

NEW JERSEY'S FIRST RESOURCE RECOVERY FACILITY

(The Warren County Energy Resource Facility)

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ABSTRACT

New Jersey's first waste-to-energy facility has been constructed in Oxford Township, New Jersey, and has been in operation since June, 1988. This paper provides a detailed description of the Warren County Energy Resource Facility, its major process systems and post-startup design modifications. Certain aspects of the plant design philosophy are also described.

INTRODUCTION

The Pollution Control Financing Authority of Warren County, New Jersey formulated a long-range Waste Management Plan to comply with a mandate established by the New Jersey legislature. This plan called for the construction of a 400 TPD resource recovery facility to serve the population of 584,500 in the Warren County area. A flow control plan was established that directs the anticipated 94,660 TPY of MSW to the resource recovery facility. In addition, a sanitary landfill has been constructed adjacent to the facility to receive the residue from the facility as well as bypassed MSW, and unprocessable or unacceptable waste. The landfill also accepts small private loads of refuse, eliminating the need for a public dumping station at the facility.

The Pollution Control Financing Authority has negotiated contracts for the supply of additional refuse to the facility from adjacent counties to assure full capacity of the facility.

In June 1985, the County of Warren contracted with BERC to design, build and operate their resource recovery facility. Under the contract, the facility was to guarantee the annual processing capacity of 116,800 tons of MSW with a design heating value of 5300 Btu/lb (HHV), whereas the reference fuel heating value of the fuel, upon which all guarantees are based, is 4500 Btu/lb (HHV).

An ultimate analysis of the design fuel is presented in Table 1. Of interest is the relatively high sulfur content in the fuel analysis supplied by the County.

GENERAL PLANT DESCRIPTION

The plant consists of two independent processing trains with a nominal capacity of 200 TPD each, based upon the design fuel. This allows for combusting the guaranteed amount of MSW with an 80% plant availability.

The higher anticipated availability, in addition to the design conservatism, permits this facility to process significantly larger amounts of reference MSW, or MSW with higher calorific values, provided that the

TABLE 1 ULTIMATE ANALYSIS

| Component | Weight Percent |
|-----------|----------------|
| Carbon | 29.50 |
| Hydrogen | 4.40 |
| Nitrogen | 0.50 |
| Oxygen | 28.20 |
| Sulfur | 0.30 |
| Water | 17.70 |
| Ash | 19.40 |
| | 100.00 |

New Jersey Department of Environmental Protection (NJDEP) permit limits on throughput capacity could be extended. At present, the capacity of the plant is limited to 404 TPD of design fuel or 448 TPD of reference fuel by the permitting agencies.

The plant is located on a 22 acre site in Oxford Township, New Jersey and is bordering on farm land, a few residential properties, and an area zoned for future residential and commercial development. A photograph of the facility and a site plan are shown in Figs. 1 and 2.

Truck access is via a new access road from New Jersey Route 31. Truck traffic enters the general Facility grounds from U.S. Route 31 along the access road to the scale for weighing and determination of acceptability. Unprocessable waste, not acceptable at the facility, is directed to the landfill. Trucks with processible waste proceed to the tipping hall.

Trucks enter the tipping hall to discharge their loads into the bunker. The trucks then leave the tipping area through the same door by which they entered.

The refuse bunker is totally enclosed and contains two full-span, overhead traveling bridge cranes. The cranes are operated from a remote, air conditioned pulpit containing dual control capability. Each crane is equipped with a 5 cu yd orange peel type grapple for refuse mixing and charging.

The overhead cranes mix municipal solid waste in the bunker to homogenize the fuel, and then transfer it to one of the grate feed hoppers. Any white goods inadvertently discharged into the refuse bunkers are removed by the crane to a container on the ground floor level.

The bunker has a storage capacity of three days of refuse below ground level and a total of seven days when stacked above ground level. This allows for gar-

bage delivery fluctuations and for long weekend storage.

The sectional elevation of the Facility is presented in Fig. 3. As shown, the boiler and turbine are totally enclosed in a boiler/turbine building with the exception of the tail end of the economizer, which protrudes outside the building. All support and auxiliary systems are located in the boiler building. A maintenance shop area and spare parts storage are also located inside the building.

The administrative offices and general support functions are located separate from, but immediately adjacent to, the main facility. Included in this area are offices for the plant manager, administrative manager, secretaries, clerks and general files, as well as offices for NJDEP personnel. Additional accommodations include a conference room, first aid area, lunch room, showers, and lockers. The operations manager's office is located adjacent to the control room in the main facility.

MAJOR PLANT SYSTEMS

A detailed description of the major plant systems and their basic design philosophy is presented below.

Table 2 lists the design conditions for the major plant process equipment. The plant performance is depicted in the firing diagram and in the energy balance, which are discussed later in this report.

Firing System

The boiler design and firing system are based on the standards of W+E Umwelttechnik AG of Zurich, Switzerland.

Feed System

Refuse is admitted to the combustion system through a water-cooled feed chute, which is lined with abrasion resistant steel plate. A hydraulically operated damper is provided to close the chute to eliminate air ingress, if required. The refuse falls by gravity onto a feeding platform from where a refuse ram feeder, (Fig. 4), will push the fuel onto the grate. Control of cycle times and stroke length permit the feed rate of the fuel to be varied in accordance to the waste composition, or as required by demand signals from the steam generators.

Grate

The heart of the combustion system is the grate, which is arranged in a horizontal position. The W+E "Double Motion Overthrust Grate" consists of a

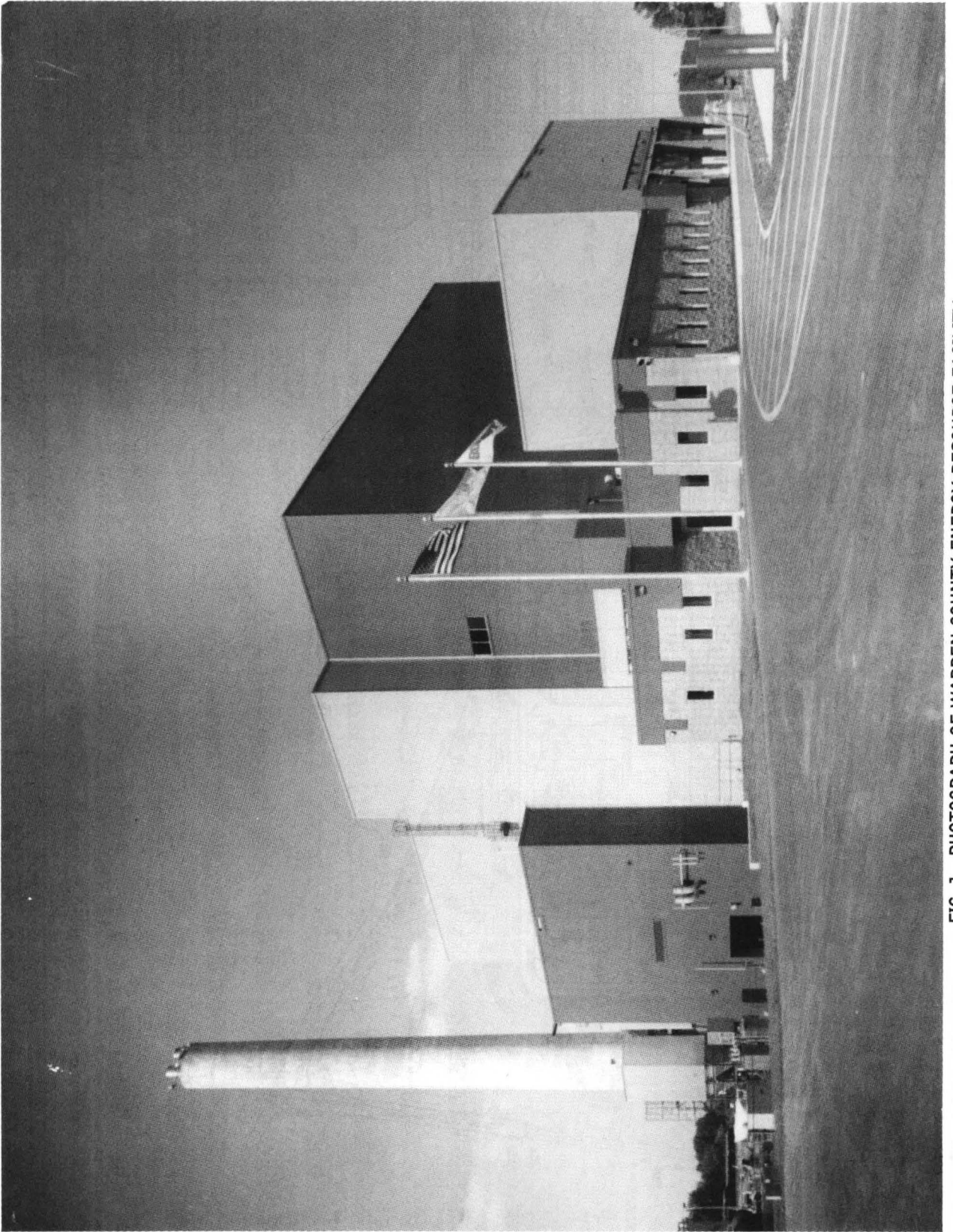


FIG. 1 PHOTOGRAPH OF WARREN COUNTY ENERGY RESOURCE FACILITY

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KEY PLAN

CLIENT: WARREN COUNTY
 APPROVAL: 2/10/10
 DATE: 2/10/10

BLOUNT
 ENGINEERS, INC.
 1000 W. 10TH STREET
 WASHINGTON, DC 20004

PROJECT:
 WARREN COUNTY NEW JERSEY
 RESOURCE RECOVERY PROJECT

DATE: 11/11/09
 SHEET NO. 02 OF 03

SITE & LANDSCAPE PLAN

SCALE: 1" = 60'

PROJECT NO. WC-02-11-09-10

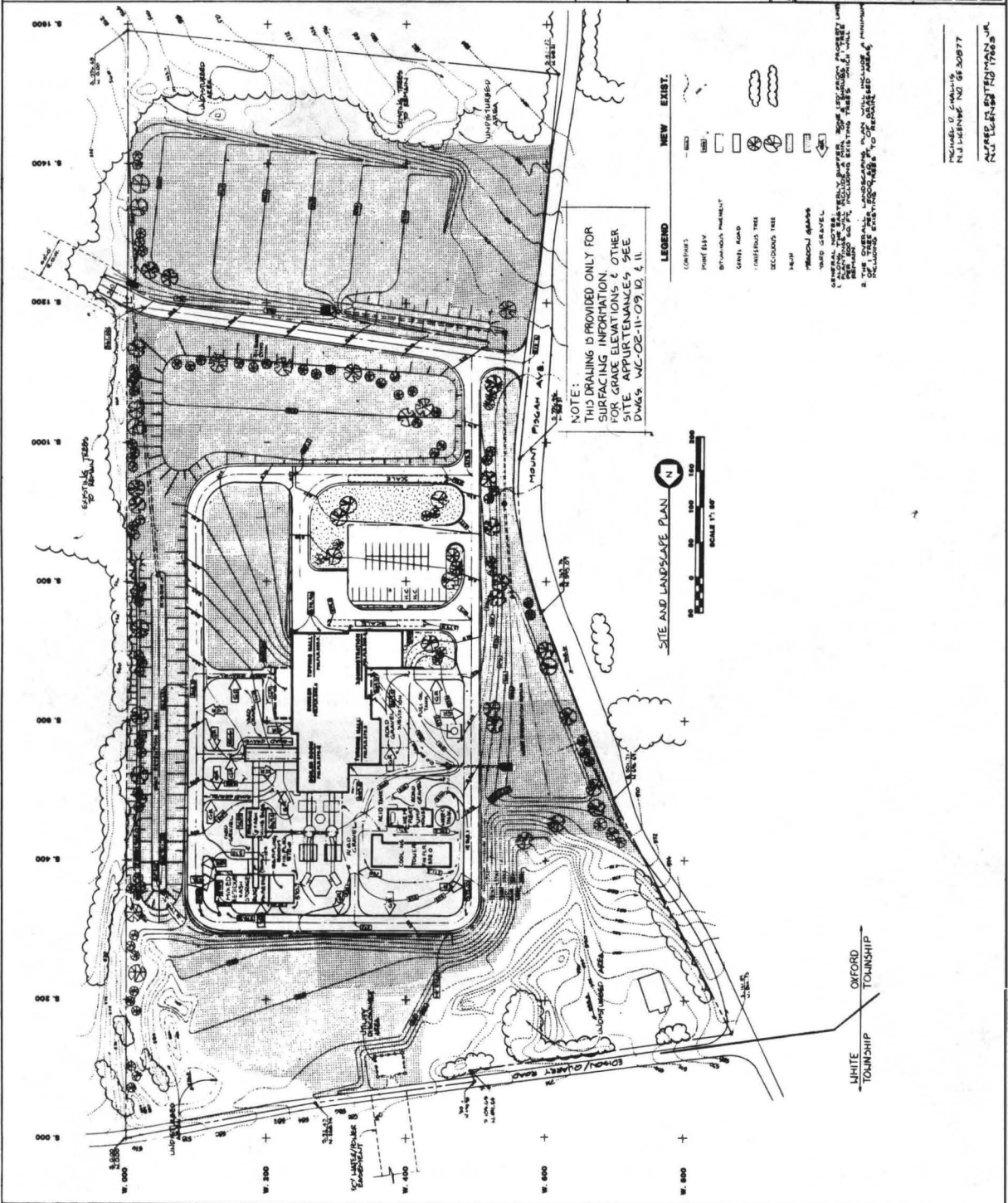


FIG. 2 WARREN COUNTY SITE PLAN

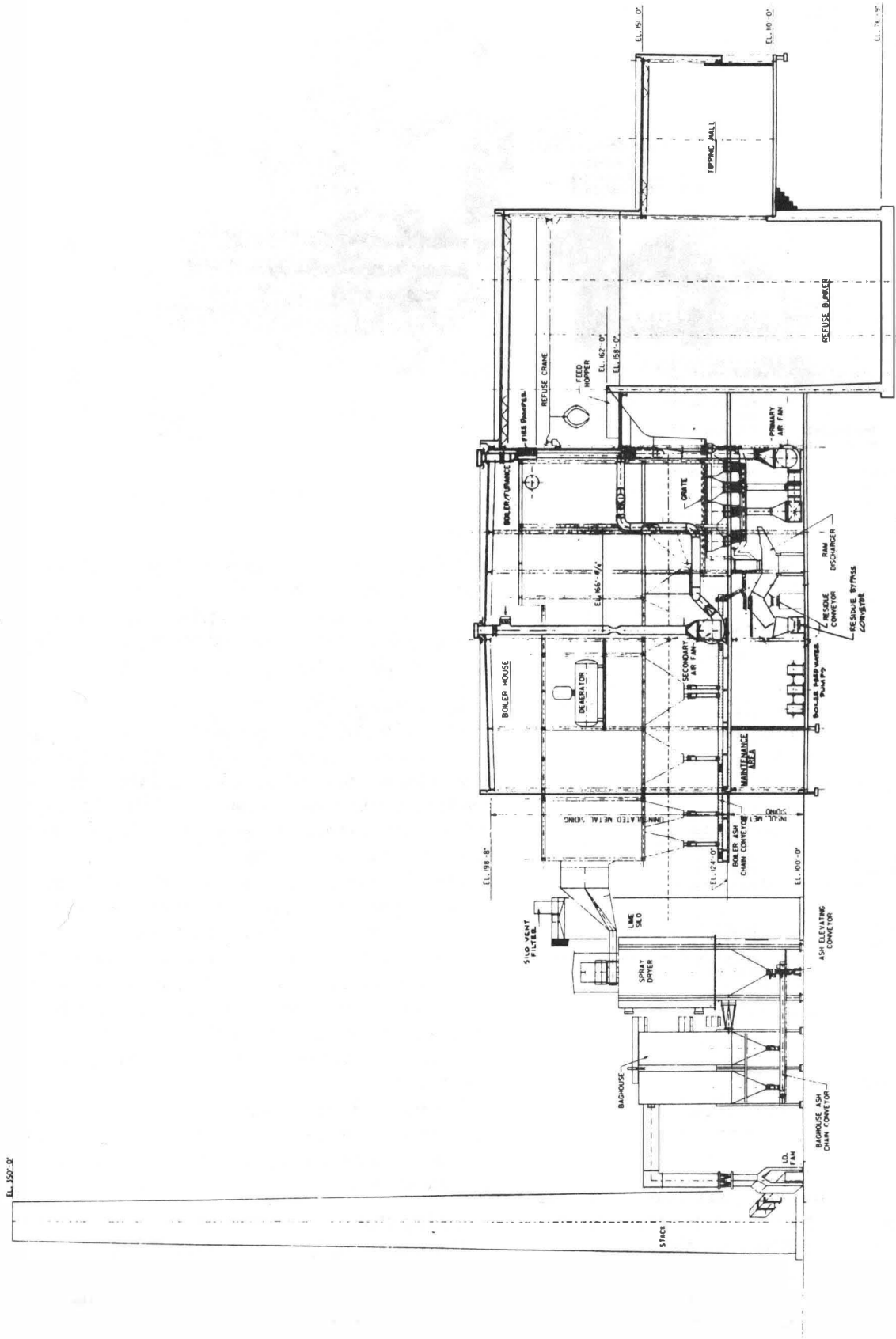


FIG. 3 SECTIONAL ELEVATION

TABLE 2 DESIGN CONDITIONS OF THE WARREN COUNTY PLANT

Refuse Cranes

| | |
|-------------------|---|
| One Operating | |
| One 100% Stand-by | |
| Grapple: | Orange Peel |
| Capacity: | 7.5 short ton/5 yd ³ (6.8 metric ton/3.8 m ³) |
| Speed: | Hoist: 190 ft./min. (57.9 m/min.) |
| | Trolley: 150 ft./min. (45.7 m/min.) |
| | Bridge: 150 ft./min. (45.7 m/min.) |

Firing System

| | |
|-------------------------------|---|
| Grate Type: | W+E 1/27/3344 |
| Effective Grate Width: | 9.3 ft. (2.84 m) |
| Effective Grate Length: | 30.5 ft. (9.29 m) |
| Effective Grate Area: | 283.5 ft ² . (26.34 m ²) |
| Grate Drive: | Hydraulic |
| Maximum Permissible Capacity: | |
| HHV = 5300 Btu/hr., 235 tpd | (1553 J/sec., 213.2 mtpd) |
| HHV = 4500 Btu/hr., 275 tpd | (1318.5 J/sec., 249.5 mtpd) |

Boiler System

| | |
|---|----------------------------------|
| One Drum, Natural Circulation, Balanced Draft | |
| Welded Water Wall Design | |
| Steam Capacity: | 63,901 lb./hr. (28,985 kg/hr.) |
| Control Load: | 51% |
| Steam Pressure, Boiler Outlet: | 630 psig (4330 kPa) |
| Steam Temperature, Boiler Outlet: | 752°F (400°C) |
| Boiler Feed Water | |
| Inlet Temperature: | 266°F (130°C) |
| Boiler Design Pressure: | 925 psig (6394 kPa) |
| Flue Gas Temperature, | |
| Boiler Outlet: | 320°F (160°C) |
| Boiler Cleaning: | Mechanical and Pneumatic Rapping |

Turbine

| | |
|-------------------------------|---------------------------------|
| 9-Stage Impulse Machine | |
| Turbine Throttle Pressure: | 615 psig (4285 kPa) |
| Turbine Throttle Temperature: | 750°F (399°C) |
| Turbine Throughput: | 128,000 lb./hr. (58,957 kg/hr.) |
| Turbine Output: | 13.63 MW |
| Exhaust Pressure: | 2.5" Hg (35 kPa) |
| Shaft Speed: | 5985 rpm |

Generator

| | |
|------------------|------------|
| Rating: | 14,445 kVa |
| Power Factor: | 0.90 |
| Nominal Voltage: | 13,800 V |
| Frequency: | 60 Hz |
| Shaft Speed: | 1800 rpm |

Air Quality Control System

| | |
|---------------------|--|
| Dry Scrubber: | |
| Atomizer: | Variable Speed, Direct Drive, Rotary Disc |
| Gas Flow: | 148,633 SCFM (4209 m ³ /min.) |
| Gas Retention Time: | 16 sec. |
| Inlet Temperature: | 320°F (160°C) |
| Outlet Temperature: | 270°F (132°C) |
| Baghouse: | |
| Modules: | 4 |
| Total Surface Area: | 18,106 ft. ² (1682 m ²) |
| Air-to-Cloth Ratio: | 2.70/1 |
| Number of Bags: | 960 Woven Fiberglass with Teflon Coating |

Cooling System

| | |
|--------------------------------|-------------------------------|
| Counter Flow Wet Cooling Tower | |
| Cells: | 4 |
| Fans: | 4 |
| Drift Loss: | 0.01% |
| Evaporation Loss: | 2% |
| Cycles of Concentration: | 5 |
| Design Temperature: | 74°F Wet Bulb (23.3°C) |
| Total Cooling Water Flow: | 10,500 g/min. (39,747 l/min.) |

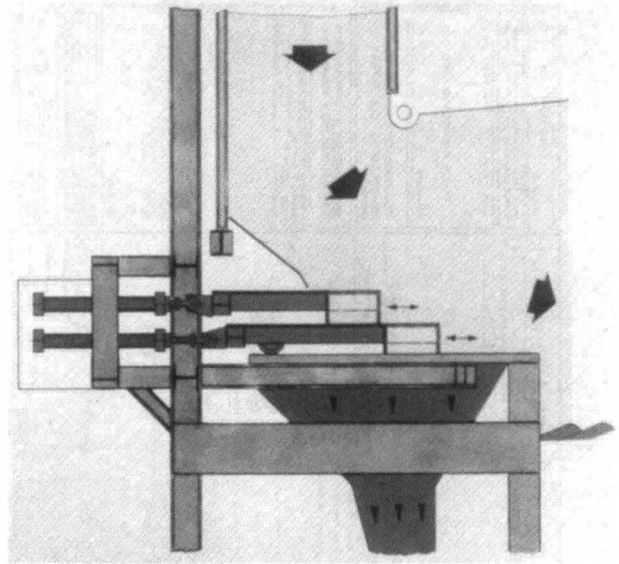


FIG. 4 W + E DOUBLE-FEEDER

and 4 fixed/movable grate pairs. Figure 7 shows the installation of the Warren County grate. Figure 8 shows the movement of the fuel on the grate as obtained from a model used to study the kinematics of fuel transport and mixing.

Grate Bars

The temperature of the grate bars typically ranges between 250°C (482°F) and 300°C (572°F). This low temperature is due to the layer of fuel which insulates the bar material from the flame, and by cooling channels on their underside through which the primary air is admitted to the fuel layer.

The grate bar material is a high alloy cast steel of proprietary metallurgy, which is designed to withstand operating temperatures without air cooling.

The grate bars are interlocked by a special coupling mechanism and fit loosely onto the grate shafts without attachments. The couplings and the shaft notches in the grate bars are designed such that they permit relative motion (rubbing) between two interlocked bars (see Fig. 9).

The tight tolerances between grate bars, the good air distribution and the grate bar metallurgy result in a grate life of up to five years and reduce the amount of grate siftings.

Cooling Plates

The grate is equipped with a single row of closure plates between the grate and the furnace side walls. These closure plates are air-cooled by a controlled amount of tertiary air to maintain them at a safe

system of movable and fixed grate bars, where the movable bars work in opposed directions to each other with fixed bars between them (Fig. 5).

Each Warren County grate system consists of one grate section with 27 parallel grate bars each (Fig. 6) and four underfire air zones corresponding to 3, 3, 4,

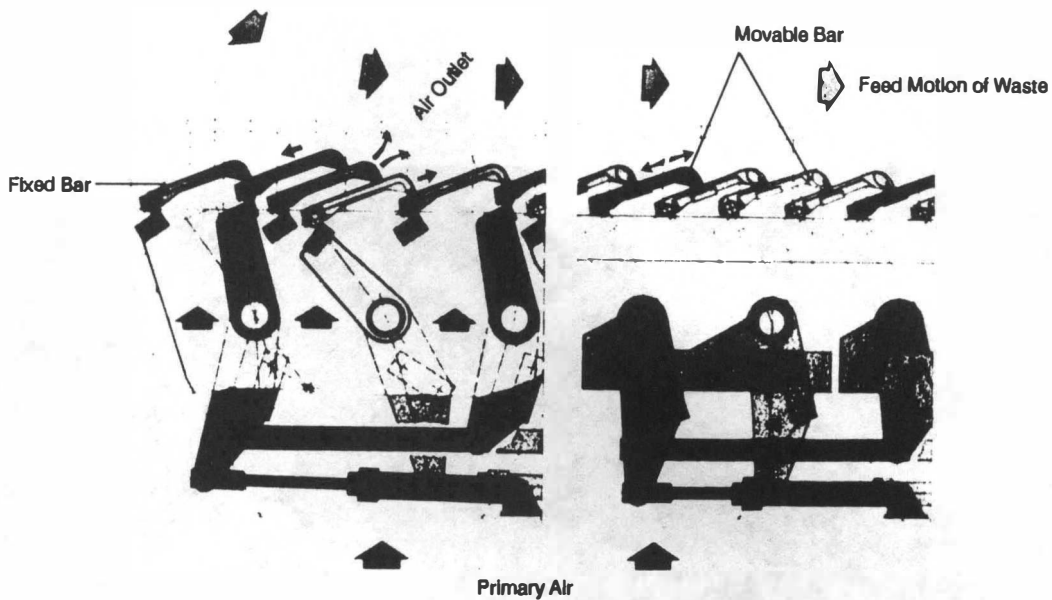


FIG. 5 W+E DOUBLE MOTION OVERTHRUST GRATE

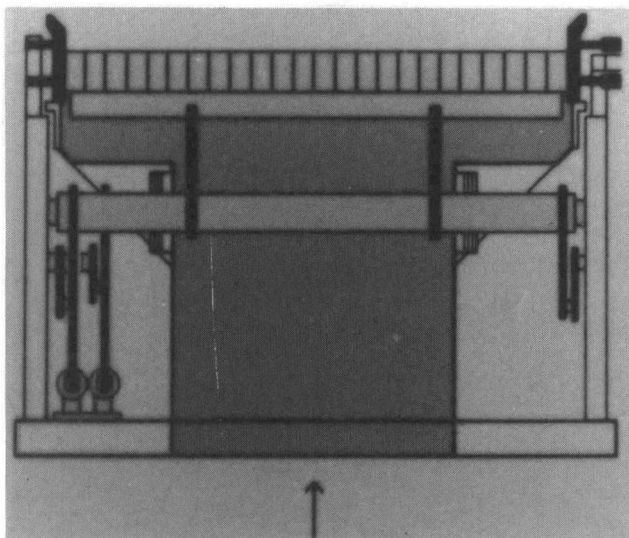


FIG. 6 CROSS-SECTION OF A W+E GRATE

temperature. Figure 10 (lower left-hand corner) shows the Warren County closure plates prior to installation of refractory.

Air Supply

Primary combustion air to the grate/boiler is supplied by a primary air fan for each boiler which takes suction from the tipping hall. This maintains the tipping hall/bunker under a slight negative pressure which serves as dust and odor control in these areas.

Primary air enters the combustion system via partitioned grate zones. Normally, primary air is preheated in the cooling channels of the grate bars.

However, an additional steam-heated air preheater is supplied in the primary air duct to assist in predrying of very wet fuel with low heat content, or to preheat extremely cold ambient air.

Secondary combustion air is supplied to the furnace by a secondary air fan for each boiler. These fans take suction from the higher elevations in the boiler building to assist in building ventilation. To assure even distribution, the air is admitted to the furnace via a large number of nozzles in the front and rear walls of the furnace. The air is injected into the combustion chamber at a very high velocity to assure complete turbulent mixing of volatiles emanating from the primary combustion on the grate.

This assures complete burn-out of all combustibles prior to leaving the furnace and also assures that all environmental requirements regarding the destruction of certain pollutants are met.

A small stream of tertiary air is utilized to cool the closure plates between the grate and the furnace walls and the feed hopper table.

The ratio between primary and secondary air is typically set at 55–45% respectively; however, this ratio is adjustable by damper control to accommodate varying fuel composition.

Combustion Control

The combustion control permits essentially full automatic operation of the combustion system which reduces plant operator requirements.

Boiler steam flow is used as the control input signal. The refuse ram feeder, the grate, and combustion air are controlled by a programmable controller (PC) to



FIG. 7 WARREN COUNTY GRATE INSTALLATION

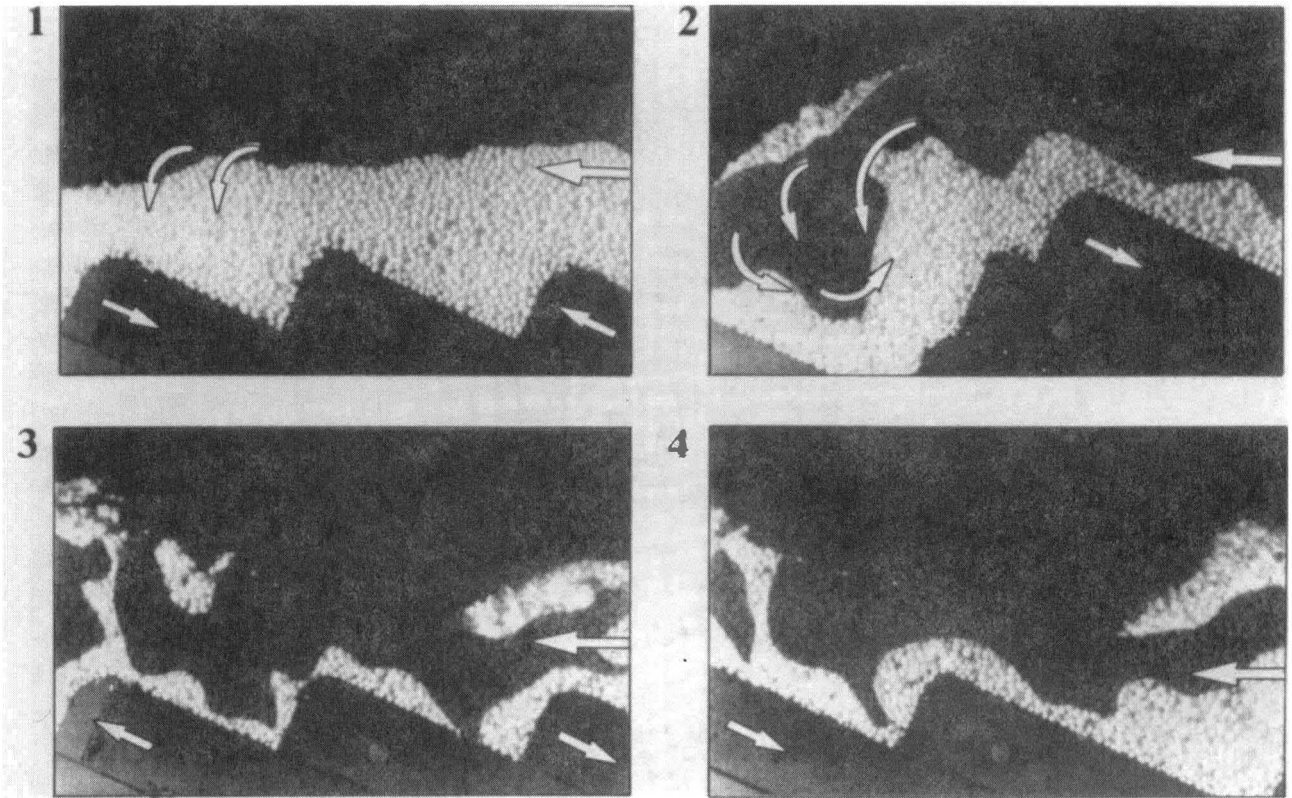


FIG. 8 FUEL KINEMATICS ON A W+E GRATE

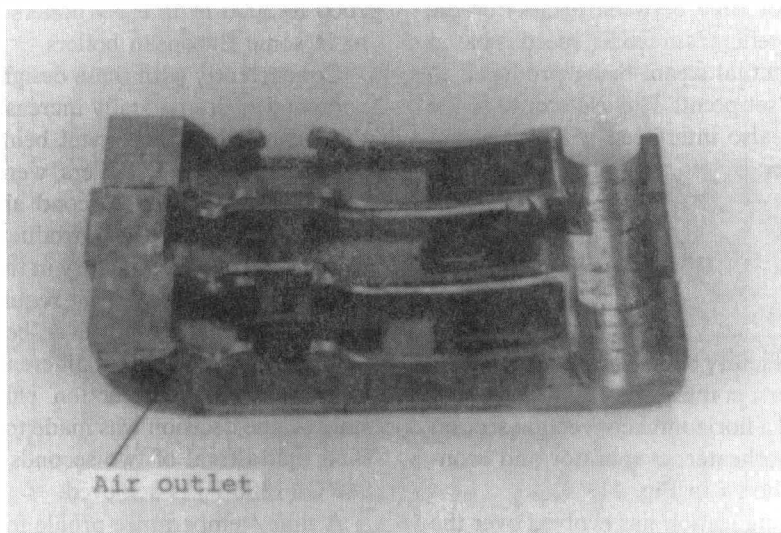


FIG. 9 W+E GRATE BAR

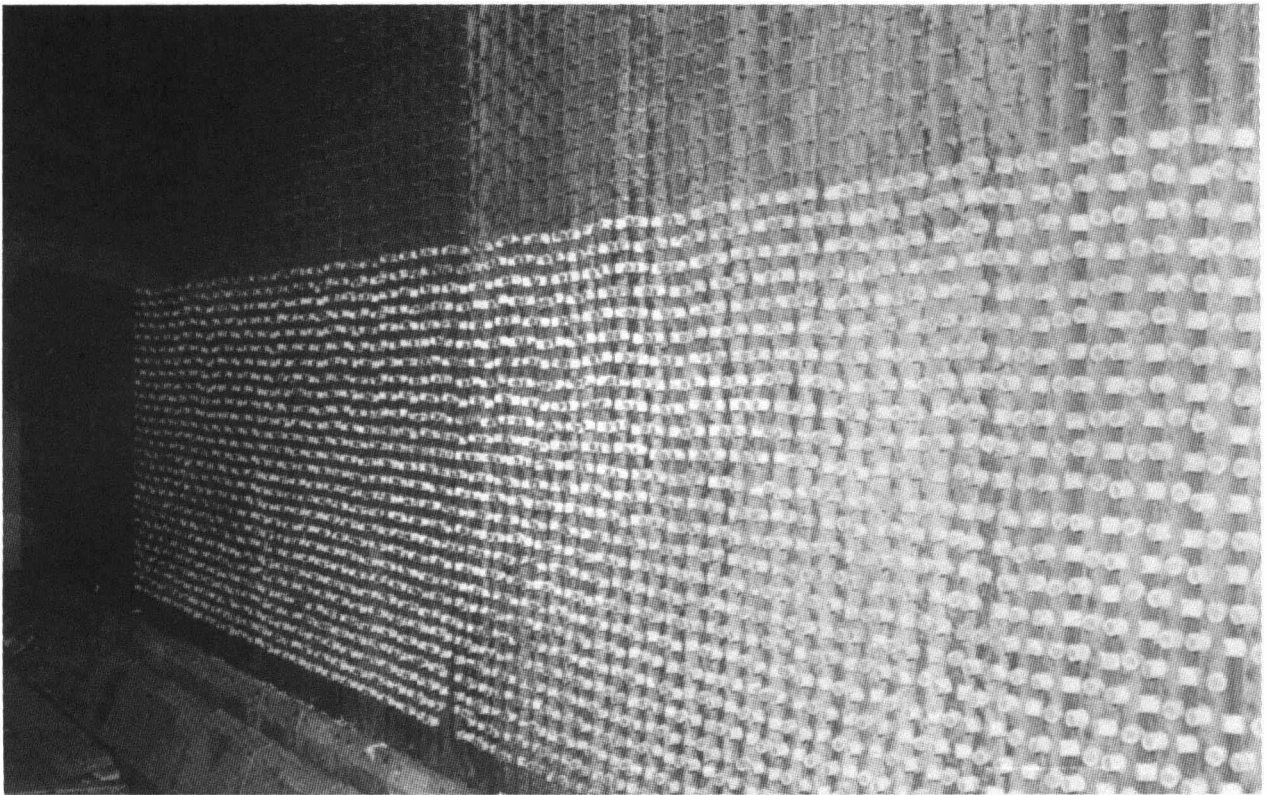


FIG. 10 WARREN COUNTY CLOSURE PLATES

maintain safe combustion chamber temperatures and O_2 levels, as these are the main parameters for controlled combustion and the avoidance of undesirable pollutants.

The amount of refuse delivered to the grate is controlled by the speed (or time between cycles) of the refuse ram feeder. The refuse ram feeder speed is based on the relation of the actual steam being produced to the steam flow control set point. The cycle time of the grate bar movement is also interfaced with the steam flow and the ram feeder.

Boiler System

Furnace

The Warren County facility boilers are typical W + E resource recovery boilers, comprised of a furnace, two radiation chambers and a horizontal convection section which includes the superheater, evaporator and economizer. The boiler is shown in Fig. 11.

The W + E boiler configuration has evolved over the years from vertical boilers with soot blowing, to vertical boilers with shot cleaning, to the present design

featuring horizontal tube sections, which are cleaned by mechanical rapping devices, and furnace walls, which are cleaned by pneumatic rappers.

The operating periods between major boiler cleanings have been improved by these design changes from 2000 to 3000 hr in early boilers to as much as 20,000 hr in some European boilers.

Concurrently with these design changes, the furnace volume was dramatically increased and resulted in the three-chamber arrangement being utilized today.

Typically, W + E boilers were designed for a gas residence time of one second above 870°C (1600°F), measured between the introduction of secondary air and the end of the refractory in the furnace. This design condition meets the permit requirements for the Warren County Facility; however, because of different regulatory requirements in different states and in order to improve the destruction efficiency of toxic substances, the decision was made to increase the furnaces such that a total of two seconds residence time above 980°C (1800°F) is achieved.

A time/temperature profile for the Warren County Facility is shown in Fig. 12 for maximum continuous load on the boiler.

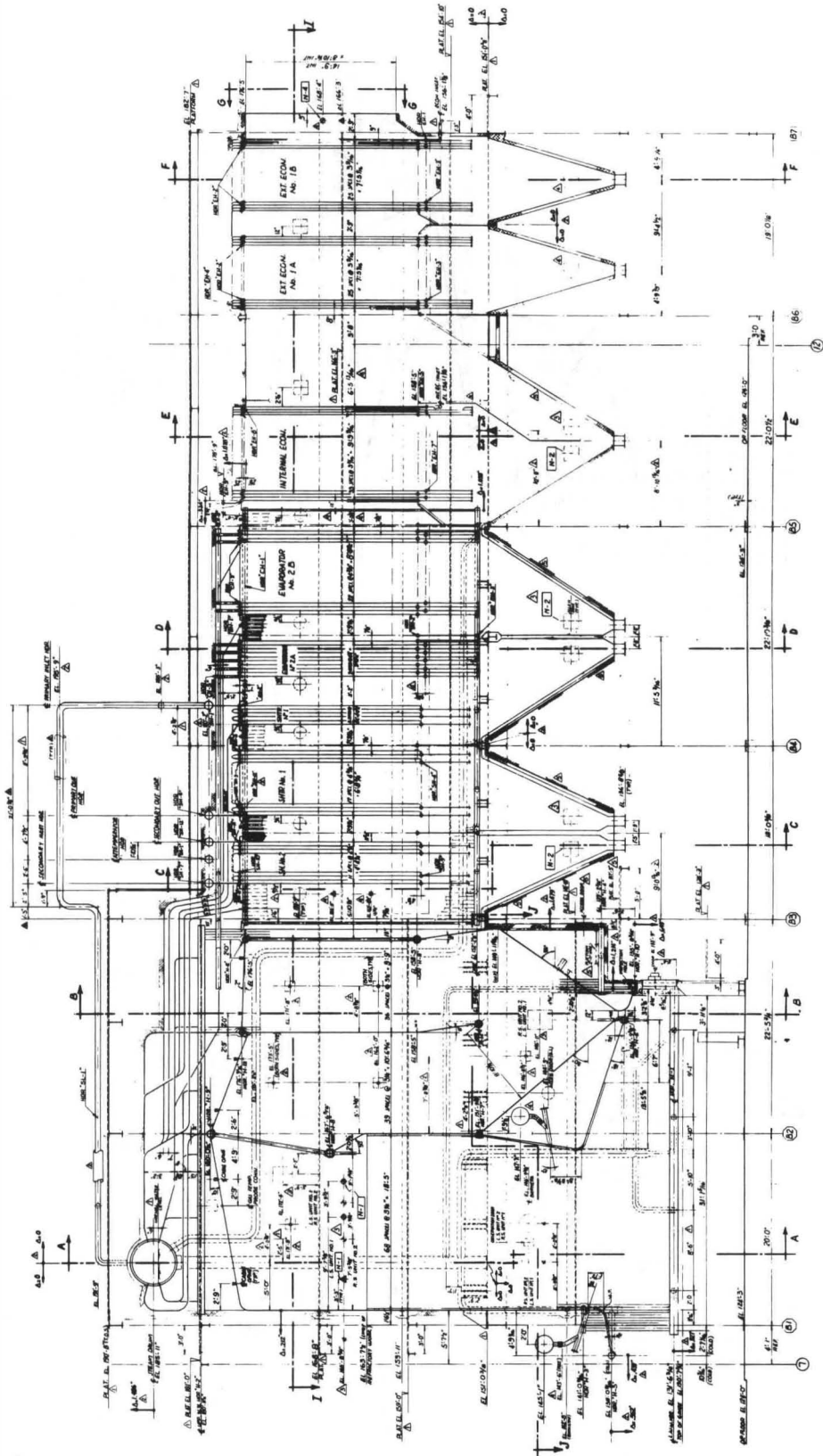


FIG. 11 BOILER CROSS-SECTION

WARREN COUNTY NEW JERSEY RESOURCE RECOVERY FACILITY

TIME - TEMPERATURE PROFILE

(COMBUSTION/RADIATION CHAMBER)

ESTIMATED FOR 100% BOILER LOAD CONDITION

FUEL (HHV) = 5300 Btu/lb MSW, EXCESS AIR = 120%

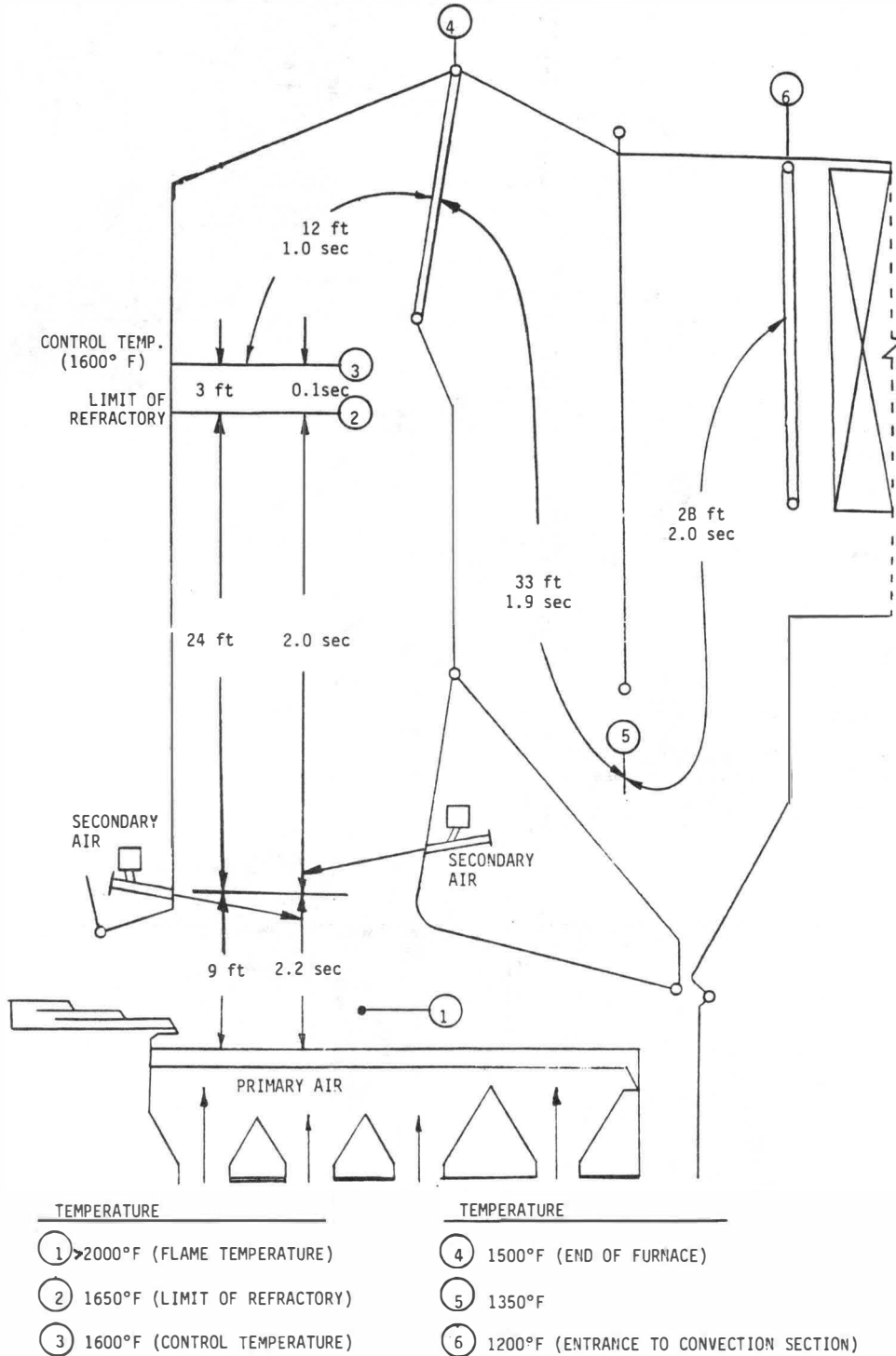


FIG. 12 TIME/TEMPERATURE PROFILE

Performance

The design conditions for the boiler are based on the maximum firing capability of the grate (see Firing Diagram, Fig. 13) and its resulting heat release, from combusting 8505 kg/h (18,750 lb/hr) of fuel with a higher heating value of 1336 kcal/kg (5300 Btu/lb). The resultant sensible heat supplied to the boiler is approximately 21.7×10^6 kcal/h (86×10^6 Btu/hr) from which approximately 29,000 kg/h (64,000 lb/hr) of superheated steam at 400°C (752°F) and 4.3×10^6 Pascals (630 psig) are generated.

The design pressure of the boiler pressure parts is 6.3×10^6 Pascals (925 psig).

Demineralized and deaerated feedwater is supplied to the boiler at 130°C (266°F).

The control load point of the boiler was selected at about 14,970 kg/h (33,000 lb/hr) steam flow, or 51% of the boiler maximum rating. This selection results in an attemperator flow of 907 kg/h (2000 lb/hr) to reduce the final superheater inlet temperature from 350°C (660°F) to 320°C (607°F) to maintain the 400°C (752°F) boiler outlet steam temperature. On the gas side, the temperature under maximum operating conditions and based upon 100% excess air are as follows:

Furnace, end of refractory = 980°C (1800°F)

Superheater inlet = 680° (1255°F)

Economizer outlet = 160°C (320°F)

The resulting boiler efficiency was predicted to be 75%.

Heating Surface

The boiler is equipped with welded waterwalls in the furnace, the radiation chambers and the convection section side walls, except for the economizer section. Here the gas temperature is too low to justify the expense of waterwalls. The roof is also water cooled. The superheater consists of a final and an initial superheater with a spray desuperheating station between the two sections. The final superheater is arranged in parallel flow with the gas in order to reduce the tube temperatures for corrosion protection. All other surfaces are arranged in counter flow. In the direction of the gas flow, the superheater is followed by two evaporator bundles and a final economizer bundle and two external economizer bundles.

Provisions are made to bypass the external two economizer bundles during start-up, shut-down, low-load operation, or operation with feedwater heaters out of service to avoid falling below the dew point in the tail end of the boiler with low feedwater temperature.

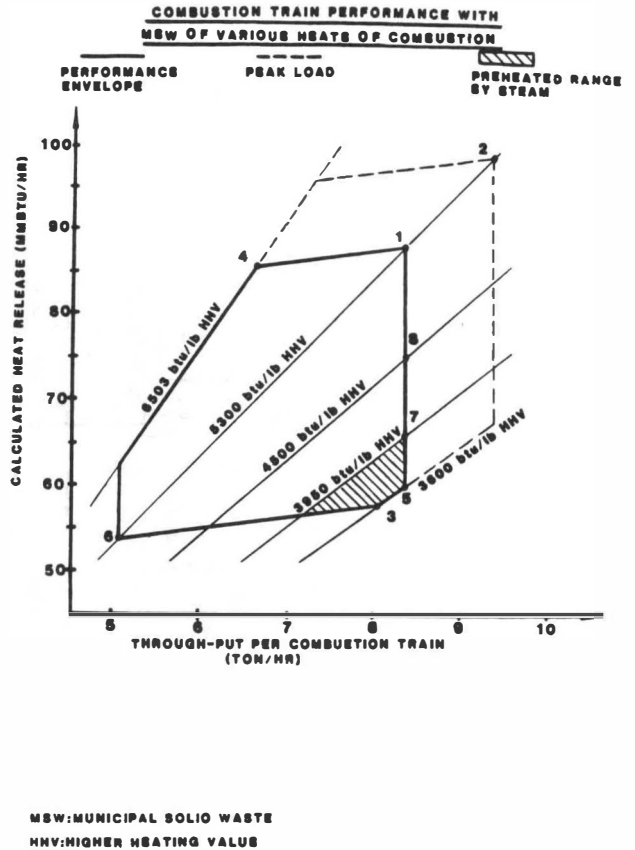


FIG. 13 COMBUSTION TRAIN PERFORMANCE

A flow-schematic of the boiler is presented in Fig. 14.

Tube materials are all low-carbon steel with the exception of the final superheater which is T-11 material for corrosion protection.

The wall thicknesses selected for all boiler tubes include a significant corrosion allowance.

Cleaning System

The boilers are designed for on-line cleaning by mechanically rapping the vertical tubes of the convection sections and pneumatically rapping sections of the welded furnace walls, the roof area, and arches. To this end, the lower header of the pendant tube sections is equipped with an impact shaft, which is hit by a free falling hammer rotating on a motor driven shaft alongside the boiler walls (Fig. 15). Multiple hammers are located on a single shaft impacting on sequential headers in a predetermined sequence. Acceleration of the headers and tubes up to about 100 g are achieved, which cause the deposits to slide off the tube in a

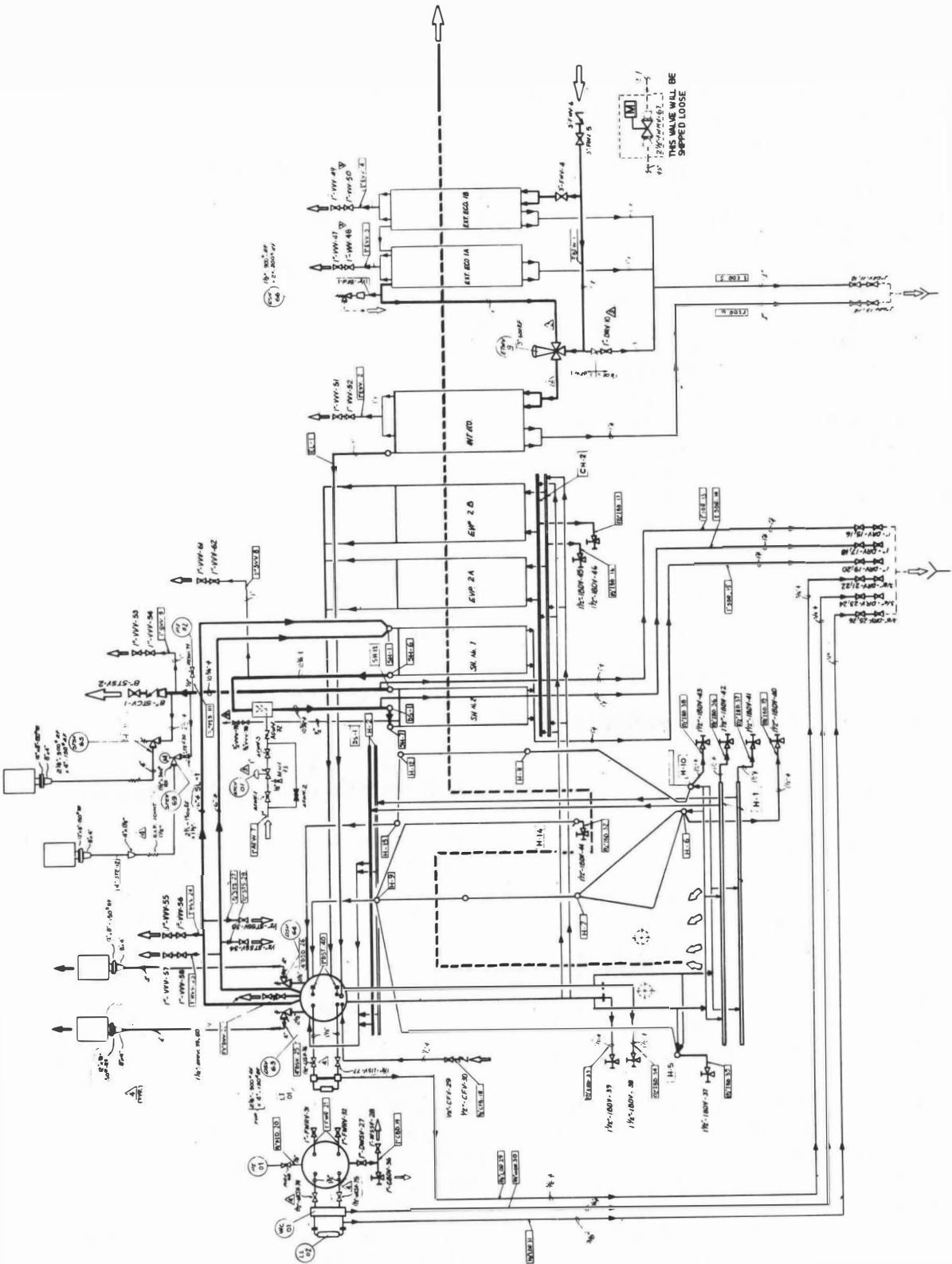


FIG. 14 BOILER SCHEMATIC

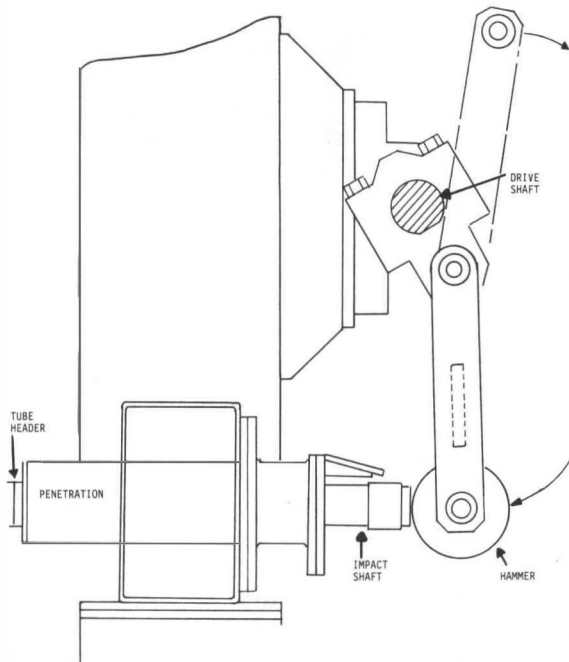


FIG. 15 MECHANICAL RAPPER SYSTEM

fashion similar to that experienced with electrostatic precipitator rapping systems. The frequency of the rapping cycles, which is a function of the fuel quality, is adjustable.

On the furnace walls, roof, and arches, pneumatic rapping devices are used because of the various required elevations. Here, pneumatically caused acceleration acts upon an impact plate, which is mounted to a number of waterwall tubes (Fig. 16). The cycle for the pneumatic rappers is also controllable as a function of furnace deposit build-up.

Auxiliary Burners

Each boiler is equipped with two auxiliary oil-fired burners in compliance with NJDEP permit conditions. The burners are sized to start-up a cold boiler and bring it up to 1800°F at the end of the furnace refractory. According to the permit, MSW charging may not begin, unless a 1500°F temperature level is reached one second downstream of secondary air injection. Oil firing is maintained until stable MSW combustion is achieved. After that, the burners are shut down and only restarted if the control temperature in the furnace falls below 1600°F.

The burners are equipped with their own air fans, as the high velocity secondary air could possibly cause a flame-out. The burners are withdrawn from the furnace, and the burner openings in the furnace wall are

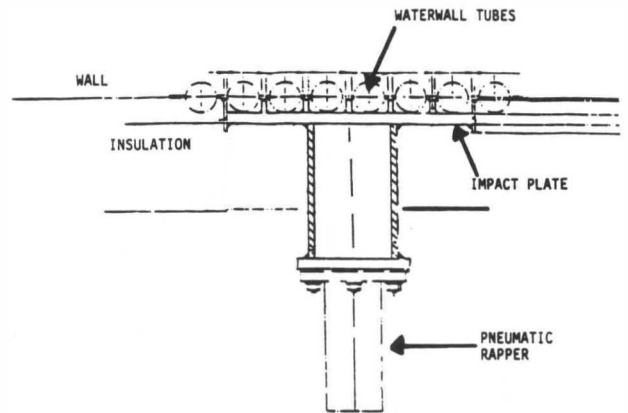


FIG. 16 PNEUMATIC RAPPER SYSTEM

closed by a refractory lined guillotine type closure when the burners are not in operation.

The Turbine Cycle

The overall turbine cycle is depicted schematically in the energy balance diagram (Fig. 17) and represents the predicted plant performance under maximum load conditions.

Steam is conveyed to the turbine-generator via a common main steam line. The turbine-generator is a nominal 13 MW Westinghouse impulse type machine with a gear-driven Brush generator rated at 14,445 kVA. The turbine, which has a total of nine stages and 30.5 cm (12 in.) long last stage blades, is equipped with four uncontrolled extraction ports for supply of steam to the two low pressure feed water heaters and the deaerator. Additional plant auxiliary requirements are also supplied from extraction steam, if needed.

The turbine exhausts into a main condenser, which is maintained at 63.5 mm (2½ in.) Hg back pressure by a water cooling system. The plant is equipped with a bypass condenser, which permits full boiler operation during turbine outage. In this case, pressure and temperature reduction takes place prior to admitting the steam to the bypass condenser. A four-cell cooling tower provides for plant cooling, including operation in the bypass mode.

The condensate pumps are sized to take suction from either the main or bypass condenser. Two condensate pumps are provided, sized for 100% flow each. Three feedwater pumps are sized for 65% of total plant flow each. There are two motor-driven and one turbine-driven feed pumps.

A make-up water treatment system and a split flow

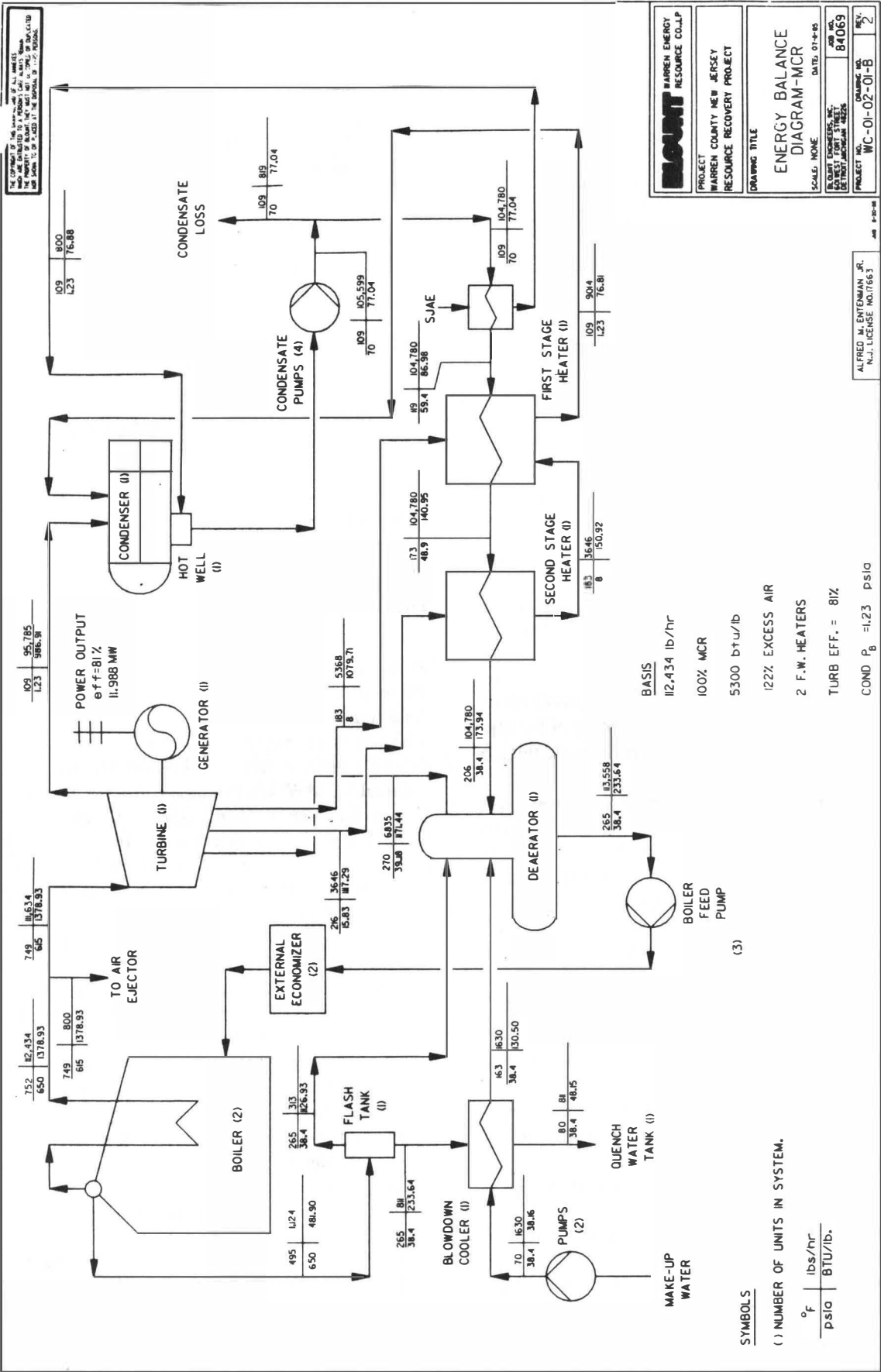


FIG. 17 ENERGY BALANCE

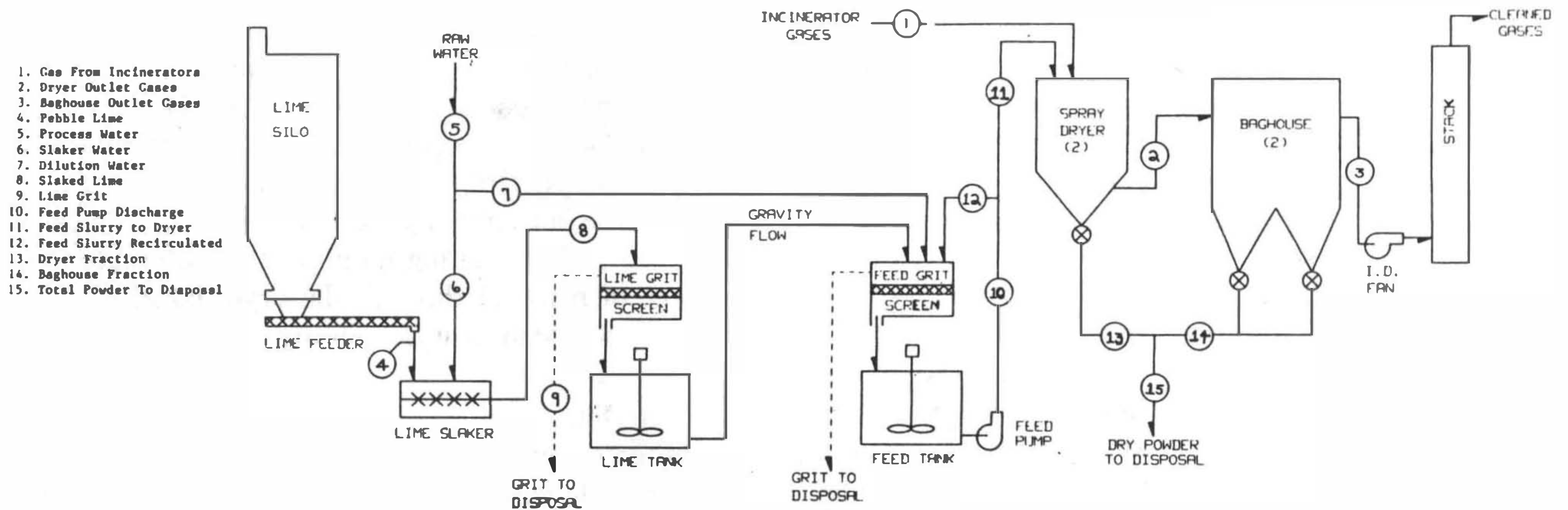


FIG. 18 AQCS SCHEMATIC

demineralizer system are provided. Boiler feedwater treatment to ABMA specifications is accomplished by phosphate treatment and oxygen scavenging. The condensate system is protected by amine injection.

Make-up water, as well as all other plant water is supplied from two wells, close to the plant site, at the bank of the Pequest River.

Air Quality Control System

Permit Conditions

The plant was initially designed for a sulfur removal capability of 70%, based upon a sulfur content of 0.3% in the design fuel. HCl removal was required to be 80% and particulate emissions were initially restricted to 0.31 g/Nm³ (0.02 gr/dscf). However, because of a high influx of SO₂ from a nearby coal-fired power plant in Pennsylvania, the NJDEP decreed during the permitting process that the facility's gas cleaning equipment should be designed in accordance with LAER with respect to HCl and SO₂, and set the permitted emission levels as follows:

SO₂ = 80% removal or 50 ppmv¹ (not to exceed 100 ppmv)

HCl = 90% removal or 50 ppmv¹

HF = 90% removal

Furthermore, since another facility in New Jersey, located in a nonattainment area for particulate emissions, had guaranteed not to exceed 0.015 gr/dscf, corrected to 7% O₂, the NJDEP required the Warren

County Facility to meet the same particulate emission limits.

As operating experience with gas cleaning equipment in MSW plants was extremely limited, an extensive review was conducted of such systems and available experience data. Based upon this analysis, it was decided to utilize a semi-dry scrubbing system in order to avoid the problems of wastewater treatment and flue gas reheating, as required with wet scrubbers. For particulate control, a baghouse was selected because of its ability to better capture the fines as may be generated in the scrubber.

Two technologies are available for lime slurry injection into the flue gas stream: nozzles and rotary disks. The rotary disk option was selected for the Warren County Facility because of the somewhat smaller droplet size which appears to be achievable with this system and the resultant lower lime consumption for the same performance conditions. Environmental Elements Corporation was selected as the supplier and erector of the complete gas treatment system.

The air quality control system consists of a spray dryer and a multiple compartment pulse jet baghouse for each process train. Both spray dryers are served by a single lime handling and slurry preparation system.

A schematic flow diagram of the AQCS is presented in Fig. 18.

Reagent Preparation System

The primary reagent is commercial grade pebble lime (90% Calcium Oxide). The pebble lime is batch-wise metered to the lime slaker in response to the rate at which slaked lime is being consumed by the spray dryer absorbers. Water is continuously metered at a

¹ Whichever is least stringent; dry basis corrected to 7% O₂.

fixed ratio to the rate of pebble lime being fed to the slaker. In order to produce the highest quality slaked lime, it is necessary to achieve high temperatures within the slaker. This is accomplished by maintaining a paste-like consistency of 43% solids in the slaker, which results in very high slaking temperatures. This high-solids lime slurry is sluiced to 20% solids by a pre-set water spray bar to enable gravity flow of the lime milk. The dilute slaked lime flows to a vibrating wire mesh screen for separation of grit and tramp material before entering the lime milk holding tank. The flow of pebble lime, slaking water and sluicing water are all turned on and off in response to the lime milk holding tank high and low level switches. The cycle time between high and low level is adjusted to achieve near continuous operation of the slaking system. The lime milk holding tank provides an inventory of high solids lime slurry. This concentrated lime slurry flows by gravity to the feed tanks for final dilution before being fed to the spray dryers.

The feed tank is a source of surge capacity for the lime feed pumps which draw suction from the tanks and deliver to the spray dryer absorber system. The concentration or percent solids of the lime milk slurry in this tank is either automatically or manually adjusted to maintain the desired stack emission of acid gases. Each spray dryer absorber has a completely dedicated pump station, consisting of one operating and one installed spare pump.

Spray Dryer

To achieve the required reaction, the combustion gases are cooled to a pre-selected temperature and contacted with the alkaline lime particles for neutralization of the acids. This is simultaneously achieved by intimately mixing the atomized lime milk slurry droplets and the hot combustion gases. The proper amount of lime is controlled in the feed preparation system by adjusting the density of the lime slurry. The proper amount of water for cooling is controlled by throttling the flow of slurry entering the spray dryer to maintain the desired outlet gas temperature.

The lime slurry is atomized into very fine droplets and is sprayed directly into the dryer in a downward spiraling pattern. The hot combustion gases are introduced through an angular opening surrounding the atomized slurry spray pattern. This turbulent zone of liquid droplets and hot gas provides the necessary contact to promote rapid drying of the lime milk slurry and efficient reaction with the acid gases. Complete drying is accommodated by the proper gas residence time in the dryer. This assures that the calcium based salts are dry enough to leave as entrained particulate

in the gas stream rather than forming deposits on the dryer walls. The combustion gases exit the spray dryer absorber at a much lower temperature and in compliance with acid gas emissions criteria. A portion of the dry particulates drop out of the gas stream and exit through the bottom flange of the dryer cone, which is equipped with a rotating lump breaker to ensure free passage of material through the dryer cone, even in the unlikely event of upsets in dryer operation.

Fabric Filter

The gases, containing fly ash, calcium based salts and dried lime particles, are drawn into the inlet plenum of the baghouse by the induced draft fan. The inlet plenum spans the length of the baghouse and directs the gases through inlet butterfly type dampers into the hopper of each compartment. The gases are directed upward by vanes and baffles into each compartment containing the filter bags. Particulates are deposited on the exterior of the filter bags. Cleaned gases, exiting the filter bags of each compartment, are drawn upward through poppet dampers into an outlet plenum which is common to all compartments. Gases in the outlet plenum are directed via ductwork to the induced draft fan and exhausted through the flue. Each process train has its own flue. Both flues are housed in a common stack.

The baghouses are not bypassed during startup operation with MSW fuel, as under NJDEP permit conditions, the filters must be in operation whenever MSW combustion takes place in the furnace. The particulates collected on the exterior of the filter bags are periodically removed by a pulse jet cleaning system. Each row of bags has a pulse pipe which is connected to a main air header. A pulse of high pressure, low volume air is supplied to each row by a double diaphragm valve located at the end of each pulse pipe.

Only one of the baghouse compartments undergoes cleaning operation at a time, with the remaining compartments "on line", collecting particulate matter. A microprocessor in the control panel sequentially controls operation of all poppet dampers.

Residue Handling System

Bottom Ash

A ram discharger (Fig. 19) is directly connected to the residue chute at the end of the grate and is designed to quench the total amount of bottom ash and fly ash from the grate and boiler. The discharge from the ram is dust free, with no significant heat or odor emission. The unit is sealed by water against the furnace

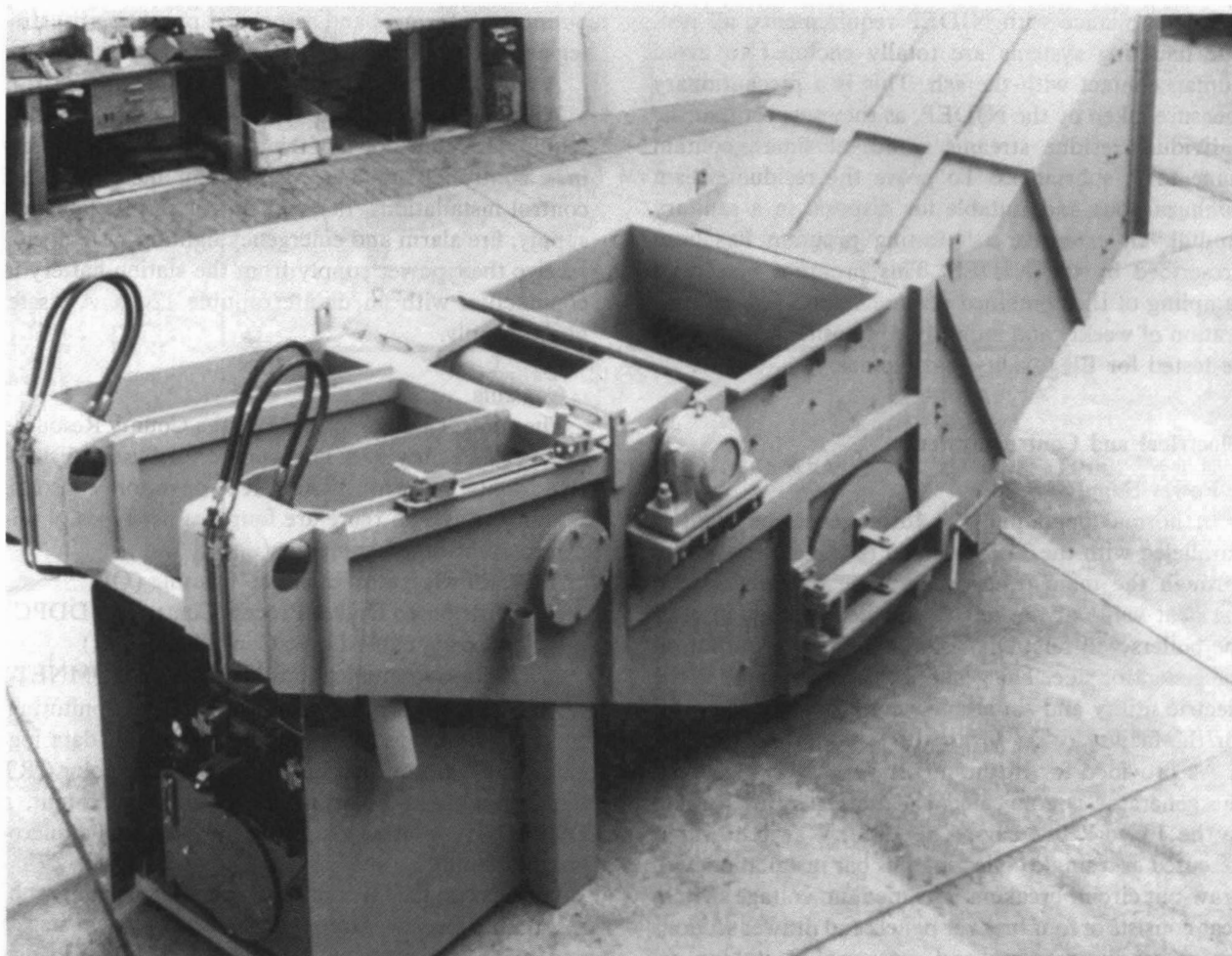


FIG. 19 W+E RAM DISCHARGER

chamber. The ash is compressed and dewatered when it leaves the ram discharger. The ram forces the ash across a wear plate into a hopper above the ash conveyor.

The residue leaving the ram discharger is sterile and inert and contains less than 20% water. Due to the highly inconsistent size of the residue discharged from the furnace, the method of transferring residue from the ram discharger onto the conveying system is the single most vital element of a reliable residue handling system.

Vibrating feeders were selected with a manually operated diverter to an emergency stand-by belt conveyor as the most reliable transfer system. The benefit of the vibrating conveyor installation is the ability to scalp off oversize material over a grizzly. The grizzly is sized to classify the residue into ± 6 in. material. The -6 in. material is conveyed by an inclined transfer belt

conveyor to the residue mixer and storage building. The $+6$ in. material is collected in containers for direct disposal at the landfill.

Fly Ash

Fly ash from the spray dryer hopper and the particulate emission control system is conveyed to a fly ash surge hopper by a series of drag conveyors. The fly ash is extracted from the surge hopper and dosed into a rotary mixer, where it is mixed into a quasi homogenous residue stream with the boiler ash. The mixed residue is conveyed to and stockpiled in the residue storage building, where it is loaded by front-end loaders onto trucks for disposal at the landfill. Homogenizing of the residue prior to disposal is a NJDEP requirement. It could potentially be achieved in either the ram discharger or in the rotary mixer, as provided for the Warren County Facility.

In compliance with NJDEP requirements, all residue handling systems are totally enclosed to avoid human contact with the ash. This is a precautionary measure taken by the NJDEP, as they suspect that the individual residue streams could, at times, contain some toxic substances. To prove the residue stream nonhazardous and suitable for disposal in a sanitary landfill, an extensive ash testing program has been prescribed by the NJDEP. This program prescribes sampling of the combined residue stream for the generation of weekly and monthly composites which must be tested for EP toxicity and dioxins.

Electrical and Control System

Power Supply

In normal operation, the turbo-generator plant is paralleled with the 34.5 kV main of the electric utility through the main transformer. Due to variations in the heat value of the refuse, the steam production of the boilers will fluctuate, as will the power output on the generator side. The generator delivers power to the electric utility and simultaneously provides the power for the facility.

As provided for in the power supply arrangement, the generator is connected via the generator breaker to the 13.8 kV bus bars. The 13.8 kV switch gear is executed as a single collecting bus bar installation with draw-out circuit breakers. The medium voltage switchgear consists of four breaker panels and drawer sections for protective relaying and metering. Switching arrangements are designed to enable the turbo-generator to operate isolated from the grid in case of failure in the 34.5 kV line. Selective automatic synchronizing equipment, which permits paralleling to the utility upon start-up, is provided for this purpose.

In case of failure of the utility, the generator is free running in the isochronous mode, supplying only auxiliary power for continuous plant operation and refuse burning. Upon restoration of the utility availability, the generator is resynchronized for immediate load ramping.

The low voltage switchgear is supplied from the 13.8 kV bus via two 13.8/0.48 kV transformers, each of 2000/2666 kVA capacity. The 480 V low voltage, double ended unit substation switchgear is contained in metal clad steel cabinets. Circuit breakers are of draw-out design. The entire double-ended unit substation is located directly on the turbine operating floor in visual range of the control room operator. The double ended unit substation feeds five motor control centers for 480 V motor loads and the lighting system. Small 120 V AC power is taken from dry type distri-

bution transformers and associated panel boards, strategically located throughout the plant.

A simplified one-line diagram is shown in Fig. 20.

All equipment and components that are implicitly required for shut-down of the resource recovery facility in a controlled manner, such as all measuring and control installations, turbine control and its lubricant supply, fire alarm and emergency lighting system, etc., receive their power supply from the station battery in conjunction with an uninterruptible 120 V AC safe-guard supply.

Controls

The control system for the Warren County Resource Recovery Facility is a microprocessor-based, distributed digital control with CRT operator consoles. Within the system there are four distinct types of microprocessor-based equipment:

- (a) CRT Operator Interface Console (OI)
- (b) Distributed Digital Process Controller (DDPC)
- (c) Programmable Logic Controller (PLC)
- (d) Data Communications Network (DCOMNET)

The OI provides the means for process monitoring, control parameter manipulation, alarm and data logging. An Operator interface consists of: one color CRT monitor with keyboard, a floppy disk drive unit, a DCOMNET interface, a graphic printer, and a microprocessor unit.

Displays on the OI consist of interactive plant graphics, plant overview, group, detail, trend, system status, and plant alarm status displays. Each OI is loaded with the same interactive graphics, groups, and alarms so that any OI may control any plant system or device interfaced with the Digital Control System (DCS).

The keyboards allow an operator to move between various displays, acknowledge alarms, adjust control parameters, connect, disconnect, download, and checkpoint anyone of the DDPCs or PLCs attached to the data highways. Engineers may place the keyboards in a configuration mode to allow for control tuning or configuration changes to the system programming.

The floppy disk drives are used to permanently store the operating system OI and DDPC configuration programs which are downloaded prior to any plant cold restart. The hard disk drives are also used to record trend data for archival purposes. Permanent archiving is achieved by transferring trend information to a floppy disk for storage.

The graphic printer capability will allow an operator to make a hard copy of present displays on the OI CRT monitor. The printer also provides an automatic means of logging both process and system status alarms, in the order in which they are detected. The

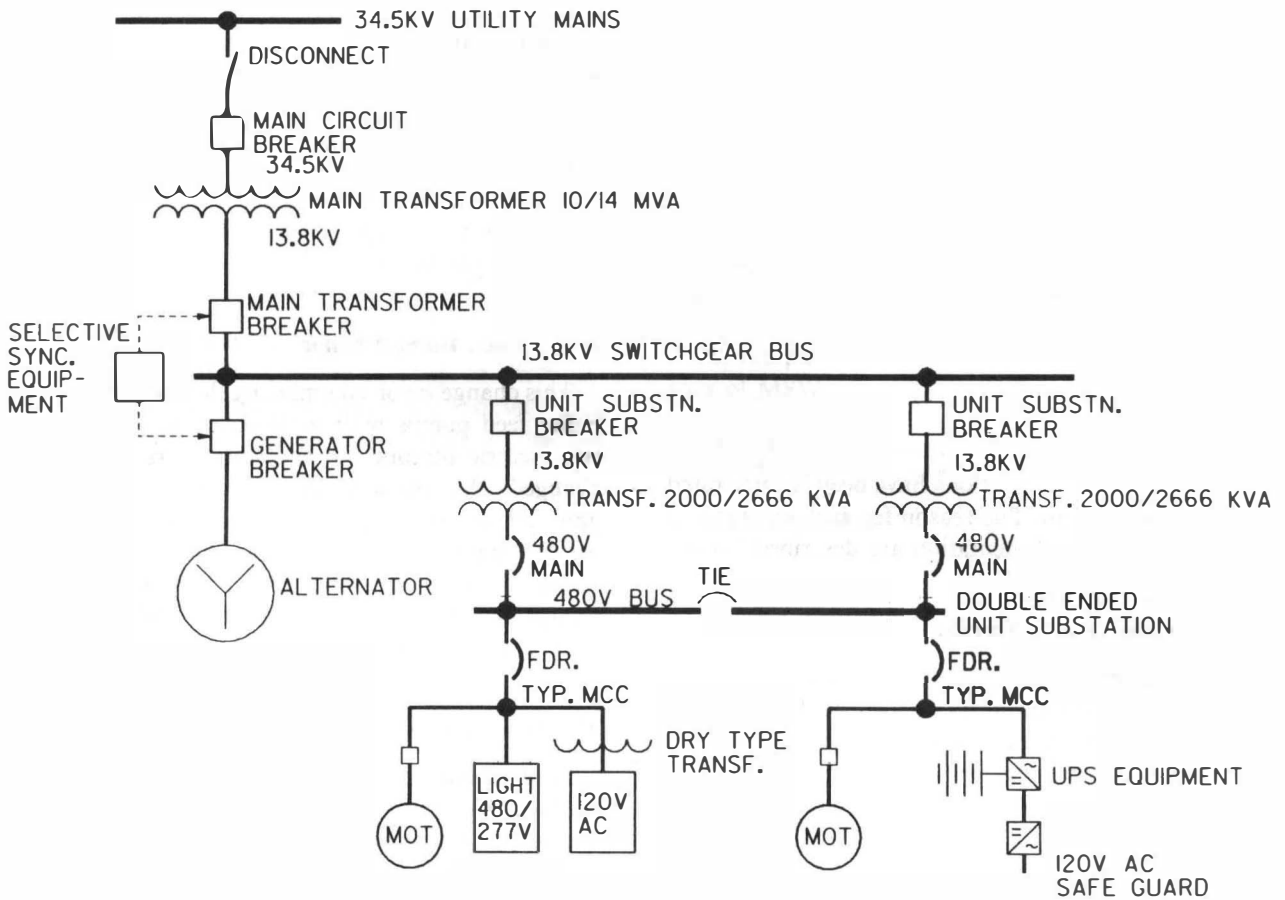


FIG. 20 ONE-LINE DIAGRAM

printer produces, on request, current logs of all loops in alarm, all loops with alarm functions disabled, and all loops which are turned off.

The communications interface connects the OI and the DCOMNET, allowing the OI microprocessor to acquire current process data. This data is used to update the various displays and trend files. The communications interface also transmits operator parameter manipulations to the various DDPCs for use in the distributed configuration algorithms.

As it has been implied, the DCOMNET connects the OIs with the DDPCs to allow data to flow between these key pieces of equipment. The DCOMNET consists of redundant communications interfaces at each OI and DDPC, interconnecting high speed serial data cables and a communications control protocol.

The DDPCs and the PLCs are the actual repositories of the plant control configuration. Therefore, certain guidelines and criteria have been set up to minimize

the probability that a single failure will affect the entire plant, and to maximize the efficiency of the plant control strategy.

These guidelines are as follows:

(a) The DDPC's are the master control devices providing both digital and analog inputs and outputs (I/O) to field devices for sequential and continuous control. Additionally, serial digital interfaces are provided to communicate between the DDPCs and PLCs apart from the plant-wide DCOMNET.

(b) PLCs are generally assigned to system, or equipment specific tasks, relying primarily on digital I/O for motor start/stop, startup permissives and other sequential operations.

(c) The PLCs perform their assigned tasks independently, but rely on the DDPCs for their communications link to the DCOMNET for supervisory commands, and related systems information outside the PLC's scope of control. Additionally, the PLCs

supply status information to the DDPs for use in the control of other systems and to relay information to the OI.

(d) The physical control entity of the plant is partitioned such that a component failure within a duplicate subsystem in the plant will not require the remaining subsystems to cease operations.

(e) Those subsystems where duplication does not exist are provided with redundancy in the control system.

PLANT MODIFICATIONS

The following modifications have been incorporated into the plant design. The reason for each change and the status of its implementation are described below.

Demineralized Water Storage

The demineralized water storage capacity was increased from 3000 gal to 24,000 gal, and a 100 gpm pump was added to supplement the two original 20 gpm pumps. This change has been completed, and the system is in service. The reason for the change was to provide increased demineralized water storage, makeup, and surge capacity found to be needed during transients and for boiler fill.

Auxiliary Cooling Water System

In the original plant design, the condensers and all auxiliary equipment utilized the same cooling water systems with the cooling tower providing the heat sink for the system. After the plant experienced problems with plugging and scaling of heat exchangers, a number of auxiliaries were removed from the plant cooling water system, and a separate auxiliary cooling water system was designed to provide additional water chemistry control. The separate closed-loop system was provided by adding two 100% capacity plate type heat exchangers which transferred the auxiliary heat load to the plant cooling water system. A water softener was added to provide the chemistry control.

In addition, a head tank was added in the auxiliary cooling system to assure a source of cooling water to the turbine-driven boiler feed pump and diesel-driven air compressor in the event of total loss of plant electrical power. Necessary pumps, piping, valves, and instrumentation were also added to complete the system design.

The system has been operating for several months with no evidence of plugging or scaling. The following

auxiliaries are served by the auxiliary cooling water system:

- (a) boiler feed pump bearing coolers
- (b) boiler feed pump turbine bearings
- (c) air compressors (3)
- (d) I.D. fan bearing coolers
- (e) I.D. fan variable speed drive coolers
- (f) sample coolers

Boiler Feed Pump Change

This change involved replacing the three single-stage boiler feed pumps with multi-stage type pumps. The two electric motors and the steam turbine were not changed. The flow was increased from 150 gpm to 170 gpm. The original single-stage pumps proved unreliable for the application. The pump manufacturer recommended changing to multi-stage type pumps. The new pumps have been in operation for several months and have given good service.

Magnetic Separator Addition

A magnetic separator was added over the existing inclined belt ash conveyor. Also, a 12 × 16 ft building was added for ferrous metal container storage. This change was required to remove ferrous metal left in the ash stream after the grizzly separator to minimize jamming of equipment such as the ash sampler and the mixing drum. The magnetic separator has performed well and has substantially reduced jamming of the ash handling equipment.

Ash/Water Separator Addition

The residue storage, ash mixing, and transfer buildings each originally employed sump pockets with centrifugal type sump pumps to transfer drainage, including washdown water directly to the boiler quench water tank. This drainage was frequently high in solids content and clogged the drain lines from the sump pocket.

A new design was developed for the drain system which added a 1000 gal ash/water separator and replaced the centrifugal type sump pumps with motor operated diaphragm pumps. The sump pumps discharge into the 1000 gal separator. The ash/water separator is a concrete settling basin with a weir. Clear water from the separator can be reused for washdown water in any of the three residue handling buildings. The ash accumulated in the ash/water separator must be periodically removed. The separator is open to allow access for manual cleaning.

The new ash/water separator pumps and associated valves and piping have been in service for several months with no significant problems reported.

SUMMARY

The Warren County Energy Resource Facility and its processing equipment has been described in detail. Construction of the facility was completed in June, 1988, and acceptance testing was successfully completed in April, 1989. A severe shortage in MSW deliveries delayed full capacity shakedown and equipment checkout, which contributed to the late completion of the Acceptance Tests.

Throughput averaged 537 TPD of essentially reference fuel during the three-day acceptance test, or 134% of guaranteed capacity. The residue combustibles content remained below the 5% guarantee despite the high throughput. Electrical generation was significantly above guarantee during the test period.

The MSW delivery shortage has been resolved by the County and initial equipment shakedown difficulties have been overcome such that the plant now normally operates at full capacity. Through January 31, 1990, the plant had processed approximately 139,092 tons of MSW.

Key Words: Combustion; Facility; Mass Burn; New Jersey; Power Generation; Refuse; Warren County