

CAMDEN RESOURCE RECOVERY FACILITY
ENHANCING ENVIRONMENTAL PERFORMANCE
with an
EMPHASIS ON RECYCLING

Bruce C. Studley, P.E.
Vice President, Plant Operations,
Foster Wheeler Power Systems
Perryville Corporate Park
Clinton, New Jersey 08809

Newton G. Wattis
Plant Manager
Camden County Energy Recovery Associates, L.P.
600 Morgan Boulevard
Camden, New Jersey 08104

ABSTRACT

The Camden Resource Recovery Facility is part of a planned solid waste management program developed by Camden County, located in southern New Jersey across the Delaware River from Philadelphia. This mass-burn plant, which began operating in March 1991, processes waste from 37 towns in the County. It is capable of burning 1050 tons per day (tpd) of refuse to generate electricity, which is sold to Jersey Central Power & Light Company. The plant is located in an industrial area of Camden and is also designed to produce high-pressure, high temperature steam to provide sufficient energy for any existing or future industrial customers.

The facility, shown in "Fig. 1", was designed and built by Foster Wheeler and is owned and operated by Camden County Energy Recovery Associates, L. P., a subsidiary of Foster Wheeler Power Systems, Inc. The Pollution Control Financing Authority of Camden County is responsible for project oversight and administration for the County. The Authority is also responsible for operating the County landfill. Camden County's comprehensive waste management system, which will be described below, has indeed been successful for its more than 500,000 residents.

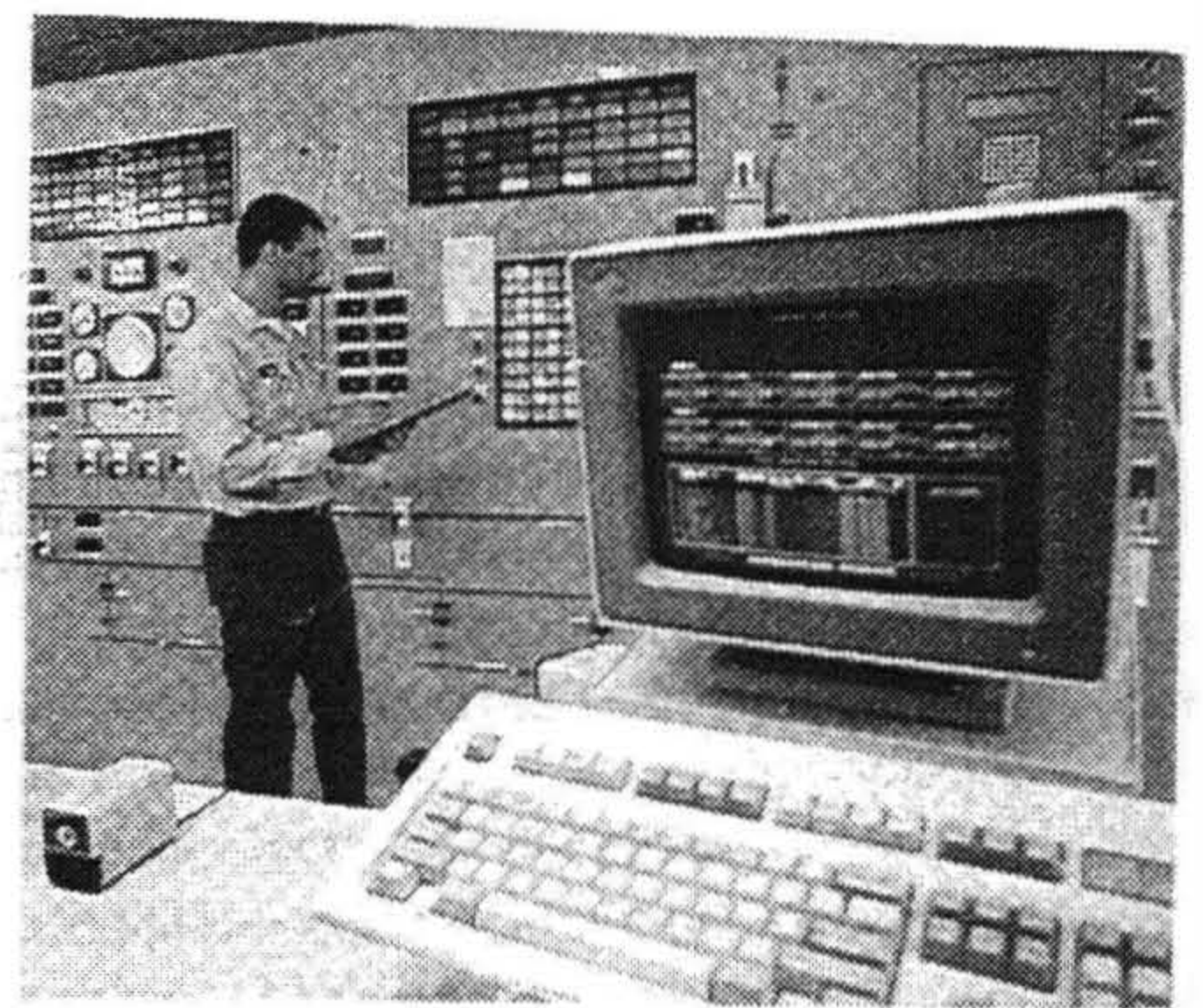
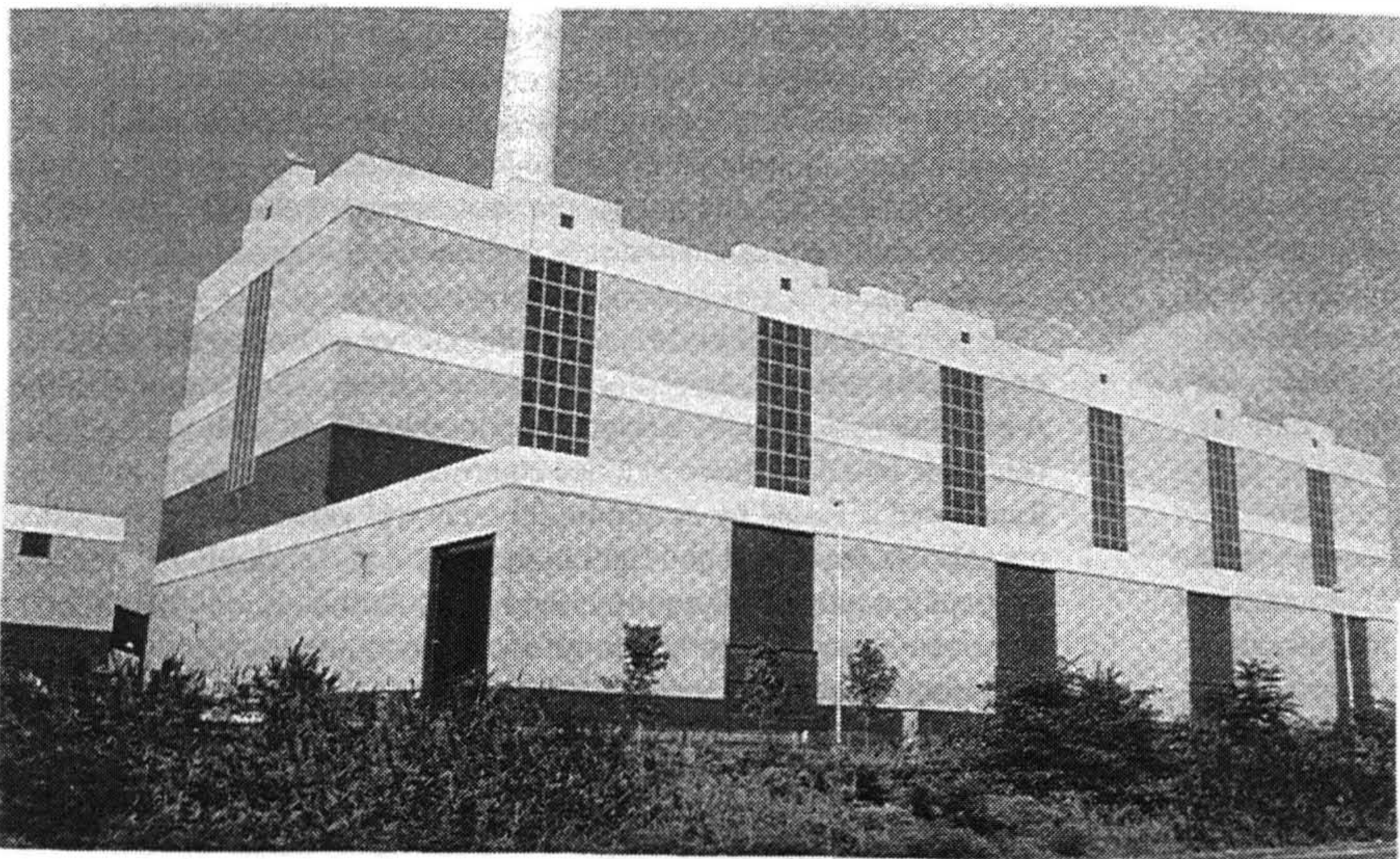


Figure 1. High visibility made esthetics an important part of the plant design (above left). In operation, real-time data from a continuous emissions monitor (above right) is telemetered to the state regulatory agency for compliance assurance.

In looking towards the future and the recently promulgated Emission Guidelines under the Clean Air Act, which will affect all municipal waste incinerators and result in reducing overall air emissions, a number of extensive Test Programs aimed at enhancing overall environmental performance were undertaken. These programs entailed testing of Activated Carbon Injection, proper Burning of Whole Tires, Reclaimed Baled Waste and Enhanced Shredder Derived Fuel, and Recycling of the Facility's Combined Ash Residue for use as Landfill Cover. All Test Programs, and more importantly their test results, were successful in demonstrating enhanced environmental performance with an emphasis on recycling.

INTRODUCTION

Representing the state-of-the-art combustion technology for a system deriving energy from municipal solid waste (MSW), the 1050-ton/day refuse-to-energy plant serving Camden County, NJ, achieved commercial operation on July 1, 1991.

A noteworthy aspect of the project is that it was the first County-wide plan in the US to combine waste-to-energy with recycling. The recycling effort included one of the country's first materials-recovery facilities. Commissioned early in 1986 - well in advance of a state law mandating recycling - it provided a model emulated by other communities. Today Camden County recycles approximately 43% of its wastes. The facility has recently completed its fourth full year of operation while processing on an average annual basis 380,000 Tons of MSW. Overall plant capacity has averaged 95% with over 775,000 megawatt hours of electricity having been exported. Emissions are continuously monitored with results displayed both in the plant and at the New Jersey Department of Environmental Protection. Actual air emissions have been substantially below the permitted limits and will be further reduced now that the installation of an Activated Carbon Injection System has been completed. Also, ferrous material is being recovered from the ash residue with facility improvements in progress to recover additional ferrous material.

Prior to discussing the various test programs and environmental enhancements, a detailed facility description is provided.

FACILITY DESCRIPTION

Mass burning involves little or no presorting of refuse. With the exception of large noncombustible objects that may be found in the incoming waste stream, the as-received refuse is charged into the furnace.

The Plant shown in "Fig. 2" has three boiler trains, each sized for 350 tons/day of 5300 BTU/lb. fuel and is designed to accommodate a fourth train. At the maximum continuous rating, each boiler generates 105,000 lb/hr of steam at 650 psig/750F, and exports in excess of 25 MWH/hr. at 26 KV during peak demand periods.

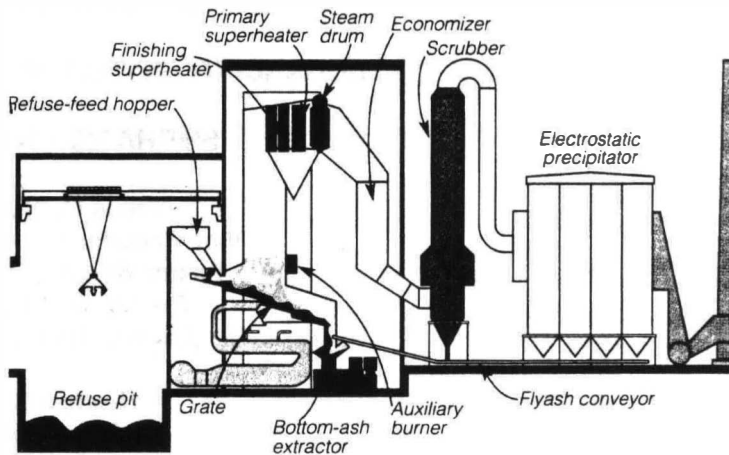


Figure 2. Resource Recovery Plant at Camden, NJ handles 1050 Tons/day of municipal waste.

The plant accepts more than 200 refuse trucks daily, which (after weighing) enter a tipping building and unload into an open storage pit. The pit is sized for four days of storage to provide the necessary capacity reserve for weekends and holidays. The tipping building houses the refuse pit for weather protection and controls fugitive dust and odors. Ventilation is provided by drawing combustion air through the building enclosure into the boilers and is used as combustion air to burn the refuse.

The tipping building also houses the two cranes that mix and load refuse into the boilers. The constant mixing is important - it ultimately results in a more homogeneous fuel for the boilers, which promotes improved furnace operation and minimizes load swings caused by variations in refuse heating value. The crane operator is responsible for the removal of oversize and undesirable material that could cause problems in either the feed chute or ash removal system. The rejected material is removed from the pit for separate disposal.

Refuse is dropped from the crane grapples into separate feed hoppers supplying each boiler. To maintain a furnace air seal, the crane operator ensures that the refuse-feed chute into the boiler is full at all times. Should the level in the feed chute drop below a prescribed level, an alarm is sounded. Typically, the crane operator charges each boiler about every five to six minutes to maintain a full chute.

Firing equipment. Once the crane has loaded the charging hopper, the material drops down the feed chute and onto a feed table. A series of hydraulically driven charging rams push material from the feed table into the furnace at a rate controlled by fuel or steam demand. Ram speed is varied by hydraulic flow-control valves. Charging rams may also be biased left and right to even out fuel distribution across the width of the furnace. For protection against burnback and radiant heat the entire charging throat area at the furnace interface is lined with refractory. A shutoff gate isolates the feed chute from the charging hopper.

The grate, also shown in "Fig. 2", consists of three inclined stepped sections with multiple air plenums. Each section is comprised of alternate rows of stationary and moving grate bars which impart a push-pull motion to agitate and move refuse progressively down the grate. The three sections perform the functions of drying, combustion, and burnout, respectively. The stepped design helps to expose unburned fuel to the combustion air and promote improved burnout. Since each grate section has at least one independent air plenum, it is possible to proportion undergrate combustion air to suit specific refuse-burning conditions.

The undergrate air plenums also serve as sifting hoppers where ash particles that fall through the grate air slots are collected. Siftings are removed from each hopper continuously by pusher-type conveyors arranged in a cascading fashion along the length of the grate. The last conveyor discharges into the ash extractor, where the siftings are removed with the balance of the bottom ash.

Boiler design. The furnace of a refuse-fired boiler has a number of special features to accommodate the combustion of aggressive and variable fuels. Besides the normal requirements of providing adequate furnace surface area and volume, the corrosive and abrasive nature of the refuse and flue gas generated must be considered.

To combat corrosion and abrasion, the lower portion of the furnace is lined with silicon carbide refractory. The lining is roughly 1 in. thick and anchored to the furnace walls with high-density pin studs. Silicon carbide was selected because of its excellent resistance to abrasion and chemical attack; it also has a relatively high thermal conductivity, which makes it less susceptible to slagging than other types of refractory. In addition, an alloy weld overlay has been applied to the waterwall surface above the refractory. The overlay improves corrosion resistance of the tube surface without reducing heat absorption.

Additional protection is provided along the grate by high-alloy castblocks. These replaceable wear liners are bolted to the waterwalls and extend up to four feet above the grate in the charging section, to one foot above the grate at the discharge.

Combustion air. Secondary air is injected into the lower furnace to supply the necessary excess oxygen for complete combustion. Rows of high-pressure air nozzles are installed at different levels on the front and rear walls. This secondary (or overfire) air promotes high turbulence and, therefore, good mixing of volatile gases for optimum combustion and emissions control. It is important that the furnace operate at the correct excess oxygen level-not only to achieve good combustion, but to reduce the potential for corrosive attack as well.

Combustion of MSW results in the formation of acid gases from the burning process. It is generally recognized that these gases, at elevated temperatures, will attack carbon steel more aggressively in a reducing atmosphere than in an atmosphere of excess oxygen. Industry experience suggests that at least 80% excess air be used in MSW units.

To promote complete destruction of organic compounds formed during combustion, it is important to maintain a specified furnace time/temperature relationship when firing refuse. To assure this temperature is maintained, furnace temperature sensors trigger

auxiliary-burner firing when the operating parameters fall below the prescribed limits.

Control philosophy. The control scheme is based on turbine-following-boiler philosophy to accommodate the inevitable swings in boiler output caused by variations in refuse heating value. The turbine controls maintain a constant header pressure while electrical load is varied in proportion to actual output.

The combustion control system maintains a target steam flow rate by adjustment of air and fuel flows. Oxygen and furnace exit-gas-temperature control loops trim the fuel-demand and air-flow signals. These loops provide feedback of changes in furnace conditions, which will ultimately result in changes in steam flow. The control system, therefore, responds to changes in refuse heating value to minimize load swings.

System operation. The Camden unit is essentially base-loaded at a high throughput. Permissible operating parameters are defined by a performance envelope that relates heat input to refuse heating value and allowable grate load. Although refuse heating value is usually known only from sampling data, plant operators are aware of averages derived from actual performance data. By using the boiler as a calorimeter, however, it is possible to compute heating value on a real-time basis. It provides additional information to the boiler operator to assist in maintaining operation within prescribed limits.

Efficient operation depends on optimum regulation of the fuel bed and combustion-air distribution. Fuel-bed depth is controlled from the refuse charging rate and grate speed, which is determined by the nature of the refuse and the position on the grate where complete burnout occurs.

Combustion air is divided into undergrate and overfire air in about a 70/30 ratio. Undergrate air is distributed to the various air zones based on observation of the burning pattern and emissions data. Dampers in the air zones provide the means of control. Preheated undergrate air assists in fuel drying and combustion; however, where moisture is low, air preheating is not required.

Ambient overfire air is injected into the furnace at various levels above the fuel bed and fed from an independent over fire air fan that permits adjustment of operating pressures. The nozzles are set up based on carbon monoxide (CO) levels in conjunction with observed flame shape and height. Once set, the overfire air system normally only needs adjustment based on changes in refuse heating value.

Air-pollution control systems. All modern-day refuse-to-energy plants include flue-gas cleaning. Environmental regulations in New Jersey which were in effect when the plant was permitted, required acid-gas scrubbers in addition to electrostatic precipitators. This pairing is quite effective in reducing acid-gas and particulate emissions.

The technology selected for the Camden plant includes a dry scrubber, so-called by virtue of its dry reaction product. It is an efficient device with relatively low power consumption. The operating principle is simple: A lime slurry is sprayed into the flue-gas stream inside a chamber that provides sufficient residence time for mixing and neutralization to take place. Intimate contact of finely dispersed droplets with the flue gas results in good reaction kinetics and rapid

evaporation of water, which leads to high acid gas removal efficiencies and a dry reaction product. The scrubbers are designed to meet removal requirements of 80% SO₂ and 95% HCl from the flue gases and are actually operating at much higher removal efficiencies.

Scrubbed flue gases, heavily loaded with particulate, are further treated in a five cell electrostatic precipitator. The equipment selected is capable of achieving removal efficiencies well below the design basis of 0.015 gr/ft³ (dry standard). A continuous emissions monitor (CEM) constantly samples and analyzes gas at both the scrubber inlets and flues within the stack. Real-time data are telemetered continuously to the State Regulatory Agency's Environmental Center located in Trenton, NJ.

Emissions. As with all municipal-solid waste plants the minimization of air emissions is critical. The Camden facility operates substantially below its permitted limits. Table 1 summarizes by emission category the normal daily operating averages currently being achieved at the Camden facility. In certain instances test results from the plant's compliance test and tests performed during activated carbon injection are shown. Also shown are the limits based upon recent amendments to the Clean Air Act for existing municipal waste combustors. As the table indicates the Camden facility will have no problems operating below the recently enacted Clean Air Act Emission Guidelines.

**Table 1.
CAMDEN AIR EMISSIONS FOR
RESOURCE RECOVERY FACILITY**

<u>Emission Category</u>	<u>Normal Operating Values</u>	<u>USEPA 1995 Emission Guidelines</u>
Good Combustion Practices Carbon Monoxide - CO	30-50 ppm	100 ppm
Metal Emissions		
Particulate Matter -PM Opacity (6-min. avg.)	0.0027gr/dscf 5 to 6%	0.012gr/dscf 10%
Mercury - Hg (1) - Hg (2)	0.217mg/dscm <0.065mg/dscm	0.080mg/dscm
Lead - Pb	0.055mg/dscm	0.49 mg/dscm
Cadmium - Cd	0.006mg/dscm	0.04mg/dscm
Acid Gas Emissions		
Hydrogen Chloride-HCl Sulfur Dioxide - SO ₂	<10 ppm 15 to 20 ppm	31 ppm 31 ppm
NO_x Emissions		
Nitrogen Oxides-NO _x	150 to 190 ppm	200 ppm
Organic Emissions		
Dioxin/Furans (Totals)(1) (2)	47ng/dscm 10ng/dscm	60ng/dscm
(1) Without Carbon Injection		
(2) With Carbon Injection		

ENVIRONMENTAL PROGRAMS AND ENHANCEMENTS

Having been designed as a State-of-the-Art Resource Recovery Facility, which initiated construction on December 9, 1988 with initial refuse firing on March 25, 1991, the importance of always controlling air emissions to values well below the permitted limits has been a priority. In addition to air emissions, recycling of both ferrous and non-ferrous metals as well as approximately 50% of all ash takes place daily. Finally, being active in the community and within Camden County as an integral part of their Solid Waste Management Plan has allowed a variety of Solid Waste issues to be resolved environmentally. For example, the facility participated in the County wide abandoned tire cleanup program and continues to accept tires as burning of whole tires is easily accomplished with no environmental impact. Also, to conserve landfill space within the County at the Pennsauken Sanitary Landfill for future needs in handling non-processible waste, reclaimed baled waste has been easily processed and safely burned within the facility. The above and other items will be discussed below.

Enhanced Removal of Air Emissions

Realizing the importance of striving to minimize all potentially detrimental air pollutants, coupled with public concern regarding Mercury (Hg) emissions, extensive testing to evaluate the effectiveness of injecting powdered activated carbon into the flue gas to improve control of Hg, other trace metals, and trace organics was undertaken. The overall Test Program was sponsored by the U. S. Environmental Protection Agency (EPA) and took place in May and June, 1992. Realizing that the Clean Air Act Amendments of 1990 required EPA to add Hg emission limits to the Municipal Waste Combustor (MWC) Standards, the EPA-Sponsored Tests were both timely and very valuable to our industry. Powdered activated carbon was chosen as the test media, because Hg vapor at normal flue gas exit temperatures does not condense, but is absorbed on the carbon particles and subsequently collected in the Electrostatic Precipitator (ESP). Specific objectives of the tests were to evaluate:

- The relationship of carbon feed rate and Hg capture
- The effects of carbon injection on the control of other trace metals, polychlorinated dibenzo-p-dioxin and dibenzo-furan (CDD/CDF) and various volatile organic compounds (VOCs)
- The effect of carbon injection rate and method (dry powder or slurried with lime) on Hg and CDD/CDF control.
- Whether there are long-term impacts of carbon injection on ESP performance in collecting particulate matter (PM).

With respect to the carbon feed, the dry injection system consisted of a screw feeder and a pneumatic transport system, while the slurried system was simply accomplished by adding carbon to the plant's lime slurry feed tank during each slaking cycle. The lime/carbon slurry mixture was injected into the reactor with the existing slurry feed through the atomization system.

During the tests, carbon feed rate was varied from 0 to 60 lb/hr., which equates to 0 to 4 lbs. of carbon/ton of MSW, the number of ESP fields in operation varied along with ESP inlet temperature, and injection location tested at both the spray dryer absorber (SD) inlet and via slurry injection at the SD nozzles. The general conclusions reached were:

- Hg reductions in excess of 90% were achieved by injection of dry carbon at both the ESP operating temperatures examined (270°F and 350°F).

- The most important process variables affecting Hg emissions were carbon feed rate and carbon injection method.

- Injection of carbon with lime slurry was less effective in reducing Hg emissions than dry injection.

- Injection of carbon reduced stack emissions of CDD/CDF by over 75% so that CDD/CDF removals increased to 95% or more. However, there was no apparent effect of carbon injection on emissions of VOCs or other trace metals.

- Carbon injection had no discernible impact on the ESP efficiency in controlling PM.

At the normal ESP inlet temperature (270°F), typical Hg emission reductions without carbon injection ranged from 30 to 55%. For normal ESP temperatures and dry carbon injection concentrations greater than 150 mg/dscm (approximately 25 lb./hr) of stack gas, Hg reductions across the SD/ESP exceeded 90% and stack Hg concentrations were less than 50 µg/dscm at 7% oxygen. Dry carbon injection concentrations greater than 340 mg/dscm (approximately 50 lb./hr.) resulted in Hg reductions greater than 95% and Hg stack concentrations less than 25 µg/dscm. Graphically, the results for all tests while performing dry carbon injection are shown in "Fig. 3". Hg reductions were not as great at elevated ESP operating temperatures. Stack CDD/CDF concentrations ranged from 39 to 58ng/dscm without carbon injection. They were reduced to 4.5 to 6.3 ng/dscm with high injection concentrations of dry carbon at normal temperatures.

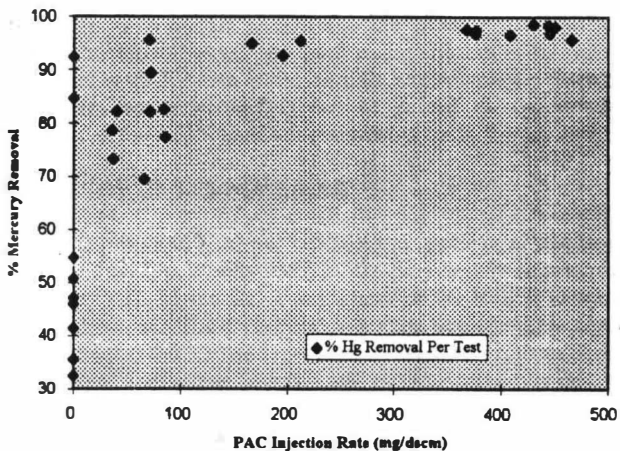


Figure 3. % Mercury Removal vs. PAC Injection Rate During Optimization Testing.

Due to the success of the Test Program, USEPA was able to use the test results along with other information in developing the recently issued and promulgated Subpart Cb Emission Guidelines (1995) for Existing Municipal Waste Combustors. Section 129 of the Clean Air Act required that the previously promulgated Ca Guidelines (1991) be revised to: (1) reflect MACT, which is Maximum Achievable Control Technology; and (2) specify guideline emission levels for additional pollutants not previously covered (i.e. Mercury, Lead, Cadmium, etc.). In addition to the above, the State of New Jersey through the Department of Environmental Protection (NJDEP) adopted and

published in November, 1994, their own regulation for the Control and Prohibition of Mercury Emissions. This regulation requires that Municipal Waste Combustors achieve either an 80% Hg removal efficiency or less than 65 µg/dscm emission limit by January 1, 1996. Because of this, the Camden Facility in early 1995 developed a detailed technical specification for the engineering, design and installation of a permanent, dry powdered activated carbon (PAC) system. This system includes a single silo which holds 3000 cubic feet of working volume that allows for greater than a 40 day supply of carbon. PAC flows from the silo to three individual supply hoppers, one per boiler train, and into its dedicated variable speed screw feeder. PAC discharges from the screw feeder into a pneumatic conveying duct where low pressure air (5 psig @ 90 scfm) conveys the carbon through 2 inch schedule 80 carbon steel piping to the injection point. Injection is into the flue gas duct upstream of the SD inlet cyclone. Based upon the extensive data obtained during the USEPA Test Program, PAC will be injected at a rate of approximately 16 lb/hr into each boiler train. The system has been operational since mid-December, 1995 with an installed cost of approximately \$1,500,000. With respect to carbon cost, it is being delivered to the facility, including transportation, for approximately \$0.50 per pound. With respect to the overall cost of operating the PAC system on an incremental basis compared to annual MSW tonnage, this value is approximately \$1.50 per ton of MSW for mercury control.

Burning of Whole Tires

In early 1994, Camden County like many other counties, was struggling with how to economically clean up the numerous abandoned piles of tires scattered throughout the County. Realizing the significant health and safety concerns associated with the above, the facility participated in a County wide abandoned tire clean-up program. This program, which lasted for two months, allowed all towns within the County to deliver to the facility at no fee any and all tires. Obviously, an extensive Test Program was conducted to assure that emissions while burning whole tires remained unchanged and substantially below all permit limits. Because of the positive results, NJDEP approval was obtained to burn up to 46 tires per hour per boiler with the MSW. This equates to approximately 4% by weight or up to approximately 230 Tons per week, and over 10% by heat input. In order to allow tires to continue to come to the facility, a reduced tipping fee, which can be varied, has been put into place.

Burning of Reclaimed Landfill Waste

The Pennsauken Sanitary Landfill is the only landfill within the County and is an integral part of their Solid Waste Management Plan. In the interest of maximizing the overall life of the landfill and therefore assuring the County's continued ability to manage all of its own non-processible waste, over 5,000 Tons of baled waste has been reclaimed from the landfill and safely processed at the facility. The bales, once reclaimed with removal of cover material, had their baling wires cut and were simply dumped directly into the MSW refuse pit where they were mixed with other MSW. Having shown that there are absolutely no detrimental effects from reclaiming and burning baled waste, the County is able to save landfill space for future needs.

Burning of Enhanced Shredder Derived Fuel (ESDF)

In late 1994, the facility, in conjunction with a local scrap metal recycling company, conducted an ESDF Test Burning Program

of 700 Tons of approximately 9,000 BTU/lb. material. ESDF is the remaining residue after all ferrous and non-ferrous separation is completed from processing old automobiles and other scrap metals. Because of the positive results and unchanged emissions, approval to receive and process quantities of ESDF up to 4,000 Tons per month, depending upon MSW availability, was received in the fall of 1995. This material, similar to tires, is accepted at a reduced rate per ton which benefits local industry, the County and when burned with MSW maximizes steam production in an environmentally sound manner.

Recycling of Ash Residue

After the Camden Facility was successfully placed into service, we with the local authority have sought out viable recycling technologies and markets for the ash residue which is produced. In addition to the technology having to be environmentally sound, it was important to have the County realize a significant savings over the conventional costs of landfilling ash. The technology chosen was the Rolite Process, which takes the facility's combined ash stream and mixes it with cement in a patented process to make lightweight aggregate. The final product is then being used beneficially as daily cover at a landfill in Pennsylvania. Other possible landfill uses include roadways, gas venting and free draining layers and for capping. At the present time, the Camden Facility is recycling approximately 50% of all ash generated, which is about 60,000 Tons annually. The savings is substantial and when looked at with respect to its impact on the tip fee for MSW, results in a savings of approximately \$5.00/Ton for all MSW entering the Facility.

CONCLUSION

As a major part of the County's integrated approach to Solid Waste Management, the Camden Resource Recovery Facility has and continues to process all acceptable MSW in a proper and safe manner. This has been accomplished with both an emphasis on recycling while striving to further enhance environmental performance. From the beginning, this facility has made a positive addition to the City of Camden, the County and to our Solid Waste Processing Industry. Its contributions continue to be recognized with receipt of such acknowledgements as;

- Solid Waste and Power Magazine's 1991 "Best Dressed Waste to Energy Facility"
- Camden County Business Leaders 1992 Award for Resource Management
- American Society of Mechanical Engineers' 1995 Facility Recognition Award for Combustion Processes

References

Kilgroe, J. D. and White D. M., 1993, "Camden County MWC Carbon Injection Test Results", paper prepared by USEPA and Radian Corp., presented at the 1993 International Conference on Municipal Waste Combustion.