INTRODUCTION

Solid waste disposal by landfills is not easy or economical. Mass fired incineration – a European development – has low availability and high ash on diverse solid waste. A simple system for processing domestic solid waste based on the Dade experience is presented, providing maximum by-product recovery, high on-line availability, high steam and power generation, minimum residue and landfill requirements.

Although man has recently managed to reach and explore the far limits of outer space, he has yet to fully resolve the problem of his ever mounting accumulation of waste that his ever expanding ingenuity has created on earth.

Previously, man's waste, either household garbage or trash, commercial and/or industrial waste, was simply disposed of by landfills existing barren lands, particularly low lying areas such as gullies or canyons. Not much thought or consideration was given to windblown contamination and even less to the perhaps more serious problem of leachate contamination from the waste. In addition, landfills are natural breeding grounds for disease carrying rodents and insects.

What are the potential solutions to acceptable disposal of man's waste? If adequate suitable low cost land is conveniently and economic solution. But is rare indeed when large, economic, suitable land is available anywhere near an urban center.

LANDFILL DIFFICULTIES

The term “suitable land” also requires proper definition. Suitable land means a land mass that must be environmentally acceptable. To determine if a potential area is suitable for landfilling requires extensive investigation and analysis before it can be classified as suitable. For example, the bottom of the landfill area must be sealed off, usually involving compacted layers of selected fill with a PVC or similar liner or suitable fill material, i.e. clay, bentonite, etc. and layers of properly selected fill materials over the liner as well. All of the area must be properly graded and controlled drainage is essential. Test wells will have to be sunk in most areas and if the landfill exists over an aquifer, water source, considerably more care and expense may be involved.

It has been determined that an environmentally acceptable landfill area is not cheap. In one recent location, it was determined that the cost of a confroming landfill would be significantly higher than other modes of disposal; in fact, over the life of the landfill the total capital cost approached $600 million for 3,000 TPD capacity, and the cost of landfill on a per ton basis greatly exceeds disposal by other means, and there remained an on-going concern that it still might not be environmentally acceptable at all times. Further, if there is significant rainfall over short periods of time or seasons, and evapotranspiration is low, the problems can be virtually unsolvable. In this latter instance, holding and storage of contaminated run-off can be impossible, and due to the totally heterogeneous nature of the waste, successful treatment of the run-off also impossible.

MASS FIRING

The general approach in Europe is mass burning or incineration. A review of these plants and facilities reveals that their availability is limited. In fact, most of the large
scale mass burning plants in the U.S. scarcely exceed 70 percent on-line availability. There are several reasons for this low availability, but the primary reason is because the European plants shun preseparation or preprocessing, which due to the variable nature of the solid waste creates severe operating and maintenance problems with attendant down-time. In addition, the ash quantities in mass fired incineration when handling diverse household garbage, trash and industrial and commercial waste are 30 percent to 45 percent of the incoming solid waste tonnage meaning for 3000 TPD (2722 tpd) a minimum of 1000 TPD (907 tpd) of residue must be handled and disposed of creating vast problems in both mobile equipment requirements as well as landfill area requirements.

**SOLID WASTE PROFILE REQUIRED**

Diverse solid waste (as received in Dade County) is extremely heterogeneous and clearly one of the most difficult materials to handle and process. Solid waste (household garbage, trash, industrial and commercial) consists of virtually every possible ingredient and combination known to man. Some of the more exotic and dangerous waste which should be excluded, include insecticides and herbicides (banned by EPA), live ammunition, detonator caps, gas and propane tanks and highly explosive and inflammable solvents, as well as pathological and liquid wastes, demolition debris and oversized manufactured products particularly those of steel or those of a non-destructible nature.

At this juncture, it is perhaps important to emphasize the need for understanding and flexibility with respect to the solid waste profile or makeup. Cooperation and flexibility are required between buyer (usually the political entity) and seller (contractor) because both have responsibility with respect to the safe and efficient operation of the facility. If there is significant deviation from the solid waste profile, the seller (contractor) can neither achieve his estimated revenue nor achieve his operating and maintenance cost objectives. It is ridiculous to expect the contractor to develop realistic revenue and cost figures, and thus a proper tipping fee (dump fee) unless there is some concurrent commitment with respect to the solid waste profile. Attached are some typical solid waste profile percentages which are fairly representative of what one might encounter. However, there are very large deviations from plant to plant, even day to day and hour by hour. It is important to emphasize that household garbage is reasonably predictable over time but not trash or industrial-commercial waste.

A number of both shredder suppliers as well as consultants have informed us that Dade County solid waste is the most diverse and difficult that they have seen anywhere. It is important when comparing plant operations; particularly as regards capacity, revenues, operating costs, tipping fees and residue, to particularly note the quality (profile) of the solid waste delivered. It is believed at the Dade County Resource Recovery plant, that if only household garbage had to be processed, the plant could readily process 5000 TPD (4535 tpd). As the saying goes, it is important to compare “apples and apples”, and not “apples and cucumbers”. In short, significant deviations in the nature of the solid waste delivered; coupled with inordinate amounts of unprocessable materials, can create havoc with plant operations, as well as with all the elements of cost and revenue.

European waste disposal systems enjoy a distinct advantage because the city or municipality normally owns and operates the waste disposal facility, and in addition, generally has a controlling interest in the utility as well. Further, the waste is frequently presorted at the household with paper, glass and metals separated. In Japan as many as five sorts take place at the household level. At the present time, this is not possible in the U.S. Generally in Europe trash is not handled and is simply sent directly to landfill. Commingled putrescible garbage in the trash can create serious landfill contamination problems.

The European political entity can control the waste stream from collection and pickup through the disposal plant to the generation and sale of steam, hot water and/or power. This has great advantages and avoids the situation so prevalent in the United States, where responsibility for the plant operations can become quite controversial.

Unlike the almost entirely municipal controlled structure in Europe, in the United States there is usually a highly structured utility on one side and a political entity on the other, which may or may not be responsible for the garbage pickup and collection, possibly supplemented with private haulers. The private company or entrepreneur’s relationship and negotiating position between these two entities can be difficult. Because of the highly varied nature of the solid waste and the inability of anyone to completely control its makeup, it is probably desirable that the municipality owns the facility. However, the design, engineering, construction, erection and subsequent operation of the facility is best left to the management and control of others who have the detailed knowledge and experience for such work.

**FEASIBILITY STUDY ESSENTIAL**

First and foremost, in undertaking the construction of a waste disposal resources recovery plant, is the need for a detailed feasibility study. Among other things, this should
involve an analysis of the nature and type of solid waste. Most importantly, what is the general profile (maximum — minimum — average) of solid waste? It must also be determined if household garbage and trash (including trees, garden clippings, white goods) should be processed and handled separately. What is the frequency and time of pick up and delivery in the area under consideration? Will industrial as well as commercial waste be handled and if so, what is its general makeup and quantity? Is pathological waste to be handled and if so, how much? Is demolition debris to be handled and how much? Is the disposal of hazardous waste involved and if so, what type of hazardous material and what techniques should be employed in this handling and ultimate disposal? Are private as well as public waste haulers involved and what type of equipment is employed? Are transfer stations involved? What is the maximum size (weight and sizes) of packer trucks involved? Are delivery operations union or non-union? What is an acceptable queuing time? How should routing best be arranged? Is pick-up and hauling involved in the contractual arrangements? What is the market for by-products — size, prices? If steam or power is to be sold, what is the rate structure and contract particulars? What permits are required and what are the specific environmental requirements? An analysis of various potential sites for plant location should be made bearing in mind the topography and soil analysis, prevailing wind direction as well as all adjacent occupancy and facilities which might be affected. The existence of any underground aquifers or any other environmental particulars which might impact the operation of the disposal plant should be evaluated.

SOLID WASTE FLOW DIAGRAM FOR LARGE CAPACITY

Attached to a solid waste processing flow sheet for a large scale plant handling very diverse solid waste which provides maximum revenue return and minimum operating and maintenance cost with high on-line availability coupled with minimum residue, all of which is achieved in a very simplified manner. There are several variations in this basic process system depending on local circumstances. The first step for household garbage would involve a two stage trommel operation for opening the material particularly for breaking open the plastic bags and removal of products under about 3 in. (7.62 cm) coupled with a second stage with minus 1¼ in. (3.175 cm) direct to final air classification. Overs from the 1¼ in. (3.175 cm) trommel go to the hydрапulper or shredder. The solid waste stream has now been fluffed and opened with deleterious glass and grit as well as small stones and ceramics largely removed. Trash as such is sent directly to the shredders after careful inspection using cherry pickers as required. After shredding, the material passes underneath an electro-magnet and goes through a screen which is equipped to remove grit, sand and dirt through the 3/8 in. (0.953 cm) section with accepted product passing through 3 in. (7.62 cm) holes. Accepted product is then sent over a simple air knife for removal of nonferrous material. Unders from the 3/8 in. (0.953 cm) trommel section as well as the heavies from the air knife are conveyed to the hydрапulpers for further processing prior to delivery to the minerals plant for recovery of the valuable by-products. The hydрапulper serve the purpose of cleaning up the metal for ease of merchandizing, while simultaneously recovering the combustible organic fraction. Contaminated metal cannot be successfully marketed. At Dade County, 800-1000 tons (762-907 t) per week of ferrous metal is shipped out, and aluminum, non-ferrous, sand, grit and glass are all merchandised. Even the ash from the boilers is sold (about 250 TPD-227 tpd). The final accepted fuel is delivered via a series of conveyors to the fuel storage area or directly to the boilers. The fuel can be readily reclaimed from fuel storage as steam and power demands require. The system includes a variable speed rotary pin drum fuel feeder which has worked extremely well. There are five fuel feeders on each boiler, with automatic bias control provision between feeders so as to insure rapid response to power demands as well as even distribution on the traveling grate stokers. Surplus fuel from the feeders is simply recycled back to fuel storage area. The flow sheet presented, represents the third generation system. Among other things this simple third generation system would sufficiently increase the net kilowatt hours for sale, at the same time providing a significant reduction in plant power usage as well as labor requirements, but still retaining all of the manifold advantages of the present Dade County plant.

SYSTEM ADVANTAGES

This simplified line up of equipment and systems thus provides a multitude of advantages:

1. Maximum recovery of organic combustible fraction in a completely homogeneous state virtually free of sand, grit, and glass as well as all metals.

2. Maximum recovery of by-products in a completely merchantable condition assuring maximum sales revenue.

3. Minimum residue due to maximum by-product extraction and sale as well as complete burn out (minimum ash) due to a homogeneous and metal, sand glass and grit free fuel.

4. Maximum on-line availability, thus insuring maximum steam and/or power generation.
FIG. 1 LARGE SCALE PLANT HANDLING VERY DIVERSE SOLID WASTE
The degree of further by-product upgrading will depend upon the solid waste profile and market conditions.

FIG. 2 FOR ALTERNATE PLANT SYSTEM
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<th>B</th>
<th>C</th>
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<td>1.0</td>
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<td>0.6</td>
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<td>0.1</td>
<td>*</td>
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<td>Glass</td>
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<td>9.9</td>
<td>14.4</td>
<td>9.0</td>
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<tr>
<td><strong>Miscellaneous</strong></td>
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<td>1.5</td>
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<td>40.1</td>
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<td>25.0</td>
<td>29.0</td>
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</tr>
</tbody>
</table>

The combustibles sub-divide approximately as follows:

- **Food Waste** 16%
- **Garden Waste** 8%
- **Paper Products** 47%
- **Plastics, Rubber, etc.** 3%
- **Textiles** 3%
- **Wood** 3%
- **Water** 20%

Notes:
A Dade County, Florida data.
C New Orleans data from NCRR report.
D Bridgeport data.
E Hempstead data.
* Included with combustibles.
** Included with non-combustibles.

FIG. 3 TYPICAL GARBAGE PROFILE PERCENTAGES
The so called minerals recovery plant, as indicated, is a very simple application of basic mining equipment including washing screw, trommel screen, heavy media separator for residual organic separation, which is subsequently recycled to the hydrapulper system and hydrasorter which is a simple jig sorter for glass, aluminum, and heavy cup separation — small nonferrous i.e., copper, aluminum, zinc, brass, bronze extraction. The following is a tabulation of the by-product resources extracted in the Dade County Resource Recovery operations:

1. 62,000 tons (56,246 t) per year of ferrous material.
2. 3000 tons (2721 t) per year of aluminum.
3. 10,000 tons (18,771 t) per year of nonferrous material.
4. 20-85,000 tons (18-77,100 t) per year of glass depending on quality desired.
5. $50-$60,000 per year in coins.
6. 90,000 tons (81,647 t) per year ash and fly ash for cement manufacture.

450-600,000 MWh — Gross Electric Generation*
380-510,000 MWh — Net Output Electric Generation*

In summary, the advantages of the simple foregoing system can be enumerated as follows:

1. Maximum merchantable by-product recovery at the highest market prices available. This includes the sale of ferrous and nonferrous metal, including aluminum, as well as sand, grit, and glass, including even the front ash and fly ash from the boilers, as well as coins.
2. Minimum system residue — between 5 to 10 percent.
3. Minimum required acreage for landfill.
4. Maximum on-line availability thus ensuring maximum processing capability.
5. Maximum generation of steam and power.
6. Minimum maintenance, since the fuel is completely homogeneous and free of destructive elements.
7. Minimum ash and minimum combustible in ash.
8. Complete environmental compliance, both for emissions as well as effluent (actually zero effluent).

At the present time aluminum is selling for a minimum of $400 a ton up to $1000/ton, ferrous metal from $60 to over $70/ton, the average price for nonferrous materials (i.e. copper, lead, zinc, brass and bronze) is approximately $800/ton. In addition, significant quantities of sand, grit and glass are sold from the Dade County facility for aggregate and landfill and even the ash from the boilers including both the front ash as well as the fly ash is sold. The ash sold amounts to 250 TPD (227 tpd). The ash is bought and picked up by the cement companies and utilized as an admixture in the manufacture of cement.

Cooling tower provision is incorporated for the condensing turbo-generator since no effluent can leave the plant facility.

The Dade County plant is situated only 4 ft (1.22 m) over the Biscayne Aquifer which is the principal drinking water supply for Dade County and specifically the City of Miami. The Dade County plant is the highest capacity solid waste plant in the world, frequently handling in excess of 4000 tons (3629 tpd) per day and constantly exceeding its designed capability of 18,000 tons (16,330 t) per week. As noted above, the plant has a reputation for handling the most diverse solid waste material delivered anywhere.

DADE PROBLEMS AND SOLUTIONS

With respect to problems at the Dade facility, the only ones of significance are the ash system and the superheater in the boilers. The ash system was corrected by eliminating the ash silos and by certain changes in the design and supply of the conveyors. With respect to the superheater problem, this involved metal tube wastage. This problem was eliminated by replacing all of the superheaters with studded tubes covered with an application of silicon carbide. Since initiating this correction last summer, there has been no further problems with the superheaters. There has been no metal tube easteage elsewhere in the boilers which have been checked constantly. Other improvements currently under review; involve upgrading metallurgy and use of ceramics in various items of equipment. An alteration in the precompression feeder and the usage of bowtie hammers in the shredders have also been noteworthy. The latter has greatly improved and extended hammer life.

STATE OF THE ART

In summary, we are extremely pleased with the overall operation of the Dade County plant which has more than met all of its expectations. Many consider the plant the “state of the art” at the present time.

Key Words: Design • Disposal • Economic Development
• Efficiency • Landfill • Resource • State-of-the-art

*Depending on system.