore, limits the flexibility of the system. However, even today's microcomputers are generally equipped with enough memory for quite elaborate programs.

The computer's operating speed is important only if operating charges are based on usage time. With a micro or mini computer dedicated to this one task, there would be no additional cost for longer run times, only minor operator inconvenience. Therefore, operating speed is not a critical consideration.

Data storage capacity is probably the most influential factor in determining the size of the computer system required for this application. The maintenance data is stored on magnetic disks so that it is accessible to the computer for processing as the programs call for it. The storage capacity is defined in terms of characters. Microcomputers are adequate for applications which acquire up to 1 or 2 million characters of data to be available at the same time. Applications requiring more storage are better handled by minicomputers.

If the data from the maintenance request forms is placed on disk as shown in Table 1, each maintenance request can be stored as 370 characters. This would permit storage of data from about 3000 maintenance requests on a popular microcomputer disk format which can store 1.25 million characters. Three thousand records is about two months' data storage for a plant producing 50 maintenance request forms per day.

The hardware investment can be as low as $10,000 for a microcomputer and increases with the requirements of the system. Software cost will vary with complexity, but once a program is written, it can be used by any number of plants. Therefore, the cost of software development does not have to be borne by any one plant or utility.

Once the system is installed and running, virtually the only operating cost is in the manpower required to enter and maintain the data. Hardware operating costs are minimal for micro or mini computers.

So, quantitative maintenance data should be available to utilities for a relatively small investment.

VII. CONCLUSIONS

A maintenance record system as described above will provide a utility with quantitative data about its own equipment problems. Armed with this type of information, the utility will be better equipped to solve its maintenance problems. Quantitative and concise information will help reduce costs in three ways. It identifies and defines problems, thereby expediting solutions. Secondly, it provides information useful in optimizing levels of plant staffing and inventory. Finally, it will aid in accurately evaluating future capital expenditures committed to alleviate operating and maintenance problems.

Table 1

Maintenance Request Data Storage Requirements

Characters	Field
6	Maintenance Request Number
2	Unit No.
12	System . . . Subcomponent (3 digits x 4 categories)
16	Originator Name
8	Origination Date
4	Origination Time
3	Assignment, Priority, Unit Status
65	Problem Description
16	Foreman Name
8	Date of Work
1	Job Status
65	Cause of Problem
65	Work Done
16	Supervisor Name
8	Completion Date
65	Materials Used
4	Total Manhours
6	Material Cost
370	Total Characters

FOSSIL MAINTENANCE DOCUMENTATION
AT
DUKE POWER COMPANY

By:

W. O. Rose
Duke Power Company
Charlotte, North Carolina

Another result of the study was the implementation of the Work Request System. This is the area I will address today. This document (Attachment C) is used in each of our fossil stations. The document serves these basic functions:

1) Authorize and define work to be performed by the maintenance function,

2) Used as an input document for entry of information into data processing and cost accounting system.

These functions are attained by:

(a) providing for systematic screening and authorization of requested work

(b) providing information required for the planning, scheduling and coordinating of all authorized work to be performed

(c) accumulating information of job progress and cost as a basis for improving and reporting on cost and performance

(d) supplying supervision and craftsmen with complete job instructions and the estimated time to complete the work

(e) pinpointing equipment in need of modification, redesign or replacement

(f) collecting data on maintenance operations and costs for use in planning, budgeting and special studies.

Again on Attachment C, some of the key areas are as follows:

1) "Date" - The date is the day the problem was discovered or the job defined. It is used to determine execution - "first in, first out" on equally important jobs.

2) "Approved by" - This verifies the need for work and job priority.

3) "Priority" - Job urgency is classified on a (code) scale from 1 to 5. Priority one's (1) are for emergency work. Priority two's (2) are for urgent work which should be completed during the day. Three's and four's (3 and 4) can be delayed and planned. Five's (5) are work jobs which must be completed during an outage.

4) "W.R. No." - The work request number is the document control number assigned by the planning group.

5) "Equipment Number" - All major equipment and equipment cost centers are given a number. That number forms the basis for cost classification.

6) "Description of work" - Originator describes work to be done with details stated clearly and concisely. Planner may add information.

7) "Estimated Labor" - Planner completes this section; by breaking the job down into steps, listing the crafts in proper sequence, specifying crew size and hours required.

8) "Material description" - Planner enters description of material, stock number, and quantity needed.

9) "Action taken" - A space is provided on the back of the document for the job supervisor or craft personnel performing the task to enter action taken.

The actual manhours are recorded on the time distribution sheet by job and craft personnel. This is shown as Attachment D and is also used for payroll tickets.

Data from the work request system has been stored on computer files. Various programs have been developed to select, sort, and analyze this data. For example, looking at the last six months in 1981, Belews Creek data on Attachment E, we can observe the normal work force of 10,000 man hours jump to 30,000 in October because of a major unit outage. With a 300% work force increase, a good document system is needed to insure control.

Using priority to classify the same data and adding together the man hours in priorities "1" and "2", we find 11,600 of the 78,100 hours or 15% of the total in this group. This is shown in Attachment F. A high percentage of priorities "1" and "2" work destroys the work force effectiveness.

A unified equipment numbering system is used for all major equipment associated with the production of electricity and/or operation of Duke Power's fossil steam stations. Each major piece of equipment has an assigned number so that the maintenance costs associated with its repair and upkeep can be accumulated in an equipment history file.

The Equipment Number is a six (6) digit number with each digit designating the information listed below:

First digit	- The Basic System
Second digit	- The Basic Type of Equipment
Third & Fourth digits	- The Class of Equipment
Fifth & Sixth digits	- The Identity or Number Assigned to a Piece of Equipment

Example of an Equipment Number:

X X XX XX

- XX — Numbers the piece of Equipment
- XX — Classifies the piece of Equipment
- X — States the Basic Type of Equipment that the piece of equipment belongs to
- X — States the Basic System that the piece of equipment is part of

The first digit in the equipment number is used to designate the basic system that a piece of equipment is part of. Below is a list of basic systems for use in the application of equipment numbers:

Basic System Number	Basic System Title
1	Steam Generator
2	Turbine-Generator
3	Condensate and Feedwater
4	Fossil Fuel Handling
5	Ash
6	Compressed Gas
7	Service Water
8	Condensers and Condenser Cooling Water System
9	Reserved
0	Miscellaneous

For example, a definition for an ash system has the following limits:

A. Bottom Ash - Shall begin at and include the bottom ash hopper(s) of the boiler along with the ash sluicing equipment.

B. Fly Ash - Shall begin with and include economizer hoppers, precipitator hoppers, fly ash silo, primary air fan hoppers (Belews Creek) and associated piping and equipment.

C. Pyrites - Shall begin with the attachment to the pulverizer mill and terminate at the entrance to the ash sluicing line.

D. Does not include service water pumps or piping.

E. Does not include sump pumps.

F. Shall include pumps used solely for ash and soot removal.

These must be understood by all plant personnel involved to properly assign the numbers.

Using the basic equipment number and sorting on the first digit, the report shown in Attachment G can be compiled. Also, note that each group has been broken down by priorities.

The second digit in the equipment number is used to designate the basic type of equipment that a piece of equipment belongs to. Below is a list of basic types of equipment for use in the application of equipment numbers.

Basic Type Number	Basic Type Title
1	Pump
2	Valve
3	Prime Mover
4	Heat Exchanger
5	Precipitators and Dust Collectors
6	Power Transmission, Conveying and Preparation
7	Electrical Switch Gear, Electric Controls and Servo Controls
8	Reserved

Basic Type Number	Basic Type Title
9	Reserved
0	Miscellaneous

These nine (9) basic types of equipment give adequate breakdown for equipment identification. The third and fourth digits in the equipment number are used to classify a piece of equipment.

Using the first four digits of the equipment number, we can obtain a more detailed listing of equipment cost by name of actual device. This is shown in Attachment H.

By looking at a specific type of equipment, such as the sulfur burner system, a listing of each job completed with description, date, and manhours is available. This is shown in Attachment I.

Additional data can be obtained by looking at a specific priority and equipment type as shown in Attachment J.

By sorting according to date and equipment, other information can be seen as in Attachment K.

By looking at a specific equipment type, equipment history can be determined which may help in design and preventative maintenance. This is shown in Attachment L.

In summary, the work request system (1) has made higher maintenance performance possible, (2) has provided adequate maintenance throughout the plants, and (3) has reduced maintenance costs.

Through computer utilization, the station management can effectively monitor performance, equipment failures and manpower productivity; thereby acting upon and correcting potential work difficulties.

ATTACHMENT A

Sept. 21. Wed.

Welding Hand West Connections No 1 Blr.

Bending outside Casing Firm 4A No Fan. This fan is in much worse condition than 4B. will need weld bunded on Blades on intake side.

F Low Ser. Pump Water Hdbk Box [illegible] - oil [illegible] Removed End bell [illegible]

Welded [illegible] plate in 5C Heater.

Cleaning Preheater wash down valves No 4 Unit.

Sept 22 Thurs.

Completed Hookup of Hand Wash piping No 1 Blr.

Replacing Liners 4A ID Fan.

Cleaning Preheater wash down Valves No 4 -

Made & installed Ladder for [illegible] Stop Valve [illegible]

Sept. 23 Fri.

Started replacing bad section coal transport pipe No 1 Mill.

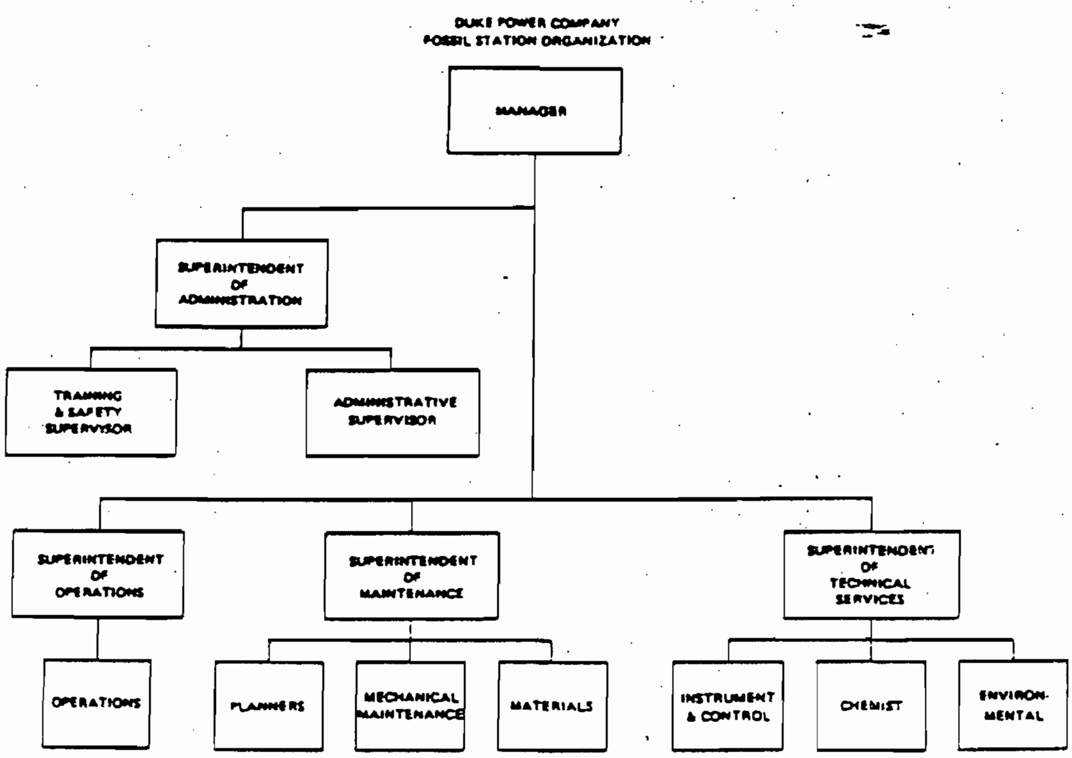
Heater Channel Covers back from [illegible]

Replacing Liners 4A ID Fan

Lapped Seat & disc 5 A Heater shell Safety valve.

Repaired small door to [illegible] [illegible] 1 & 2 Gen...

ATTACHMENT B



ATTACHMENT C

FORM [illegible]

DUKE POWER - SPD	FOSSIL STATION WORK REQUEST	ORIGINATOR	DATE	UNIT	PRIORITY	STATION AS	W. R. NO.
LOCATION - EQUIPMENT	AVAILABLE - DATE	REQ'D. COMP. DATE	RED TAG YES / NO	APPROVED BY	DATE	EQUIP. NO.	

EQUIPMENT NAME OR JOB TITLE	CHARGE TO:	PLANNER	CODE

DESCRIPTION OF JOB	TOOL LIST	CLASS

ESTIMATED LABOR DESCRIPTION OF WORK BY CRAFT SKILLS	SEQ.	CRAFT SKILL	MEN X HOURS	TOTAL ESTIMATED MAN/HOURS

SAFETY PROCEDURES:

SAFETY EQUIPMENT REQUIRED:

REMARKS:

MATERIAL REQUIREMENT DATE REQ'D. DELIVER TO:

DESCRIPTION	STOCK NO.	QTY.	AVAIL.	USED

SPECIAL EQUIP. REQUIRED

ACCEPTED BY	DATE	MAINTENANCE SUPERVISOR	DATE	CODE

ATTACHMENT D

TIME DISTRIBUTION SHEET

DATE	MAINT SUPV	CODE	STATION

CODE	PLANNER

PM ONLY	W/R NO	ACCT NO	DESCRIPTION	NON SCHD	DAILY TOTALS ST	DAILY TOTALS OT		ST	OT	ST	OT	ST	OT	ST	OT	ST	OT	ST	OT	ST	OT	ST	OT	ST	OT	ST	OT	ST	OT	ST	OT	ST	OT	ST	OT	ST	OT

PRODUCTION CODES
NPT NON PRODUCTIVE TIME
CO CALL OUT
CS CHANGE OF SCHEDULE
V VACATION
EA EXCUSED ABSENCE
H HOLIDAY
SA SICK ALLOWANCE
EOS EXTENSION OF SCHEDULE
OTHER EXPLAIN REMARKS ON BACK

TOTAL MANHOURS		
TOTAL NON SCH M/H WORKED	EMERG	
	OTHERS	
TOTAL SCH M/H WORKED		
TOTAL M/H WORKED		

REMARKS:

SUPERVISOR APPROVAL   DATE

SUPERVISOR'S COPY

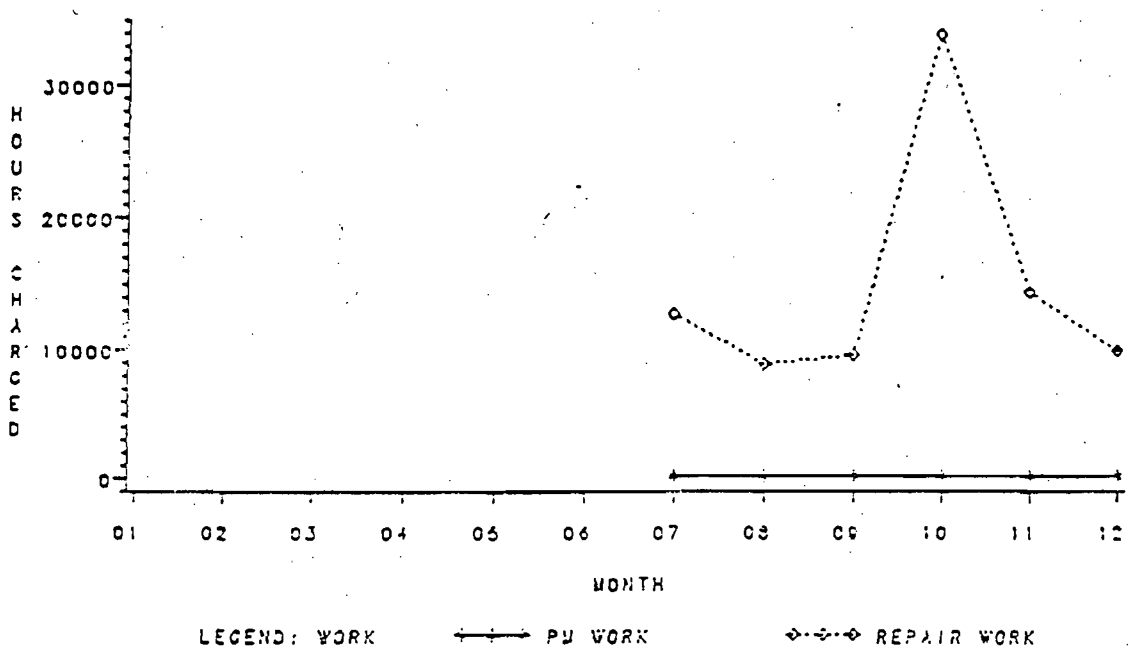
5-31

(180)

ATTACHMENT E

BELEWS CREEK

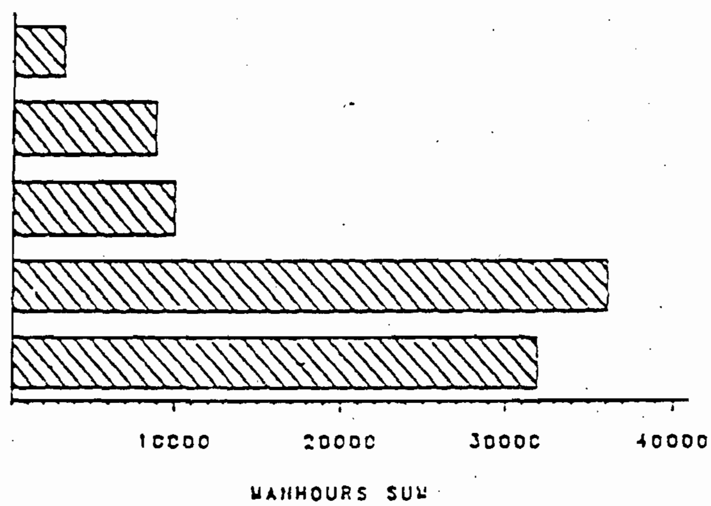
PM WORK VS REPAIR WORK



YEAR TO DATE

1981

BELEWS CREEK
MANHOUR DISTRIBUTIONS BY PRIORITY



PRIORITY	FREQ	MANHOURS SUM
1	310	3212.00
2	1017	8378.00
3	1167	10022.00
4	3470	36136.00
5	1410	31980.00

YEAR TO DATE
1981

Attachment G

7/10/82

BELEWS CREEK

MANHOUR DISTRIBUTION (07/01/81-12/31/81)

SYSTEM NAME	PRIORITY 1		PRIORITY 2		PRIORITY 3		PRIORITY 4		PRIORITY 5		TOTAL M/H (PM INCL.)
	M/H	%	M/H	%	M/H	%	M/H	%	M/H	%	
UNCLASSIFIED	120	.0	791	.3	82	.0	19,106	9.2	738	.3	20,827
MISCELLANEOUS	231	.1	636	.4	1,206	.8	6,853	4.7	5,470	3.7	14,396
STEAM GENERATOR	593	.2	3,974	1.6	2,850	1.2	3,130	1.3	13,040	5.5	23,587
TURBINE GENERATOR	144	.2	322	.6	251	.4	322	.6	4,026	7.9	5,065
CONDENSATE FEEDWATER	417	.6	562	.8	236	.3	442	.7	4,634	7.3	6,291
FOSSIL FUEL HANDLING	1,512	1.4	1,447	1.3	2,600	2.5	2,587	2.4	2,222	2.1	10,368
[illegible]	92	.1	894	1.8	1,937	4.0	909	1.9	934	1.9	4,766
COMPRESSED AIR	30	.1	91	.4	425	1.9	1,668	7.5		.0	2,296
SERVICE WATER		.0	9	1.0	16	1.8	24	2.7	38	4.3	97
CONDENSER SYSTEM	73	.2	242	.9	419	1.5	1,023	3.8	878	3.3	2,435
UY TOTAL	3,212	.3	8,878	.9	10,022	1.1	36,136	4.0	31,980	3.5	90,228
STATION TOTAL	3,212	.3	8,878	.9	10,022	1.1	36,136	4.0	31,980	3.5	90,228

ATTACHMENT H

BELEWS CREEK

EQ NAME	MANHOURS
ELECTROSTATIC PRECIPITA	2,089
SULFUR BURNER SYSTEM	918
ECONOMIZER HOPPER	4
PRECIPITATOR HOPPER	1,082
PRI AIR FAN HOPPER (BC)	117
CLINKER GRINDER	727
SLUICE HANDLING PIPING	904
SEPARATOR TANK	359
ASH LINE	1,393
DRY ASH PIPING (PRESS S	503
BOTTOM ASH HOPPER	1,690
MILL PYRITE SYSTEM	460
FINAL TOTALS	10,246

ATTACHMENT I

BELEWS CREEK
SULFUR BURNER SYSTEM
151023

REQUEST	DATE	MANHOURS	JOB NAME	DESCRIPTION
53010	051481	8	2A SULFUR PUMP	2-A-SULFUR PUMP
53211	062181	10	2B SULFUR PUMP	2B-SULFUR PUMP
53211	062181	16	2B SULFUR PUMP	2B-SULFUR PUMP
60127	0[illegible]781	16	2B SULFUR PUMP	2B SULFUR PUMP LEAK
53376	07[illegible]281	11	#2 B SULFUR PUMP CHECK VALVE	2B-SULFUR PUMP CHECK VALVES
23288	081[illegible]81	16	2B SULFUR PUMP	REPAIR SULFUR PUMP
23288	08[illegible]81	12	2B SULFUR PUMP	REPAIR SULFUR PUMP
23288	08[illegible]81	21	2B SULFUR PUMP	REPAIR SULFUR PUMP
23355	0[illegible]2[illegible]81	8	2B SULFUR PUMP	REBUILD SULFUR PUMP
23355	082081	17	2[illegible] SULFUR PUMP	REBUILD SULFUR PUMP
60530	082381	6	1B SULFUR PUMP	1B SULFUR PUMP OLIVE OIL LEAK
54347	121681	5	2B SULFUR PUMP	2B SULFUR PUMP REPAIRS
54348	121781	13	2B SULFUR PUMP	2B SULFUR PUMP REPAIRS
54348	121781		2B SULFUR PUMP	2B SULFUR PUMP REPAIRS
EQUIP TOTAL		159		

BELEWS CREEK
SULFUR BURNER SYSTEM
151023

REQUEST	DATE	MANHOURS	JOB NAME	DESCRIPTION
52673	022781	2	SULFUR LINE	SULFUR LINE LEAK
52830	033081	2	#2 UNIT SULFUR LINE	#2 UNIT SULFUR LINE
52[illegible]	033081	2	#2 UNIT SULFUR LINE	#2 UNIT SULFUR LINE
53[illegible]4	051381	9	#2 SULFUR SYSTEM	#2 SULFUR SYSTEM LEAK
53[illegible]	080381	20	SULFUR EJECTION HEADERS	SULFUR EJECTION HEADER
5[illegible]9	080381	20	SULFUR EJECTION HEADERS	SULFUR EJECTION HEADER
538[illegible]	080381	22	SULFUR EJECTION HEADERS	SULFUR EJECTION HEADER
538[illegible]	080381	20	SULFUR EJECTION HEADERS	SULFUR EJECTION HEADER
53[illegible]	080381	35	SULFUR EJECTION HEADERS	SULFUR EJECTION HEADER
53829	080381	28	SULFUR EJECTION HEADERS	SULFUR EJECTION HEADER
53829	080381	20	SULFUR EJECTION HEADERS	SULFUR EJECTION HEADER
5422[illegible]	112781	20	UNPLUG SUFLUR NOZZLES	UNPLUG SULFUR NOZZLES
54224	112781	4	UNPLUG SUFLUR NOZZLES	UNPLUG SULFUR NOZZLES
EQUIP TOTAL		204		

BELEWS CREEK
SULFUR BURNER SYSTEM
151024

REQUEST	DATE	MANHOURS	JOB NAME	DESCRIPTION
22[illegible]5	042181	12	SULFUR CAR	REPAIR GASKET
52[illegible]70	05[illegible]681	2	SULFUR LINE	SULFUR LINE-STEAM TUBING LEAKING
12[illegible]1	063081	8	SULFUR SYSTEM RECORDER	REPAIR CHART #40
23460	092381	9	SULFUR LEAK AT CAR HOOK-UP	REPAIR SULFUR LEAK
23460	0923[illegible]	8	SULFUR LEAK AT CAR HOOK-UP	REPAIR SULFUR LEAK
23460	0923[illegible]	8	SULFUR LEAK AT CAR HOOK-UP	REPAIR SULFUR LEAK
23460	0923[illegible]	12	SULFUR LEAK AT CAR HOOK-UP	REPAIR SULFUR LEAK
13351	0223[illegible]	6	COMBUSTION AIR FLOW	CAL RCRD-IND INCORR
13364	022[illegible]82	6	TL-17 SO3 SYSTEM	REPAIR-CAUSES SO3 PMP TO TRIP
13365	022682	3	#7 SO3 SYSTEM	REPLACE PRESS GAUGE
13436	0[illegible]1282	6	SULFUR SYSTEM	CAL GAUGE & SWITCHES
EQUIP TOTAL		80		
EQ NAME TOTAL		918		

ATTACHMENT J

1 BELEWS CREEK
02/03/82

EQUIPMENT	DATE	UNIT	PRTY	REQUEST	JOB NAME	DESCRIPTION
164475	01/02/82	02	2	69082	2BF-15	2BF-15
1644A3	01/02/82	001	2	69115	1AF 3 NUVA FEEDER	1AF-3
1644A2	01/02/82	001	2	69114	1AF 2 NUVA FEEDER VENT LINE	1AF-2
164413	01/02/82	001	2	69119	1AF-13 NUVA FEEDER	1AF-13
164424	01/02/82	001	2	69120	1AF-24 NUVA FEEDER	1AF-24
164463	01/03/82	2	2	69102	2AF 23	2AF23
1644D3	01/04/82	02	2	54408	2BF 3	2-BF-3 VENT LINE STOPPED UP
1644D4	01/04/82	02	2	54409	2BF 4	2-BF-4 STOPPED UP
164430	01/05/82	1	2	69123	1BF17	1BF-17
164441	01/05/82	1	2	69124	1BF 20 VENT LINE	1BF-20
164439	01/08/82	1	2	23912	1BF 18	UNSTOP VENT LINE
164453	01/10/82	002	2	23926	2BF-13	REPLACE AIR CYLINDER
164453	01/11/82	2	2	54449	#2 AF-13 HOPPER VENT VALVE	2-AF-13 VENT VALVE SOL
164451	01/11/82	02	2	54455	2AF-11	2-AF-11 DOT GATE
164442	01/12/82	1	2	69201	1BF 21 NUVA FEEDER	1BF-21
164433	01/12/82	1	2	69200	1BF 13 NUVA FEEDER	1BF-13
1644B3	01/12/82	1	2	69199	1BF 3 NUVA FEEDER	1BF-3
164438	01/16/82	1	2	54481	1BF 17 NUVA FEEDER	1-BF-17 TOP GATE SOL.
164459	01/20/82	002	2	54904	2AF-19	2-AF-19-VENT VLV BLOWING THRU
164418	01/20/82	001	2	69235	1AF-18	1AF-18 PREC HOPPER TOP GATE SOLENOID
164420	01/20/82	001	2	69234	1AF-20	1AF-20 PREC HOPPER TOP STONE REPLACE
164443	01/22/82	001	2	69240	1BF-22 NUVA FEEDER	1-BF-22 NUVA FEEDER REPLACE AIR LINE
164419	01/22/82	001	2	69244	1A19 ASH HOPPER VENT LINE	1AF-19 VENT VLV
164483	01/23/82	2	2	69262	#2 BF-23 VENT VALVE SOLENOID	2BF-23
164417	01/23/82	1	2	69263	#1AF-17 HOPPER VENT LINE	1AF-17
164471	01/26/82	002	2	54939	2BF-11 NUMA FEEDER	2-BF-11 DOT GATE
164473	01/26/82	002	2	54940	2AF13 VENT VALVE	2-AF-13 REPLACE VENT VLV
164473	01/27/82	02	2	54936	2BF 13	2-BF-13 DOT GATE SOL
1644B8	01/28/82	01	2	69303	1BF 8 VENT LINE	1BF-8
164479	01/31/82	01	2	24064	2BF 19 BOTTOM GATE	REPAIR BOTTOM GATE
1644D8	01/31/82	02	2	24063	2BF 8 VENT LINE	UNSTOP VENT LINE
164401	01/31/82	02	2	24061	2BF 1 VENT LINE	UNSTOP LINE
164476	01/31/82	02	2	24060	2BF 16 VENT LINE	UNSTOP VENT LINE

ATTACHMENT K

1 BELEWS CREEK
07/13/82

EQUIPMENT	DATE	UNIT	PRTY	REQUEST	JOB NAME	DESCRIPTION
1644	01/04/82	001	5	69285	HEATED AIR TO STONES 1A1 HTR	HEATED AIR TO STONES
1644D3	01/04/82	02	2	54408	2BF 3	2-BF-3 VENT LINE STOPPED UP
1644D4	01/04/82	02	2	54409	2BF 4	2-BF-4 STOPPED UP
164438	01/05/82	1	2	69123	1BF17	1BF-17
164441	01/05/82	1	2	69124	1BF 20 VENT LINE	1BF-20
164439	01/08/82	1	2	23912	1BF 10	UNSTOP VENT LINE
164453	01/10/82	002	2	23926	2BF-13	REPLACE AIR CYLINDER
164451	01/11/82	02	2	54455	2AF-11	2-AF-11 BOT GATE
164453	01/11/82	2	2	54449	#2 AF-13 HOPPER VENT VALVE	2-AF-13 VENT VALVE SOL
164403	01/12/82	1	2	69199	1BF 3 NUVA FEEDER	1BF-3
164433	01/12/82	1	2	69200	1BF 13 NUVA FEEDER	1BF-13
164442	01/12/82	1	2	69201	1BF 21 NUVA FEEDER	1BF-21
164438	01/16/82	1	2	54401	1BF 17 NUVA FEEDER	1-BF-17 TOP GATE SOL.
164453	01/17/82	2	3	54894	2AF 13	2-AF-13 VENT VLV SOL.
164418	01/20/82	001	2	69235	1AF-18	1AF-18 PREC HOPPER TOP GATE SOLENOID
164420	01/20/82	001	2	69234	1AF-20	1AF-20 PREC HOPPER TOP STONE REPLACE
164459	01/25/82	002	2	54904	2AF-19	2-AF-19-VENT VLV BLOWING THRU
164419	01/22/82	001	2	69244	1A19 ASH HOPPER VENT LINE	1AF-19 VENT VLV
164443	01/22/82	001	2	69240	1BF-22 NUVA FEEDER	1-BF-22 NUVA FEEDER REPLACE AIR LINE
164417	01/23/82	1	2	69263	#1AF-17 HOPPER VENT LINE	1AF-17
164483	01/23/82	2	2	69262	#2 BF-23 VENT VALVE SOLENOID	2BF-23
164419	01/26/82	001	3	69299	1AF-19	REPLACE 3-WAY VLV
164471	01/26/82	002	2	54939	2BF-11 NUMA FEEDER	2-BF-11 BOT GATE
164473	01/26/82	002	2	54940	2AF13 VENT VALVE	2-AF-13 REPLACE VENT VLV
164473	01/27/82	02	2	54936	2BF 13	2-BF-13 BOT GATE SOL
164408	01/28/82	01	2	69303	1BF 8 VENT LINE	1BF-8
164405	01/29/82	002	4	54975	2BF5 PRECIP HOPPER VIBRATOR	2-BF5 PREC BIF
164455	01/29/82	002	3	24048	2AF 15 BOTTOM STONE	REPLACE STONE
164471	01/29/82	002	4	54974	2AF 11 PRECIP HOPPER VIBRATOR	2-AF11 PREC VIB
164477	01/29/82	002	4	54976	2AF 16 PRECIP HOPPER VIB	2-AF-16 PREC HOPPER VIB
1644A5	01/31/82	01	2	24056	1AF 5 VENT LINE	UNSTOP LINE
1644A6	01/31/82	01	2	24052	1AF 4 VENT LINE	UNSTOP LINE
1644D8	01/31/82	02	2	24063	2BF 8 VENT LINE	UNSTOP VENT LINE

1 BELEWS CREEK
07/13/82

EQUIPMENT	DATE	UNIT	PRTY	REQUEST	JOB NAME	DESCRIPTION
***						
* 164451	04/10/81	002	3	11940	2AF-11	CHECK AND REPAIR LEVEL CONTROLS
* 164451	08/27/81	002	3	53691	2AF-11	2-AF-11
* 164451	07/06/81	002	3	23390	2AF-11	UNSTOP VENT LINE
* 164451	09/07/81	2	3	53796	02-AF-11 HOPPER TOP GATE	2-AF-11 ASH HOPPER TOP GATE
* 164451	09/23/81	02	3	12710	2AF11	ADJUST LEVEL CONTROL
* 164451	01/11/82	02	2	54455	2AF-11	2-AF-11 BOT GATE
* 164451	02/14/82	02	3	55031	2AF 11	2-AF-11.VENT VLV SOL
* 164452	11/10/80	002	2	51986	2AF-12	2-AF-12 ASH HOPPER
* 164452	01/30/81	002	3	52447	2AF-12	2AF-12 VENT VLV SOL
* 164453	01/27/81	002	3	52436	2AF-13	2-AF-13 VENT VALVE
* 164453	01/10/82	002	2	23926	2BF-13	REPLACE AIR CYLINDER
* 164453	01/11/82	2	2	54449	02 AF-13 HOPPER VENT VALVE	2-AF-13 VENT VALVE SOL
* 164453	01/17/82	2	3	54894	2AF 13	2-AF-13 VENT VLV SOL.
* 164454	01/24/80	2	2	17000	2AF14	2AF14 3WAY VLV
* 164454	09/01/81	02	4	53740	2AF-14	2-AF-14 INSULATION
* 164454	02/03/82	2	3	13261	02-AF-14 HOPPER	TIGHTEN BINDICATOR
* 164455	01/03/80	2	2	16901	2AF-15	VENT LINE HAS A HOLE AT ELBOW WHERE
* 164455	01/10/80	2	2	16931	2BF-15	REPLACE 2B-15 VENT IN SOLONOID
* 164455	01/15/81	002	4	52363	2AF-15 HOOPER	2-AF-15-HOPPER
* 164455	02/22/81	2	2	11636	02 AF 15 NUVA FEEDER	CHECK OVERFILL ALARM
* 164455	02/24/81	002	3	11667	2AF-15	CHECK HI ASH ALARM
* 164455	09/01/81	2	4	53761	2AF-15	2-AF-15 INSULATION
* 164455	01/29/82	002	3	24040	2AF 15 BOTTOM STONE	REPLACE STONE
* 164456	02/08/80	2	2	13780	02AF-16 VENT LINE	02AF-16 VENT LINE IS STOPPED UP PLEASE
* 164456	10/01/80	002	3	51747	2AF-16 NUVA FEEDER	2-AF-16 VENT LINE
* 164456	11/27/80	02	2	21764	2AF16 NUVA FEEDER	UNSTOP VENT LINE
* 164456	11/27/80	002	3	21771	2AF-16 NUVA FEEDER	TROUBLE SHOOT CIRCUIT
* 164456	02/11/81	02	2	52543	2AF16	2AF-16
* 164456	09/01/81	2	4	53762	2AF-16	2-AF-16 INSULATION
* 164457	01/24/80	2	2	16999	VENT VLAVE ON HOPER 2AF16	REPLACE OR ADJUST VENT VALVE SEATON 2AF1
* 164457	08/05/80	002	2	65811	2AF17 HOPPER STONES	2AF17 STONE
* 164457	09/02/80	002	2	51604	2AF16 NUVA FEEDER	2AF-16 VENT LINE
* 164457	12/12/80	002	3	52999	2AF17 FLYASH HOPPER	2AF-17 VENT LINE LEAK