magnetic separation:

recovery of saleable iron and steel from municipal waste

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MAGNETIC SEPARATION:

Recovery of Salable Iron and Steel

from Municipal Solid Waste

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U.S. ENVIRONMENTAL PROTECTION AGENCY

1977

MAGNETIC SEPARATION:

Recovery of Salable Iron and Steel from Municipal Solid Waste

This pamphlet is an introduction to the technology, economics and objectives of magnetic separation. It should serve as a preliminary planning and decision guide for a municipality considering the addition of the magnetic separation process to its present solid waste management system.

Magnetic separation of municipal solid waste (MSW) is perhaps the simplest of the unit processes for recovering materials. The process is used routinely in other industries, such as minerals beneficiation of iron ores. Also, the scrap industry uses magnetic separation to produce clean iron and steel metal scrap. Magnetic separators are used with the more than 100 automobile shredders throughout the country and more recently have been installed at municipal solid waste shredding installations (1). Manufacturers of magnetic separators are listed in Appendix A.

Generally, municipal solid waste must first be shredded to produce a salable magnetic fraction. In some processing schemes, the shredded waste is air classified. If magnetic separation follows air classification, a cleaner and hence higher quality iron and steel can be recovered. If shredding equipment is already installed, it is relatively simple and inexpensive to add magnetic separation.

What Is Magnetic Separation?

Magnetic separation utilizes the magnetic properties of iron and steel which allow them to be removed from the refuse stream with a simple magnet. Proper installation of a magnetic separator in an MSW shredding or shredding and air classification plant permits the valuable iron and steel fraction to be recovered as salable products. The revenue from these materials will help offset the cost of solid waste disposal (2,3).

The two major types of magnetic separators used for recovering iron and steel from MSW are the drum magnet and the overhead belt magnet. Both types of separators, the drum and belt, are available either as permanent type magnets or as electromagnets.

In a typical drum magnetic separator, Figure 1, the drum revolves past the stationary magnet causing non-magnetic materials to drop off and pulling the magnetic metals from the waste stream. Another method of feeding material to a drum separator is to suspend the drum over a conveyor head pulley or over the end of an oscillating conveyor.

The overhead belt separator, Figure 2, is usually installed parallel to and suspended over a conveyor carrying shredded MSW. As shown in Figure 2, a belt moves past a stationary magnet; the metals recovered by this method are not always sufficiently clean to meet market specifications. This experience led to the development of an improved type of in-line belt separator, Figure 3, which utilizes several magnets, arranged with alternating polarities. The magnetic metals are pulled from the MSW and tumbled several times while changing polarity and following the curve or bend in configuration. The reverse magnetic fields allow the separated metals to be tumbled causing contaminants to drop and resulting in the recovery of cleaner metals (4).

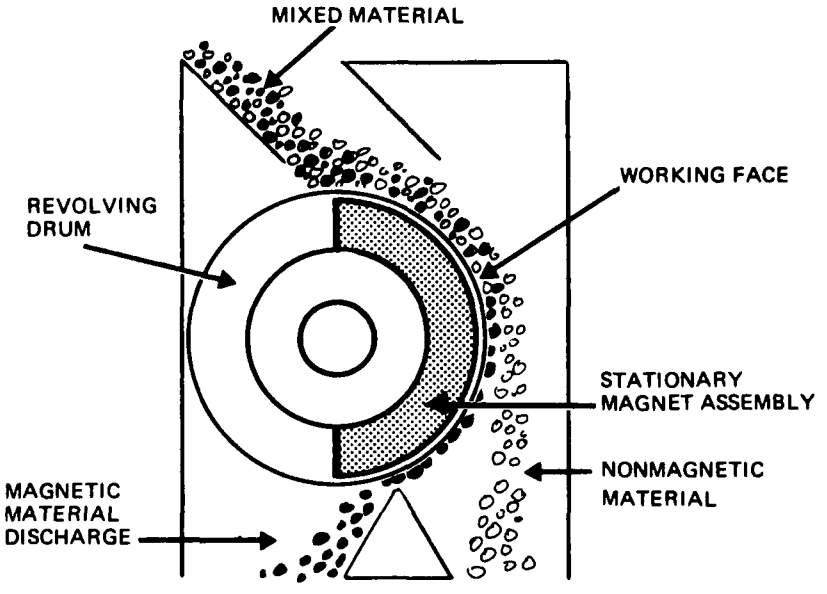
The magnetic separator in Figure 3 cleans the recovered metal by using the series of magnets to pick up, drop and pick up the material again. A similar cleaning can be achieved using drum separators. As an example, Figure 4 shows a possible arrangement of two drum separators. The first pulls the magnetic metals from the solid waste while the second drum picks up the metals a second time, allowing contaminants to drop off (5,6).

Magnetic separation devices of the capacity of 10 to 100 tons per hour of shredded MSW can be designed. The particle size of the shredded MSW is not critical. Generally, shredding must precede magnetic separation if clean and salable metal is to be obtained. If air classification - to separate the "light" paper and plastics from the "heavy" metals, stones and wood - is used in the total recovery system, the recovered metal is likely to be cleaner and of higher value. (This is so only when the air classification precedes the magnetic separation.)

Why Install a Magnetic Separator?

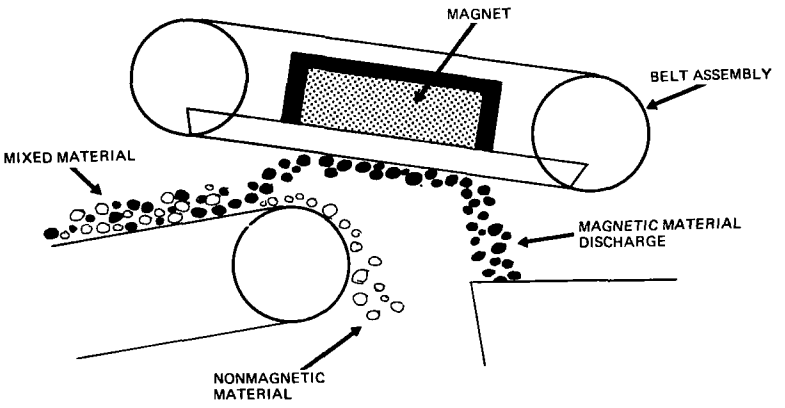
If a municipality has a shredder or is planning the installation of one, a magnetic separation system properly installed and operated can produce a salable product from the solid waste stream and offset a portion of the disposal cost (7). Such a system must include support structures, conveyors and associated materials handling equipment (8).

FIGURE 1



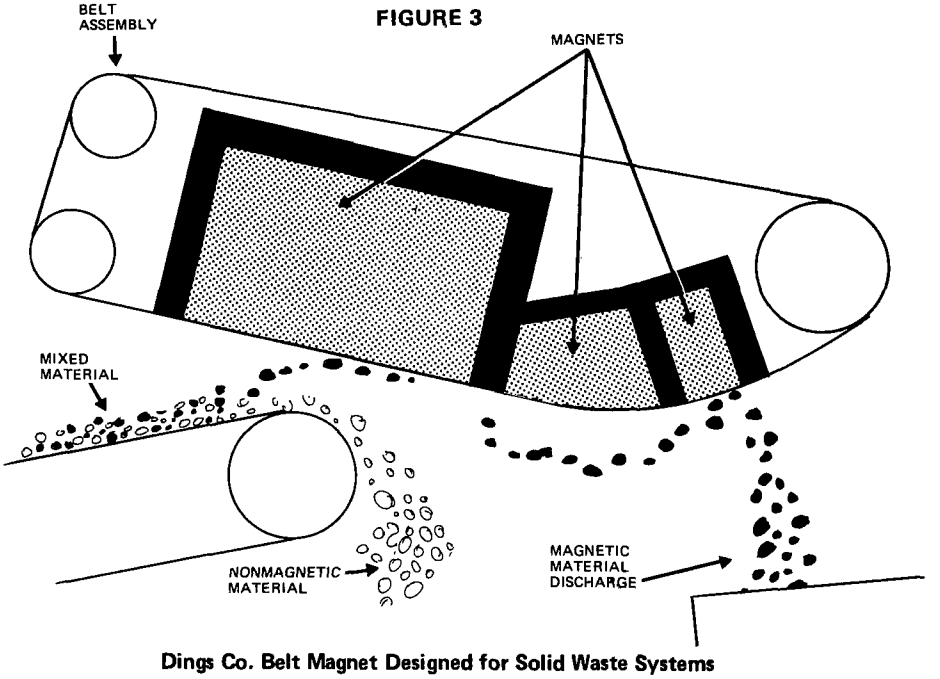
Magnetic Drum Separator

FIGURE 2



Overhead Belt Separator

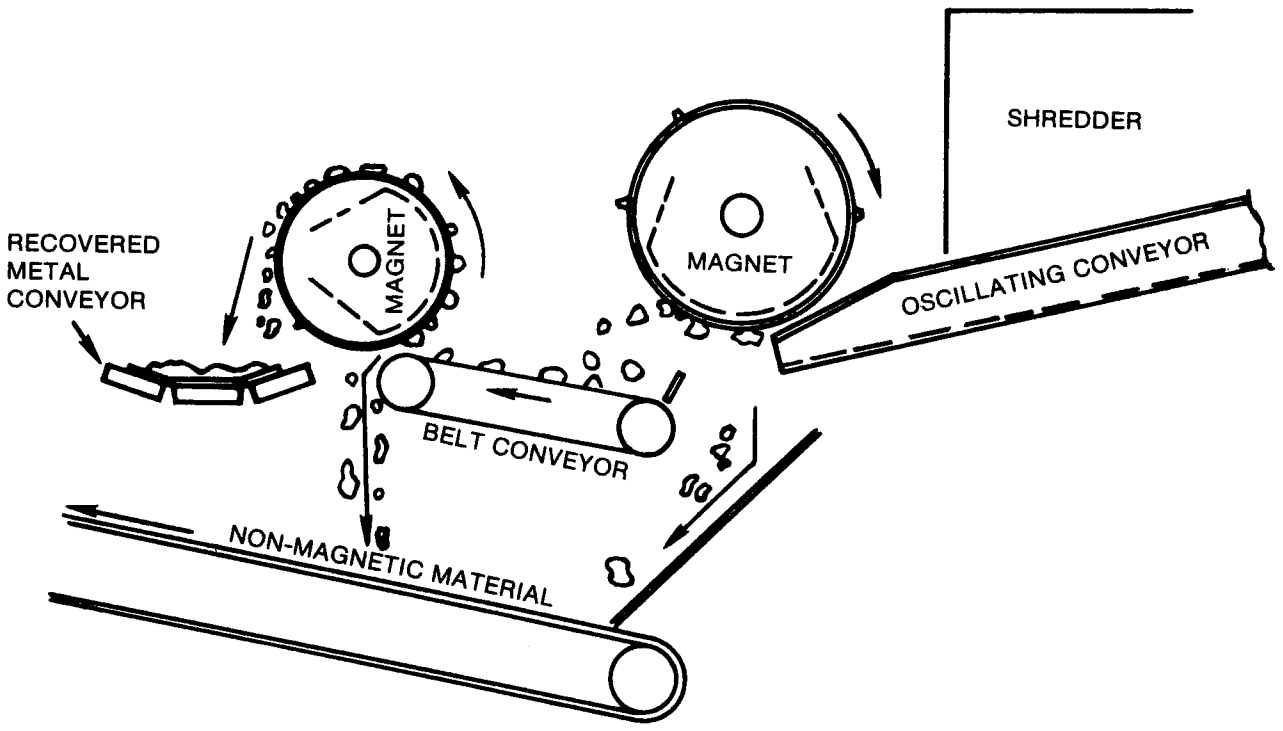
FIGURE 3



Dings Co. Belt Magnet Designed for Solid Waste Systems

Figure 4

DUAL DRUM MAGNETIC SEPARATOR



The net revenue received from magnetic metals recovery will vary depending on local circumstances. Market value of the recovered ferrous metals and transportation costs are factors which can change significantly in each case. In addition, the percentage of ferrous metals in the incoming waste and the recovery efficiency of the equipment are important considerations.

Analysis of country-wide MSW samples indicated that the average household portion of municipal solid waste contains between 7 and 8 percent iron and steel, not including discarded appliances and other obsolete household goods. A recovery efficiency of almost 90 percent for magnetic metals is not uncommon, which means that of the waste 6 to 7 percent is recovered as ferrous metals.

The price paid for recovered magnetic metals depends on the quality of the product, the specific buyer and the national trends in scrap markets. Experience over the past few years suggests a price range of $20 to $50 per (long) ton. Recent transactions indicate that magnetic metal scrap recovered to proper specifications will bring prices in the upper end of this range. Also, it may be possible to obtain long term contracts for the purchase of the scrap which reduces the vulnerability to scrap market fluctuations.

Under these conditions, the gross revenues from magnetic metals would amount to $1.07 to $3.12 per input ton of waste. From this revenue, operating and transportation costs must be subtracted. Operating costs are discussed later in this report.

A magnetic separation system requires little operator attention but must receive the same routine maintenance as other industrial equipment. A separation system can be tailored to meet the needs of the user, to match a present or planned shredding system and to produce metal according to the specifications. Market commitments should be obtained before investing in detailed planning and hardware. Specifications for recovered products are important determinants of facility design.

What Is a Shredding and Magnetic Separation System?

A typical system for processing MSW includes a concrete pad, or floor for packer trucks to dump their loads, a pit conveyor which is filled with MSW by a front-end loader, and an inclined conveyor to transport the MSW from the pit conveyor to the shredder. At the discharge end of the shredder, the pulverized MSW is usually dropped onto a

vibrating conveyor and then onto a rubber belt conveyor for transport to further processing. The magnetic separator is usually installed at the head pulley of this belt. The non-magnetic material proceeds to further processing, a transfer compactor, or to disposal.

A solid waste processing system, Figure 5, includes shredding and air classification followed by magnetic separation. The air classifier is shown for illustration and is not absolutely needed for magnetic separation. The heavy fraction from the air classifier which contains metals, glass, stones, and similar heavy items, is magnetically separated. The non-magnetic portion can be further processed for resource recovery or disposed of in a sanitary landfill.

The material conveyed past a magnet for separation must be evenly fed and distributed and this is accomplished by the installation of belt type magnetic separators above a conveyor head pulley.

To meet customers' specifications, magnetic metals may be reshredded, baled or just conveyed to a hopper prior to shipment in a truck or by open rail car (9). A municipality may purchase a magnetic separation system as part of a "turn-key" MSW processing system or have the system designed by a consulting engineer, but it must be designed to meet the particular needs of the magnetic metals market(s).

What Type of System to Install?

After determining the market specifications for the magnetic metals (which may be for loose, baled, densified or other form), more detailed considerations for selecting a unit or for preparing a request for bids should be examined. While a full discussion of these considerations is beyond the scope of this pamphlet, the major points to analyze are listed below:

Magnetic Metals Markets
- de-tinning
- copper precipitation
- steelmaking
- foundry
- local scrap processor

Capacity
- amount to be processed, per day and per shift

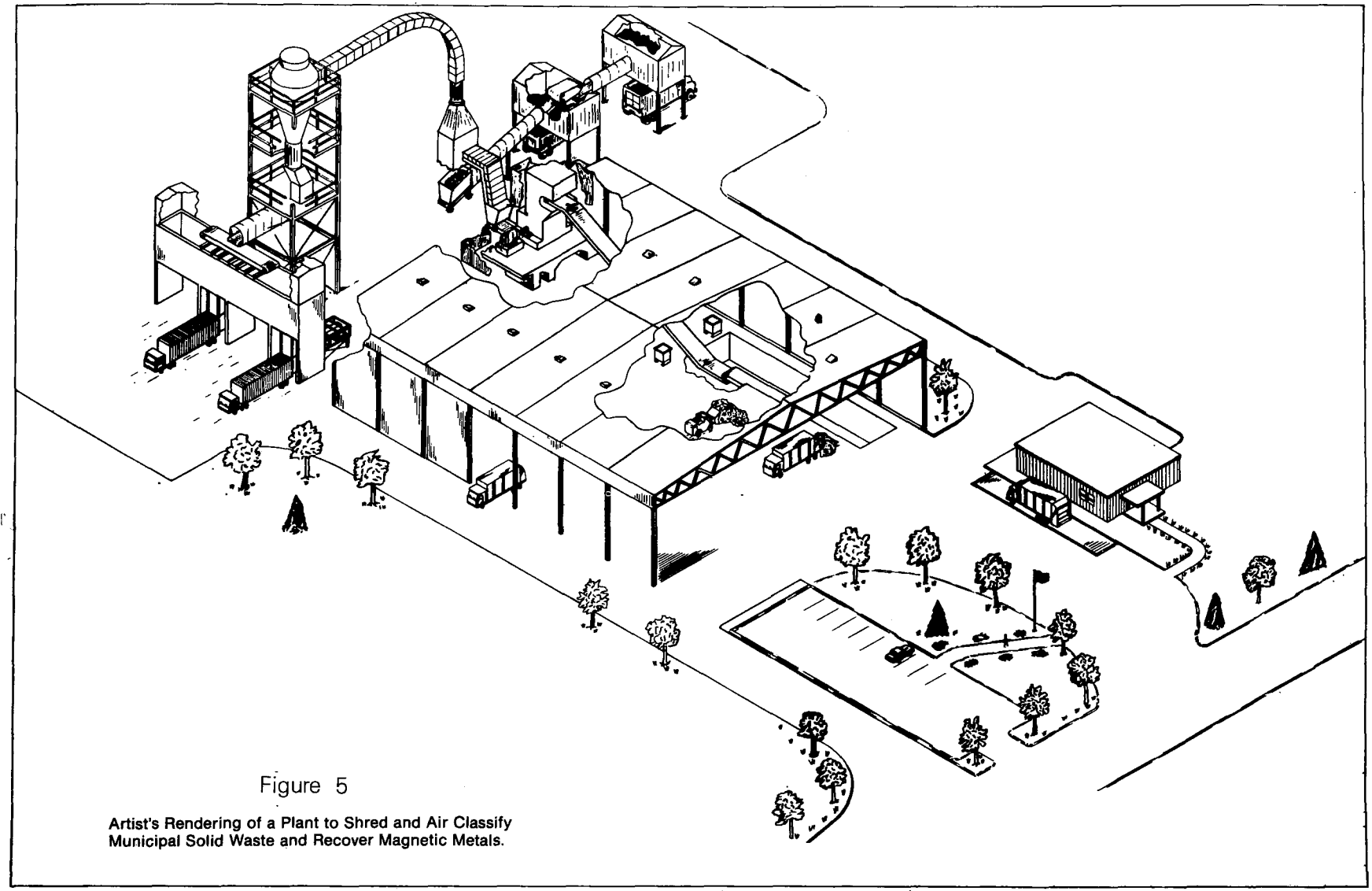


Figure 5

Artist's Rendering of a Plant to Shred and Air Classify Municipal Solid Waste and Recover Magnetic Metals.

Location in System
- after shredding
- after air classification

Type of Magnetic Separator
- belt or drum
- permanent or electro

Redundancy
- single or multiple units
- contingency plan if unit is down

Maintenance
- ease and schedule

Manufacturer's Warranties
- term and coverage

Systems Responsibility
- interfacing of shredder, buildings, materials handling and other system components

Manufacturers claim that the multiple drum installation and the multi-pole belt magnet give similar performance, but the initial cost of the drum installation may be 50 percent more than the belt separator (6). There is also a difference in the maintenance costs of the two separators. Belt life is guaranteed for one year by one manufacturer while drum shell life is guaranteed for three years by another supplier. In the long run, belt separators may cost more to operate than drum separators.

A primary concern of any magnetic separation system operation is the removal of organic contamination from the magnetic metal product. This may present some difficulty depending on the degree of shredding and treatment prior to magnetic separation. Previous experience has shown that blowing air perpendicular to the flow of metals can remove much of the organic material (8).

What Does Magnetic Separation Cost?

The cost of a magnetic separator with all motors, electrical controls and conveyors is approximately $100,000 for a 50 ton per hour (TPH) system. This includes supports and a hopper to receive and store the magnetic metals.

The actual installed cost of a complete system is difficult to estimate without knowledge of the specifications for the

recovered metal and site-specific requirements. In the fourth quarter of 1974, a conservative cost estimate, excluding the cost of land and the air classifier, was made of the system illustrated in Figure 5. The system, designed to process 50 TPH of MSW, with covered storage capacity for 500 tons of MSW, was estimated to cost $2,412,000 using a price of $105,000 for all components of the magnetic separation system. Table 1 details the estimated cost.

Table 2 estimates the operating cost of the facility. The installation was designed for 50 TPH, operating 12 hours of a two-shift, 16-hour work day. It was assumed that the shredder output particle size would be four inches, or less. If a different particle size must be produced, maintenance and operation costs would change. On the basis of design criteria, the total number of employees was placed as 22, which did not include operators for any associated landfill. Fringe benefits were calculated at 25 percent of direct salary. Supplies included housekeeping and office supplies, lubricants and gasoline. Services and maintenance included major repairs performed by outside contractors, welding rod for the shredder hammers, replacement parts, and associated equipment. Power cost was based on the total installed horsepower, anticipated use factor and a cost of three cents per kilowatt-hour. The costs of actual operation amounted to $3.51 per ton of MSW fed to the plant on a yearly basis.

Debt service (amortization and interest) was computed as total debt financing (e.g., municipal bond financing). The life of the equipment was assumed to be 10 years. Although the buildings might have a longer life, for simplification no breakout of this was made, and the entire facility was amortized over the 10 year period. The interest is included in the calculation. The cost of land and its associated debt service are not included in the capital cost estimate in Table 1. Table 2 indicates the total anticipated plant operating costs to be $5.52 per input ton. This figure may be compared to a cost of $4.91 per input ton for only shredding in a facility identically designed but without magnetic separation.

Appendix B is a calculation of a reasonable revenue from metal recovery of $2.21 per input ton. Deducting this figure from anticipated operating costs of $5.52 per input ton results in a net cost of $3.31 for processing each input ton.

TABLE 1

Sample Capital Cost Estimate of a
Shredding and Magnetic
Separation System
(4th quarter 1974)

50 TPH Design Capacity System

System Direct Costs

Equipment

Truck Scale	$ 65,000
Front End Loader (2)	120,000
Feed Conveyor System	200,000
Shredder	350,000
Discharge Conveyor System	80,000
Magnetic Separation System	60,000
Magnetic Metals Discharge Conveyor and Hopper	45,000
Dual Push Pit	75,000
Transfer Packers (2)	30,000
Transfer Tractors & Trailers (3)	150,000
Magnetic Metals Trucks (2)	50,000
Total Equipment Costs	$1,225,000

Building Installation

Land	$ *
Site Preparation	110,000
Receiving Building	150,000
Shredding Building	50,000
Water & Sewage Systems	25,000
Electrical Distribution System	130,000
Shop Tools & Equipment	10,000
Office Furniture & Fixtures	10,000
Total Building Installation	485,000
Total Direct Costs	$1,710,000

*Not included
Source: Reference 10

TABLE 1—Continued

System-Indirect Costs

Contractor's Overhead	$ 338,000
Contractor's Profit (5%)	85,000
Engineering (6.5%)	110,000
Contingency	169,000
Total Indirect Costs	$ 702,000
Total Direct Costs	$1,710,000
Total Indirect Costs	$ 702,000
Grand Total	$2,412,000

Table 2

Anticipated Annual Operating Costs
(4th quarter 1974)

Labor (Including Fringe Benefits)	$294,000
Supplies	40,000
Services and Maintenance	120,000
Power	178,000
	$632,000
Amortization or Depreciation (10 Yr. Str. Line)	241,000
Interest (10%, 5th Year)	120,000
Total Operating Costs	$993,000

Which is equivalent to $5.52 per input ton based on processing 180,000 tons of MSW per year.

Source: Reference 10

How Does the Cost of Shredding and Magnetic Separation Compare With Current Costs?

Capital and operating costs of adding shredding and magnetic separation, or magnetic separation only, to a solid waste management system may be determined and compared to current or projected costs if all costs are calculated on the same basis. The installed cost of the new system should be estimated using the entries in Table 1. Then, the costs of an existing solid waste disposal system and the projected costs of shredding and magnetic separation must be calculated and compared item by item. The anticipated annual operating costs estimate in Table 2 may be used as a guide. Appendix C is a worksheet for making this item by item calculation. In all likelihood, present or projected costs have not been calculated or estimated for all of the entries in Appendix C. If this has not been done, current costs cannot be used as a planning guide and must be recalculated using tne worksheets provided. The worksheets allow direct comparison of shredding and magnetic separation to current (or projected) costs on a per ton basis.

Credits to the new system include savings from possibly using less landfill space, cover dirt, landfill equipment and revenue from the sale of the recovered magnetic metals.

What Is the Next Step?

The municipal manager is urged to use the discussion presented here and the sample calculations made on the worksheets in Appendix C to determine if shredding and magnetic separation should be considered further. Potential purchasers of the magnetic metals in the local area should be contacted. These may include steel companies, foundries, de-tinners, and scrap processors. If discussions and projections for sale and use of the recoverable magnetic metals are encouraging, the next step is to contact shredder and magnetic separation suppliers or a reputable consulting firm with solid waste processing experience for detailed planning of the recovery and disposal system.

The municipal manager is also urged to obtain market commitments for the recovered metal in advance of investing in detailed planning or hardware. Part of the commitment will be a specification for the recovered metal (9). This specification will help determine the design of the recovery facility. If these steps are not followed, it is possible that the shape, form and cleanliness of the recovered metal will not be suitable for any application within a

reasonable shipping distance. In addition, a municipality should attempt to obtain from potential purchasers a floor or base price for the scrap, when possible. This is discussed in more detail in a separate publication (11).

Information concerning specifications for the recovered magnetic metals may be obtained from the American Society for Testing and Materials. Free professional advice on obtaining specifications and purchase commitments in advance is available to municipal planners from the Institute of Scrap Iron and Steel and from the American Iron and Steel Institute. The addresses of these organizations are listed in Appendix D.

APPENDIX A

Magnetic Separator Manufacturers

Dings Company
4740 Electric Avenue
Milwaukee, Wisconsin 53246

Eriez Magnetics
Asbury Road at Airport
Erie, Pennsylvania 16512

Stearns Magnetics, Inc.
6001 South General Avenue
Cudahy, Wisconsin 53110

Indiana General
407 Elm
Valparaiso, Indiana 46383

APPENDIX B

Revenue Potential

Magnetic Metals

Assume 180,000 TPY Refuse Processed
7% Magnetic Metals
90% Recovery of Magnetic Metals

6.3% x 180,000 TPY = 11,340 TPY Magnetic Metals

Assume Selling Price of $35.00 per short ton, net of shipping costs
11,340 TPY x $35.00 = $396,900 per year.

Revenue = $2.21 per input ton

APPENDIX C

Operating Cost Comparison

Annual Cost Current (or Projected) Solid Waste Management System	Annual Cost Shredding & Magnetic Separation Waste Management System
Tonnage Handled	Tonnage Handled
Tons Per Day _____	Tons Per Day _____
Days Per Week _____	Tons Per Week _____
Tons Per Year _____	Tons Per Year _____
Direct Operating Costs	Direct Operating Costs
Personnel	Personnel
Title, Salary, Benefits, Total	Title,Salary,Benefits, Total
_____,_____,_____,_____	_____,_____,_____,_____
_____,_____,_____,_____	_____,_____,_____,_____
_____,_____,_____,_____	_____,_____,_____,_____
Total $_____	Total $_____

APPENDIX C

Operating Cost Comparison
(continued)

Annual Cost Current (or Projected) Solid Waste Management System	Annual Cost Shredding & Magnetic Separation Waste Management System
Materials & Supplies	Materials & Supplies
Item, Quantity, Unit Price, Cost	Item, Quantity, Unit Price, Cost
_____, _____, _____, _____	_____, _____, _____, _____
_____, _____, _____, _____	_____, _____, _____, _____
Total $_____	Total $_____
Power, Utilities & Services*	Power, Utilities, & Services
Item, Quantity, Unit Price, Cost	Item, Quantity, Unit Price, Cost
_____, _____, _____, _____	_____, _____, _____, _____
_____, _____, _____, _____	_____, _____, _____, _____
Total $_____	Total $_____

*Outside services and maintenance can be calculated as 5% of capital investment.

APPENDIX C

Operating Cost Comparison
(Continued)

Annual Cost Current (or Projected) Solid Waste Management System	Annual Cost Shredding & Magnetic Separation Waste Management System
Current System	Shredding & Magnetic Separation System
Indirect Operating Costs	Indirect Operating Costs
Depreciation or Amortization	Depreciation or Amortization
Building & Structures	Building & Structures
_____ _____	_____ _____
_____ _____	_____ _____
Equipment	Equipment
_____	_____
_____	_____
Land Purchased for Facility	Land Purchased for Facility
Annualized Cost	Annualized Cost
_____	_____
Interest on Capital	Interest on Capital
Total $_____	Total $_____

APPENDIX C

Operating Cost Comparison
(continued)

Annual Cost Current (or Projected) Solid Waste Management System		Annual Cost Shredding & Magnetic Separation Waste MAnagement System	
Current System		Shredding & Magnetic Separation System	
Annual Cost		Annual Cost	
Personnel	_____	Personnel	_____
Materials & Supplies	_____	Materials & Supplies	_____
Power & Services	_____	Power & Services	_____
Administration	_____	Administration	_____
Insurance	_____	Insurance	_____
Depreciation or Amortization	_____	Depreciation or Amortization	_____
Interest	_____	Interest	_____
Total Annual Cost	_____	Total Annual Cost	_____
Tons Per Year	_____	Tons Per Year	_____

APPENDIX C

Operating Cost Comparison
(continued)

Annual Cost Current (or Projected) Solid Waste Management System	Annual Cost Shredding & Magnetic Separation Waste Management System
Current System	Shredding & Magnetic Separation
Annual Cost	Annual Cost
Cost Per Ton =	Cost Per Ton =
Annual Cost Tons Per Year	Annual Cost Tons Per Year
$_____per ton	$_____per ton

APPENDIX D

For free advice on specifications and markets for recovered iron and steel, contact:

American Society for Testing and Materials
(specifications only)
Attn: Committee E-38.02
1916 Race Street
Philadelphia, Pennsylvania 19103

Institute of Scrap Iron and Steel
1729 H Street, N.W.
Washington, D.C. 20006

American Iron and Steel Institute
1000 16th Street, N.W.
Washington, D.C. 20006

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