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BAY COUNTY, FLORIDA WASTE-TO-ENERGY FACILITY AIR EMISSION TESTS

DAVID S. BEACHLER
JILL WELDON
D. MICK POMPELIA

WESTINGHOUSE ELECTRIC CORPORATION
RESOURCE ENERGY SYSTEMS DIVISION (RESD)
PITTSBURGH, PA 15221

PRESENTED AT THE MUNICIPAL
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ABSTRACT

Air emissions were measured at the Bay County Waste-to-Energy Plant in Panama City, Florida. Concentrations for particulate and gaseous emissions were measured using test methods established by the U.S. Environmental Protection Agency (EPA) or by using continuous emission monitors.

The Bay County Facility is a 510-ton per day facility that uses two Westinghouse-O'Connor combustors and boiler trains to recover energy to generate approximately 11.5 MW of electricity. Each water-walled rotary combustor is designed to mass burn 255 tons of municipal solid waste (MSW) per day or a mixture of MSW and wood chips.

The plant began burning MSW during the spring of 1987. Emission compliance tests conducted in May and June, 1987 showed that the facility met the permit requirements of the Florida Department of Environmental Regulations.

INTRODUCTION

The Bay County Resource Management Center is located 10 miles Northeast of Panama City, Florida. Panama City is a resort community approximately 100 miles east of Pensacola, Florida, on the northwest coast of Florida's panhandle. The average population of this area is approximately 115,000. The average quantity of municipal solid (MSW) waste generated in Bay County during most of the year is 300 tons per day. However, during the summer months when the population increases to more than 150,000, the community must handle in excess of 350 tons of MSW per day. The County decided to design the facility to ultimately burn 510 tons of MSW to allow additional waste to be processed as the population and quantity of waste increased.

The facility began initial start-up equipment check-out, and instrument calibration in February 1987. Equipment start-up and adjustment was done from February through May. Emission testing was conducted from late April through early June. The emission compliance tests were completed on June 4-5, 1987. The facility acceptance test and emission compliance test were completed five months ahead of the original projected schedule.

FACILITY DESCRIPTION

The Bay County Resource Management Facility uses two Westinghouse-O'Connor water-walled rotary combustors to mass burn up to 510 tons per day of MSW. The combustors can also burn a mixture of MSW and wood waste. Heat generated by the combustion of waste produces steam to drive a turbine generator. A process flow diagram of the Bay County facility is shown in Figure 1.

The plant consists of two combustor/boiler units, a turbine-generator, a truck scale, tipping floor, front end loaders, conveyors, air emission control equipment, a stack, ash handling equipment, a central control room, and all required ancillary equipment. The facility also includes administration offices, change rooms, parking areas, roadways, and security fencing.

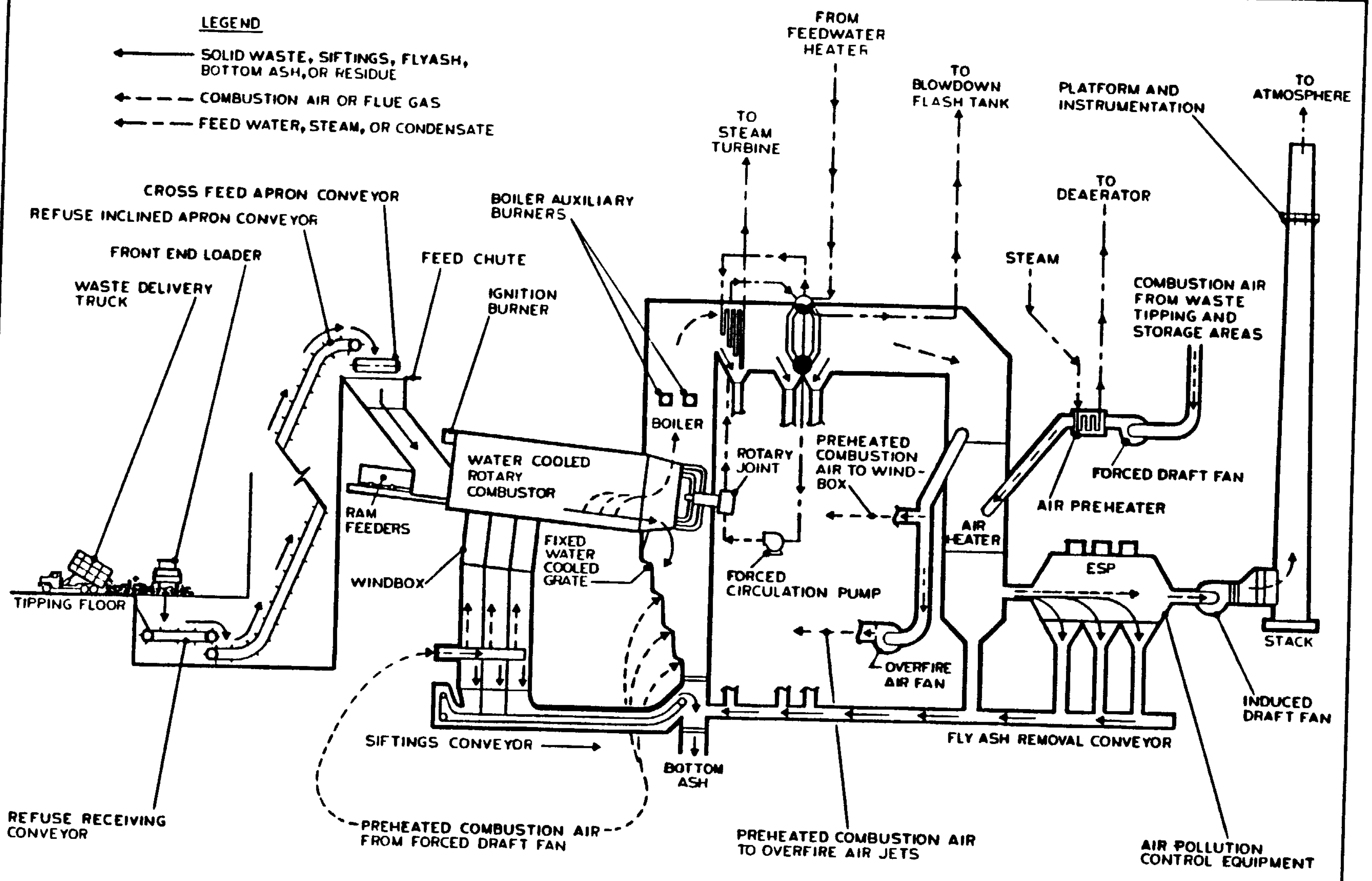

Figure 1. Simplified Process Flow Diagram, Gas Cycle for the Westinghouse-Bay Resource Management Center

All MSW received at the plant enters through an automatic gate system and is unloaded on the tipping floor. Solid waste collection vehicles hauling the material to be processed are weighed at the scale prior to entering the plant and are then directed to a specific bay on the tipping floor. The weight is automatically entered into a computer system that records and files all pertinent data for each transaction. The vehicles enter the designated bay and discharge their load on the floor. The tipping floor accommodates approximately 1500 tons of waste while allowing room for maneuvering the incoming trucks and front end loaders.

A man-operated front-end loader disperses MSW on the tipping floor to separate large and unprocessible objects. Large items are separated from MSW; the large combustible items are processed through a shear shredder; the large noncombustible items are removed and stored temporarily for landfill disposal. After sorting, the MSW is thoroughly mixed and then pushed onto the horizontal apron conveyor by the front-end loader. The horizontal apron conveyor transfers the MSW to the inclined apron conveyor and then into the combustor charging chute. The inclined apron conveyor contains a weigh scale that continuously measures the weight of MSW being fed into the charging hopper. When one line of apron feed conveyors is down for maintenance, a transfer conveyor at the charging hopper level feeds both combustors by changing the moving direction of the conveyor apron belt.

From the combustor charging chute, the MSW is pushed into the combustor by the hydraulic ram feeders (see Figure 2). The speed of the ram feeders and, consequently, the amount of solid waste fed to the combustor are controlled by the automatic combustion control system. The feed throat of the combustor chute is provided with a water-cooled isolation door to prevent the flames in the rotary combustor barrel from reaching the solid waste in the charging chute. The combustion process begins when the MSW is pushed into the combustor. The slightly inclined combustor barrel rotates slowly, causing the waste to tumble and advance as combustion proceeds. A forced draft fan draws combustion make-up air from the tipping area to reduce odor and dust levels in the tipping hall and to prevent them from escaping the building. The air is preheated before entering the multiple zone windbox located beneath each combustor barrel.

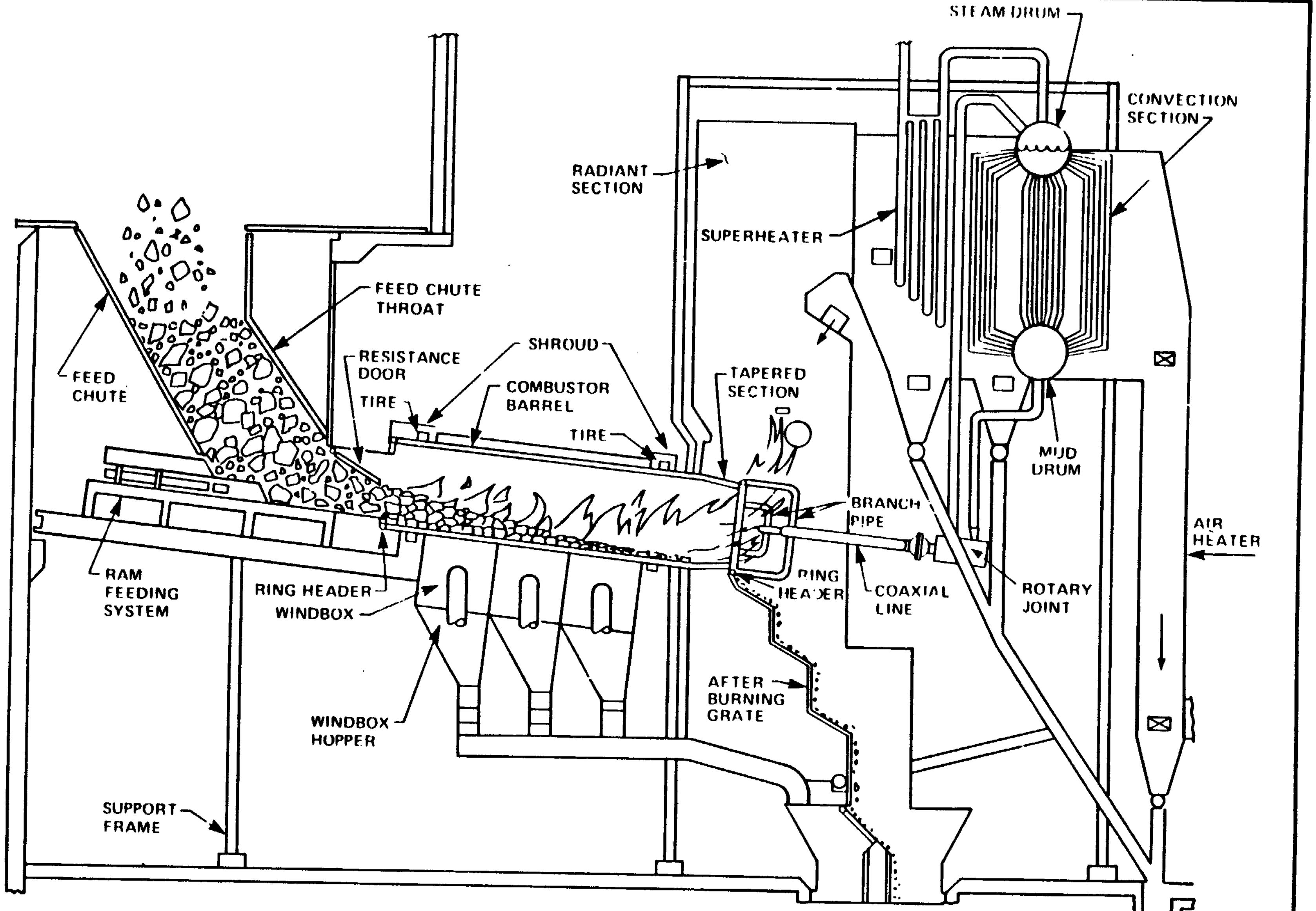

Figure 2. Westinghouse O'Connor Water-Cooled Rotary Combustor/Boiler

Figure 3 shows the cross-section of the rotary combustor and the flow of underfire and overfire air into the combustor. The combustor barrel has a diameter of 10 feet and is constructed by alternating steel tubes with carbon steel perforated webs and welding them together. The steel webs have a width of 1-1/2 inches with 3/4 inch diameter holes used to bring in combustion air. The tubes direct cooling water through the outside wall of the combustor barrel which upon heating is delivered to the boiler through the rotary joint.

The flow of waste is maintained to provide a steady mass flow rate into each combustor. The mass flow rate setpoint can be adjusted by the operator, based on the observed waste (fuel) characteristics and the average flow. The air flow is readily controllable, and can be quickly and precisely adjusted to respond to measured process variables.

The air flow to Zone A is used to promote drying of the waste without initiating combustion in that zone. The combustor inlet temperature, read by a thermocouple in the front wall of the combustor, provides the signal on which to base the air flow control to this zone.

The air flow to Zone B, where most of the devolatilization and surface combustion takes place, is adjusted to control the total combustion rate. Air flow to Zone C is introduced to complete combustion of the devolatilized gases.

The oxygen concentration of the flue gas in the furnace is continuously read by an oxygen monitor located in the boiler convection section. The air flow to Zone C is adjusted to maintain the oxygen concentration setpoint (approximately 6%). The air flow to Zone C is increased as the oxygen concentration goes below the set point and is decreased as the oxygen concentration goes up. If the oxygen setpoint is not reached after the air flow adjustments to Zone C have been made, then a change in air flow to Zone B is initiated. The air flow to Zone B is reduced if the oxygen concentration goes below the set point level and increased if the oxygen concentration goes above the set point level. The main purpose in adjusting

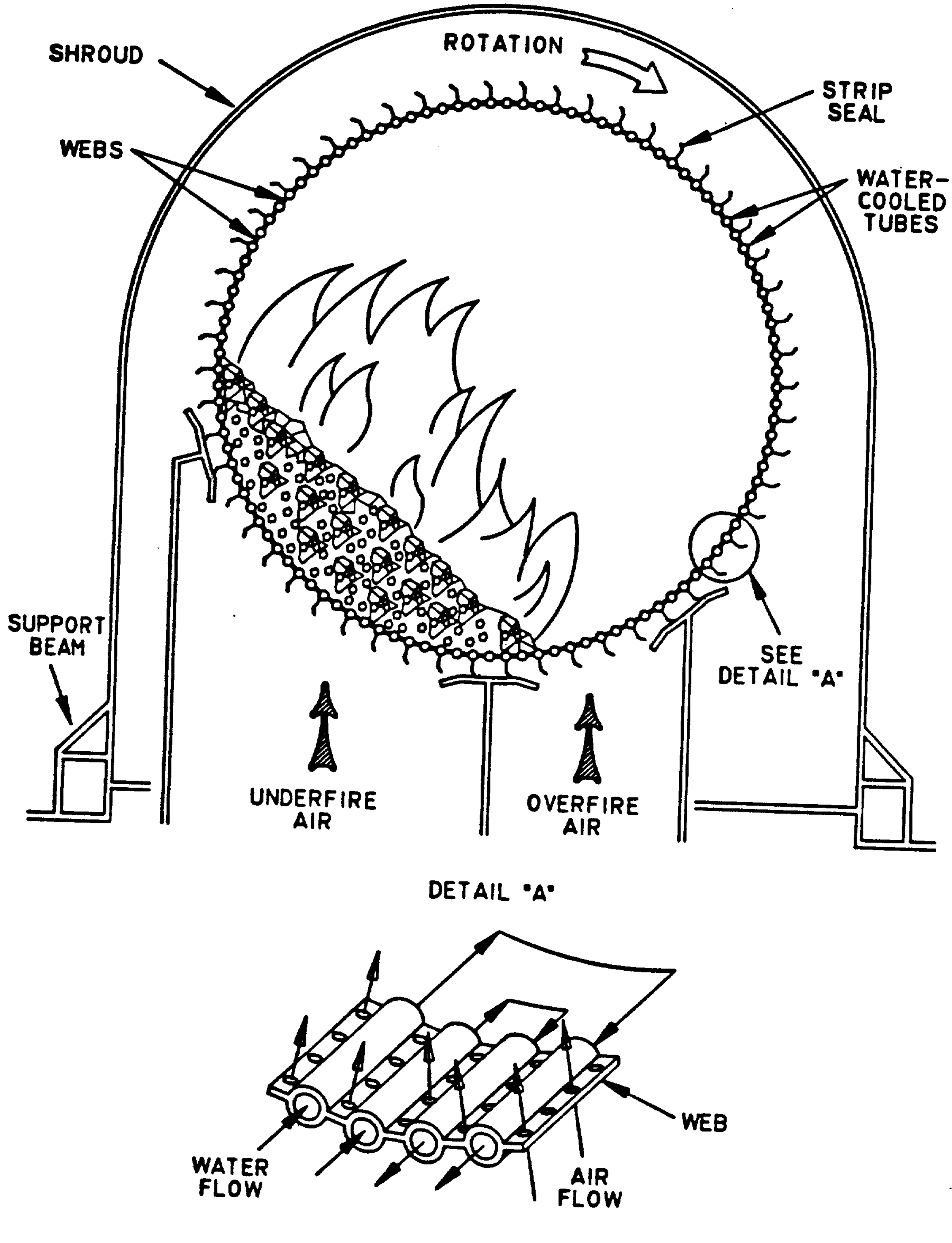

Figure 3. Cross-Section of the Westinghouse O'Connor Water-Cooled Rotary Combustor

the air flow in this manner is to maintain a constant firing rate in the barrel. For example, if a load of waste having a high heating value (paper, asphalt shingles, wood, etc.) is burning in Zone B, the total air flow will not be able to keep up with the excess air requirements of the burning waste. Therefore, the amount of air to Zone B is reduced to slow down the burning process.

The heat released from the combustion process is recovered through the rotary combustor walls, boiler water walls and tubes, primary and secondary superheater, and the air preheater. Hot gases, produced during the combustion process, flow from the combustor barrel through the boiler's radiant, superheater, and convection sections. To maximize energy recovery and expedite combustion of high-moisture waste, the combustion gases exiting the convection section pass through a heat exchanger that preheats the incoming combustion air. To prevent corrosion problems in the lower part of the boiler air heater, a steam preheater is located at the air heater inlet to increase the air temperature from ambient to 150°F.

The flue gases from the air heater enter the electrostatic precipitator (ESP) to remove particulate matter before exiting the stack. The ESP's are arranged into three mechanical fields, each with its own electrical field and ash removal hopper. They are designed to meet the Florida Department of Environmental Regulations permit condition for particulate matter of 0.03 gr/dscf corrected to 12% CO_2. The ESP's are sized to accommodate a nominal gas flow rate of 56,000 ACFM (400°F) and a particulate inlet loading of 3 gr/dscf.

The flue gas is drawn from the ESP by an induced draft fan before being discharged to the atmosphere through a separate flue in the common stack. The stack is made of precast concrete with two 4-ft, 6-in. diameter flues that are constructed of 4-in. thick acid resistant bricks. The stack is 125 feet tall and has air emissions monitoring ports located 60 feet from the stack base.

Three types of ash by-products are produced by the process: fly ash, siftings, and bottom ash. Fly ash is collected in hoppers under the convection, superheater, air heater, and ESP sections of each combustor/boiler train and is conveyed pneumatically to the bottom ash conveyor. Siftings are collected underneath the combustor by the siftings conveyor and are transferred by an ash drag system to the bottom ash conveyor. Bottom ash falls from the rotary combustor onto a fixed afterburning grate located beneath the combustor outlet. The afterburning grate provides additional time for the remaining combustibles to be consumed prior to their discharge through a bifurcated chute into one of two submerged wet drag conveyors. The fly ash, siftings, and bottom ash mixture are water quenched, dewatered, and removed by one of two redundant bottom ash drag conveyors into trucks, then disposed of in a landfill.

Heat from the combustion of MSW produces steam to drive the turbine-generator. Boiler feedwater moves through the boiler tubes by natural circulation as it is transformed into a mixture of saturated steam and water. Pumps circulate water through the rotary combustor by drawing water from the lower drum of the boiler through the rotary joint and into one of the combustor barrel's ring headers. The water passes through the combustor tubes and returns to the boiler steam drum as a mixture of saturated water and steam. Steam leaves the drum and passes through the primary and secondary tubes of the superheater section where the steam is heated to the design steam condition for the turbine (750°F).

The steam flows from the superheater to the multiple extraction condensing turbine-generator where a portion of its energy is converted to electricity. The generator produces 3-phase, 60 Hz electrical power. Transformers provide power at reduced voltage for in-plant use, and at increased voltage for distribution to the utility grid. Turbine exhaust steam is condensed in a shell and tube condenser that is cooled by an external cooling tower. Steam condensate is pumped back to the boiler through feedwater heaters and a deaerator.

EMISSION COMPLIANCE TEST RESULTS

Emission tests for determining the particulate matter concentration were conducted from April 22 through June 5, 1987. Individuals from Westinghouse RESD and stack testing engineers from ETS, Inc. participated in the testing program. Some tests were witnessed by observers from Roy F. Weston, the consulting engineer for Bay County.

The results of scheduled testing indicate that both Units 1 and 2 are in compliance with the particulate and visual emission levels required by the State of Florida Department of Environmental Regulations. The Method 5 particulate measurements conducted for determining compliance on June 4 and 5 are given in Table 1. The particulate matter concentration levels at the design capacity of 255 tons of MSW per day per unit averaged 0.0193 gr/dscf at 12% CO_2 for Unit 1 and 0.0243 gr/dscf at 12% CO_2 for Unit 2. Method 9 opacity measurements were consistently at or less than 10% for both units during the test runs. Additional testing, conducted at the plant for verification and troubleshooting purposes, are listed in Table 2. The results confirm the low emission levels measured during the compliance test runs indicating an average particulate emission concentration from Unit 1 of 0.0229 gr/dscf at 12% CO_2 and 0.0196 gr/dscf at 12% CO_2 from Unit 2. The air quality compliance tests clearly demonstrate that the plant meets the air quality permit conditions established by the Florida Department of Environmental Regulations. These conditions require particulate matter emissions to be less than 0.03 gr/dscf corrected to 12% CO_2 and limits plume opacity to no more than 10%.

TABLE 1

EMISSION COMPLIANCE TEST RESULTS
FROM THE BAY COUNTY RESOURCE MANAGEMENT CENTER

Bay County Compliance Test Results - Unit 1

Date	Time	Flue Gas Flow kdscfm	Flue Gas Flow kacfm	Stack Temp deg F	Steam Flow klb/hr	Percent of Rated Capacity	Particulate Matter gr/dscf @ 12% CO_2
6/5	959	25.8	52.4	425.0	71.1	104.5	0.0140
6/5	1140	27.9	55.1	429.0	66.5	97.8	0.0240
6/5	1307	25.8	52.8	427.0	65.0	95.6	0.0200
AVERAGE					67.5	99.3	0.0193

Bay County Compliance Test Results - Unit 2

Date	Time	Flue Gas Flow kdscfm	Flue Gas Flow kacfm	Stack Temp deg F	Steam Flow klb/hr	Percent of Rated Capacity	Particulate Matter gr/dscf @ 12% CO_2
6/5	945	27.7	52.6	429.0	69.7	102.5	0.0250
6/5	1310	28.4	58.1	449.0	62.7	92.2	0.0190
6/5	1525	29.2	59.0	451.0	62.3	91.6	0.0290
AVERAGE					64.9	95.4	0.0243

TABLE 2

ADDITIONAL TEST RESULTS FROM THE
BAY COUNTY RESOURCE MANAGEMENT CENTER

Bay County Additional Test Results - Unit 1

Date	Time	Flue Gas Flow kdscfm	Flue Gas Flow kacfm	Stack Temp deg F	Steam Flow klb/hr	Percent of Rated Capacity	Particulate Matter gr/dscf @ 12% CO_2
4/22	1436	25.0	45.5	373.0	58.6	86.2	0.0176
4/22 (1)	1652	25.9	50.3	387.0	70.4	103.5	0.0279
4/27	1505	24.9	48.1	441.0	68.9	101.3	0.0265
4/29	1214	19.9	39.0	441.0	61.1	89.9	0.0252
5/20	1542	29.8	49.8	426.0	70.4	104	0.0256
6/1	1903	25.5	51.2	426.0	64.0	94.1	0.0177
6/1	2029	23.7	52.3	436.0	57.2	84.0	0.0195
AVERAGE					64.4	94.7	0.0229

Bay County Additional Test Results - Unit 2

Date	Time	Flue Gas Flow kdscfm	Flue Gas Flow kacfm	Stack Temp deg F	Steam Flow klb/hr	Percent of Rated Capacity	Particulate Matter gr/dscf @ 12% CO_2
4/23	925	28.9	56.8	422.0	64.0	94.1	0.0161
4/23	1148	24.3	48.2	422.0	65.6	96.5	0.0215
4/23	1356	23.4	45.4	405.0	62.6	92.1	0.0192
4/30	957	27.4	51.7	427.0	NO DATA	NO DATA	0.0167
5/12	1350	25.7	54.2	437.0	76.0	112	0.0246
5/13 (2)	1635	23.7	48.2	408.0	72.0	106	0.0355
5/14	826	25.3	51.3	421.0	80.0	118	0.0157
5/21	1016	34.1	57.3	431.0	72.6	107	0.0172
5/21 (3)	1705	30.6	50.2	411.0	69.9	103	0.0184
6/1	927	25.9	54.4	436.0	64.5	94.8	0.0164
6/1	1045	24.3	52.3	428.0	60.8	89.4	0.0173
6/1	1215	25.2	55.4	426.0	57.8	85.0	0.0177
6/3	1023	25.8	52.0	438.0	59.8	87.9	0.0191
AVERAGE					67.1	98.7	0.0196

(1) Test discontinued after 1/2 hour due to plant shutdown.
(2) Furnace went positive for a few minutes while conducting this test when an air actuator valve was being repaired.
(3) Incinerator was fired with municipal waste and wood chip mixture.

GASEOUS EMISSION TESTING

Gaseous emissions testing was conducted from April through June to determine the stack gas concentration of SO_2, NO_x, and HCl. The testing was conducted to verify the emission factors used to project the annual emission rates in the PSD permit application.

The SO_2 emissions were determined using U.S. EPA Reference Method 8. The results of nine tests performed on five days are contained in Table 3. The average flue gas SO_2 concentration was 111 ppm_{dv}, corrected to 12% CO_2.

NO_x emissions were measured continuously using a Theta Sensor CEM over a nine-day test program. NO_x levels measured by the CEM were verified during an eight-hour period by simultaneously sampling using EPA Reference Method 7. Table 4 contains the eight-hour NO_x emissions data showing the average NO_x levels measured by the CEM and EPA Method 7. The average of NO_x emissions data from the CEM and Reference Method 7 were 180 and 157 ppm_{dv} corrected to 12% CO_2, respectively, for the eight-hour test. NO_x emissions measured by the CEM during the nine-day test period were in the range of 150 to 200 ppm_{dv} with a maximum of 300 ppm_{dv} during boiler excursions.

HCl concentrations determined using NIOSH Method 112B are listed in Table 5. Nineteen samples were taken on seven different days with an average HCl concentration of 467 ppm_{dv} corrected to 12% CO_2.

FUTURE TESTING

Westinghouse is planning to conduct a comprehensive test program at the Bay County facility in the fall of 1987. The primary goal of the testing is to fully document the environmental and thermal performance of the facility while varying the feed rate of MSW in the combustor, burning MSW having various heating values (approximately 3000 to 6000 Btu/lb), burning MSW along with other materials including sewage sludge, and additives such as lime.

TABLE 3 UNCONTROLLED SO2 EMISSIONS DATA FROM WESTINGHOUSE BAY COUNTY RESOURCE RECOVERY FACILITY

DATE	TIME	UNIT	FLUE GAS FLOW KSCFM	TEMP OF GAS DEG F	BOILER STEAM FLOW Klb/hr	H20 VOL%	CO2 DRY VOL%	SO2 DRY PPMv	SO2-DRY CORRECTED TO 12% CO2 PPMv
4/27	1100	1	25.1	428	64.7	13.3	12.1	113	112
4/27	1505	1	24.9	440	68.9	12.3	11.7	89	91
4/29	1214	1	19.9	441	61.1	14.6	11.0	213	233
4/29	1456	1	17.8	418	63.5	13.9	11.5	171	178
5/13	920	1	29.7	436	66.0	19.1	8.8	36	49
5/13	1337	2	26.4	451	65.6	19.5	9.7	68	84
5/13	1632	2	23.7	408	72.0	19.2	9.6	36	46
5/13	1850	2	28.0	434	70.5	16.4	9.7	82	102
5/14	826	2	25.3	421	80.0	17.8	9.7	85	105
AVERAGE			24.5	431	68.0	16.2	10.4	99	111

TABLE 4 NOX EMISSIONS DATA USING METHOD 7 AND A CEM ON BOILER 2 AT THE WESTINGHOUSE BAY COUNTY RESOURCE RECOVERY FACILITY

						METHOD 7		CEM	
DATE	TIME	FLUE GAS FLOW KSCFM	TEMP OF GAS DEG F	BOILER STEAM FLOW Klb/hr	CO2 DRY VOL%	NOX DRY PPM	NOX-DRY @ 12% CO2 PPM	NOX DRY PPM	NOX-DRY @ 12% CO2 PPM
5/20	2252	29.5	414	72.6	10.9	166	183	165	182
5/20	2254	29.5	414	72.6	10.9	186	204	165	182
5/20	2352	27.0	410	72.3	10.3	136	158	155	181
5/20	2353	27.0	410	72.3	10.3	191	223	155	181
5/21	52	27.3	415	72.0	12.0	92	92	155	155
5/21	53	27.3	415	72.0	12.0	122	122	155	155
5/21	152	26.6	418	71.9	11.7	85	87	140	144
5/21	153	26.6	418	71.9	11.7	148	152	140	144
5/21	249	29.7	412	72.0	11.5	167	174	155	162
5/21	251	29.7	412	72.0	11.5	180	187	155	162
5/21	361	28.2	405	71.6	11.5	191	199	210	219
5/21	352	28.2	415	71.6	11.5	129	135	210	219
5/21	451	26.7	405	71.4	12.1	140	139	220	218
5/21	452	26.7	415	71.4	12.1	141	140	220	218
AVERAGE		27.9	413	72.0	11.4	148	157	171	180

TABLE 5 UNCONTROLLED HCL EMISSIONS DATA FROM WESTINGHOUSE BAY COUNTY RESOURCE RECOVERY FACILITY

DATE	TIME	UNIT	FLUE GAS FLOW KSCFM	TEMP OF GAS DEG F	BOILER STEAM FLOW Klb/hr	H2O VOL%	CO2 DRY VOL%	HCL DRY PPMv	HCL-DRY CORRECTED TO 12% CO2 PPMv
4/22	1436	1	25.0	373	58.6	13.3	11.9	591	596
4/22	1652	1	25.9	387	70.4	17.5	14.0	432	371
4/23	925	2	28.9	422	64.0	15.1	12.8	857	802
4/23	1148	2	24.3	422	65.6	15.8	12.6	703	669
4/23	1356	2	23.4	405	62.6	15.5	13.7	657	577
4/26	1200	1	17.8	468	61.8	20.0	15.0	819	655
4/26	1352	1	29.7	473	61.8	22.1	15.1	422	336
4/26	1545	1	30.5	481	60.0	18.8	12.0	677	675
5/12	1350	2*	25.7	488	76.0	19.6	10.2	473	556
5/12	1350	2	25.7	437	76.0	19.6	10.2	301	354
5/13	920	1	29.7	436	66.0	19.1	10.4	481	555
5/13	1130	1	30.5	466	69.0	19.3	10.7	456	511
5/13	1337	1	26.4	451	65.6	19.5	11.4	301	316
5/13	1632	2	23.7	408	72.0	19.2	10.4	523	603
5/14	825	2	25.3	421	80.0	17.8	10.2	581	684
6/2	1139.0	1	26.6	461	66.7	16.9	10.2	167	196
6/2	1338.0	1	24.8	460	68.4	17.8	10.4	260	300
6/2	1512.0	1	25.6	455	ND	15.1	9.1	148	195
6/3	910.0	2	28.3	437	70.2	13.7	8.3	151	218
6/3	1023.0	2	25.9	438	59.8	15.7	12.0	161	161
AVERAGE			26.2	439	67.1	17.6	11.5	458	467

*Sample taken at inlet to precipitator.

The plant's thermal efficiency will be measured using ASME power tests codes. Emission testing using CEM's will be conducted to determine stack gas concentrations of SO_2, NO_x, CO, CO_2, THC, and NMHC. Manual samples will be taken to determine the concentration of SO_3, HF, HCl, NH_3, vinyl chloride, CO, CO_2, SO_2, NO_x, dioxins, furans, chlorophenols, PCB's, chlorobenzenes, and PAH including BaP. The dioxin and furan samples will be analyzed for tetra through octa-isomers cogeners including the 2,3,7, 8-isomer. Particulate matter concentration and heavy metal analysis for Hg, Cd, As, Pb, Be, Ni and Cr^{+6} will also be measured. A detailed report should be available in early spring 1988.