SOLID WASTE RESOURCE RECOVERY FACILITY
MONROE COUNTY, NEW YORK

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ABSTRACT

Monroe County, New York is engaged upon a project to recover the maximum amounts of energy, metal and mineral values from solid waste. Raytheon Service Company is the prime contractor for the design and development of an 1814 metric tons per day (2000 TPD) resource recovery facility. Products which will be reclaimed by this facility include refuse derived fuel, iron, glass, aluminum, heavy non-magnetic metal, sand, and a residual product for disposal. This paper describes the past history of the project, the approach which was taken in development of the basic design, the processing techniques to be employed, and the products which will be produced.

INTRODUCTION

The Monroe County Resource Recovery Facility will process municipal, commercial and light industrial waste at a rate of approximately 127 metric tons per hour (140 TPH). Two fully identical primary process lines will be incorporated to extract ferrous metals and a light paper fraction which will be burned as a supplementary fuel in utility boilers for power generation or alternatively, reclaimed as paper in the future. Rochester Gas and Electric Company (RG&E), as the primary fuel user, may convert four boilers at its Russell Station facility to burn minus 2.5 cm (1 inch) shredded refuse derived fuel (RDF) in combination with pulverized coal. Additional processing modules will result in the recovery of glass, aluminum, heavy non-magnetic metals, and sand products.

Following competitive bidding through national solicitation, Raytheon Service Company was awarded the prime multi-phase contract for this project which includes design, construction management, startup, and operations. A photograph of the architectural model of the resource recovery facility is shown in Figure 1. Detailed design of the facility is being performed by United Engineers and Constructors, a Raytheon subsidiary.

The process which will be utilized was developed by Raytheon and is based heavily on experimental work performed by Raytheon and the U.S. Bureau of Mines (USBM) at the USBM Raw Refuse Processing Pilot Plant in Edmonston, Maryland, under a cooperative agreement for testing and scaleup of resource recovery technology. Similar to operations at the USBM plant, shredding and air classification will be performed in multiple stages in the Monroe Project. In addition, however, it is planned to utilize a rotary drum air classifier and non-ferrous metal separator developed independently by Raytheon Company and Iowa Manufacturing Company, a Raytheon subsidiary engaged in the manufacture of heavy process machinery.

BACKGROUND

Monroe County began to consider resource recovery as a solution to the solid waste disposal problem in 1971. At that time, the City of Rochester as well as the surrounding towns and villages
were disposing of almost all solid wastes, through municipal or private collection, at landfill sites throughout the area. Several of these sites had been closed or exhausted by 1968 due to violations of the New York State Sanitary Code, and many of those still operating no longer complied. In addition, Rochester’s municipal incinerators had been closed due to non-conformance with air pollution standards.

The growing solid waste disposal problem and projected estimates of waste generation in the county were defined in earlier engineering studies [1]. The quantity of municipal waste was almost equally divided between the City of Rochester and the surrounding towns and villages. Waste generation was predicted to go to approximately 1814 metric tons per day (2000 TPD) by the late 1970’s or early 1980’s; and, in addition to the decline of existing landfill sites, public dissatisfaction with the landfill concept was apparent.

Recognizing the critical state of solid waste disposal in the county, the Rochester Engineering Society (RES) established a task force of more than 70 technically-trained volunteers to undertake a comprehensive study and recommend a positive long range program for solid waste management. Figure 2 shows the RES approach to the implementation of such a program. The study resulted in a published report [2] in early 1972 which indicated the feasibility of developing a major resource recovery program which would provide both economic and environment benefits to the county. Subsequently the county initiated a long-range solid waste management program to fulfill future needs and to ultimately reduce and/or eliminate the need for landfill sites.

Following open competition, the county retained Hercules, Inc. to perform a detailed market analysis and to formulate the basic resources recovery system design. The resultant management plan [3] determined that sufficient markets were either already available or could be developed to accept the anticipated recoverable products from the facility. The system design paralleled that of the RES and called for the recovery of ferrous and non-ferrous metals, glass, sand, and a light paper fraction which could be used as a supplemental boiler fuel.


FIG. 2. ROCHESTER ENGINEERING SOCIETY PLAN
As a result of a Request for Proposal issued in May 1974, Raytheon contracted with the county in early 1975 to perform the following services: Phase 1 — design and construction management; Phase 2 — startup; and, Phase 3 — operations. Project events are delineated in Figure 3. After award, Phase 1 was actually split into two distinct phases, the first covering design and the second covering construction management. This was done so that the market values of output products as well as the capital cost of construction could be firmly established by competitive bidding before construction contracts were awarded. At the present time, the final plans and specifications are nearing completion and will be released for construction bidding in early 1976.

**DESIGN APPROACH**

The basic approach used in the design of the facility is illustrated in Figure 4. The approach to process design was totally empirical and based upon many tests made on municipal solid waste (MSW) processed at the USBM over the past several years. To confirm the results of these tests, a 7-metric ton sample of Monroe County MSW was collected, trucked to the USBM pilot plant in Edmonton, Maryland, and processed. An overview of this raw refuse processing pilot plant is shown in Figure 5. Additional testing was performed at Raytheon’s own laboratories. It was determined that the composition and variability of composition of the Monroe County MSW was not significantly different from the previously processed MSW from other areas of the country.

Further, the Monroe pilot plant provided actual samples of output products to be used in marketing. These samples were provided to potential users for their independent evaluation and formed the basis of product specifications to be used for negotiated user agreements. It is worthwhile to point out that product specifications developed were based on chemical and mechanical tests made by independent laboratories normally utilized by users of the products. This was done to insure consistency in the methods of analysis.

The capacity of the facility will be 1814 metric tons per day (2000 TPD). However, since no facility of this type, size or complexity has been constructed to date, a degree of conservatism has been built into the system to insure that the incoming solid waste stream can be moved reliably on and off the site each day. For example, the capacity of each equipment item within the process has been designed with a minimum of 25 percent excess capacity to accommodate surges in the feed rate or compositional variations. Also, bypasses have been built into the system so that in the event of critical equipment shutdown for a substantial period of time, the facility can continue to operate essentially at full capacity. Finally, emergency landfill provisions have been incorporated into the design.
in order to allow for short-term transfer haul of the incoming waste in the event of a critical system failure.

The above design criteria along with the process data developed during pilot plant testing and the product user requirements were then utilized to develop basic system diagrams, process flowsheets and materials balance data. This information, along with engineering studies concerning traffic, transportation and site development led to a detailed concept design which was approved by the County on August 14, 1975. The preliminary facility design was completed on October 31, 1975 and the final design should be completed and out for municipal bidding by March 1976. Capital cost of the facility itself is expected to be about $30 million.

FACILITY DESIGN

The facility will accept MSW from either packer trucks, transfer trailers or open dump trucks or
trailers. Incoming waste is automatically weighed and dumped from one of ten 6-meter (20 foot) wide tipping bays into a storage area depressed 3.6 meters (12 feet) and capable of storing 1814 metric tons (2000 TPD) of MSW. From the storage floor it is pushed onto apron feeders by front-end loaders and carried into the processing plant (described in the following section).

Products produced by the facility are stored in storage bins or in portable containers. Up to a full day's production can be stored on the site and on adjacent rail sidings. Transportation of output products is primarily by rail but a complete truck transport capability exists within the facility design. Special mobile units (Figure 6) pick up the portable containers which contain the compacted RDF to stack them on the site or place them on standard flat bed rail cars situated on a nearby rail siding (Figure 7). All output products are weighed before they leave the site. Adequate provisions have been made for administration and storage of spare parts and supplies. Staging of trucks and trailers will be accomplished at a nearby site for products produced on the second shift.

**PROCESS DESIGN**

As shown in Figure 8, the system configuration consists of the following basic elements:

1) Baseline Process
2) Residue Recovery
3) Ferrous Refining
4) Nonferrous Refining

It should be noted that refining here refers to a re-cleaning of the product and not to refining in the metallurgical sense of the word. The prime basis of design has been to produce high quality products that are readily marketable while minimizing the quantity of material going to landfill. A materials balance for the facility is shown in Figure 8, as are specification designations for each output product.

A general flow diagram of the baseline process is shown in Figure 9 for one process line. It consists of the following operations:

1) **Primary Shredding** - A primary shredder reduces the incoming waste to less than 30 cm (12 inches) in size. Coarse shredding is used to reduce
FIG. 6. TYPICAL YARD OPERATION
FIG. 7. RAIL SIDING LOCATION
FIG. 8. PROCESS SYSTEM CONFIGURATION
the amount of fine glass produced and to reduce the maintenance costs of shredding. The shredders will be protected against explosions, projectiles, and fire.

2) Skim Classification — A skim classifier removes an initial small quantity (approximately 15 percent) of light combustible materials (paper, light plastic and dust) from the coarse shredded refuse.

3) Primary Air Classification — The shredded feed material is separated into light and heavy fractions according to the density, shape and aerodynamic characteristics of each particle. Raytheon has designed and built a unique primary air classifier which may be utilized to process coarse and fine particle sizes and obtain a high separation efficiency by forcing multiple passes of the mater-
material through an air stream. The heavy fraction, consisting of putrescibles, glass, metals, and heavy organics will be further processed. The light materials will be screened to remove grit and further processed to produce a refuse-derived fuel product.

4) Magnetic Separation and Screening — The ferrous metals are removed from the air classifier heavy fraction by magnetic separation. A rotary screen removes a glass-rich residue fraction from the non-magnetic discharge of the magnetic separator. The screen prevents entrapment of particles because of the tumbling action and provides a long retention time so that many chances are given to remove fine particles. The residue fraction from the rotary screen undersize is made up of putrescibles, glass, non-ferrous metals and heavy organics to be further processed in the residue recovery system.

5) Secondary Heavies Shredding and Air Classification — A secondary shredder reduces the size of the rotary screen oversize to approximately 5 cm (2 inches) in order to facilitate maximum recovery of combustibles and to liberate as much non-ferrous metals as possible. The feed to this unit represents approximately 25 percent of the incoming waste and typically includes telephone books, shoes, magazines, handbags, wood, plastic toys and bottles, and coarse non-ferrous metals from which the light combustibles, ferrous metals, glass and putrescibles have already been largely removed. The discharge from the secondary shredder is then air classified separating the light combustible materials liberated by secondary shredding.

6) Nonferrous Metal Separation — A nonferrous metal separator removes the mixed nonferrous metal from the secondary air classifier heavy fraction. This separator utilizes eddy currents created by permanent magnets to remove nonferrous metals from heavy combustible materials as they slide down an inclined ramp. No moving parts or electrical power are required to operate the separator. Approximately 70-85 percent of the nonferrous metals in the feed stream can be separated at a product purity, as determined by hand picking, of 90-98 percent. The non-metallic product from the separator consists mostly of heavy combustible materials (wood, leather, rubber, plastic and corrugated) which have a heating value of approximately 3778 k-cal/kg (6800 Btu lb) on an as-received basis, but which have a relatively high moisture content.

7) Combustible Fuel Preparation — The light fractions from the air classifiers are combined, screened to remove fine glass, grit and dirt and fine shredded to less than 2.5 cm (1 inch) for use as a fuel supplement. This finely shredded fuel product is compacted for storage and transport or pneumatically transported to user facilities.

8) Dust Collection — Dust collectors are used to remove dust from process air resulting from classification and transport of material. The dust will be added to the combustible materials to be used as RDF.

The residue recovery system (Figure 10) consists of the following operations:

1) Jigging — A jig removes the organic matter from the incoming glass-rich residue fraction so that the glass and nonferrous metals can be more readily recovered.

2) Dewatering — A compression device is used to reduce the water content of the organic matter separated by jiggling. The solids content is increased from 25 to 50 percent by weight, thus reducing the weight going to landfill.

3) Pulverizing — A pulverizer reduces the friable glass-like materials into less than 0.63 cm (1/4 inch) in size. Nonferrous metals are not reduced in size since they are ductile (although some balling may occur).

4) Screening — A screen separates the mixed nonferrous metals as a plus 0.63 cm (1/4 inch) fraction while passing the friable glass-like materials as a minus 0.63 cm (1/4 inch) material. These nonferrous metals are combined with the nonferrous metals from the baseline process and sent to nonferrous refining. The minus 0.63 cm (1/4 inch) fraction is combined with the minus 0.63 cm (1/4 inch) material from the previous screen and further processed for recovery of glass.

5) Grinding — In closed circuit the glass and sand are reduced to less than 20 mesh so that ceramics and stones can be removed by froth flotation.

6) Flotation — Froth flotation selectively coats the glass particles in the feed stream and separates them via air bubbles from the ceramics, refractories, brick, and stone (tailings). The tailings are removed and combined with the sand product.

7) Wet Magnetic Separation — A magnetic separator removes weakly magnetic particles (Fe₂O₃, FeO, etc) from the glass product. The magnetic particles along with some glass are combined with the sand product.

8) Dryer — A dryer reduces the moisture content of the glass product to less than 1 percent so
FIG. 10. RESIDUE RECOVERY SYSTEM
that it is free flowing and can be easily handled and transported to a glass container manufacturer.

All residue recovery process water is processed for solids removal and chemical adjustments made as required for discharge or recycle. Internal recirculation within the process plant prior to water treatment reduces the size and complexity of the equipment necessary to treat the water for recycle or disposal.

The ferrous refining and nonferrous refining modules are rather simple in nature and are designed, respectively, to densify the ferrous metals and clean adhering contaminants; and to separate the nonferrous metals into a light fraction comprised of aluminum and a heavy fraction consisting of the remaining non-magnetic metals.

PRODUCTS AND MARKETS

Establishing product quality and confidence levels and market development have been a key part of the work performed on this project. As noted earlier, this has included testing of sample products over a wide range of pilot plant tests, optimizing processing techniques to improve product quality, and testing of sample products by potential users in their own operations.

Potential users were contacted for the following products: refuse derived fuel (RDF), ferrous scrap, aluminum and copper-zinc based alloys, and glass. Facilities employing coal firing boilers were approached to explore the possibilities of substituting RDF for fossil fuels. Buyers for the recovered metals include large scrap metal dealers, secondary smelters, detinning scrap processors, steel mini-mills, primary mills and refiners. Selection of buyers of the recovered mixed-color glass cullet was based on geographic proximity and all considered this product an attractive new material. The above products are all confirmed saleable materials. A potentially saleable item is the sand aggregate which is of low value. This material is usable as normal fill and as a road surfacing material mixed with coarse aggregate according to ASTM specifications and used in asphalt, bituminous or concrete paving or for sanding during winter. Products obtained from pilot plant tests of the processing schemes described are shown in Figures 11 and 12.

REFUSE DERIVED FUEL (RDF)

This is a quality fuel product usable as a supplementary fuel in large fossil-fuel boilers or as a primary fuel in smaller utility or industrial boilers. It may also be pelletized or compacted for selected users. On a per pound basis, it has 50-60 percent heating value of coal and has 50-100 percent more contained moisture, grit and ash when fired. A comparison of RDF with other fossil fuels is given in Table 1.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Value k-cal/kg (Btu/lb)</th>
<th>Ave. S (%)</th>
<th>Ave. Cl (%)</th>
<th>Ave. Ash Content (%)</th>
<th>Ave. Moisture Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refuse Derived Fuel</td>
<td>3,667 (6,600)</td>
<td>-</td>
<td>-</td>
<td>12.5</td>
<td>21</td>
</tr>
<tr>
<td>St. Louis MSW</td>
<td>2,778 (5,000)</td>
<td>0.1</td>
<td>0.4</td>
<td>17.6</td>
<td>30</td>
</tr>
<tr>
<td>Coal</td>
<td>6,944 (12,500)</td>
<td>1.5</td>
<td>0.05</td>
<td>10.0</td>
<td>5-10</td>
</tr>
<tr>
<td>Oil</td>
<td>8,333 (15,000)</td>
<td>1-2.5</td>
<td>-</td>
<td>0.1</td>
<td>Low</td>
</tr>
</tbody>
</table>

1) From Monroe County pilot plant tests.
2) As produced by the St. Louis facility.

FERROUS SCRAP

This product consists largely of light ferrous scrap such as tin cans, nails, caps and other metal pieces. It is refined in different ways for different markets and customers. For sale to detinners, the product is shredded to increase exposed surface areas, and magnetically separated to remove impurities.

ALUMINUM AND COPPER BASE ALLOYS

The aluminum product is a high quality product with a 91-97 percent purity, few contaminants, very little oxidation, and a yield on melting from 72-90 percent. It is a combination of shredded stock and nugget-like particles ranging in size from 0.3-10.1 cm (0.1 to 4 inches) with a density of approximately 1450 kg/cm³ (90 lbs/ft³).

The copper-zinc product is a nugget-like mixture of nonmagnetic heavy metal alloys. Particles range in size from 0.3-10.1 cm (0.1 to 4 inches) with a density of approximately 2880 kg/m³ (180 lbs/ft³).

GLASS

This product is a finely ground mixture of mixed color glass resembling a yellow-white beach sand.
FIG. 11. FINISHED PRODUCTS
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>APPLICATION</th>
<th>RAW MATERIALS</th>
<th>FINISHED PRODUCTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALUMINUM SCRAP</td>
<td>PRIMARY PRODUCER</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SECONDARY SMELTER</td>
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<td></td>
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<tr>
<td></td>
<td>FOUNDRY</td>
<td></td>
<td>ALUMINUM SCRAP</td>
</tr>
<tr>
<td></td>
<td>SCRAP DEALERS</td>
<td></td>
<td>ALUMINUM SCRAP</td>
</tr>
<tr>
<td>COPPER, ZINC BASE SCRAP</td>
<td>SECONDARY SMELTERS</td>
<td></td>
<td></td>
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<tr>
<td>FERROUS SCRAP</td>
<td>PRIMARY MILL</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>MINI MILL</td>
<td></td>
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<tr>
<td></td>
<td>FERRO SILICON MFG.</td>
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<td></td>
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<tr>
<td></td>
<td>SCRAP DEALER</td>
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<tr>
<td>GLASS BASED</td>
<td>CONTAINER MFG.</td>
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<td></td>
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<tr>
<td>MATERIAL &amp; SANDS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>INSULATION MFG.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BRICK MFG.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CONCRETE BLOCK &amp; PAVING</td>
<td></td>
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</tr>
</tbody>
</table>

**FIG. 12. PRODUCT MARKETS**

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When melted in a 100 percent mix, the melt is transparent, green or amber in color, and largely free of stones, seeds or similar defects. It is dry and free flowing with a density of 1200 kg/m\(^3\) (75 lb/ft\(^3\)). Iron oxide contaminates average 0.15 percent and chromium oxide 0.25 percent. This product is suitable for making amber or emerald green bottle glass.

**SAND**

This product is a finely ground mixture of clean waste products such as ceramics, brick, stone, slag and other friable materials including some glass. It resembles a dark gray beach sand with a density of 75 lbs/ft\(^3\) (1200 kg/m\(^3\)).

**REMAINDER**

The residual product resembles a fine, light ash-like substance with a density of 28 lbs/ft\(^3\) (448 kg/m\(^3\)). This a clean inert material usable as a fill or soil substitute material and consists largely of dirt, ash and fines recovered from the water treatment system.