

# FIRST YEAR OF OPERATION AT THE SEMASS WTE FACILITY

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## ABSTRACT

SEMASS is a large, privately owned, prepared fuel, waste-to-energy facility located in South Eastern Massachusetts. This paper will review significant aspects of the facility along with operating data from the first year of operation (1989) for this new 1900 TPD (19.95 kg/s) "Shred Burn" facility. Presentation topics include:

- (a) Brief description of the facility.
- (b) A more detailed description of some of the unique features of SEMASS.
- (c) Summary of waste throughput for the first year, and energy production.
- (d) A discussion of the first year's operational highlights.

## INTRODUCTION AND FACILITY DESCRIPTION

SEMASS is a large waste to energy facility located in the Town of Rochester, Massachusetts (see Fig. 1), about 45 miles southeast of Boston. The facility is designed to convert 1900 tons of municipal solid waste each day (19.95 kg/s) into electricity and recovered materials. The plant, which is owned by the SEMASS Partnership, services 32 communities in Southeastern Massachusetts including 14 of the 15 communities on

Cape Cod. The plant has a rated gross electrical generation capacity of 54 MW. Commercial operations of the facility commenced at the end of January 1989 following start-up and testing that began in August 1988.

## PROCESSING OF REFUSE

Refuse is processed prior to combustion in one of three equipment trains that utilize a simplified RDF fuel preparation scheme (see Fig. 2). This processing scheme, commonly referred to as a "shred-burn" process, is organized into three discrete stages: Inspection Shredding, and Magnetic Separation.

### Inspection

The first stage of the processing scheme is to inspect the waste for any hazardous or unprocessable materials such as propane cylinders, hot water tanks, auto engine blocks, etc. This is accomplished by first inspecting the waste when the truck driver tips his load. A second follow-up inspection is performed by the front end loader operator, who spreads the refuse out on the tipping floor before feeding into the first conveyor. The waste is then inspected one final time by two operations personnel, who are positioned on one of three inspection platforms parallel to the three shredder feed con-

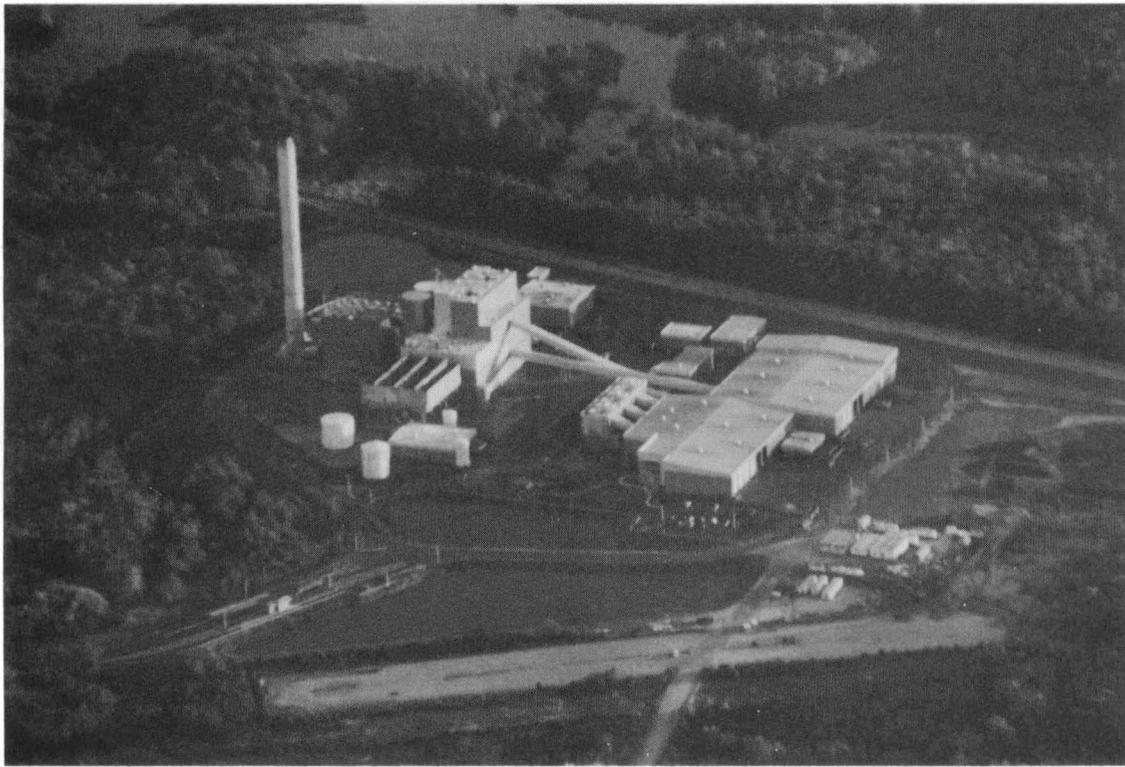


FIG. 1 SEMASS WTE FACILITY — ROCHESTER MASSACHUSETTS

veyors. Their primary job is to remove all objects that pose a hazard to the operation of the shredder or any of the material handling equipment.

### Shredding

The second stage of the fuel preparation process shreds the waste such that 99% of the product material ends up being smaller than 6 in. (15 cm). The shredding system is made up of three processing lines, each with its own horizontal shaft, single direction, down running hammermill. Each of the 1500 hp (1120 kW) motor driven shredders is fed from the top side and is capable of shredding up to 100 tons/hr (40 kg/s) of MSW. All of the shredders have rotor tip wear caps and four edge "Bow-Tie" hammers.

Each shredder is housed in its own reinforced concrete enclosure located approximately 30 ft (9 m) away from the tipping floor building and is protected with Fenwall explosion suppression equipment. Additional safety aspects for the shredders include a vertical vent through the roof of the building and a combustible vapor detection system at each shredder discharge.

### Magnetic Separation

The third and final step in fuel preparation is to remove ferrous metal from the shredded waste. This is accomplished by having all three of the shredders discharge onto a common transfer conveyor that feeds a single two stage magnetic separator. The magnet removes 60–70% of the ferrous metal from the waste stream. An installed spare magnetic separator is utilized if the first unit has to be taken out of service.

Following the ferrous metals separation stage, the Processed Refuse Fuel (PRF) is conveyed via belt and drag conveyors to the boiler feed system. Flow variations in the PRF are evened out at this point through the use of ten vibrating feed bins (five for each boiler) that hold approximately 5 min of full load feed to the boiler.

Any excess PRF supplied to these feed bins is recycled back to a PRF storage area on the tipping floor. This PRF storage pile then becomes the backup source of feed to the boilers through an independent feed conveyor that bypasses both the shredders and the magnetic separator. If there are any interruptions in

## SEMASS Waste to Energy Facility

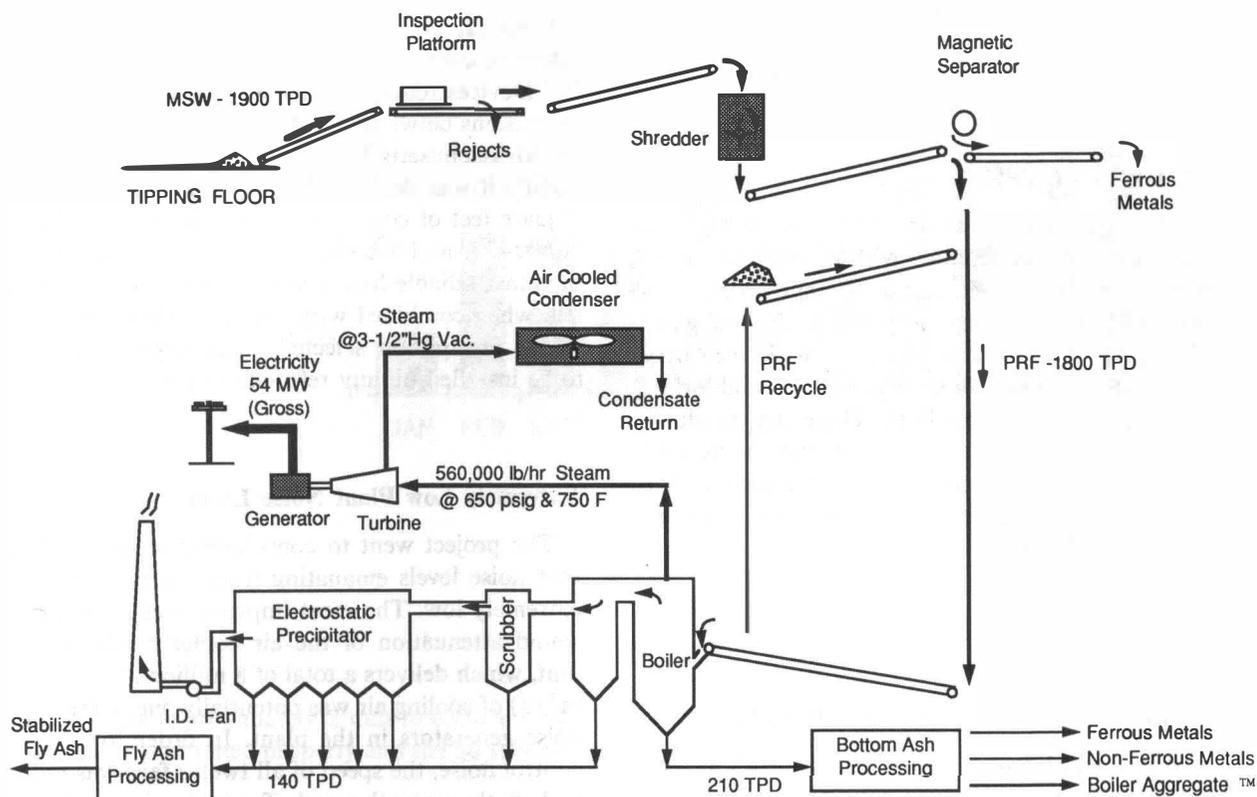


FIG. 2 SEMASS PROCESS FLOW SCHEMATIC

the operation of either the shredder or magnetic separator, this backup PRF pile is utilized for the feed to the boiler. Typically, a 4–8 hr supply of PRF is maintained for feed interruptions.

### COMBUSTION/STEAM GENERATION SYSTEM

The PRF is combusted in two large traveling grate “semi-suspension” stoker boilers, 30 ft (9 m) wide by 98 ft (29.9 m) tall [ 1]. PRF is blown into each combustion chamber by five fuel distributors. The light fraction of the fuel burns in suspension while the heavy fraction falls to the grate before being combusted. Each of these boilers is designed to process 900 TPD (9.5 kg/s) of PRF @ 5000 Btu/lb (11.6 MJ/kg) resulting in a steam production of 280,000 lb/hr (35.3 kg/s) @ 650 psig (44.8 barg) & 750°F (672 K).

The traveling grate, which moves the PRF from the rear of the boiler to the front ash discharge, is made up of a series of flat grate clips approximately 1.5 in. (3.8 cm) wide by 5.5 in. (14 cm) long that are supported by structural steel bars. Underfire air blows through the grate via slots located along the edge of each clip. Heat release on the grate is rated at 600,000 Btu/hr/sq ft (1890 kW/m<sup>2</sup>) [ 1] which is relatively low for a PRF or RDF fired boiler.

The ash produced by the boilers is handled in a dry system that conveys both the bottom ash and fly ash to processing facilities. Fly ash is treated through a stabilization process that mixes the ash with a solidifying agent and water in a patent-pending process to form a concrete-like solid product [ 2]. Solidification of the fly ash after placement in the landfill takes approximately 24 hr.

Bottom ash is processed into three recyclable products; ferrous metals, nonferrous metals, and Boiler Ag-

gregate<sup>™</sup>. These three materials are produced through a series of mechanical processes that include magnetic separation, screening, and size reduction.

## **FLUE GAS CLEANUP SYSTEM**

The flue gas exiting the boilers is treated for acid gas removal via direct contact with a rotary atomized lime slurry mixture inside one of two spray dryer absorber (SDA) units. In the spray dryers, the acid gases (SO<sub>2</sub> & HCl) react with the lime particles in the slurry forming a dry product consisting of calcium chloride, calcium sulfite and excess lime. These dry products are removed from the flue gas (along with the fly ash) in both the SDA unit, and in one of two parallel five stage electrostatic precipitators immediately downstream of the SDAs.

## **UNIQUE ASPECTS OF SEMASS FACILITY**

### **Zero Water Discharge**

SEMASS is located in the middle of the largest U.S. cranberry growing region. Consequently, water conservation and the avoidance of ground water pollution were of prime concern during the design phase of the project. The result of this concern is a facility that has no discharge of wastewater, or in other words a "zero discharge" facility [3].

What this designation means in practical terms, is that the facility does not discharge any wastewater other than treated sanitary sewage (which is discharged to a septic tank/leach field). In fact, there is no sewer connection for the facility and thus all waste water streams, except for sanitary sewage, must be consumed in-plant.

The major reason that this highly desirable feature could be accomplished, is that an air cooled turbine exhaust steam condenser is employed, avoiding a cooling tower, which is typically the largest single wastewater source and water consumer in a WTE facility.

All of the industrial wastewater generated by the plant, such as boiler blowdown, general process drains, demineralizer regeneration waste, etc., are all consumed inside the facility. The primary means of waste water consumption is in the Spray Dryer Absorber which uses recycled wastewater as dilution water for the lime slurry.

## **Largest Electrostatic Precipitators at a Waste-To-Energy Facility**

Early on in the design of the project there was an extensive evaluation of the type of Air Pollution Control Devices required for the facility [4]. After many discussions between the plant engineers (Bechtel) and the Massachusetts Dept. of Environmental Protection (DEP) it was decided that a large ESP, with a SCA (square feet of collection surface per thousand acfm) of 600–700 and five stages of collection would provide the most reliable high efficiency emission control system when combined with the spray dryer absorber.

The precipitator selected is the largest known unit to be installed on any refuse-fired plant.

### **Extremely Low Plant Noise Level**

The project went to considerable lengths to insure that noise levels emanating from the plant would be extremely low. The most impressive effort was in the sound attenuation of the air cooler condenser. This unit, which delivers a total of 8 million ft<sup>3</sup>/min (3700 m<sup>3</sup>/s) of cooling air was potentially one of the loudest noise generators in the plant. In order to effectively control noise, the speed of all twelve fans was reduced to half the normal speed. To attain the required air flow, special airfoil type blades were then utilized to compensate for the reduced fan blade speed. In addition to these modifications, the fan gearboxes were custom manufactured to minimize sound generation and designed with special soft, resilient mounts to deaden any noise transmission through the support structure.

The result of these noise reduction efforts is a total plant sound pressure level of 50 dB on an "A" weighted scale at the plant boundary.

### **Waste Deliveries by Rail**

SEMASS is one of the few waste to energy facilities to receive wastes by both truck and rail car. Roughly 10% of the daily waste supply is currently transported to the facility in covered rail cars. By the end of 1990, it is anticipated that deliveries by rail will double, after another rail transfer station is completed on Cape Cod.

A rotary dumper type unloader is used to empty the contents of each rail car (roughly 40 tons of loose MSW) onto the tipping floor. The unloader utilizes four retractable hydraulic clamps to hold the car secure while it is inverted through a 150 deg. arc. The

## SEMASS MONTHLY PRODUCTION - 1989 Total MSW Processed

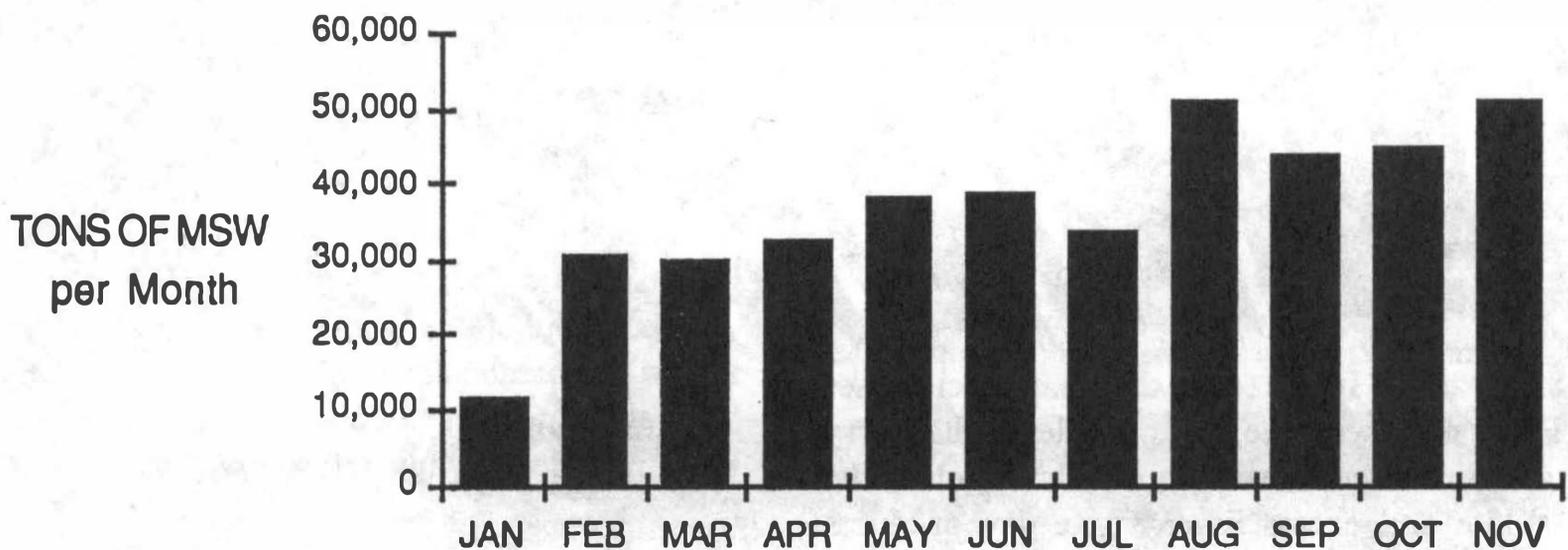


FIGURE 3

tip cycle takes approximately 2 min to complete once the rail car is positioned properly and the lid removed.

### PRF Processing Schedule

The plant processes the waste stream on a different schedule than most MSW processing facilities. This is because the PRF is fed directly to the boilers. There is no intermediate storage between the shredding/magnetic separation process and the boilers besides the 5 min storage in the feed bins. Consequently, MSW processing is performed on a 7 days per week, 24 hr per day basis utilizing one of the three available shredding lines.

Selection of which operating line to be used is based on the shredder motor amp hours accumulated since the last rotation of shredder hammers. Typically, the shredding line is shut down for hamper rotation after 6800 amp hr of service, which corresponds to about 2-2½ days of operation.

### OPERATION AND MAINTENANCE

Operation employs 91 full time personnel. There are 8 persons in management and administration, 71 in operations (including supervision) and 12 in the maintenance group (including supervision).

### FIRST YEAR OPERATIONS RESULTS

#### Waste Throughput

As expected with any new facility, the operations personnel have gone through a learning period during the first year as evidenced by the upward trend in MSW throughput (see Fig. 3).

#### Net Power Generation

During the first 12 months of operation, the average net power generation rate was 582 kwh/ton of PRF combusted.

#### Materials Recovery

During 1989, roughly 2½% of the incoming refuse was separated out by the front end magnetic separator. Additionally, the ash plant separated out another ferrous fraction that represented approximately 1½% of the incoming waste.

The total weight of ash produced from the facility was 19.4% of the incoming waste. The total Boiler Aggregate product came to approximately 10% of the incoming waste while the fly ash averaged approximately 7½% of the refuse. The ash processing facility also produced a nonferrous product that amounted to approximately 0.4% of the MSW.

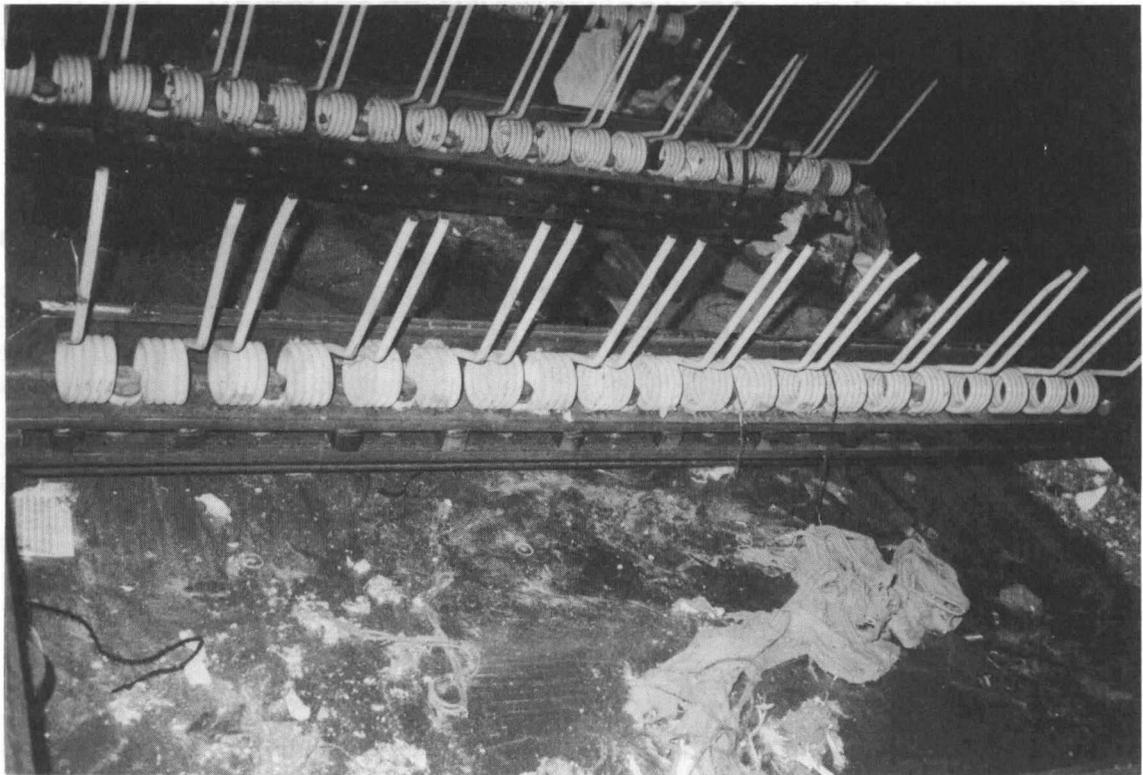


FIG. 4 "SPRING FINGERS CONVEYOR"

#### Air Pollution Control Performance

A subset of the air emission results from the facility during acceptance testing are as follows:

<u>Emission</u>	<u>Limit</u>	<u>Average Values</u>
SO <sub>2</sub>	65% removal	68%
HC1	90% removal	93%
Particulate	0.03 gr/dscf (@12% CO <sub>2</sub> )	0.01 gr/dscf

#### Condenser Performance

As expected, the air cooled steam condenser performance varied significantly with the weather conditions. During winter, spring and fall, the air cooled unit was able to produce a consistent vacuum level of 3½ in. Hg (0.12 kg/cm<sup>2</sup>). However, during the summer months, the daytime average back pressure ran as high as 7 in. Hg (0.24 kg/cm<sup>2</sup>) resulting in a 7.5% reduction in turbine heat rate. Night time operation during the summer typically found the turbine back

pressure down to 3½ in. (0.12 kg/cm<sup>2</sup>) or 4 in. Hg (0.14 kg/cm<sup>2</sup>).

#### Water Treatment Facility

The zero water discharge design for the facility worked extremely well during this first year of operation. In fact, the actual water balance for the plant made it fairly easy to achieve the zero discharge goal.

This favorable water balance was due to two major factors. First, the production of wastewater from the various sources in the plant turned out to be significantly below what was forecast; 35,000 GPD (5.6 m<sup>3</sup>/h) actual versus 47,000 GPD (7.5 m<sup>3</sup>/h) design. Second, the consumption of water by the spray dryer was higher than anticipated; 126,000 GPD (20 m<sup>3</sup>/h) actual versus 109,000 GPD (17.3 m<sup>3</sup>/h) design. The combination of these two effects allowed the facility to easily use all of the cleaned up wastewater it created and thus avoid any wastewater discharge.

## Material Handling System Modifications

One of the more successful modifications made during the first year of operations (actually during the startup period) was the installation of the "spring fingers".

Back in August of 1988, during startup of the various conveyor systems, the boiler feed drag chain conveyor (which distributes the PRF to the five feed bins for each boiler) was experiencing a high number of failures. These failures were primarily the result of severe bending of the steel push plates or the chain attachments which connect the plates to the chain. To rectify this situation, the project engineer replaced the rigid steel push plates with a series of "tedder tines" that are used for raking hay. These "spring fingers" have worked extremely well in gently moving the waste into the tops of the five boiler feed bins

Since August of 1988, less than 100 fingers have been replaced (there are 20 fingers on every conveyor flight) after processing over 300,000 tons of refuse.

## CONCLUSIONS

The shred-burn concept, with zero water discharge, has proved to be a highly efficient and environmentally

attractive waste-to-energy configuration. The first year of operations at SEMASS produced a very satisfying steady improvement in performance with each ensuing month. All those persons involved with the project are proud of the success to date and look forward to the proposed expansion of the facility to 2800 TPD (29.4 kg/s).

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**Keywords:** Electrostatic Precipitator; Materials Handling; Rail Haul; Refuse-Derived Fuel; Shredding; Stoker; Zero Discharge