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A TECHNICAL, ENVIRONMENTAL AND ECONOMIC EVALUATION OF THE GLASS RECOVERY PLANT AT FRANKLIN, OHIO

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1.0 SUMMARY OF EVALUATION

1.1 INTRODUCTION

This report presents an evaluation of the Glass Recovery Plant in the Franklin Solid Waste and Fiber Recovery Facility. This evaluation includes technical, economic and environmental assessments of the "Glass Plant" portion of the Franklin plant.

The Franklin plant is an EPA demonstration project which incorporates solid waste processing and resource recovery using wet processing techniques. These techniques are extensions of pulp and paper industry technology. The operation of this solid waste processing plant begins with the pulping of incoming refuse to form a liquid slurry with the concomitant removal of large nonpulpable items, followed by the further separation of dense materials (cyclone rejects) from the main process stream. The cleaned main stream or light fraction is subsequently processed to recover long cellulose fibers. The nonrecoverable portion of the light stream is ultimately incinerated.

The system of interest to this report is an add-on to the original solid waste handling plant. It was intended to demonstrate the removal and recovery of glass and metals from the cyclone rejects, i.e., the stream of small dense materials removed from the fiber recovery stream immediately after pulping.

A complete evaluation of the main portion of the Franklin plant was reported previously by Systems Technology Corporation in "A Technical, Environmental and Economic Evaluation of the Wet Processing System for the Recovery and Disposal of Municipal Solid Waste," by Wittmann et al.[1] The reader is advised that much of the present report may be more readily understood if used in conjunction with the previous study.

1.2 PLANT PERFORMANCE

During its operating history, the glass plant has undergone several changes and modifications. These changes involved both mechanical corrections, major component renovations and additions. The data collected for this report was limited to a six-week period (February to March 1976) after the system had been sufficiently upgraded to continuously produce an acceptable product while operating as a production plant. This evaluation has demonstrated that the separation and recovery processes operating during the study period offer a

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[1]T. J. Wittmann, D. J. McCabe, and M. C. Eifert, A Technical Environmental and Economic Evaluation of the Wet Processing System for the Recovery and Disposal of Municipal Solid Waste, EPA Contract 68-01-2211, January 1975.

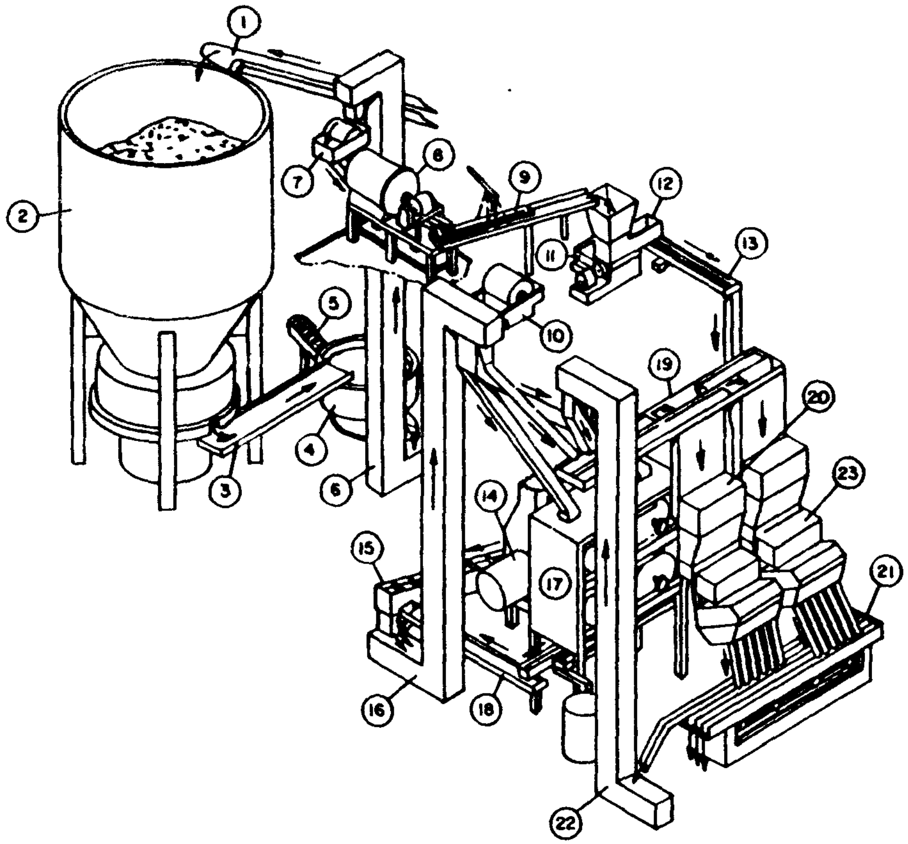
viable option for the recovery of aluminum and glass from the cyclone rejects stream. Since the study period, additional system changes have improved the product yields and quality. However, that data was not available for this report.

Glass recovery at the Franklin plant can be looked upon as a two-stage operation. The first stage is a wet process subsystem using magnetic separation and density separation techniques to produce a marketable aluminum fraction plus a glass rich fraction which is cleaned of magnetic metals, aluminum and most organics. The second stage is a dry process utilizing electrostatic and optical sorting techniques to produce a clean glass fraction. During this study, the glass fraction was separated into flint and mixed color glass fractions (flint/amber/green).

1.3 BRIEF GLASS PLANT OPERATIONAL DESCRIPTION

Full descriptions of the theory of operation regarding the individual separation processes involved in the glass plant are presented in subsequent sections of this report. In this section a brief overview of the plant operation is given. A flow diagram of the glass plant as it was operated during this evaluation is shown in Figure 1.1.

GLASS AND METAL RECOVERY PLANT



1 - CONVEYOR, FROM HYDRASPOSAL
2 - BIN
3 - CONVEYOR
4 - ROTARY SCREEN
5 - FINES DEWATERER
6 - ELEVATOR
7 - MAGNET
8 - HEAVY MEDIA SEPARATOR
9 - WASHING CONVEYOR
10 - MEDIA RECOVERY
11 - ALUMINUM DEWATERING SCREEN
12 - JIG
13 - CONVEYOR
14 - DRYER
15 - CONVEYOR WITH MAGNETIC PULLEY
16 - ELEVATOR
17 - HIGH TENSION ELECTROSTATIC SEPARATOR
18 - CONVEYOR
19 - CONVEYOR
20 - TRANSPARENCY SORTER
21 - CONVEYOR
22 - ELEVATOR
23 - COLOR SORTER

FIGURE 1.1 MODIFIED FRANKLIN GLASS RECOVERY SYSTEM - 1976

The glass and aluminum rich fraction of the refuse separated from the input waste by the liquid cyclone is partially dewatered and delivered to a surge bin for temporary storage and feed rate control. This material is then metered at a fixed rate into the glass plant. Since many of the separation processes are size dependent, the first operation in the glass and aluminum recovery processing is a washing and sizing step to remove particles smaller than 1/4 in. From there the process stream passes a rotating drum magnet which removes the magnetic materials from the process stream. The magnetically cleaned process stream is then delivered to a heavy media separator where materials with a specific gravity less than 1.8 (mostly organic materials) float and are removed for landfill disposal. Materials with a specific gravity greater than 1.8 (glass, stones, metals) sink in the heavy media separator and are carried to a jig where the aluminum is separated from the glass and stones. The aluminum rich fraction prepared by the jig can be stored for market, or upgraded to improve its market value.

The glass rich process stream is dewatered on a vibrating screen and dried in a kiln dryer. The dried material is then conveyed to a high-tension electrostatic separator for the removal of any remaining conducting materials, such as metals or any hygroscopic materials which might reabsorb sufficient moisture to show a high surface conductivity.

The materials passing the electrostatic separator are conductors which consist mostly of glass. They enter the final separation process that utilize differences in optical properties to segregate glass and stones. The material first passes through a transparency sorter. Here, the opaque materials are rejected and removed for landfill disposal. The transparent materials are then color sorted into a flint and a mixed color glass product. Both of these final glass products are commercially salable glass cullets. If desired, the mixed color glass product can be further color sorted into an amber and a green product, both of which have a higher market value than the mixed color glass cullet.

1.4 TECHNICAL EVALUATION

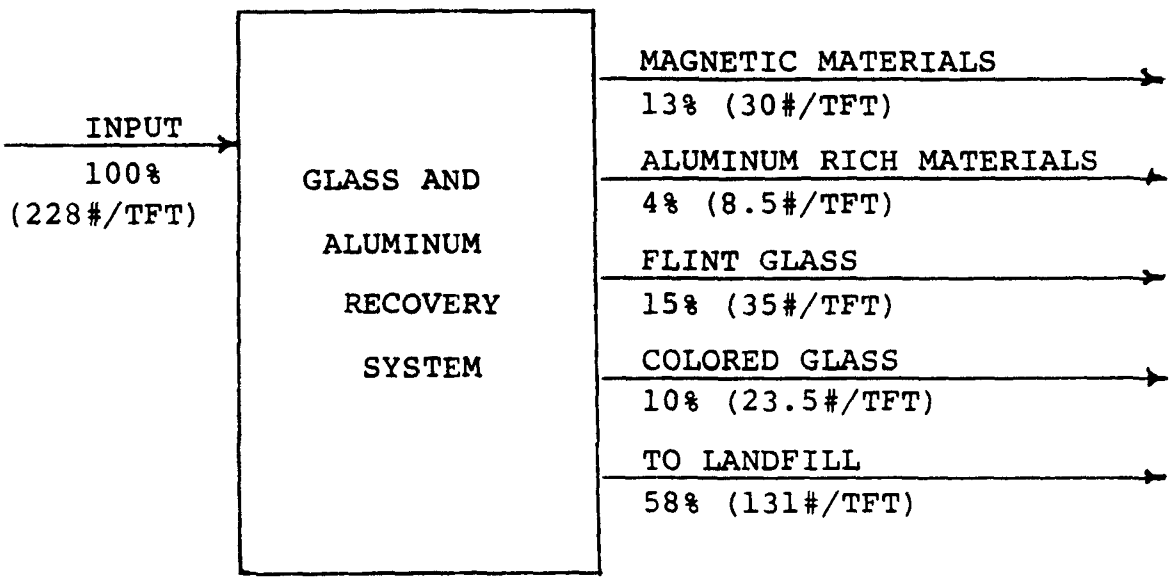
The Glass Recovery Plant is a major subsystem of the Franklin Solid Waste and Fiber Recovery Facility. The feed to the glass plant originates in the pulping and separation system of the solid waste processing facility. After the solid waste is pulped, the material is pumped through a cyclone where the slurry is separated into heavy and light fractions. The light fraction from the cyclone is processed in the fiber recovery system, and the heavy fraction from the cyclone is fed to the glass plant.

During the evaluation period, 228 pounds of cyclone rejects were generated for every ton of refuse deposited on the tipping floor. These cyclone rejects would normally constitute the feed to the glass plant. Because of size limitations in some glass plant components, the glass plant did not process all of the cyclone rejects that were available. Instead, the glass plant operated on a slip stream. The cyclone rejects have the following composition:

	Percent*
Flint Glass	38
Colored Glass	18
Magnetics	9
Aluminum	5
Other Metals	0.3
Organics	8
Plastic and Rubber	8
Ceramics and Stones	12
Miscellaneous	3

*Percentages may not add to 100 due to rounding of individually determined values.

The following diagram shows the mass balance for the glass plant assuming that all the cyclone rejects were processed. The percentages refer to the ultimate disposition of input to the glass plant. The numbers in parentheses are pounds of material recovered per ton of refuse deposited on the tipping floor given in pounds per tipping floor ton (abbreviated to #/TFT).



The separation efficiency of any unit operation, involves both the efficiency of removal (the ratio of removed material to available material) and the cleanliness of the product in terms of the fraction of the recovered product that is contaminanted. This data was obtained for the product streams emanating from the glass plant.

The magnetic separator recovered 86 percent of the magnetic materials in the glass plant feed, but produced a product which was 59 percent magnetics and 41 percent contaminant.

The jig separator recovered 50 percent of the aluminum from the glass plant feed and produced a product which was 62 percent aluminum and 38 percent contaminant.

The optical sorters produce a flint glass product and a mixed color glass product. The flint glass product contains 39 percent of the flint glass in the glass plant input feed and is 96.0 percent flint glass, 2.9 percent green glass, 0.7 percent amber glass, 0.3 percent ceramics and stones and 0.1 percent other contaminants. The optical sorters recover 58 percent of the colored glass available in the glass plant feed as a mixed color glass cullet. This product is 99.2 percent glass, 0.7 percent ceramics and stones and 0.1 percent other contaminants.

1.5 ENVIRONMENTAL EVALUATION

The glass plant evaluated in this study was designed specifically as a back-end to the pulping and separation system. As such, it would be meaningless to discuss the environmental impact of the Glass Recovery Plant alone. Therefore, the evaluation investigated the environmental impact of the total solid waste plant which was presented in the report of Wittmann et al.[2] However, where possible and meaningful, independent environmental assessments were made exclusively on glass plant operations.

1.5.1 Environmental Impact On Air

Those portions of the glass plant which could impact on air quality include the dryer off-gases and the dust created at several locations in the plant. In-plant dust control is accomplished with a hooding system with the dusty air being cleaned in a Venturi scrubber prior to atmospheric discharge. The dryer exhaust is vented through the same Venturi scrubbing system. Tests performed indicate that the system exhaust gas has a composition similar to normal air with a particulate emission rate equivalent to 3 percent of the allowable particulate emission in the State of Ohio for such a system on a process weight basis.

1.5.2 Environmental Impact On Water

There is no water emitted from the glass plant to the environment. All water used in the glass plant is returned to a common sump and pumped to the whitewater sump in the pulping and separation system where it is used as dilution water. The dilution water contaminant level is lower than that

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[2] Ibid.

existing in the whitewater system and, when so used, does not degrade the whitewater quality. Thus, there is no significant environmental effect on water quality due to the operation of the glass plant.

Glass plant water usage was 1980 gallons per hour of operation. This usage was dependent on equipment size (much of which is oversized) and does not relate directly to throughput tonnage. For example, the jig could process 5 tons of material per hour with no significant increase in water usage.

1.5.3 Environmental Impact On Land

A result of operating the glass plant is a 24 percent decrease in the amount of material to be landfilled. Furthermore, the solid materials emanating from the glass plant have not been degraded by that processing; thus, they are equivalent in composition to the totality of the liquid cyclone effluent stream which otherwise would be landfilled. On a dry weight basis, approximately 6.5 percent of the input to the tipping floor is landfilled via the glass plant.

1.5.4 Noise Pollution

Noise measurements taken throughout the glass plant indicate consistent noise levels in excess of 90 dBA which is the OSHA limit for 8 hour exposure. A major cause of noise in the glass plant is the operation of vibratory conveyors and bucket elevators filled with primarily nonresilient solids, i.e., metal fragments and glass particles. Any new plant of this type would require a different type of conveyor system or enclosures around the bucket elevators and vibratory conveyors to achieve compliance with present OSHA noise regulations.

1.5.5 Odor Analysis

No appreciable odor is present in the glass plant since the material being processed is washed in the first stage of the processing. This washing removes the majority of putrescible matter contained in the process stream. Thus, as long as the system continues to operate and large quantities of cyclone rejects are not retained within the plant, odor is not expected to be a significant problem.

1.6 ECONOMIC EVALUATION

Economic data presented are based on the operation of the present glass and aluminum recovery system, scaled to 500 TPD and 1,000 TPD plants and with system changes indicated for improved operation.

Economic data is not given for the present system since it includes equipment with different throughput capacities. Some equipment is considerably oversized and others undersized for the plant's processing requirements. Thus, any economic analysis of the existing glass and aluminum recovery system shows disproportionately high capital costs for the oversized equipment, disproportionately low capital costs for the undersized equipment, and generally disproportionately high operating costs for the total system because of this disparity in equipment sizes. The net operating costs and income for a glass plant serving 500 and 1,000 TPD solid waste processing plants are displayed in Table 1.1. The costs are normalized per ton of solid waste entering the plant. Note that the loss associated with the glass plant operation indicates that the plant cannot pay for itself or make a profit for the investor.

The glass plant alone is not a money maker at 500 TPD; but at 1,000 TPD, it is projected as a break even operation. It should be noted that the revenue from the sale of aluminum is twice that received from the sale of glass.

A glass plant requires a front-end system to provide the glass plant process stream. Hence, the total economics of both the front-end system and the glass plant should be

TABLE 1.1 GLASS PLANT COST BALANCE

	500 TPD	1,000 TPD
Capital Costs*	$1,874,000	$3,290,000
Facility Expense**	$1.70/T	$1.49/T
Operating Expense	$2.19/T	$1.48/T
Income		
Magnetic Sales (#25/T)[+]	$0.02/T	$0.02/T
Aluminum Sales ($300/T)	$1.95/T	$1.95/T
Glass Sales		
Flint ($20/T)	$0.60/T	$0.60/T
Amber ($20/T)	$0.22/T	$0.22/T
Green ($20/T)	$0.13/T	$0.13/T
Total Income	$2.93/T	$2.53/T
Net Savings (Loss)	($0.96/T)	($0.04/T)

+Assumed Sale Price for each Recovered Product - $/T
*Includes Financing Costs
**Based on Capital Recovery Factor of .11683 (15 years at 8 percent).

considered. Table 1.2 summarizes the economics of a Franklin type facility with a glass recovery subsystem. Note that the analysis excludes fiber recovery but it does include the sale of all the fiber from the system as fuel. Revenues from sludge disposal and magnetic and nonmagnetic metal sales are included. The glass plant data is separated from the pulping and separation system economics for easy assessment of the glass plant's relative contributions.

The net savings for a 500 TPD plant is $1.28 and for 1,000 TPD the net savings if $3.19/T. No tipping fee is included in this analysis. One can quickly realize that the wet process is more financially attractive without a glass and aluminum recovery system. However, at 1,000 TPD, the analysis shows that a glass plant becomes less risky.

TABLE 1.2 ECONOMIC SUMMARY OF PROJECTED FRANKLIN PLANT WITH NO FIBER RECOVERY, WITH GLASS PLANT, AND SELLING REJECTS AS A FUEL

Costs	Franklin Projected to 500 TPD	Franklin Projected to 1,000 TPD
Income*		
Pulping and Separation		
Magnetic Metals	$ 2.40/T	$ 2.40/T
Sludge Disposal	1.75/T	1.75/T
Fuel	10.71/T	10.71/T
Glass Plant	.02/T	.02/T
Magnetics	0.25/T	0.25/T
Aluminum	1.95/T	1.95/T
Glass	0.95/T	0.95/T
	$17.78/T	$17.78/T
Operating Expenses		
Pulping and Separation	$ 6.04/T	$ 5.50/T
Glass Plant	2.19/T	1.48/T
	$ 8.23/T	$ 6.98/T
Facility Expense		
Pulping and Separation	$ 6.57/T	$ 6.12/T
Glass Plant	1.70/T	1.49/T
	$ 8.27/T	$ 7.61/T
Net Savings	$ 1.28/T	$ 3.19/T

*Based on following revenue factors:

Magnetic metals selling at $25.00/T.
Sludge disposal--disposed of at a rate of 0.07/T Input--$25.00/T.
Fuel--$1.25/1,000,000 Btu.
Aluminum--$300.00/T.
Glass--flint, amber and green--each at $20.00/T.

The annual before-tax return on investments for 500 and 1,000 TPD total facilities, including the operation of the glass plant, is presented in Table 1.3*.

TABLE 1.3 BEFORE TAX AROI FOR 500 AND 1000 TPD TOTAL FACILITY

	Net Savings	Total Investment	$0.0/T Tipping Fee Before-Tax AROI
500 TPD	$165,000	$ 7,966,000	2.1%
1,000 TPD	$823,000	$14,676,000	5.6%

The before-tax AROI does not meet industrial investment standards.

However, addition of a tipping fee to provide more revenue changes the picture. Figure 1.2 illustrates the effect adding a tipping fee to the revenue side of the balance sheet and its effect on the before-tax AROI for a 1,000 TPD facility.

Thus, with a tipping fee of approximately $8.00/T added to the net income of $3.19/T, a before-tax annual return on investment of 20 percent can be realized for a 1,000 TPD plant. For a capital intensive and high risk business, industry would require a before-tax AROI of at least 40 percent.

*This analysis assumes that all cash flows remain relatively constant in time. This is effectively a "Unicost" assessment.

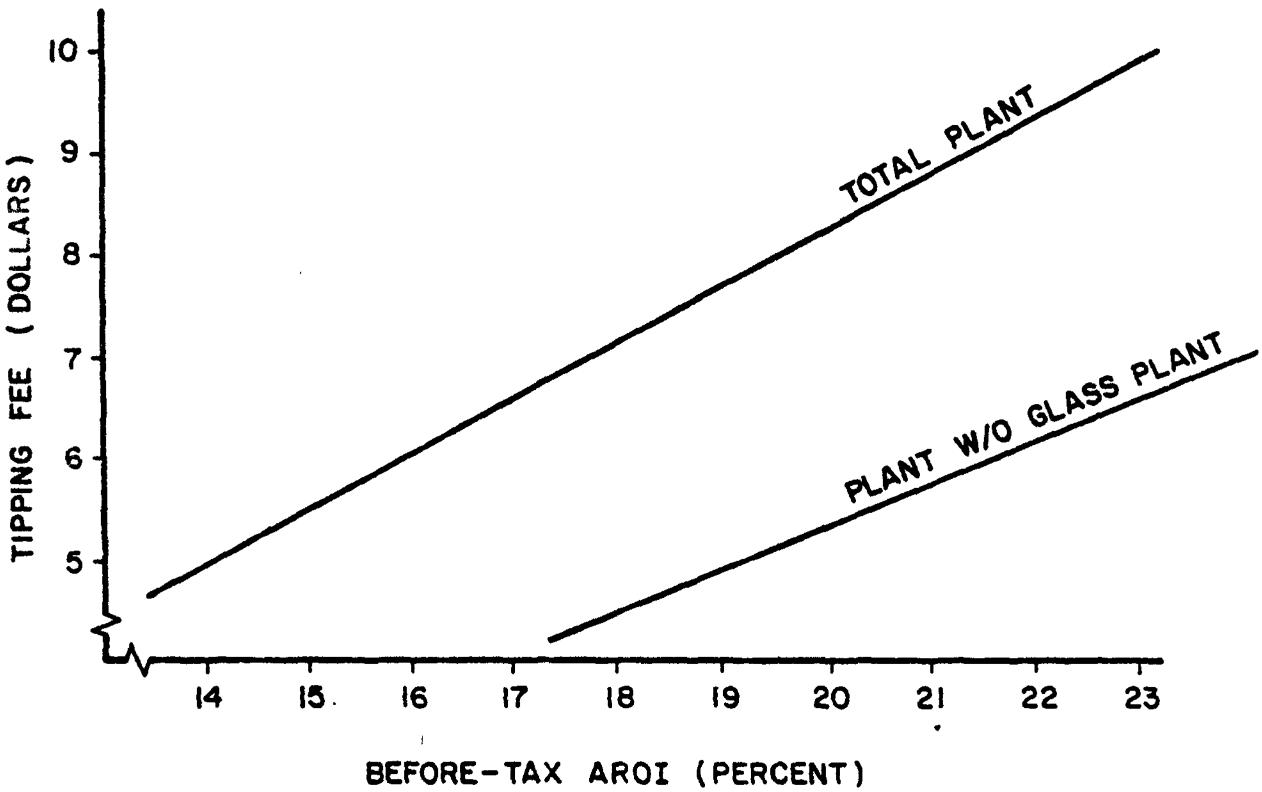


FIGURE 1.2 EFFECT OF TIPPING FEE ON AROI FOR A 1000 TPD TOTAL FRANKLIN FACILITY

Industry and municipalities use different techniques to assess the merit of an investment. What may not be attractive to industry could very well be attractive to a municipality since the community might apply a break even analysis to solve a pressing waste disposal problem where private industrial participation (funding) would make the venture unattractive.

2.0 INTRODUCTION

2.1 PROGRAM EVALUATIONS

The objective of this study was to perform a technical, economic, and environmental evaluation of the Franklin Glass Recovery Plant, which is a subsystem of the Franklin Solid Waste and Fiber Recovery Facility located in Franklin, Ohio.

The evaluations were performed over a six-month period (September 1975 to March 1976). Because of the changing nature of the facility, the data presented in this technical evaluation was collected during February and March of 1976.

2.1.1 Technical Evaluation

The technical evaluation included:

1. A description of the Franklin Glass Recovery Plant
2. Power and water consumption
3. Stream characteristics
4. Material balances
5. Equipment description, theory of operations, and efficiencies.

The results of the technical evaluation are presented in Section 4.

2.1.2 Environmental Evaluation

The environmental evaluation included an analysis of the potential for polluting the air, land, and water. It also evaluated the noise levels in the plant and observations of odor and industrial hygiene requirements. Results of the environmental evaluation are presented in Section 5.

2.1.3 Economic Evaluation

The economic evaluation of the glass recovery subsystem included a determination of the economic viability of the technology being used at Franklin. Cost and performance data collected at the plant provides a measure of the economics that would be experienced if the glass plant were to be incorporated into a different type of solid waste/energy recovery facility.

The data is presented, where possible, in non-dollar value terms so that it can be readily used by all interested parties. Results are projected for facilities scaled up to 500 and 1,000 TPD. Results of the economic evaluation are presented in Section 6.

2.2 HISTORY AND BACKGROUND

2.2.1 Franklin Plant

In 1967 the City of Franklin assessed its solid waste problems and realized that its landfill would be complete in three to four years. At the same time, employees of the Black Clawson Company, Middletown, Ohio, conceived the idea of using paper mill machinery to pulp solid waste, eject the nonpulpable items, separate the finely chopped noncombustibles from the paper fibers, recover them and burn the organic residual in a fluidized bed reactor. The Black Clawson Company investigated this concept further and, to prove its feasibility, constructed a pilot plant at their Middletown facility. This pilot plant showed that municipal solid waste could be pulped, that separation of the inorganic fraction from the organic material could be accomplished, and that the organic material could be burned with the remaining material placed into a landfill.

Based on the results obtained from the pilot plant and the City of Franklin's need to find an alternate solution to their solid waste problems, a solid waste processing demonstration grant was requested from the Public Health Service under the Solid Waste Act of 1965.

The City of Franklin made this grant request to design and construct a full-scale plant which would demonstrate this new and innovative concept of solid waste disposal recycling with the recovery of magnetics. The grant was awarded to the city on September 24, 1970. Land was acquired for the project from the Miami Conservancy District near the new waste water treatment plant. The solid waste plant was completed in May 1971, and the fiber recovery plant was completed in June 1971.

While the Franklin Solid Waste and Fiber Recovery Facility was being constructed, the Glass Container Manufacturers Institute (GCMI) announced that, under their sponsorship, the Sortex Corporation of North America had completed a series of test and trial operations using the glass rich fraction separated from the pulped refuse by the liquid cyclone at Black Clawson's Middletown pilot plant. Using a series of screening and classifying steps to separate the extraneous material, Sortex was able to recover a stream of color sorted glass cullet and an aluminum rich stream. Based upon the laboratory bench/pilot studies on the glass rich fraction, GCMI proposed to the City of Franklin that the City apply for a supplemental grant to add a glass and aluminum recovery line. GCMI indicated that they would reimburse the City of Franklin for the matching funds required for the demonstration grant. This grant request was submitted and approved. Construction of the glass plant began in the summer of 1972 and was completed by the end of 1972.

2.2.2 Contract History

As part of Contract No. 68-01-2211 with the U.S. Environmental Protection Agency, SYSTECH was to perform a nine-month evaluation of the Franklin Solid Waste and Fiber Recovery System including the glass recovery system. However, during much of the technical evaluation period (January through September 1974) of the total plant the glass recovery system was nonoperational. In mid 1974 it became apparent that the glass plant would not be commercially operational during the remainder of the nine-month evaluation. The major difficulty stemmed from the use of air classification as a primary technique for separating organics from the remainder of the glass concentrate stream.

After several modifications to the system, start-up of the modified glass recovery subsystem and this evaluation began in November 1974. However, it became apparent during the beginning of the evaluation period that the system would again not meet end product objectives (yield, quality). Equipment malfunction, low quality of salable output, and relatively high maintenance costs necessitated further changes in the process. Hence, the evaluation was postponed pending these changes.

The Black Clawson Company offered to "turnkey" the modifications based on technology which they had originated and previously piloted at the Institute of Minerals Research, Houghton, Michigan. The GCMI and the EPA agreed to provide the funding, and the new technology was integrated into the system during May and September 1975. The original concept and the modified concept of the glass plant are discussed in the following section.

Other problems (e.g., plugging of lines and screens, etc.) further delayed the evaluation. Finally in February 1976, the glass plant was modified sufficiently to produce an acceptable color sorted glass product on a continuous basis. The data presented in this report represent the data collected during February and March of 1976, e.g., once the plant was made operational.

2.3 PLANT DESCRIPTION

Before a description of the glass plant is presented, it is important that the reader understand the operation of the front-end system that prepares the feed to the glass plant.

The following section briefly describes this procedure, and the reader is encouraged to read reference 1 if further information is desired.

2.3.1 Franklin Front-End System

Incoming solid waste is weighed and deposited on a covered tipping floor. Large nonpulpable items (e.g., tires, wood pallets, carpets, and bedsprings) are separated from the bulk of the refuse and, except for some salvage material, are landfilled. The remaining (93 percent) pulpable solid waste is then deposited on a conveyor for transport to a hydrapulper where it is mixed with water and macerated to form a slurry. (The action of the hydrapulper is similar to that of a home garbage disposal unit.)

Nonpulpable materials are ejected by the centrifugal action of the hydrapulper and removed from the tank by the junk remover. The "junk" materials are rich in metallics and are conveyed under a magnetic separator for recovery of the magnetic materials. The nonmagnetic "junk" can be recycled to the head of the plant or can be landfilled.

When the stream of pulped refuse, which contains some dense gritty material, leaves the hydrapulper it is pumped through a liquid cyclone for separation of organic fibers from gritty material. The cleaned process stream contains mainly fibrous organic materials and can be directed to a fiber recovery system which produces a paper pulp marketable for the manufacturing of roofing shingles and other low grade fiber applications. This material can also be disposed of by first dewatering and then using it in a combustion/ heat recovery system.

The cyclone reject stream (the heavy gritty materials removed by the liquid cyclone) is the feedstock to the glass recovery plant. This fraction of the refuse processing stream is rich in glass and small pieces of metal, especially aluminum when the nonmagnetic junk is recycled. It represents approximately 11 percent of the original waste stream.

2.3.2 Glass Plant - 1974

Figure 2.1 is a schematic of the glass recovery subsystem "as built" in 1974. The outputs from this configuration were not acceptable and the items encircled in dotted lines were removed and replaced with newer technology. Several of the reasons for renovating this subsystem are as follows:

1. Air classifiers did not effectively remove heavy organics from the glass rich fraction.

2. Excessive glass breakage was encountered in bucket drops, dryers, etc., resulting in a decrease in potentially recoverable materials.

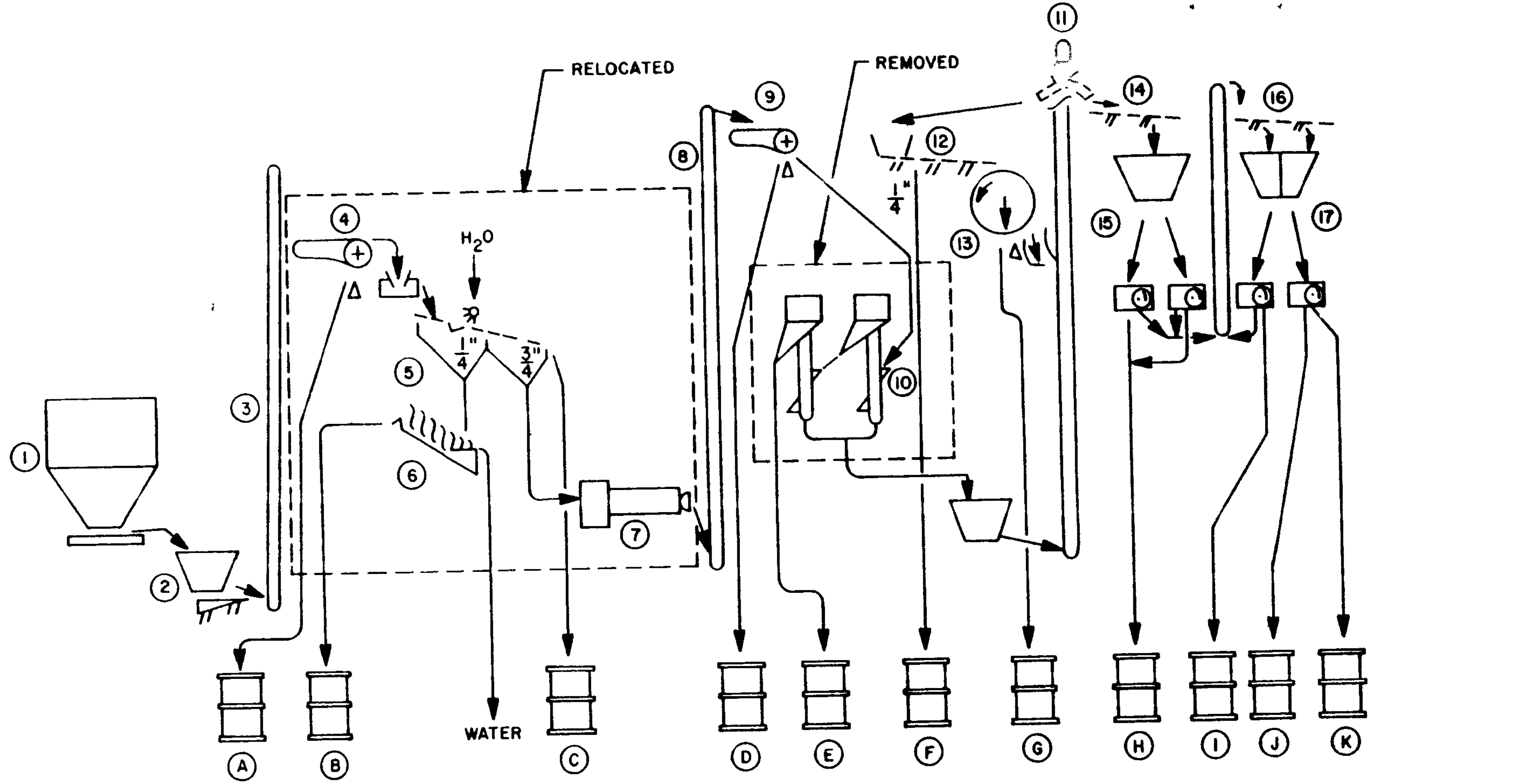
3. The high tension electrostatic separators did not operate effectively because the process stream reabsorbed moisture from the atmosphere after leaving the dryer. The moisture caused the separators to operate ineffectively.

These three problems caused excessive process losses and resulted in unacceptable contaminant levels in recovered products.

Other minor problems also contributed to production of unmarketable end products. Hence, the glass recovery subsystem was modified to the configuration shown in Figure 2.1.

2.3.3 Modified Glass Plant - 1976

Figure 1.1 displays the evaluated glass plant configuration. A detailed description of this revised configuration follows.



1. STORAGE BIN & FEEDER
2. VIBRATING FEEDER
3. ELEVATOR
4. MAGNETIC PULLEY
5. SCREEN
6. SCREW DEWATERER
7. DRYER
8. ELEVATOR (½ OF UNIT NO. 6)
9. MAGNETIC PULLEY
10. AIR CLASSIFIERS
11. ELEVATOR
12. SCREEN
13. HT./ES. SEPARATORS
14. SCREEN
15. SORTEX TRANSPARENCY SORTER
16. SCREEN
17. SORTEX COLOR SORTER

A. WET MAGNETICS
B. FINES (-¼") — WET
C. + ¾" GLASS & METAL (RECYCLE)
D. DRY MAGNETICS
E. LIGHTWEIGHTS — METAL & ORGANICS
F. DRY FINES
G. CONDUCTORS
H. OPAQUE MATERIAL
I. FLINT GLASS
J. AMBER GLASS
K. GREEN GLASS

FIGURE 2.1 CONFIGURATION OF FIRST PROTOTYPE GLASS PLANT AS CONSTRUCTED IN 1974

3.0 OPERATIONAL CAPABILITY

The glass recovery system at Franklin, Ohio demonstrates the technical feasibility of recovering marketable glass and aluminum products from the heavy rejects of a "wet process" resource recovery system. The glass plant utilizes a variety of separation techniques to recover a clean, color-sorted glass product and an aluminum product. The separation steps employed include methods utilizing the magnetic properties, material size and density, electrical conductivity and optical properties of the various components of the glass plant feed stock.

3.1 EQUIPMENT DESCRIPTION

This section describes only the major pieces of equipment installed in the glass plant. No attempt will be made to describe all the conveyors, bucket elevators, and dewatering conveyors.

3.1.1 Surge Bin

The surge bin is a 10 cubic yard cylindrical hopper with a conical bottom. Cyclone rejects from the pulping and separation system are dropped in the top of the hopper. Material to be processed is removed at the bottom by a rotary feeder.

3.1.2 Initial Sizing And Cleaning

Many of the separation operations in the glass plant depend upon having a consistent size for the particles being processed. Thus the first step in the glass and aluminum recovery operation involves screening. A 48-inch Sweco Incorporated "Vibroenergy" vibrating screen separator rated at 3,000 lb/hr and fitted with screens that will pass particles smaller than ½ in. is used. A rotating wash removes fines which adhere to larger particles. Particles which do not pass the screen are scraped into a feed control bin which regulates the rate of feed to the following separation processes. The +½ in. fraction becomes the feed stock to the rest of the plant. The -½ in. fraction is dewatered and landfilled.

3.1.3 Magnetic Separation

Oversized material from the screen is passed to a drum magnet which draws off magnetic materials and deposits them in a container for recovery and sale. The rest of the glass and aluminum rich fraction passes on to the next unit operation.

3.1.4 Heavy Media Separator

The magnetic free +¼ in. material enters a heavy media separator to purge it of residual organic materials. The dense media separator is a Wemco HMS laboratory unit with a rated capacity of up to 500 lb/hr. The HMS is a rotating drum partially filled with a pool of water whose apparent specific gravity has been adjusted to 1.8 by the addition of magnetite. The feed enters one end of the drum just below the surface of the pool. Materials with a specific gravity less than 1.8 will then float to the top and eventually overflow a circular opening at the discharge end of the drum. Particles with a specific gravity greater than 1.8 sink to the bottom of the drum and are picked up by lifters, elevated out of the pool and dropped into a sinks hopper. Both the floats and sinks are spray washed to remove residual magnetite which is recovered for reuse.

The floats are mostly heavy organic materials. These are collected for subsequent landfill disposal.

The sinks include glass, nonmagnetic metals, rocks, dirt and ceramic materials.

3.1.5 Jigging

The dense media sink material is processed in a Wemco-Remer jig. In this device, liquid is pulsated vertically through a horizontal bed of material being processed. This causes the heavier material to work its way to the bottom of the jig bed as the lighter material rises to the top. The Wemco-Remer jig uses a double stroke jig mechanism for improved separation efficiency.

Aluminum rich material comes off the top of the jig and can be further refined for sale. The bottoms consisting primarily of glass are passed on to dewatering and drying. The middlings may be reprocessed or rejected to the landfill.

3.1.6 Electrostatic Separator

The sink material from the jig is gravity dewatered then dried in a rotary drum drier. It then passes to a Carpco high tension electrostatic separator. The electrostatic separator is a device consisting of rotating, electrically grounded drums on which the feed material is dropped. Near the feed entry point, a high voltage ion source charges the particles in the process stream. Conducting materials, once beyond the influence of the ion source, rapidly dissipate their charge to the grounded drum. These conducting materials then drop from the drum since there is no electrical force holding them. (A charged body creates an "image" force which causes it to adhere to a grounded surface). Nonconducting materials, however, do not readily lose their electrical charge. Thus they adhere to the drum longer than the conductors.

Some nonconductors drop off with the conductors in the electrostatic separator, but they tend to be principally stones and ceramic materials. Theories as to why this occurs are presently in dispute, but for our purposes the result is fortuitous since it tends to aid in cleaning up the glass product. The phenomena does result in contamination of the mixed non-ferrous concentrate.

3.1.7 Opacity Sorter

The process stream, having been cleansed of conducting materials and some stones and ceramics, passes to an optical sorter for the removal of opaque materials. This is a Sortex Model 962M Optical Sorter with a rated capacity of 400 lb/hr per channel. In the optical sorter, each piece of material passes through a beam of light. If the light beam is cut off (the particle appears opaque) a small air jet blows that particle aside and it is rejected. Transparent materials are not subjected to the air blast and thus report with accepted material. It should be noted that because of the irregular surface of the glass materials in the process stream, transparent materials will be rejected because they happen to pass through the light beam at such an angle that their reflectivity makes them appear opaque. Rejected opaque materials are removed for landfill disposal. Transparent materials are passed on for further sorting into colored and flint glass products.

3.1.8 Color Sorting

The final step in the glass plant processing is to sort the glass product into a clear or flint glass cullet and a mixed color glass cullet. This sorting is also performed by a Sortex Model 962M Optical Sorter with colored filters installed on the optics so that colored glass appears to be "opaque". The principle of operation is exactly as before, with the resultant products being clear glass cullet and mixed color glass cullet. The colored glass mixture could be further sorted into a green and an amber product, but that is not presently done at the Franklin Glass Recovery Plant.

4.0 TECHNICAL EVALUATION OF THE GLASS RECOVERY PLANT

4.1 EVALUATION METHODS USED

This chapter presents the data gathering and analysis methodologies used in the evaluation of the glass recovery system. Results of the data analysis and the overall glass plant technical evaluation are also presented. These include: recovery efficiencies, material balances, power and water usages and some maintenance history.

4.1.1 Development Of A Study Matrix

To organize the principal areas of evaluation and to aid in defining the data to be measured, a study matrix was developed. The study matrix is a graphic representation of all possible measurements. This allows the experimenter to rapidly assess the necessity of any particular measurement, the relationships between measurables and the completeness of his final experiment. This study matrix is presented in Figure 4.1. Along the horizontal axis, the unit operations of the glass recovery system are listed. The vertical axis is divided into the three evaluation categories. Each of the evaluation categories is subdivided into its component parameters. A mark is placed at the intersection of each unit process/parameter relationship that was evaluated during this effort.

EVALUATIONS	UNIT PROCESSES / PARAMETERS	INPUT SYSTEM	WASH SCREEN	MAGNETIC SEP'N	HEAVY MEDIA SEP'N	JIG	KILN DRYER	SCREEN	ELECTROSTATIC SEP'N	TRANSPARENCY SEP'N	COLOR SEP'N	SYSTEM
TECHNICAL	DESCRIPTION OF EQUIPMENT	0	0	0	0	0	0	0	0	0	0	0
	THEORY OF OPERATION	0	0	0	0	0	0	0	0	0	0	0
	MAINTENANCE HISTORY	0	0	0	0	0	0	0	0	0	0	0
	POWER REQUIREMENTS											0
	STREAM CHARACTERIZATION	0	0	0	0	0	0	0	0	0	0	0
	MATERIAL BALANCE	0	0	0	0	0	0	0	0	0	0	0
	EFFICIENCY		0	0	0	0	0	0	0	0	0	0
	RECOVERED PROD. CHARACT.			0		0				0	0	0
ECONOMIC	OPERATING LABOR COSTS											0
	OPERATING POWER COSTS											0
	MAINTEN. LABOR COSTS											0
	MAINTEN. PARTS COSTS											0
	GENERAL CONSTR. COSTS											0
	EXTENDED CONSTR. COSTS											0
	REVENUES											0
ENVIRON-MENTAL	AIR											0
	WATER											0
	LAND											0
	IN-PLANT NOISE											0
	ODOR											0

FIGURE 4.1 GLASS RECOVERY SYSTEM STUDY MATRIX

4.1.2 Sampling And Analysis Methods

Of the parameters listed in Figure 4.1 under technical evaluation, brief descriptions of the equipment and theory of operation have already been presented in Section 3.

Since so much of the technical and economic evaluation of the plant hinges on the separation efficiencies of the unit processes, the weights of the output streams and the characterizations of the output and process streams are of great importance.

Process streams within the plant were sampled daily and these daily samples were composited for weekly analysis. Figure 4.2 shows the points at which the process stream samples were collected and the points at which the output streams were weighed.

The weekly composite samples were used to characterize individual process and reject streams within the plant. The weekly composites were also used to determine the recovered product characteristics and individual unit efficiencies. Analyses of the collected samples were performed by Systech personnel by hand sorting into the characterization categories appropriate for the stream under analysis. Magnetic metals were separated from other metals using a small lab magnet.

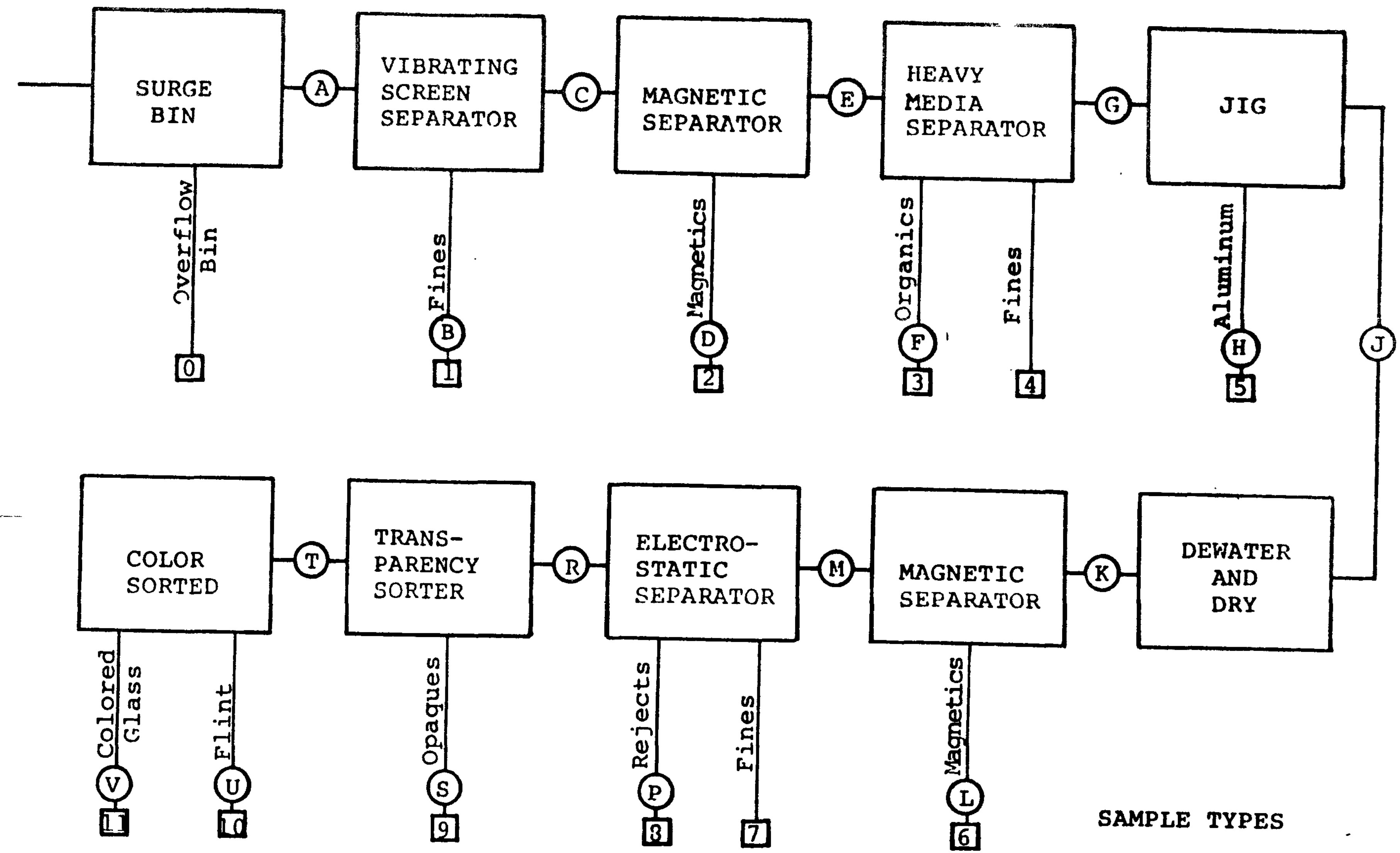


FIGURE 4.2 GLASS PLANT SAMPLING POINTS

There are no in line scales for measuring the input to the glass plant, nor are there any scales on any of the conveyors within the process. Therefore, the analysis of material flows had to be accomplished by network analysis using the weights of the output streams from the plant and recognizing that their sum had to be the total input. Each output stream was collected in barrels and weighed periodically and these weights were recorded. In addition, spillages and other losses were collected and weighed so that they might be accounted for. When all outputs had been measured, they were appropriately added together to determine total input weights. The operating time for the plant was used to compute average flow values per unit time based on the assumption that plant operation was quasi steady state.

The maintenance history for the plant was obtained from operating logs kept by plant operating personnel. These logs were verified by SYSTECH personnel who monitored the operation at the glass plant during the study.

Power requirements were determined for the system as a whole by using electric power meters. Power requirements per unit time were determined by using a timer attached to the power supply of the washing and sizing screen. Since this unit was required for all subsequent operations, it was felt that its time of operation effectively measured the time of operation of the whole plant. There were operations in the glass plant which did not run as long as the washing and sizing screen (e.g., the color sorters), but no unit ran longer.

Section 4.2 of this report presents the results of the technical evaluation phase of the study. The data represents a compilation of six weeks data extending from 3 February 1976 through 12 March 1976. Findings presented in the following sections of this report represent average operating and characteristics data.

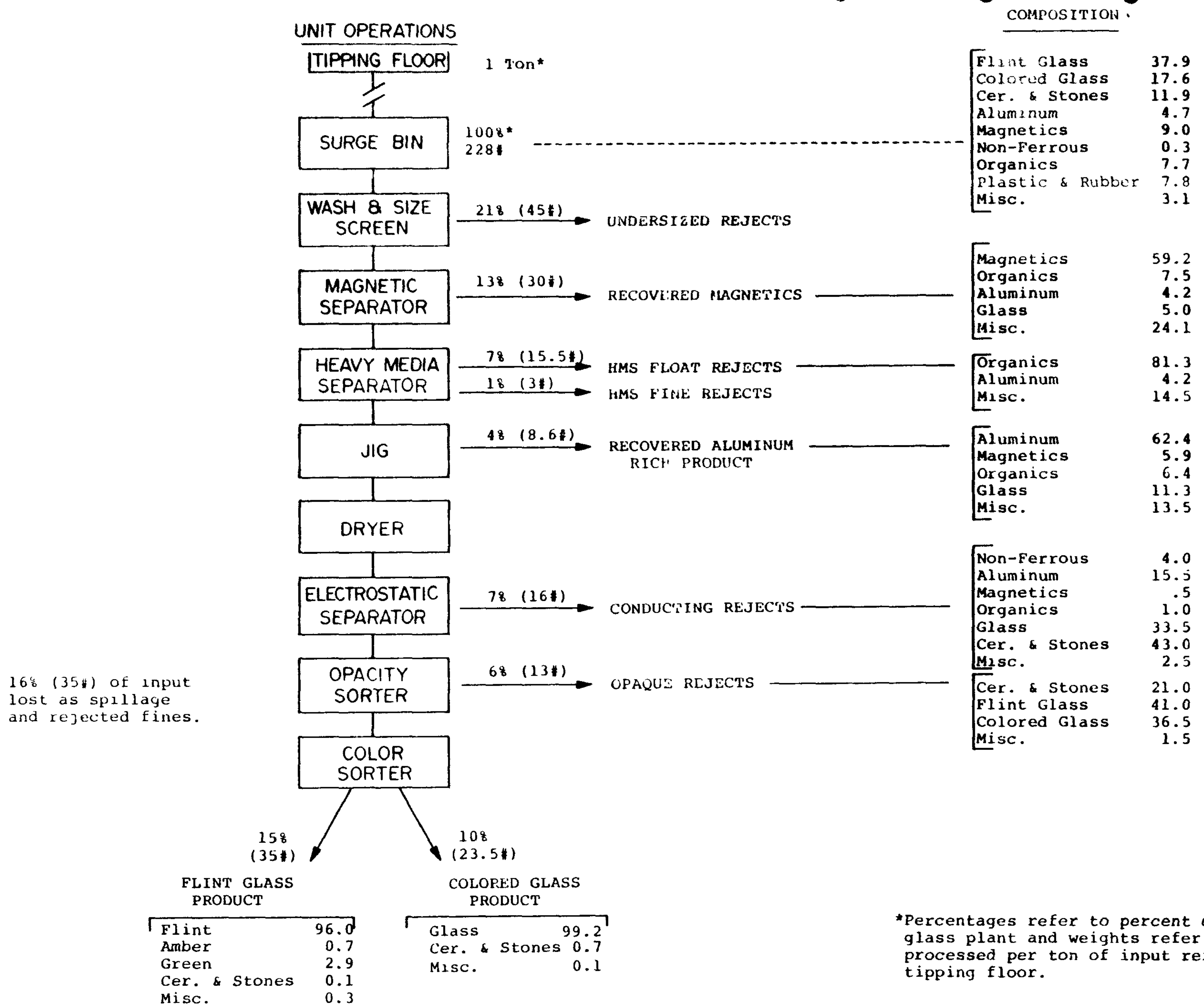
4.2 RESULTS OF THE TECHNICAL EVALUATION

The items covered in this section of the technical evaluation of the glass plant include: (1) material balance data; (2) characterization of the input, process and reject streams and output products of the plant; (3) power and water usage data; and (4) efficiencies of the separation equipment used in the glass plant. Actual data collected with raw material balance data, periodic test data, and data collection forms are too numerous to include in this report. Hence, only summaries are presented.

4.2.1 Mass Balance Data For The Glass Plant

Figure 4.3 is a material balance diagram for the glass recovery system. The input is for a typical 5-day operating week at the Franklin Solid Waste and Fiber Recovery Facility. About 43 percent of the processed input to the glass plant is recovered; so only 57 percent of the cyclone rejects are landfilled.

Mass balance data for the glass plant can be related to the refuse received at the tipping floor by assuming that the glass plant is appropriately sized to accept all the cyclone rejects. For every ton delivered to the tipping floor, 228 pounds of cyclone rejects would be received at the glass plant in a community with Franklin waste characteristics. Figure 4.3 shows the different output streams from the glass plant. Percentages shown in that figure refer to the fraction of input to the glass plant recovered, while the weight numbers refer to pounds of material removed per ton of refuse at the tipping floor. Thus, for example, 30 pounds of magnetic materials are recovered in the glass plant for every ton of Franklin refuse at the tipping floor. The jig top product, which is the aluminum rich stream, is 8.6 pounds per Franklin tipping floor ton. The flint glass product is 35 pounds per Franklin tipping floor ton, while the mixed color glass product is 23.5 pounds per Franklin



*Percentages refer to percent of input to the glass plant and weights refer to the Pounds processed per ton of input refuse at the tipping floor.

FIGURE 4.3 GLASS PLANT PROCESS FLOW WITH OUTPUT CHARACTERIZATIONS tipping floor ton. Because some processing equipment in the glass plant is undersized (especially the heavy media separator) only a fraction of the available cyclone rejects were processed by the glass plant. Total cyclone rejects were measured at 11.4 percent of the incoming refuse during the test period. However, because of this undersizing, the material handled by the glass plant was only 1.9 percent of the refuse received at the tipping floor or a slip stream of approximately 20 percent of the available cyclone rejects was actually processed.

4.2.2 Glass Plant Stream Characterization

The characteristics of the streams in the glass plant were developed from composite samples collected at various points in the process stream and all the output points (see Figure 4.2). The input to the glass plant consists of the water-saturated cyclone rejects which are rich in glass, magnetic materials, and aluminum. The majority of this material (70 percent) is -3/4 in. and +¼ in. In addition to the fraction of the material entering the glass plant which is separated at various points within the process, Figure 4.3 also shows the characteristics of those output products. All the compositions are reported as appropriate weight percents.

Magnetic materials comprise approximately 9 percent by weight of the Franklin cyclone rejects*. Eighty-six percent of these magnetic materials are recovered by the magnetic separator. However, contaminant levels are high (41 percent) in this product stream. This contaminant level is caused primarily by wet materials sticking together; thus, the wet magnetics carry contaminants along with them on the magnetic drum and into the recovery bin. This magnetic material would require further cleaning for sale. Once it is dried, it can be easily processed through another magnetic separator to achieve a much higher purity and enhance its value.

The cyclone rejects at Franklin are the input to the glass plant. They have an aluminum content of 4.7 percent. Due to the high economic value of this metal, an attempt is made to recover this fraction of the cyclone rejects. Fifty-one percent of the aluminum in the cyclone rejects was recovered at the jig. The remainder of the input aluminum is removed at the magnetic separation step, the heavy media separation step, and past the jig by the electrostatic separator.

*The cyclone rejects are a poor fuel with 94 percent ash and 417 Btu/lb higher heating value. It is evident from this low Btu content and high ash content that this material is not considered a useful fuel source and that little fuel value is lost in the cyclone rejects. These numbers are consistent with the characterization data of the input which indicates a total organic content of 15.5 percent on a dry weight basis.

The Franklin cyclone rejects have a glass content of about 54 percent, 53 percent of which is recovered as glass cullet. This is equivalent to approximately 29 percent of the feed coming into the glass subsystem (i.e., 36 percent of the glass received on the tipping floor in Franklin).

4.2.3 Utilities Requirements

During the study period the electric power consumption was recorded for the glass plant. The average power usage of the glass plant was 63.3 kilowatt hours per ton. This is equivalent to 215 kilowatt hours per ton of material processed in the glass recovery system, or to 26 kilowatt hours per ton of solid waste delivered to the tipping floor. Power usage for individual unit processes is not available since no individual units were metered.

There are four areas of water usage in the glass recovery system: they are the surge bin conveyor, the washing and sizing screen, the heavy media separator, and the jig. Flow meters were not available to measure water used by the jig and the heavy media separator. For the most part they used their own recycled water and needed only makeup water. The surge bin conveyor uses approximately three gallons per minute and the washing and sizing screen uses approximately 30 gallons per minute of operation. This represents a total flow of 1,980 gallons per hour or 6,712 gallons per ton processed. Water used in the glass plant at Franklin is "city water", i.e., clean potable water. At another installation, non potable process water could be used.

All the water used in the glass plant is collected in a common drain system and is pumped to the whitewater sump in the pulping and separation system of the main solid waste plant. Thus, all water in the glass recovery system is used as makeup water in the whitewater system. No whitewater (recycled process water from the pulping and separation system) is used in the glass recovery system. The primary contamination of the water used is an increase in total suspended solids. This results because fine particles are rinsed off the feed material going to the glass recovery system.

4.2.4 Efficiency Of Equipment

Separation efficiencies for unit operations within the glass recovery system are calculated for the following unit operations: washing and sizing screen, wet magnetic separator, heavy media separator, the jig separator, the rotary kiln, the electrostatic separator, the transparency sorter, and the color sorter. The overall material balance for the glass plant is presented in Figure 4.4.

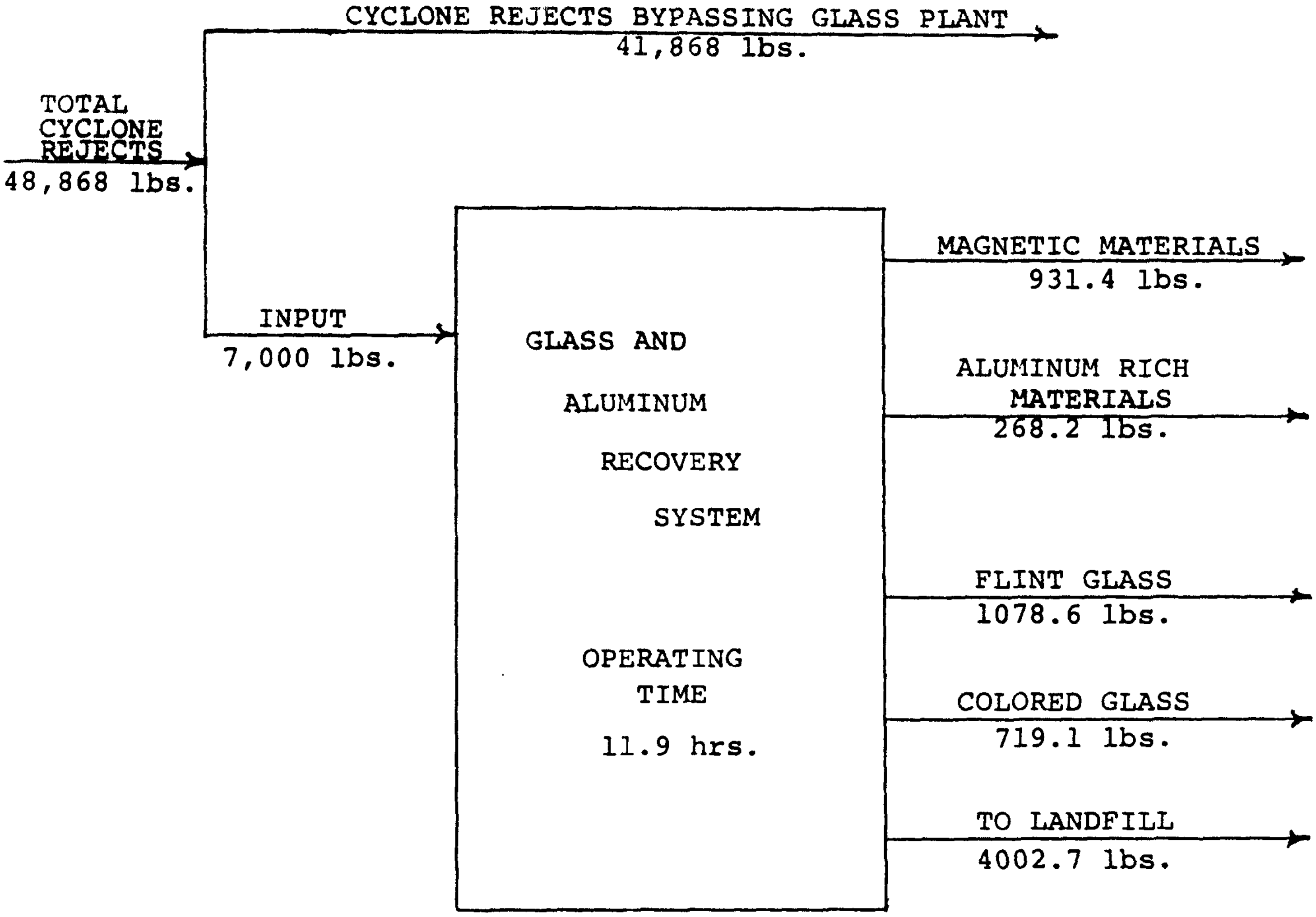


FIGURE 4.4 MATERIAL BALANCE DIAGRAM FOR GLASS AND ALUMINUM RECOVERY SYSTEM*

*Figures represent operating data for an average week; all weights are given on a dry basis.

4.2.4.1 Washing And Sizing Operation

The input to the glass plant from the liquid cyclone is directed to a surge bin having a rotating feed table which meters the solid flow to the initial separation operation. This first operation in the separation process is the vibrating screen separator which rejects materials smaller than ¼ in. from the remainder of the process stream. To aid this removal, material on the vibrating screen is flushed with water to remove small particles adhering to the surface of the large particles. The rejected material from the screen separator is fed to an inclined dewatering screw and landfilled.

Twenty-one percent of the total input to the glass plant is removed as undersized rejects at this point. Of the material passing as process stream, only 3 percent (equal to about 2 percent of the input) is less than ¼ in. in size. This indicates an efficiency for the washing and sizing operation of 90 percent.

4.2.4.2 Magnetic Separation

The process stream from the washing and sizing operation is fed to an electromagnetic drum separator which scalps off the easily removable magnetic materials. The materials removed by this magnetic scalping of the wet feed are moist

(12 percent water). As a result, materials stick together so that this recovered stream is only 59 percent magnetic material. However, 86 percent of the available magnetic materials are removed at this step. Even though the removal efficiency is 86 percent, since the product is 41 percent contaminants, the market value of this product is questionable without further cleanup.

4.2.4.3 Heavy Media Separator

After removal of the wet magnetics, the process stream flows to the heavy media separator. The function of the heavy media separator is to remove organic materials from the glass rich stream. By blending material with a solution of water and magnetite, which is held at a specific gravity of 1.8, the organic materials are floated off and the heavy fraction is passed on to the next operation. Eight percent of the input to the glass plant is removed at this point and contains 93 percent of the organic materials remaining in the process stream at this point.

4.2.4.4 Jig Separator

The primary function of the jig is to separate the aluminum fraction from the process stream. The jig is fairly efficient since it removes 73 percent of the aluminum in the jig feed.

The jig output product contains only 62 percent aluminum. Further cleanup of the jig output product can be achieved by drying the material and then subjecting it to an electrostatic separation process because the contaminants are primarily organics which bypassed the heavy media separator.

4.2.4.5 Rotary Drum Dryer

After leaving the jig, the process stream passes a dewatering screen for the removal of excess surface water; then it passes to a rotary drum dryer. The moisture content of the influent material averages 2.9 percent, and the moisture content of the stream leaving the dryer averages 0.3 percent. This indicates an average reduction in moisture of approximately 90 percent.

4.2.4.6 Electrostatic Separator

Following the rotary dryer, the process stream is passed through a magnetic scalping operation to remove any residual magnetic materials. It is then fed to the electrostatic separator which separates materials according to their ability to hold a static charge. Removal efficiency for metallic material is nearly 100 percent. Also, almost all of the remaining organics and 66 percent of the ceramics and stones are removed by this device. About 6 percent of the available glass is lost from the process stream at this point.

4.2.4.7 Transparency Sorter

The process stream from the electrostatic separator is conveyed to the transparency sorter. The removal efficiency of opaque materials was determined to be 90.5 percent. The transparency sorter also rejects 17 percent of the incoming glass. This results in a glass contamination level of 77 percent in the sorter rejects. This percentage varies with the feed rate to the sorter and the quantity of opaque materials in the feed. During the evaluation, the feed rate to the sorter was held at 400 lb/hr.

4.2.4.8 Color Sorter

The last unit operation in the glass recovery system is the color sorter. The function of this device is to separate the flint glass from the colored glass. Efficiency in this operation has been computed as the contaminant content in the flint glass product, where contaminant means any constituent which is not flint glass. The flint glass product was measured to be 96 percent flint glass, 2.9 percent green glass and 0.7 percent amber glass. Other contaminants include 0.2 percent ceramics and stones, and 0.1 percent unidentifiable tramp fine material.

The colored glass product was 99.2 percent glass, 0.7 percent ceramics and stones, and 0.1 percent unidentifiable fine materials.

The GCMI specifications for recovered glass are presented in Appendix B of this document. Although the recovered glass products do not meet GCMI specifications, they are marketable glass cullets. Cullet samples from Franklin were evaluated by glass users and served as the basis for long term purchase contracts for the glass to be produced by a similar plant in Hempstead, New York.

4.2.5 Comments On Maintenance History

Four major unit operations were improved prior to data collection. The first change was the replacement of the vacuum tube electronic systems in the electrostatic separator with solid state components. Solid state components improved the operating life and reliability of the system as well as enhancing overall operating efficiencies.

The second improvement involved the magnetic separator. The unit in use at the beginning of the testing program was not of sufficient size and strength to give adequate magnetics recovery. The heavy media separator output was not sufficiently free of magnetic materials thus resulting in a lowering of the operating efficiency both of the heavy media and jig separators. The present magnetic separator resulted in the reported separation efficiencies and in improved operation both in the heavy media separator and the jig.

The third item to be improved was the Sortex Optical Sorting System. During the testing period the Sortex Model 962 Optical Sorter was replaced with the Sortex Model 962M System which has an improved, high-speed ejector device. This has resulted in an improved quality of output product as well as an increase in throughput capacity up to 500 lb/hr.

The fourth item to be improved was the bucket elevators. Friable materials dropping into the buckets caused flying chips and dust which accumulated in the bucket pivots and made the elevators bind at turns. The resulting stress increase caused some of the buckets to crack and necessitated system shutdowns to remove and replace the cracked buckets. The problem was minimized by replacing exposed drive gears with enclosed gears. A maintenance program requiring ongoing cleaning of the buckets has effectively controlled this problem.

There were some minor problems involving the operation of the heavy media separator due to the fact that it was considerably undersized. The unit has a throughput rating of only 500 lb/hr, whereas a rate of about 1 T/hr is required to process all the cyclone rejects. Thus, the unit required considerable operator attention which would not be necessary if the unit were sized with a 4-ft. diameter or larger drum. These problems with the heavy media separator are responsible for much of the contamination in the aluminum product coming from the jig.

It should be noted that the glass recovery system in the Franklin Solid Waste and Fiber Recovery Facility is a large test operation which represents the first plant of its type in the world. As such, many equipment modifications and changes were incorporated as an ongoing process. Thus, a long-term history of the maintenance requirements of the equipment in the plant is not available. Based on the limited knowledge gained at the Franklin plant, routine maintenance requirements are not excessive. During the evaluation, maintenance time never exceeded 10 manhours per 40 operating hours.

5.0 ENVIRONMENTAL EVALUATION OF THE FRANKLIN GLASS PLANT

5.1 INTRODUCTION

The major environmental impact of the Franklin Glass Recovery Plant is that it reduces the land required for disposal of solid waste and recovers valuable resources. These benefits, of course, must be weighed against the environmental impact of various waste streams resulting from the operation of the plant.

The environmental impact of the Glass Recovery Plant on air quality can best be characterized by the evaluation of the particulate emissions from the glass plant. Particulates are produced by various operations (moving of the glass) of the glass plant. Tests were conducted to quantify the air emissions from the glass plant. The test results are discussed in Section 5.2.

The environmental impact of any system with respect to water quality is usually evaluated by characterizing the influent and effluent flows from the plant. However, since the glass plant is not a "stand alone" system, it must be evaluated in terms of its additional effect on the environment over and above the effect of the front-end solid waste plant.

Finally, an occupational safety and health evaluation was also conducted with respect to industrial hygiene and noise. Sections 5.4 and 5.5 will present the results of this evaluation.

5.2 ENVIRONMENTAL IMPACT ON AIR QUALITY

The input to the glass recovery subsystem contains friable material (a material that will fracture and crumble easily). The separation and handling techniques used in the glass recovery process tend to fracture the friable materials so that dust is generated.

Hoods are used at those locations within the glass plant where dust might be generated. The collected dust and air are exhausted through a venturi scrubber located outside the Glass Recovery Plant. This exhaust is the only major source of air emissions to the outside environment. Thus, the effect of the glass plant on air quality can be determined by measuring the particulate emissions from the venturi scrubber system.

ASME Power Test Code No. 27 type particulate emissions tests were conducted to measure the emissions from the dust collection system in the Glass Recovery Plant. The EPA Method 5 sampling procedure was not employed because the ambient stack temperature and low moisture content did not require a heated sampling probe. The results of these tests are included in Figure 5.1. It was determined from these tests that the particulate emission rate is 0.089 pounds per hour. The stack temperature (since there is no combustion device other than the dryer) was approximately room temperature or 74°F. The flow rate at standard conditions was approximately 8500 dry standard cubic feet per minute. An Orsat analysis conducted on the exhaust stack indicated that the gas composition was similar to air.

At the process weight rate of 20 pounds per minute, the allowable emission rate in the State of Ohio is 2.90 pounds per hour*. Thus, the emissions from the glass plant (0.089 lb/hr) are only 3 percent of the allowable emission rate. There are no Federal regulations limiting emission rates in terms of the process weight rate of an industry or system. Thus, the Glass Recovery Plant is in compliance with applicable regulations.

*Ohio Regulation AP-3-11, Table 1

				AVERAGE		
GENERAL						
Date	10/22/74	10/22/74	10/23/74			
Emission Source Test	#1	#2	#3			
Barometric Pressure (ins. Hg)	29.77	29.77	30.40			
Specific Gravity of Gases Referred to Air	1.0	1.0	1.0	1.0		
Coal Usage Rate During Test (lbs./hr.)						
Coal Heat Value (BTU/lb.)						
BTU Input (BTU/hr.)						
Average Steam Load (lbs./hr.)						
GAS FLOW DATA						
Stack Area (ft^2)	1.58	1.58	1.58	1.58		
Avg. Velocity at Stack Conditions (FPM)	5766	5621	5588			
Flow Rate at Stack Conditions (CFM)	9110	8881	8829			
Stack Temperature (°F)	74°	74°	74°			
Flow Rate at Standard Conditions (SCFM)	8997	8771	8719			
	8827	8183	8564	8525	DSCFM	
PARTICULATE EMISSION DATA						
Total Particulate Collected (mg)	4.2	3.2	0.5			
Volume Dry Gas Sampled at Std. Cond. (SCF)	33.21	32.76	35.88			
Volume Water Vapor Sampled at Std. Cond. (SCF)	.640	.555	.635			
Total Sampled Volume at Std. Cond. (SCF)	33.85	33.19	36.52			
Particulate Concentration (gr./SCF $\times 10^{-4}$)	19.5	15.0	2.15			
Particulate Concentration (lbs./SCF $\times 10^{-7}$)	27.8	21.4	3.06	17.42		
Particulate Emission Rate (lbs./hr.)				.089		
Particulate Emission Rate (lbs./10^6 BTU)						
Percent Isokinetic Sample (%)						
Process Weight Rate Ton/Hr						
Allowable Emission Rate lb/Hr						
MISCELLANEOUS DATA						
% Moisture	1.9	1.7	1.8	1.8		
Estimated Process Weight Rate	20#/Min	20#/Min	20#/Min			
Orsat Analysis						
CO_2 - 0.5%						
O_2 - 20.5%						
CO - 0.0%						
N_2 - 79.0%						

Process Weight Rate 20#/Min = 1200#/Hr

FIGURE 5.1 FRANKLIN SOLID WASTE GLASS PLANT SCRUBBER - AIR EVALUATIONS

It should be noted that the moisture content of the exhaust gases from the wet scrubbing system is only 1.8 percent by volume. This low moisture content is due to the high volume of air being pulled through the system.

5.3 ENVIRONMENTAL IMPACT ON WATER QUALITY

Water used in the glass plant consists of city water and process water (final clarified water from the adjacent waste-water treatment plant). The city water is used in the wash screen for the purpose of washing and separating the various size fractions of glass and organic material. This washing step is necessary because the glass plant feed material is saturated with lower quality water (i.e., whitewater, which is water that is used and recirculated in the pulping and dewatering subsystems) containing particulate matter that needs to be removed.

Process water is used in the glass plant as makeup water for both the jigging operation and for the heavy media separator. All the water used in the glass recovery system is returned to a common sump and pumped to the whitewater sump in the pulping and separation system where it is used for dilution water in the whitewater system. There is no direct discharge from the glass plant to a receiving stream or wastewater treatment plant. Thus, the environmental effect on water quality solely due to the operation of the glass plant is not significant from a water quality standpoint. Characteristics of the process water used in the glass plant are given in Figure 5.2.

5.4 ENVIRONMENTAL IMPACT ON LAND

One of the side benefits of the Franklin Solid Waste and Fiber Recovery Plant with the Glass Recovery Plant addition is a reduction in the amount of material that would normally require landfilling. The glass plant yields the following landfillable material: wet fines, heavy media separator fines, heavy media separator floats, dry fines, conductors, opaques, and transparency and color sorter fines.

During the evaluation period, the average input tonnage to the glass plant was 590 pounds per hour. Of this amount, approximately 252 pounds per hour is recovered and is not landfilled. This amounts to a 43 percent recovery rate of the incoming feed to the glass plant. If the glass plant were sized to accept all of the cyclone rejects available (11.4 percent of the tipping floor tonnage at Franklin), then 43 percent of this material would be recovered. This is equivalent to a recovery of an additional 98 pounds from

PROCESS WATER CHARACTERISTICS

PARAMETER	UNITS	MAXIMUM	MINIMUM	AVERAGE
Water Temp.	°C	28.1	6.3	20.5
Dissolved Oxygen	mg/l	11.4	5.1	8.2
Turbidity Lab	JTU	60.0	6.0	21.4
Conductivity Lab	Micro-MHO	2173.0	1440.0	1603.9
pH Lab	S.U.	8.5	7.1	7.8
Alkalinity	mg/l	544.0	142.0	407.0
Hardness	mg/l	710.0	196.0	451.9
Chlorides	mg/l	224.0	162.0	193.0
Sulfates	mg/l	220.0	70.0	156.2
Total Solids	mg/l	1525.0	1037.0	1188.4
Dissolved Solids	mg/l	1449.0	987.0	1138.4
Suspended Solids	mg/l	121.0	1.0	51.0
Ammonia Nitrogen	mg/l	44.0	0.0	7.7
Organic Nitrogen	mg/l	3.1	0.1	2.3
Nitrate Nitrogen	mg/l	22.0	0.0	5.3
Total Phosphorus	mg/l	3.7	0.1	1.2
C-BOD2	mg/l	110.0	0.6	8.4
C-BOD5	mg/l	176.0	2.5	18.4
C-BOD7	mg/l	182.0	5.0	25.5
C-BOD10	mg/l	214.0	7.3	35.2
C-BOD15	mg/l	282.0	9.0	53.7
C-BOD20	mg/l	292.0	10.2	70.0
N-BOD5	mg/l	9.8	8.5	9.2
TOC	mg/l	140.0	25.0	50.9
COD	mg/l	431.0	70.0	174.3

FIGURE 5.2 PROCESS WATER CHARACTERISTICS

every ton of waste at the tipping floor. This is a net reduction of 24 percent of the material to be taken to the landfill from the Franklin plant.

The glass plant rejects taken to the landfill are low in putrescible organics and may not require covering, depending upon the location. Nuisance conditions resulting from landfilling this material are minimal. Some flies were detected in warm weather where the material was landfilled and a slight but unobjectionable odor is detectable. No negative environmental impact exists because of landfilling this material.

5.5 NOISE

Systech performed a noise survey of the plant during normal operations to determine the noise level in the glass plant.

The Occupational Safety and Health Act requires that no employee be exposed to noise levels greater than 90 dBA for a period 8 or more hours a day. As the noise level increases, the allowable exposure is reduced.

The glass plant has noise levels in excess of 90 dBA. The average noise level was approximately 94 dBA. Thus, personnel cannot work in the Glass Recovery Plant full time without exposure to levels exceeding Federal standards.

A second generation plant could easily make provision for reducing the noise levels. This could be accomplished through the use of sound-absorbing materials and partial enclosures about some of the noisy items (air ejectors and optical sorters).

A major source of the noise in the glass recovery system is the operation of the vibratory conveyors and bucket elevators. It would also be necessary in a new plant to enclose the bucket elevators and the vibratory conveyors to achieve compliance with Federal noise level standards. Another approach to noise control would be to replace the bucket elevators with another type of conveyor.

5.6 COMMENTS ON INDUSTRIAL HYGIENE

5.6.1 In-Plant Dust

The dust collection system at the Franklin Glass Recovery Plant appears to function efficiently and, as a result, no appreciable in-plant dust problem exists. Dust is removed from the kiln dryer, electrostatic separator, transparency sorter and color sorter, so that dust accumulations do not occur. If a less efficient dust collection system was used, dust problems could be significant. Excess glass dust in the air could contribute to silicosis and other respiratory problems.

5.6.2 Bacteriological Comments

In a previous study, samples were taken of several streams within the pulping and separation system and the whitewater system and analyzed for bacterial contamination. Of these, only whitewater passes to the glass plant. The whitewater was found to contain a total coliform count of 2.0 x 10^8/100 ml, fecal coliform count of 13 x 10^8/100 ml, and a total plate count of 0.28 x 10^9/100 ml. The input to the glass plant coming from the liquid cyclone is saturated with whitewater, and thus is highly contaminated from a bacteriological viewpoint.

Water added at the washing/sizing screens is city water. The water used by the heavy media separator and the jig is process water. Except for the jig (most of its water is recycled to the jig), this water is collected in the sump and used as makeup water for the pulping and separation system. Thus, there is no water effluent, per se, from the glass plant to the outside environment.

The process streams within the plant and recovered products are biologically contaminated and workers who handle this material should do so only when required. They should wash or shower appropriately after handling the material.

5.6.3 In-Plant Odor

No appreciable odor is present in the glass recovery system. The material processed by the glass plant is washed in the washing and sizing screen at the front-end of the plant. This removes the majority of the putrescible matter which is on the surface of the glass particles. In addition, the material down stream of the drying operation is of a relatively dry nature and does not produce an appreciable odor. The wet material input to the glass plant, if allowed to stand for a length of time, develops a sharp, rancid odor. Mold growths will also develop. This is not a problem with the drier material in the following sections of the plant or a plant operating in a continuous manner. In general, odor is not a significant problem in the Glass Recovery Plant.

6.0 ECONOMIC ASSESSMENT

6.1 INTRODUCTION

The Franklin Solid Waste and Fiber Recovery Plant is a facility designed to demonstrate wet processing of solid waste for disposal and recovery of some materials. It must be remembered that the plant was designed and constructed for demonstration purposes. As such, the glass plant module of the Franklin Solid Waste and Fiber Recovery Plant has undergone extensive modifications, additions, and changes during the past 2 years, to improve reliability and product quality. Hence, the economics of the glass plant at Franklin are not truly representative of glass recovery economics.

Many of the changes, additions, and modifications that have been made at the glass plant, tend to skew the overall economics of the system. Since work to accomplish these changes has been classified as maintenance activities for accounting purposes, the modification related labor and the actual maintenance labor are not distinguishable. Hence, an assessment of the real economics of the glass plant in Franklin required definition of a system that would yield the desired recovered products and then obtaining pertinent economic data for such a system. This data was scaled from the Franklin plant to 500 and 1000 TPD plants.

Because of the volatile nature of the Franklin glass plant configuration, most of the subsequently reported economic projections were developed using engineering cost accounting procedures. Considerable effort was expended to assure that the results are representative of an operating plant and not simply this developmental experience. To accomplish the economic evaluation, it was necessary to develop the costs associated with both the construction and operation of the glass plant module. The glass plant includes the unit operations discussed in Section 2.0.

The data required to perform the economic evaluation was derived from information provided by vendors, the U.S. EPA, Black-Clawson, GCMI, and the City of Franklin.

It must be remembered that the glass plant is indeed a module that must be attached to a separation system which yields a heavies fraction. When evaluating the economics of the glass plant, it is important to simultaneously evaluate the economics of the pulping and separation system with the glass plant module. This is appropriate because the glass plant requires a specific type of feed that can be obtained from the pulping and separation system. This report presents the economic analysis of the glass plant module by itself and also couples this data with an integrated disposal facility producing refuse derived fuel (RDF).

6.2 APPROACH TO DEVELOPING THE ECONOMIC DATA

The basis of the economic analysis is the operating experience gained at the Franklin Glass Plant. Where possible, data incorporated in the base is representative of the actual operating experience at Franklin. The cost factors used to quantify the Franklin operating experience included the following:

a) revenues - non-magnetic metals, magnetic metals, and glass sales.

b) operating costs - operating labor, maintenance labor, operating supplies, maintenance materials, utilities (fuel, power, water, etc.), and other expenses.

c) facility expense - amortization and interest.

The objective of the economic analysis is to use the data gathered from the Franklin experience to help project the economics of larger commercial plants. No attempt will be made to show the economics of the Franklin facility because it is a demonstration plant. Hence, it has not been operated to maximize output and minimize cost. For example, there has been no continuous sale of glass or aluminum from the operation of the Franklin Glass Plant. Plant changes have been made continuously throughout the last two years to upgrade the quality of the recovered products. Hence, to make an economic evaluation of this facility would be inappropriate and misleading since it has inherently no chance of being economic. Instead, the technical and economic data available from the operation of this facility will be used to project commercial facility configuration and cost for 500 and 1000 TPD plants.

6.3 DEVELOPMENT OF COST DATA AND PROJECTED ECONOMICS

In order to have a complete understanding of all factors comprising the income and expense for the operation of the Franklin plant and the projections to 500 and 1000 TPD, the following sections describe the income and expense categories used. The cyclone reject inputs to the glass plant will be 53.5 TPD and 107 TPD, respectively for the 500 and 1000 TPD plant size.

6.3.1 Income

Income that can be realized form the operation of the Franklin Glass Plant are from the sale of three commodities: magnetic sales, non-magnetic sales (aluminum), and glass (see Table 6.1). A potential credit also exists because the amount of material taken to the landfill for disposal is reduced.

TABLE 6.1 INCOME SOURCES

INCOME SOURCE	PERCENT OF MATERIAL IN RAW REFUSE (TIPPING FLOOR)	PERCENT RECOVERED IN GLASS RECOVERY SYSTEM
Glass		
Flint	6.0	50**
Amber	2.2	50
Green	1.3	50
Magnetic Metals	1.0 (9.8) *	10
Aluminum	0.9	72

*Remaining fraction of the magnetics in the solid waste is recovered in the pulping and separation system.
**Based on recovering approximately 50% of input glass. Actual operating experience showed this to be lower. However, it is estimated that new operating procedures and equipment changes will yield a 50% recovery of input glass or higher.

TABLE 6.2 REVENUE FACTORS

INCOME SOURCE	TONS MATERIAL RECOVERED/ PER TON INPUT (Tipping Floor)	ASSUMED MARKET VALUE IN DOLLARS PER TON (Early 1976)	INCOME PER TON INPUT (Tipping Floor)
Glass			
Flint	.03 T/T	$ 20.00/T	$ .60
Amber	.011 T/T	$ 20.00	$ .22
Green	.0065 T/T	$ 20.00	$ .13
Magnetic	.001 T/T	$ 25.00	$ .025
Aluminum	.0065 T/T	$ 300.00	$1.95

The assumed market values indicated in Table 6.2 for the aluminum, magnetics, and glass are based upon quotations received by Black-Clawson from sources who have agreed to purchase these materials from their Hempstead (Long Island) facility which is currently under construction. This facility will include design changes that are expected to improve the purity of the recovered glass and aluminum compared to the Franklin products. These market values were substantiated by contacts with other sources made by SYSTECH during this study as well as during a separate study being performed for the Navy's Civil Engineering Laboratory[3]. All commodity purchase prices are F.O.B. the plant and consequently assume a user within 500 miles of the plant.

The revenue factors were based on an average percentage input of 9.8 percent for magnetics, 0.9 percent for aluminum, and 9.5 percent for glass in the received refuse (tipping floor). These fractions are typical of Franklin Refuse and the procedure outlined in Tables 6.1 and 6.2 should be followed to revise the revenue projections for the solid waste characteristics in other areas. By using tonnage based revenue factors, they remain constant for all plant sizes. Hence, they can be used directly in the 500 and 1000 TPD plant economics.

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[3]Rigo, H.G. and Hausfeld, B.A., Development of Alternative Approaches to a Small Scale Solid Waste Transfer/Resource Recovery Station for Navy Installations, Contract No. N68305-76-C-0025, Civil Engineering Laboratory, Port Hueneme, California, 1977 (in press).

6.3.2 Description Of 500 And 1000T/D Glass Plant

Before projecting costs of 500 and 1000 TPD (Tipping Floor) glass plants, it is necessary to determine the processing equipment required by these glass plants. The required processing equipment was determined in the following manner:

1) unit operations data gathered at Franklin formed a basis

2) needed improvements were identified and translated into hardware changes using literature and vendor information

3) consultation with Black-Clawson representatives was coupled with our observations.

It must be recognized that many components projected to be installed in large glass plants are bigger than any heretofore operated. Hence, cost and performance projections are based heavily on vendor and Franklin experience.

It is known that several pieces of equipment sized in Figure 6.1 and 6.2 is used in minerals and minimg industries, and is frequently capable of processing tonnages much in excess of that indicated. Equipment that is based upon Franklin performance data includes the jig, color sorter, and opacity sorter.

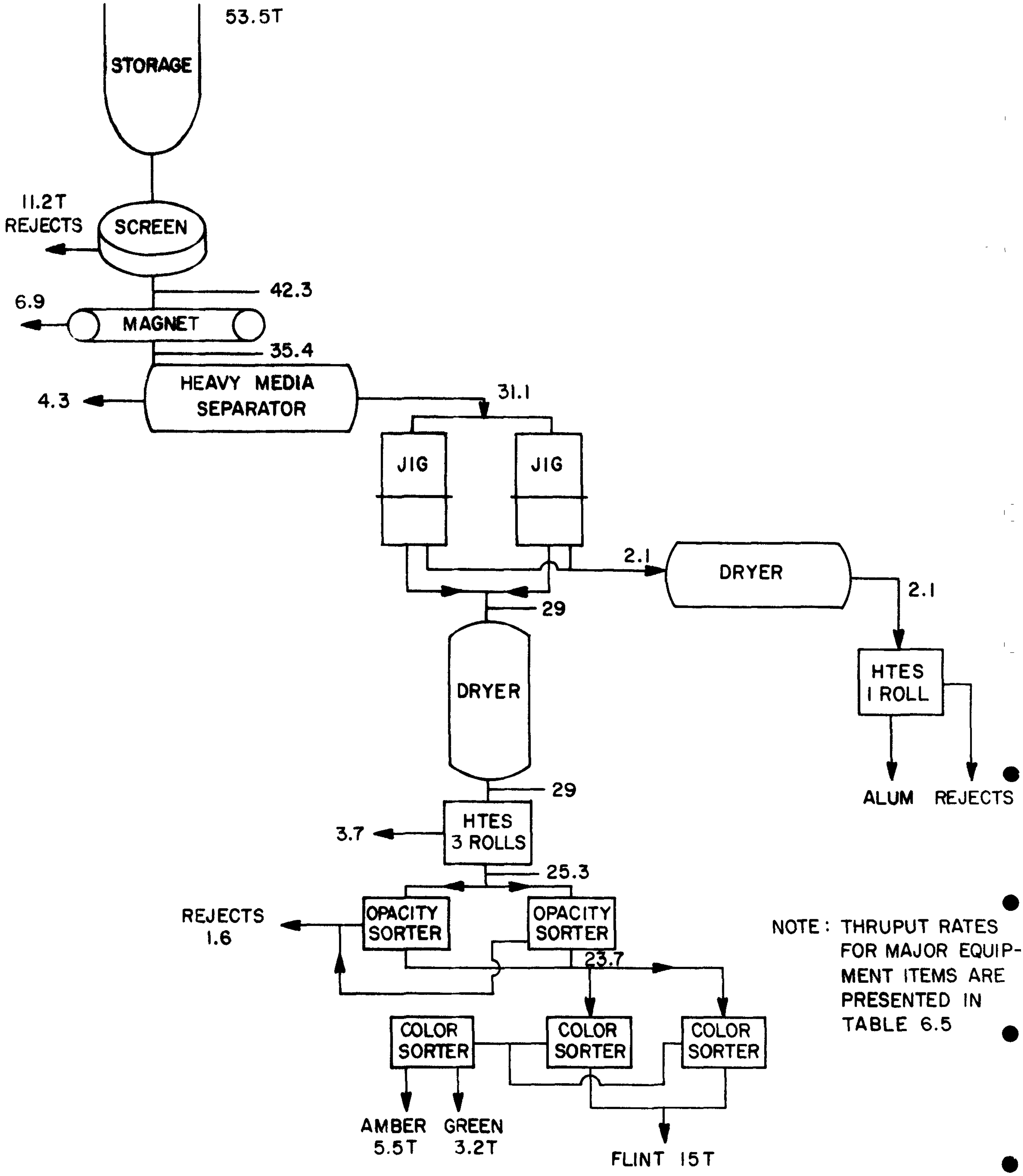


FIGURE 6.1 PROJECTED FACILITY DESCRIPTION FOR A FRANKLIN GLASS PLANT SIZED TO PROCESS FEED FROM 500 TPD PLANT

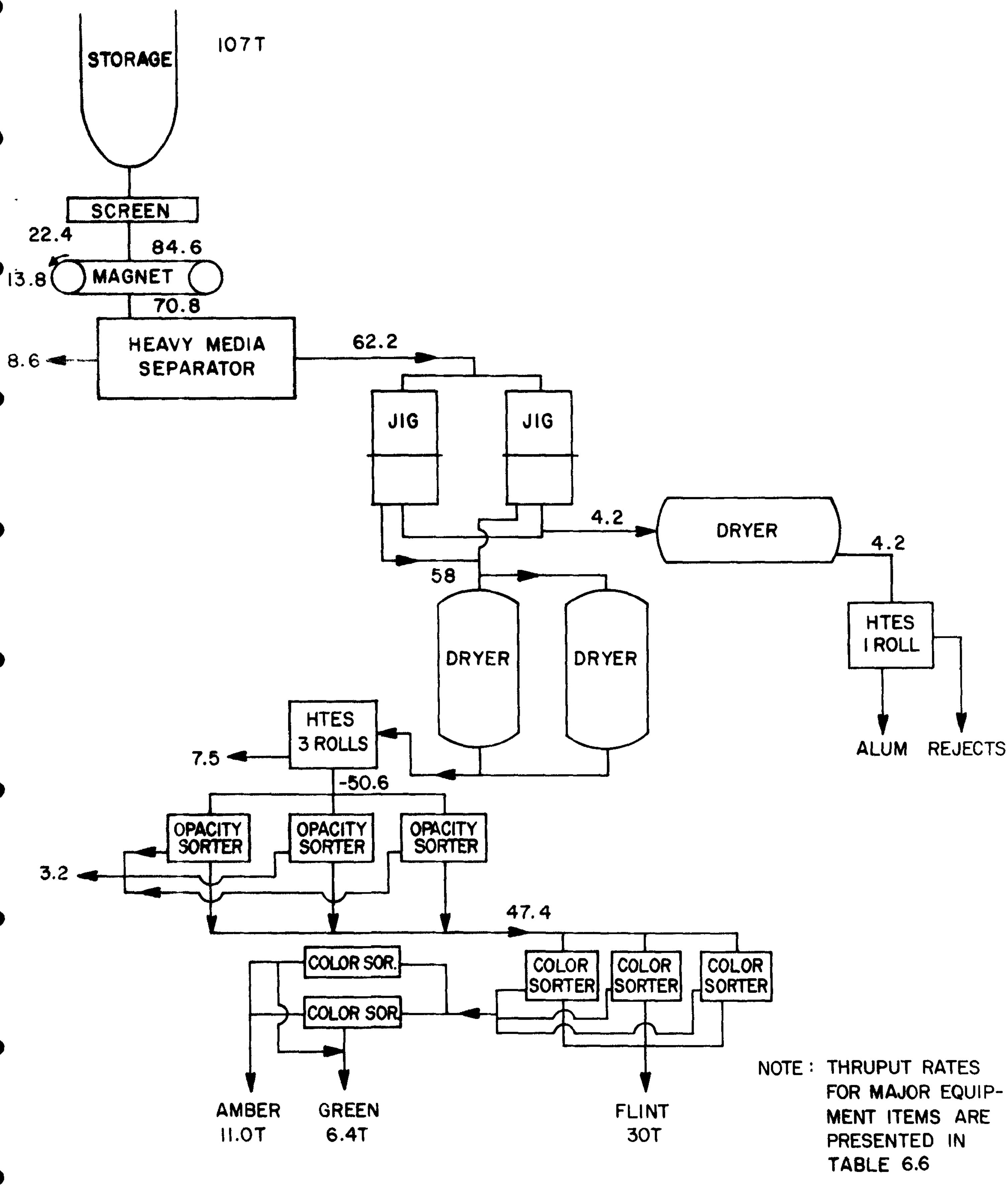


FIGURE 6.2 PROJECTED FACILITY DESCRIPTION FOR A FRANKLIN GLASS PLANT SIZED TO PROCESS FEED FROM A 1000 TPD PLANT

The large plants are sized to process the glass plant feed in two shifts or approximately 12 to 14 hours.

No attempt was made to use the thru-put rates of the Franklin Glass Plant to size the equipment required for the 500 and 1000 TPD facilities. The Franklin plant had undersized equipment early in the processing line that adversely effected the thru-put of the entire system. Hence, no meaningful thru-put rates could be established for many of the components installed at Franklin. Hence, manufacturers data and the literature became a major technique for estimating the equipment for the entire process line.

6.3.3 Operating Expense Items

The following categories were developed and used for deriving the operating expenses for a Franklin Glass Plant.

6.3.3.1 Operating Labor

This category includes the personnel required for the operation of a Glass Recovery Plant and projects the operating labor force needed at a glass plant coupled to a facility receiving 500 and 1000 TPD (Tipping Floor) of solid waste. Table 6.3 summarizes the development of this data. The total operating man-hours (MH) required per day by each of the facilities are:

Franklin 50 TPD - 26 MH

Franklin 500 TPD - 68 MH

Franklin 1000 TPD - 68 MH

These man-hour projections and appropriate salary rates can be used to project operating labor costs for each size facility. It should be noted that the proposed facilities for 500 or 1000 TPD operations will require two shifts to process the mater:al. As can be seen in Table 6.3, the operating labor force for the 500 and 1000 TPD plant is identical. The reason for this is that operational tasks are identical for both size facilities and there is not a significant difference in the amount of equipment that must be operated for the processing of the material. The data for the 50 TPD plant was the actual operating experience at Franklin.

TABLE 6.3 OPERATING LABOR

	Franklin 50 TPD	2 Shift Total 500 TPD	2 Shift Total 1000 TPD
Supervision	¼	½	½
Chief Operator	1	1	1
Assistant Operator	1	2	2
General Labor	1	4	4
Office	0	1	1

6.3.3.2 Maintenance Labor

Very little data has been recorded for the maintenance requirements of the Glass Plant as it exists at Franklin. The reason for this is that the plant has been significantly modified many times over the last two years and it is impossible to separate actual maintenance costs from the cost of changes in equipment that have been performed by maintenance personnel. Table 6.4 presents an estimate of the maintenance man-hours associated with the operation of the Franklin plant in the evaluated configuration and also projects the maintenance labor requirement to 500 and 1000 TPD plants (Tipping Floor). Table 6.4 is a projection of the maintenance hours required to maintain these facilities based upon equipment similar to that being used at Franklin and assuming that the maintenance problems observed for this equipment will continue but that obvious improvements will have been made.

TABLE 6.4 MAINTENANCE LABOR

	FRANKLIN 50 TPD	FRANKLIN 500 TPD	FRANKLIN 1000 TPD
Chief Mechanic	¼	½	1
Helper	¼	1	1

6.3.3.3 Operating Supplies

This category reflects all the cost for the operating supplies and includes all consumables required to operate the Glass Plant. Since no record for the Franklin Glass Plant has been maintained at Franklin, this factor had to be estimated ($.03/T).

6.3.3.4 Maintenance Supplies

Again, no records exist at Franklin that adequately describe the glass plant maintenance supply cost. However, during the evaluation period, it was observed that little maintenance was actually required in the glass plant.

Maintenance supplies are often estimated at 3 to 6 percent of the installed equipment costs. It is believed that a 5 percent factor would conservatively indicate the appropriate maintenance supply costs.

6.3.3.5 Utilities

Power - In Section 4.2.3 it was shown that approximately 26 Kwh are required to operate the glass plant per ton input to the tipping floor. This cost factor can be applied directly to the power costs required for larger plant sizes.

Fuel - Fuel oil is used to heat the building housing the glass plant facility. No technique was available for making a direct measurement of the building heat fuel requirements. Since the plant area approximates that of the fiber recovery module, the cost factor derived for the fiber recovery module (.09 gallon/ton) will be used.[4]

Additional fuel oil is required to operate the dryers. The type and size of the dryer can vary depending upon the material and thru-put desired.

The type used for this analysis was the rotary drum (same as used at Franklin). The fuel estimates were based upon vendor information supported by literature describing the operational requirements for rotary drums.

Water - Although some water is consumed in the washing and screening operations within the glass plant, it becomes part of the whitewater system which is used as a feed to the pulper. Hence, no charge will be levied against the glass plant for water consumption. If the user of the data wants to estimate the charge

[4] Wittmann, T.J., et al, ibid.

for water usage, if the plant were attached to another process, he should refer to Section 4.2.3 for water consumption data and use his local water supply and treatment costs to estimate this operating cost factor.

6.3.3.6 Land Disposal

With the glass plant module, some material that would normally be landfilled is recovered. That is, approximately 43 percent of the cyclone reject stream is recovered as magnetics, aluminum, and glass.

Hence, the rejects from the glass plant that require landfilling will not be defined as an operating costs to the glass plant, but for purposes of this evaluation will be assumed as part of the operating cost of the pulping and separation system. However, if a potential user desires to levy a charge against the landfilled material from the glass plant, it can be based upon the fact that 6.5 percent of the refuse received at the tipping floor is landfilled from the glass plant. A credit for reduced landfill requirements could also be developed if residue disposal were a significant total cost element.

6.3.3.7 Miscellaneous Expenses

This category includes all other expenses that are required for operating the plant. They include insurance, accounting, taxes, security, etc. Since records at Franklin do not separate the miscellaneous expenses for the glass plant from the total plant account, it is estimated that the expense will be approximately $20,000/year, e.g., a proportional amount of the total facility expense.

6.3.4 Facility Expense Charge

In order to develop a full economic evaluation, costs for each of the two larger facilities must be determined so that appropriate amortization and interest charges, depreciation or other related facility expenses can be derived.

No attempt will be made to present the total capital costs of the Franklin Glass Plant because, for the reasons detailed previously, no economic evaluation of the Franklin operation was made. If the reader desires to know more about the costs of the Franklin Glass Plant, he should refer to the report, "Glass and Aluminum Recovery Demonstration Subsystem for the City of Franklin, Ohio", prepared by John P. Cummings, dated November 22, 1976, Owens - Illinois, Glass Container Division, Toledo, Ohio.

The cost for the 500 and 1000 TPD (Tipping Floor) glass plant module was based on the process as modeled in Franklin and displayed in Figures 6.1 and 6.2. Equipment costs were developed from manufacturers literature and construction costs were estimated using Mean's[5] and Richardson[6] construction cost estimating handbooks. Tables 6.5 and 6.6 tabulate the estimated costs for 500 and 1000 TPD glass plant modules.

The total facility costs for the 500 and 1000 TPD (Tipping Floor) Franklin Glass Plant are $1,442,000 and $2,531,000, respectively. However, there are other factors that contribute to the total cost of the facility. For purposes of the analysis, it will be assumed that the facility will be owned by a municipality and that 15 year bonds at 8 percent interest would be issued to finance the facility. Furthermore, it is known that the total cost of the facility must include monies to cover a "Debt Service Fund", a "Debt Revenue Fund", and the "Bond Finance Charges". These items cause the total bond issue to be approximately 30 percent higher than the actual facility cost.[7] Hence, the total capital and bond costs are as follows for the 500 and 1000 TPD (Tipping Floor) Glass Plant Facilities.

[5]Building Construction Cost Data, 35th Annual Edition Robert Snow Means Company, Inc., Duxbury, Mass.
[6]Process Plant Construction Estimating Standards, 1976, Richardson Engineering Services, Inc., Solena Beach, California.
[7]Wittmann, T.J., et al, ibid.

TABLE 6.5 CAPITAL COSTS FOR 500 T/D
FRANKLIN GLASS PLANT
(PROCESS DESCRIBED IN FIGURE 6.1)

Major Equipment Items and Cost for Processing Input To Glass Plant From 500 T/D (Tipping Floor) Facility

1 - Screen - Vibro Energy Separator - 8' D - Est. Capacity 5T/HR - - - - - - - - -	40,000
1 - Magnetic Separator - - - - - - - - -	12,000
1 - Heavy Media Separator 4'D x 4'L - Est. Capacity 4T/HR - - - - - - - - -	100,000
2 - Jig 2 Section Jig - 26" x 26" .5T/HR/sq.ft. - - - - - - - - -	40,000
1 - Dryer Rotary Kiln 4'0 x 30' - Est. Capacity 3T/HR - - - - - - - - -	100,000
1 - Dryer Rotary Kiln 2'0 x 8' - Est. Capacity 0.4T/HR - - - - - - - - -	50,000
1 - HTES - 3 Rolls 1.75D Roll - CAP. 1500#/HR/FT Of Rotor Length - - - -	120,000
1 - HTES - 1 Roll 1'D Roll - Cap 300#/HR/FT of Rotor Length- - - - - -	40,000
2 - Opacity Sorters - 6 Channel-400#/HR/Channel- - - - -	60,000
3 - Color Sorters - 6 Channel-400#/HR/Channel- - - - - -	90,000
- Conveyors, Silo's for Storage of Recovered Products, Input Storage, etc. (Estimated)- - - - - -	200,000
- Building-5000 sq.ft. x 30 Ft. Hight, including building electrical and plumbing (16.00/ft^2) - - - - - - - - -	80,000
- Electrical and Plumbing for Process Equipment- - - -	60,000
- Installation of Above Equipment Estimated Cost - - - - - - - - -	200,000
	$1,192,000
Engineering Costs 10% of facility Cost - - - - - - - - -	119,000
	1,311,000
Start-Up Costs 10% of Total - - - - - - - -	131,00
	$1,442,000

Note - No Land Cost Included

TABLE 6.6 CAPITAL COSTS FOR 1000 T/D FRANKLIN GLASS PLANT (PROCESS DESCRIBED IN FIGURE 6.2)

Major Equipment Items and Cost for Processing Input to Glass Plant From 1000 T/D (Tipping Floor) Facility

2 - Screen - Vibro Energy Separator - 8'D Est. Capacity 5T/HR - - - - - - - - -	80,000
1 - Magnetic Separator - - - - - - - - -	12,000
1 - Heavy Media Separator 6'D x 5" Long - Est. Capacity 6T/HR - - - - - - - - -	150,000
2 - Jig - 2 Section 36" x 36" 5T/HR/ft² - - - - - -	80,000
2 - Dryers - Rotary Kiln 4'D x 30' - Est. Capacity 3T/HR - - - - - - - - -	200,000
1 - Dryer - Rotary Kiln 2'D x 8' - Est. Capacity 0.4T/HR - - - - - - - - -	50,000
1 - HTES - 3 Roll - 2.5'D Roll - 1500#/HR/ft of Rotor Length - - - - - - - - -	160,000
1 - HTES - 1 Roll - 1'D Roll - 300#/HR/ft of Rotor Length - - - - - - - - -	40,000
3 - Opacity Sorters - 6 Channel-400#/HR/Channel- - - - -	90,000
5 - Color Sorters - 6 Channel-400#/HR/Channel- - - - - -	150,000
- Conveyors, Silos for Storage of Recovered Products, Input Storage, etc. (Estimated) - - - - - - - - -	400,000
- Building - 10,000 sq.ft. x 30 FT High including building electrical and plumbing (16.00/ft²) - - - -	160,000
- Electrical and Plumbing for Process Equipment- - - -	120,000
- Installion of Above Equipment (Estimated)- - - - - -	400,000
	$2,092,000
Engineering Costs 10% of Facility - - - - - - - - -	209,000
	$2,301,000
Start-up Costs 10% of Total - - - - - - - - -	230,000
TOTAL CAPITAL COSTS - - - - - - - - -	$2,531,000

NOTE: No land cost included.

CAPITAL AND BOND COSTS

	500 TPD	1000 TPD
Project Cost	$1,442,000	$2,531,000
Total Bond Issue	$1,874,000	$3,290,000
Annual A & I (11.683 percent)*	$ 218,900	$ 384,300

*Based upon 15 years and 8 percent (a Capital Recovery Factor of .11683).

6.3.5 Estimated Economics For A Franklin Glass Plant To Service 500 and 1000 TPD (Tipping Floor) Facilities

6.3.5.1 Introduction

Before presenting the estimated operating costs for the glass plant modules servicing a 500 and 1000 TPD (Tipping Floor) facility, some discussion about the facilities and its operation is necessary.

Each of the facilities are to be operated such that all received products and/or landfilled material will be conveyed to storage bins for easy removal by a contractor. This is done to reduce the labor required for material handling.

Each of the facilities will operate two shifts with maintenance being performed on the third shift. The glass plant modules for the 500 and 1000 TPD facilities will require approximately 5000 and 10,000 sq. ft. of building space, respectively.

Much information has been gained from the operation of the Franklin Glass Plant regarding the processing of material to achieve a better quality product. This information will be used extensively in the design of the larger glass plants.

The recovered aluminum at Franklin has too high a contaminant level to be of much commercial interest. It was determined that by drying the aluminum rich fraction from the jigging operation and running the material through an electrostatic separator, a higher quality aluminum product could be achieved. Hence, new facilities should incorporate an additional dryer and electrostatic separator for the aluminum recovery operation.

Recent changes, made after our evaluation, have included new optics in the color sorters to allow color sorting of smaller glass particles. The glass sorters during the evaluation required particles to be ¼ in. The new optics will permit sorting of particles down to 1/8 in. This modification will increase the glass yield; however, no yield estimate can be made until performance tests are conducted. The revenues from glass in this analysis were based upon a 50 percent yield (a 4 percent improvement), although Black-Claeson anticipates even higher yields.

The cost estimates presented for the 500 and 1000 TPD plants do not reflect the cost of land. This value varies considerably and, hence, was not considered in this analysis. All labor rates and other schedules for determining the total category costs are presented in the notes for each projected facility cost.

6.3.5.2 Estimated Economics For 500 TPD Franklin Glass Plant

Table 6.7 summarizes the estimated costs for the operation of a 500 TPD Franklin Glass Plant.

Income from the sale of recovered material amounts to \$2.93/T (Tipping Floor). Operating expenses are 2.19/T and the facility expense is \$1.70/T. Hence, the net loss from the operation is \$.96/T). An analysis for the recovery of magnetics and aluminum only also show a non-profitable operation.

6.3.5.3 Estimated Economics For 1000 TPD Franklin Glass Plant

Table 6.8 summarizes an estimated cost summary for the operation of a upgraded 1000 TPD Franklin Glass Plant.

TABLE 6.7 MONTHLY FRANKLIN GLASS PLANT COSTS PROJECTED TO 500 TPD

INCOME			
Magnetic Sales	$ 269.00	$ .025/T	Based on Sale Value of $25.00/T
Aluminum Sales	20,962.00	1.95/T	Based on Sale Value of $300.00/T[1]
Glass Sales			
Flint	6,450.00	.60/T	Based on Sale Value of $20.00/T
Amber	2,365.00	.22/T	Based on Sale Value of $20.00/T
Green	1,397.00	.13/T	Based on Sale Value of $20.00/T[2]
	$31,443.00	$2.93/T	
OPERATING EXPENSES			
1. Operating Labor			
Supervision	$ 903.00	$ .08/T	Based on $10.50/hr. Including Fringes
Chief Operator	1,634.00	.15/T	Based on $9.50/hr. Including Fringes
Assistant Operator	2,924.00	.27/T	Based on $8.50/hr. Including Fringes
General Labor	4,816.00	.45/T	Based on $7.00/hr. Including Fringes
Office	1,032.00	.10/T	Based on $6.00/hr. Including Fringes
2. Maintenance Labor	2,322.00	.22/T	Based on $9.00/hr. Including Fringes
3. Operating Supplies	322.00	.03/T	
4. Maintenance Supplies	4,633.00	.43/T	Based on 5% Installed Equipment Cost
5. Utilities - Power	1,290.00	.12/T	Based on Usage 120 Kwh/hr. operating @ 2.5¢/Kwh
- Fuel Oil -			
Heating	387.00	.04/T	Based on Usage of .09 gal./T @ $.40/gal.
Kilns	1,612.00	.15/T	Based on Estimated Operating Cost of $.15/T
6. Other Expenses	1,612.00	.15/T	
	$23,487.00	$2.19/T	
FACILITY EXPENSE			
Project Costs	$1,442,000.00	$134./T	
Total Bond Issue	$1,874,000.00	$174./T	
Monthly A & I[3]	$ 18,241.00	$1.70/T	
COST SUMMARY			
Income	$31,443.00	$2.93/T	
Expenses	23,487.00	2.19/T	
Facility Expense	18,241.00	1.70/T	
NET COSTS	($10,285.00)	($ .96/T)	

NOTES
1. Based on Contracts with Alcoa and Reynolds for Aluminum from Hempstead Plant (FOB Plant).
2. Based on Contract with Glass Container Corporation for Glass from Hempstead (FOB Plant).
3. Based on Capital Recovery Factor of .11683 (15 yrs. at 8%).

TABLE 6.8 MONTHLY FRANKLIN GLASS PLANT COSTS PROJECTED TO 1000 TPD

INCOME			
Magnetic Sales	$ 537.00	$ .025/T	Based on Sale Value of $25.00/T
Aluminum Sales	41,925.00	1.95/T	Based on Sale Value of $300.00/T[1]
Glass Sales			
Flint	12,900.00	.60/T	Based on Sale Value of $20.00/T
Amber	4,730.00	.22/T	Based on Sale Value of $20.00/T
Green	2,795.00	.13/T	Based on Sale Value of $20.00/T[2]
	$62,887.00	$2.93/T	
OPERATING EXPENSES			
1. Operating Labor			
Supervision	$ 860.00	$ .04/T	Based on $10.50/hr. Including Fringes
Chief Operator	1,505.00	.07/T	Based on $9.50/hr. Including Fringes
Assistant Operator	3,010.00	.14/T	Based on $8.50/hr. Including Fringes
General Labor	4,730.00	.22/T	Based on $7.00/hr. Including Fringes
Office	1,075.00	.05/T	Based on $6.00/hr. Including Fringes
2. Maintenance Labor	3,010.00	.14/T	Based on $9.00/hr. Including Fringes
3. Operating Supplies	645.00	.03/T	
4. Maintenance Supplies	8,050.00	.37/T	Based on 5% Installed Equipment Cost
5. Utilities - Power	1,720.00	.08/T	Based on Usage 160 Kwh/hr. operating @ 2.5¢/Kwh
- Fuel Oil -			
Heating	860.00	.04/T	Based on Usage of .09/gal/T @ $.40/gal.
Kilns	3,225.00	.15/T	Based on Estimated Operating Cost of $.50
6. Other Expenses	3,225.00	.15/T	
	$31,915.00	$1.48/T	
FACILITY EXPENSE			
Project Costs	$2,531,000.00	$118./T	
Total Bond Issue	$3,290,000.00	$153./T	
Monthly A & I[3]	$ 32,000.00	$ 1.49/T	
COST SUMMARY			
Income	$61,887.00	$2.93/T	
Expenses	31,915.00	1.48/T	
Facility Expense	32,000.00	1.49/T	
NET COSTS	($1,028.00)	($ .04/T)	

NOTES
1. Based on Contracts with Alcoa and Reynolds for Aluminum from Hempstead Plant (FOB Plant).
2. Based on Contract with Glass Container Corporation for Glass from Hempstead (FOB Plant).
3. Based on Capital Recovery Fact of .11683 (15 yrs. @ 8%).

Income from recovered materials are the same as in the 500 TPD case and amount to \$2.93 (Tipping Floor). Operating expenses are lower, however, due to no increase in labor and amount to \$1.48/T. The facility expense also falls on a per ton basis to \$1.49/T. Hence, the net loss from operation of the plant is (\$.04/T).

The recovery of aluminum accounts for 67 percent of the total revenue. By installing only the equipment necessary to recovery the magnetics and aluminum, it can be shown that an aluminum recovery plant servicing a 1000 TPD facility can yield a pre tax profit of \$.44/T. Hence, it appears that magnetic and aluminum recovery would be more attractive than adding glass recovery.

6.4 COST SUMMARY OF FRANKLIN SOLID WASTE FACILITY

Table 6.9 presents an economic summary of the operation of a Franklin Solid Waste Plant projected to 500 and 1000 TPD. The facility costs have been adjusted to reflect early 1976 prices. This summary sheet is presented to show the complete operation of a Franklin type facility. The summary is presented for a plant that does not recover fiber but rather it sells the rejects as a fuel. The projection includes the recovery of magnetics, glass, and aluminum. This assessment

TABLE 6.9 ECONOMIC SUMMARY OF PROJECTED FRANKLIN PLANT WITH NO FIBER RECOVERY, WITH GLASS PLANT, AND SELLING REJECTS AS A FUEL

COSTS	FRANKLIN PROJECTED TO 500 TPD		FRANKLIN PROJECTED TO 1000 TPD	
INCOME*				
Pulping And Separation				
Magnetic Metals	$ 2.40/T		$ 2.40/T	
Sludge Disposal	1.75/T		1.75/T	
Fuel	10.71/T		10.71/T	
Glass Plant				
Magnetics	.02/T		.02/T	
Aluminum	1.95/T		1.95/T	
Glass	.95/T		.95/T	
Total Income		$17.78/T		$17.78/T
OPERATING EXPENSES				
Pulping And Separation	$ 6.04/T		$ 5.50/T	
Glass Plant	2.19/T		1.48/T	
	$ 8.23/T		$ 6.98/T	
FACILITY EXPENSE**				
Pulping And Separation	$ 6.57/T		$ 6.12/T	
Glass Plant	1.70/T		1.49/T	
	$ 8.27/T		$ 7.61/T	
Total Expenses		$16.50/T		$14.59/T
NET SAVINGS		$ 1.28/T		$ 3.19/T

*Based On Following Revenue Factors
Magnetic Metals - $25.00/T
Sludge Disposal At A Rate Of .07/T Input - $25.00/T
Fuel - $1.25/MBtu
Aluminum - $300.00/T
Glass - Flint, Amber And Green - Each At $20.00/T

**Based On Following Facility Costs Projected To 1976 Prices.

	500 TPD	1000 TPD
Weighing & Receiving, Pulping, Separation And Dewatering	$6,524,000	$12,145,000
Glass Plant	1,442,000	2,531,000
TOTAL PLANT COST	$7,966,000	$14,676,000

is presented because the glass plant cannot exist without some front-end system preparing the feed to the glass plant. The economic data for the front-end system was taken from the data reported and collected in Wittmann, et al.[8]

The net savings for this type of operation is $1.28/T for a 500 TPD plant and $3.19/T for a 1000 TPD plant. The use of the fiber as a fuel is necessary for a facility of this type to be financially sound. Sixty percent (60 percent) of the income is derived from the sale of the fuel product.

The data presented in Table 6.9 includes no tipping fee, hence, the net operating costs can be compared directly to existing disposal costs with the following exception. It should be noted that for these examples, no charge is made for the land on which the facility is to be established. Individual communities may readily approximate the cost of land locally and add the appropriate amortized capital cost of the land to the facility expense charge to obtain a specific projection for their community.

6.5 ECONOMIC OBSERVATIONS

Industry and municipalities use different techniques to assess the merits of an investment. What may not be attractive to industry could be attractive to a municipality.

[8]Wittmann, et al, ibid.

The following discussion presents an appraisal concept used by industry to determine the merits of a potential investment. This approach was used because it is our opinion that most municipalities are looking for turn-key operation of an energy/resource recovery system with industries providing the capital to protect municipal bonding limits.

One of the techniques used by industry to determine the merit of an investment is to use a term called Annual Return On Investment (AROI). This term, depending upon the industry, can be defined in many different ways. For purposes of our discussion here, AROI will be defined as follows:

$$\text{AROI} = \frac{\text{Gross Profit (Year)}}{\text{Total Investment}}$$

Analyzing a complete Franklin type facility projected to 500 and 1000 TPD with a glass plant and the sale of the fiber as a fuel (RDF), the following table was derived.

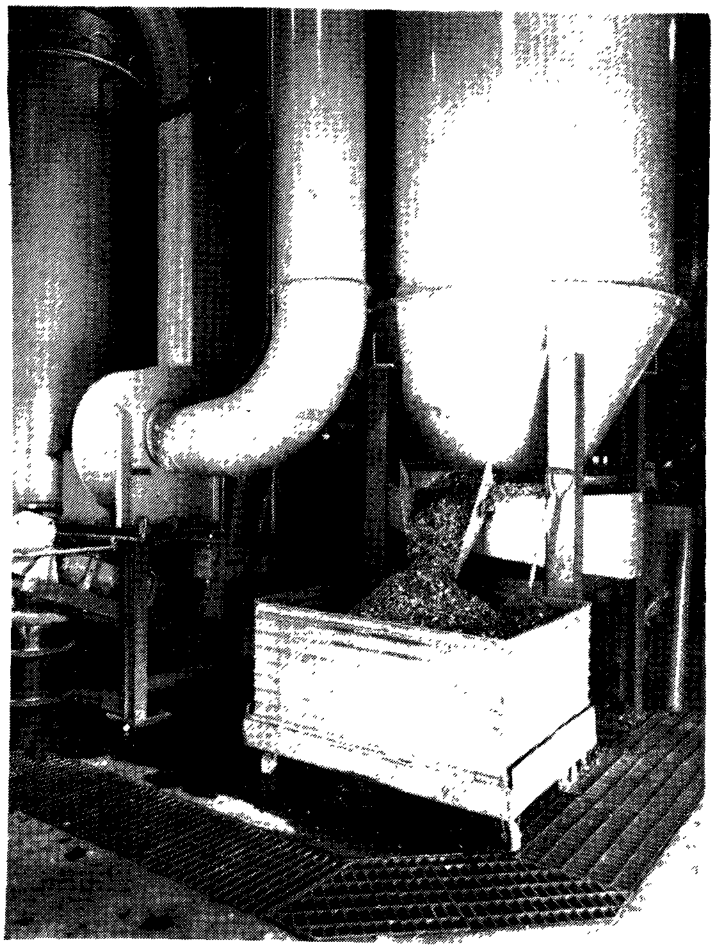
	TIPPING FEE	GROSS SAVINGS	TOTAL INVESTMENT	BEFORE TAX AROI
500 TPD	0.0	$165,000	$ 7,966,000	2.1%
1000 TPD	0.0	$823,000	$14,676,000	5.6%

As indicated, an AROI for the 1000 TPD plant size is only 5.6% before tax, a very unacceptable AROI for industry. It should be remembered that the data is based on net savings which does not include a tipping fee. As an illustration, if a $10.00 tipping fee were included in the above analysis, a before tax AROI of 23% is realized. The AROI now approaches a level where industry would become interested if the risks are small.

APPENDIX A

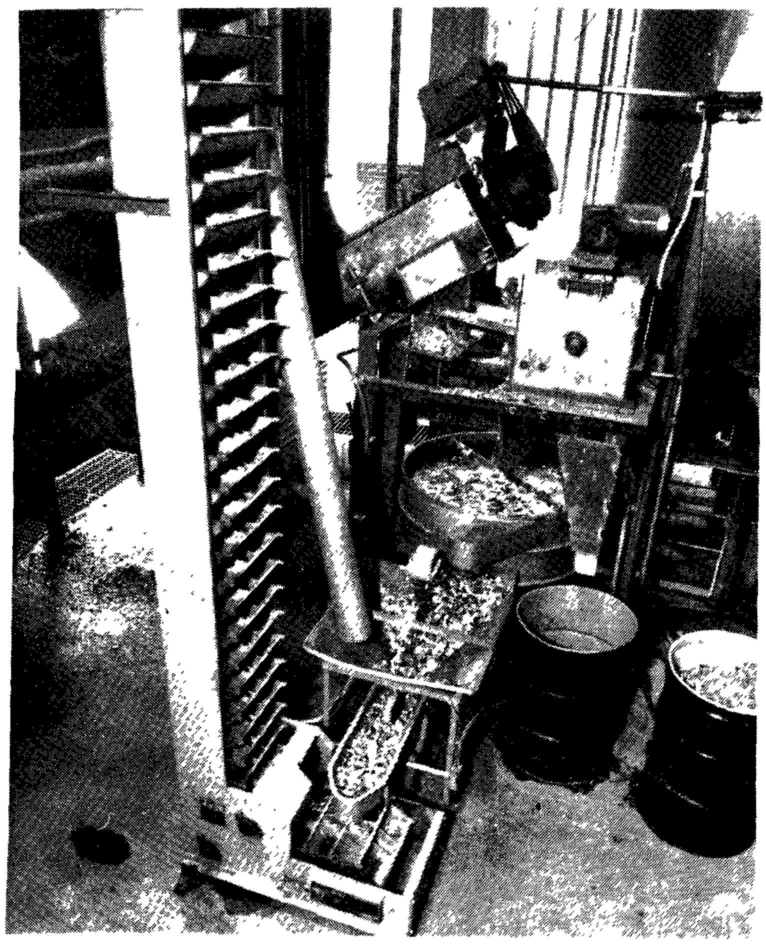
PICTORIAL FLOW DIAGRAMS

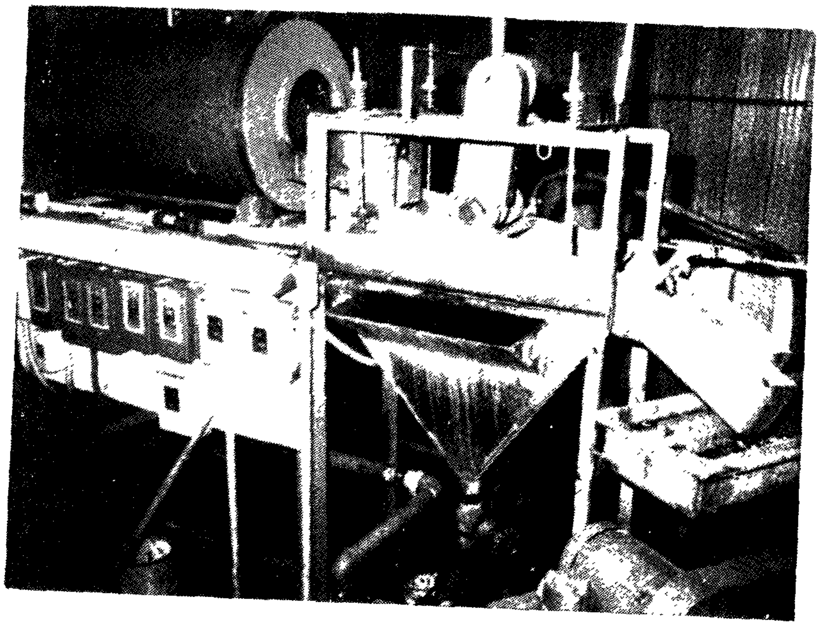
This section presents a pictorial flow diagram with which the reader can visualize the various equipments used in the Franklin Glass Plant. Section 3, Operational Capability describes the process flow and can be used to supplement this pictorial presentation.



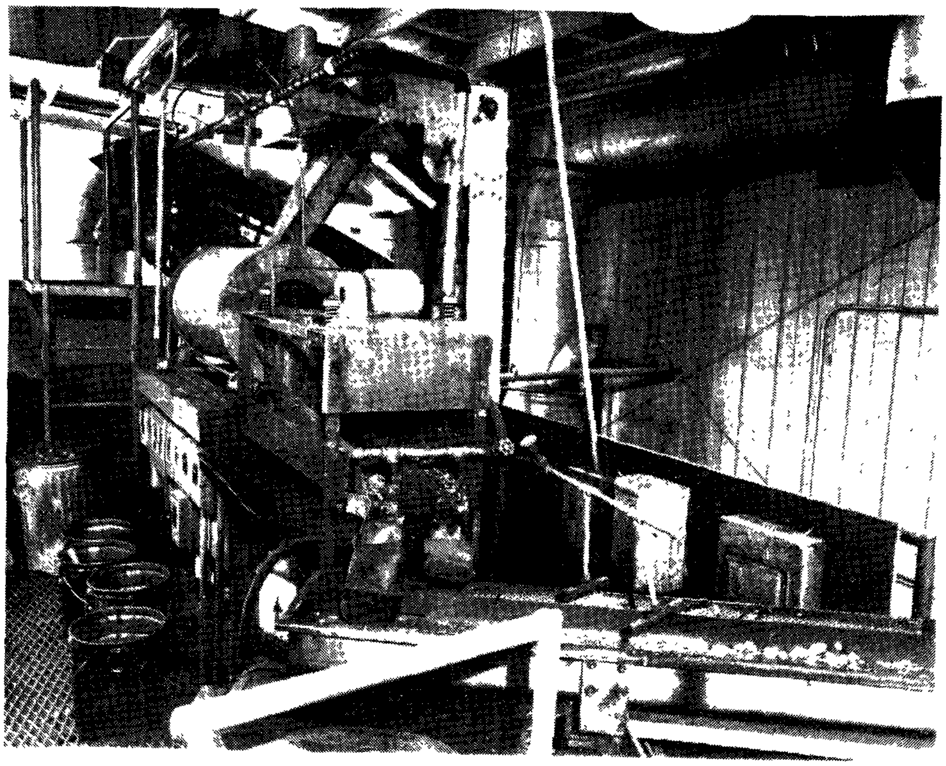
(1) Storage Vessel For Feed To Glass Plant

(2) Rotary Screen, Metering Hopper, And Bucket Elevator





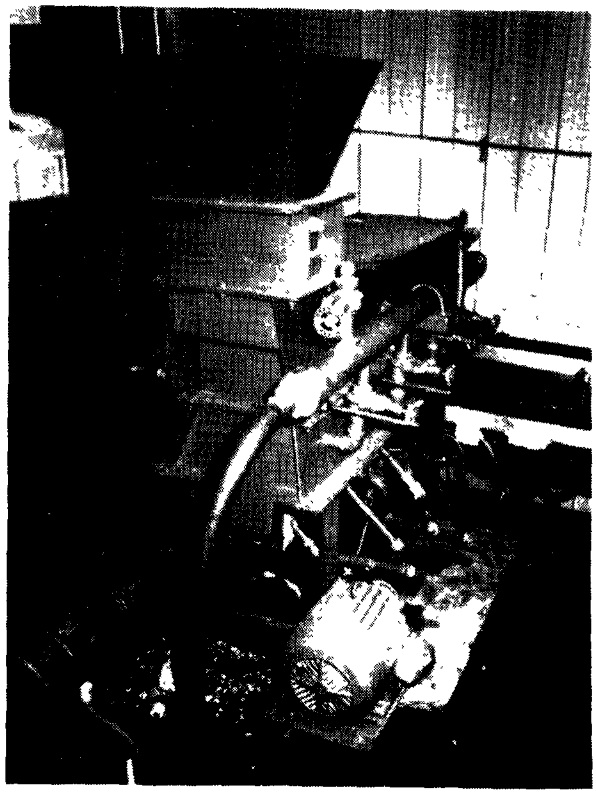
(3) Side View Of Heavy Media Separator

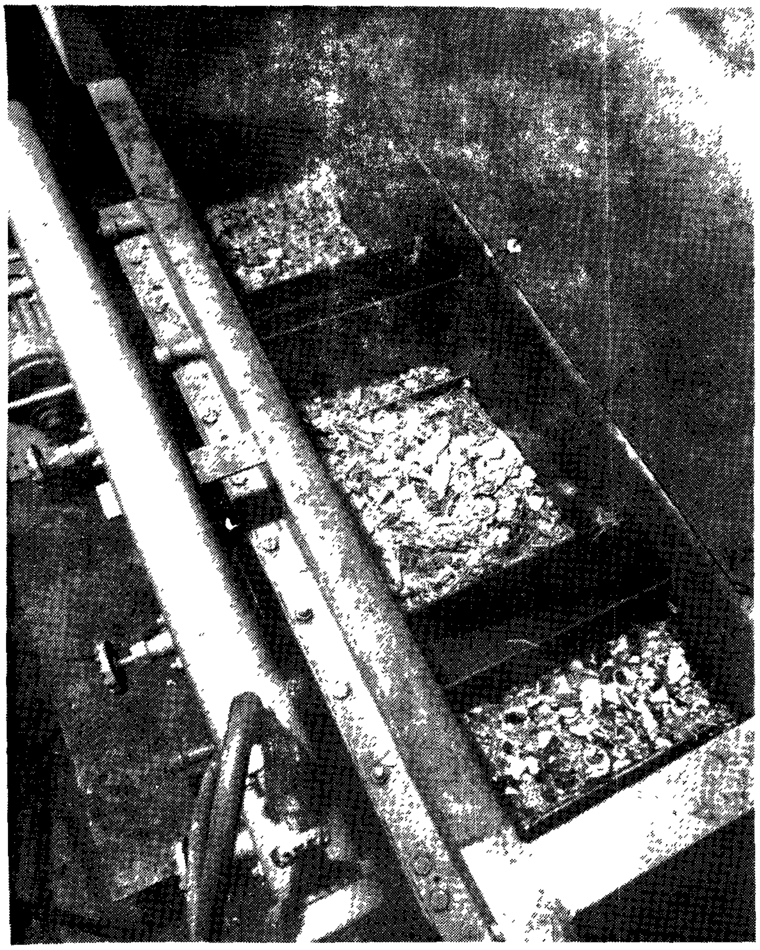


(4) End View Of Heavy Media Separator

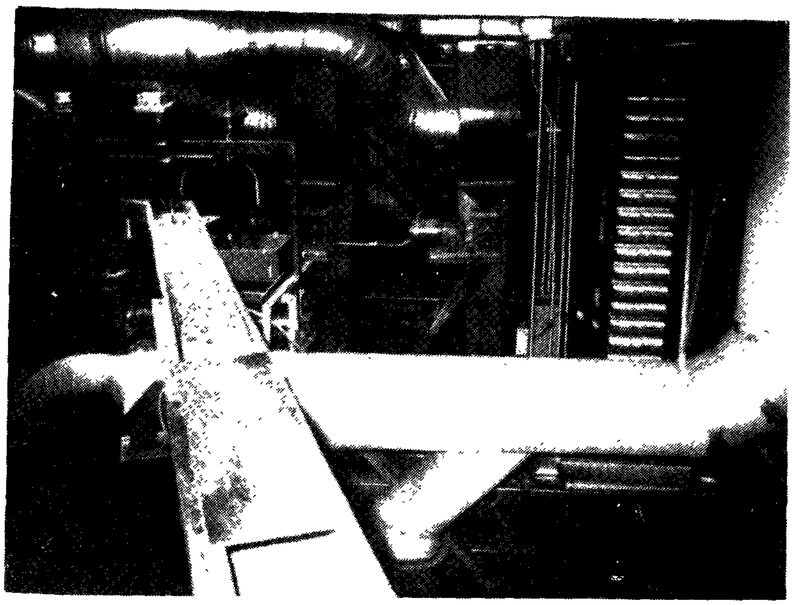
(5) Vibrating Conveyor From Heavy Media Separator To Jig

(6) Aluminum Recovery Jig

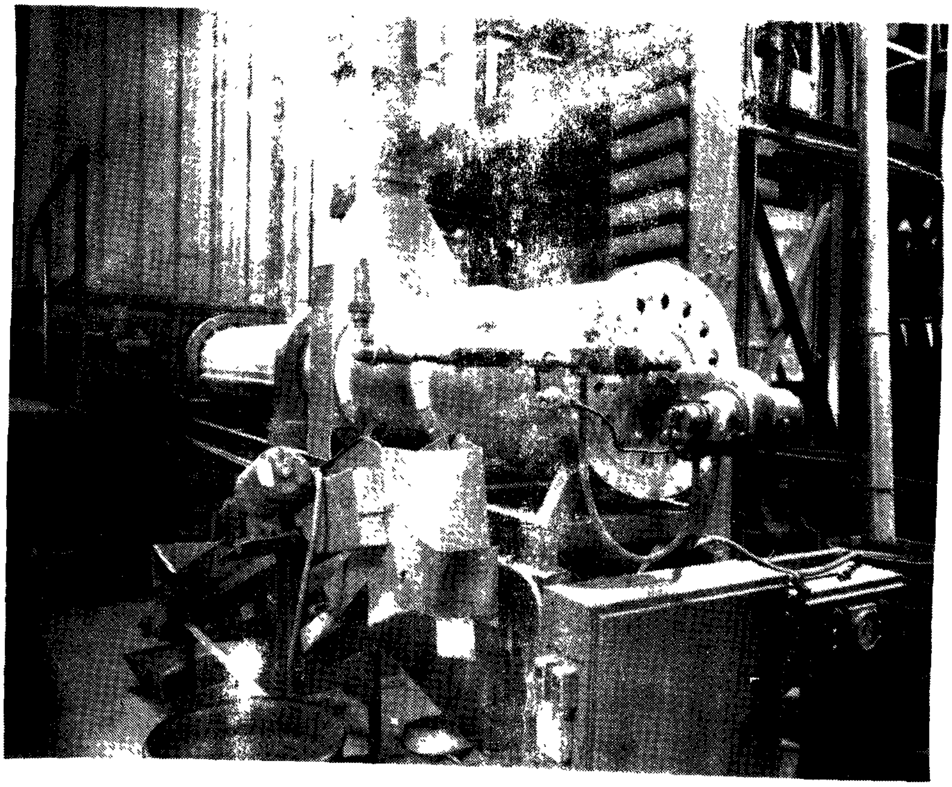




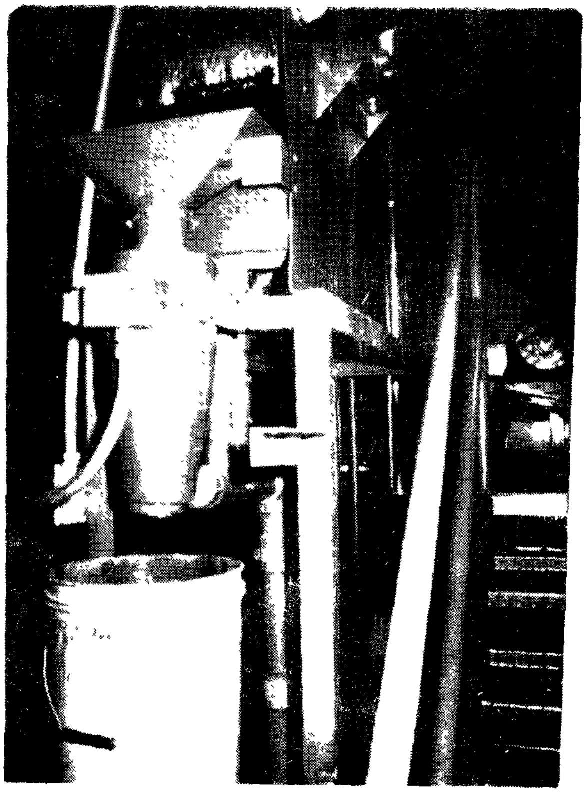
Close-up Of Jig Separator



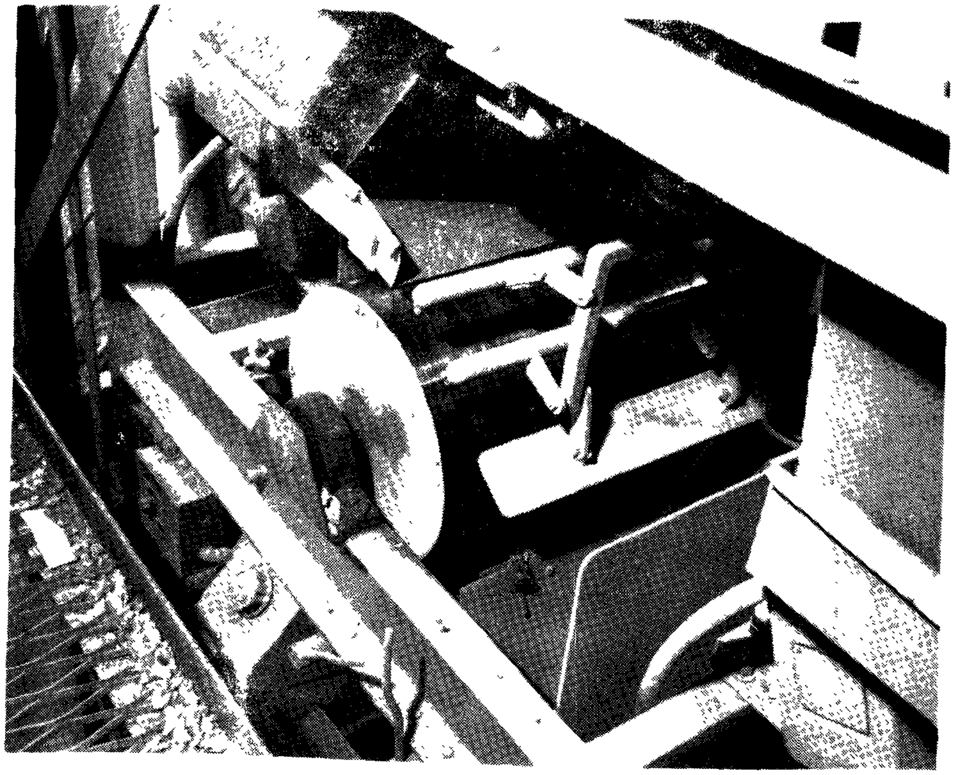
(8) Dewatering Conveyor (Electrostatic Separators Shown In Background)



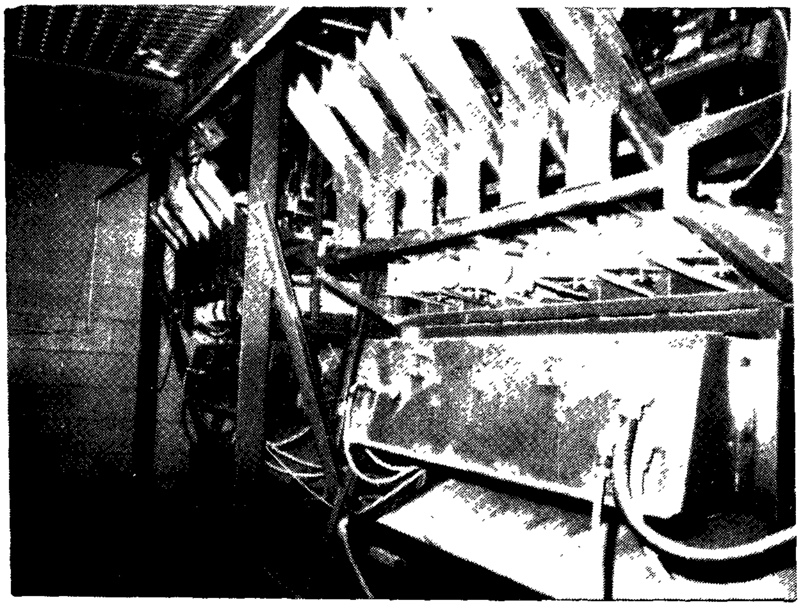
[illegible] D[illegible] D[illegible]



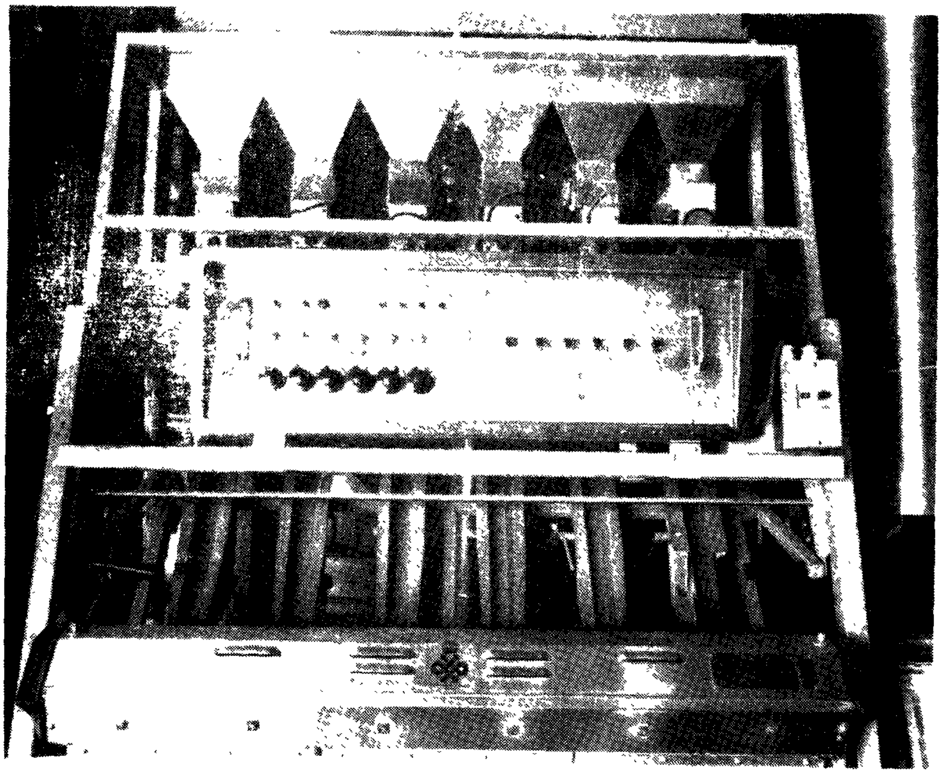
(10) Out[illegible]ors



(11) Close-up Of Electrostatic Separator



(12) Close-up Of Optical Sorters



(13) Front View Of Optical Sorter

APPENDIX B

GLASS PROCESSING INDUSTRY SPECIFICATIONS FOR GLASS CULLET*

Parameter	Original GPI Specification	Revised GPI Specification (11-9-76)
Liquid Content	10%	Do Drainage
Organic Materials	0.1%	0.2%
Magnetic Metals	0.05%	0.05%
Non-Magnetic Inorganics	0.1%	0.1%
Non-Magnetic Metals	0.015%	No Particles +¼ in. 1 (one) -¼ in +20 Mesh/ 40 lb.
Flint Glass	Min. 95%	Min. 90%
Colored Glass	Max. 5%	Max. 5.0% Amber Max. 1.0% Green Max. 0.5% Other
Refractory		
+20 Mesh	No Specification	1 Particle/40 lbs. (no Particle +¼ in.
-20 +40 Mesh	2 Particles/lb.	2 Particles/lb.
-40 +60 Mesh	20 Particles/lb.	20 Particles/lb.

NOTES

1. Flint glass containing over 0.1% Fe_2O_3 and/or 0.002% Cr_2O_3, by chemical analysis, shall be considered mixed color glass.

2. Flint glass can contain up to 1% emerald green or 10% georgia green, or a combination within these limits (1% georgia green = 0.1% emerald green).

*REFERENCE: Glass and Aluminum Recovery Demonstration Plant Subsystem for the City of Franklin, Ohio, Report by Dr. John P. Cummings, Owens-Illinois, Glass Container Division, Toledo, Ohio. Extensive cullet analysis was performed by Dr. Cummings and it is recommended that if further information is desired about the composition of the glass cullet produced at Franklin, a copy of the above referenced report be obtained.