

THE SORAIN-CECCHINI SYSTEM FOR MATERIAL RESOURCE RECOVERY

FRANCIS J. CASHIN, PE

Cashin Associates, P.C.
Mineola, New York

PIETRO CARRERA, PE (Milano)

Sorain-Cecchini S.p.a.
Rome, Italy

ABSTRACT

This paper discusses the Sorain-Cecchini system for processing solid waste, which was developed by Sorain-Cecchini S.p.a., Rome, Italy. Presented herein are: (a) the history of Sorain-Cecchini S.p.a.; (b) a description of the system; and, (c) an analysis of the operation (10 years) of the Rome-East plant, 1320 TPD capacity (1200 tpd).

HISTORY

Sorain-Cecchini, S.p.a. was incorporated on 28 July 1976 and registered as a corporation in Rome, Italy with its principal office in Rome. It included the predecessor companies of A. Cecchini & C. Spa, S.A.R.R., and SO.R.A.IN sro. to wit:

(a) A. Cecchini & C. S.p.a, a predecessor company of Sorain-Cecchini, was established on May 5, 1943. Since 1967, the company has collected 25% of the solid waste generated by the City of Rome. In 1967 it started operating a 660 TPD (600 tpd) recycling plant at Rome-East.

(b) A second predecessor company, S.A.R.R., was established on December 12, 1947. This company also collected 25% of the solid waste generated by the City

of Rome. In 1964 it started operating a 660 TPD (600 tpd) recycling plant at Rome-West.

(c) A third predecessor company, SO.R.A.IN srl, was incorporated on August 4, 1956 and also collected 25% of the solid waste generated by the City of Rome. In 1967 it started its own recycling plant at a capacity of 660 TPD (600 tpd) at Rome-East.

After the incorporation of these three companies into SORAIN, SORAIN continued to operate both recycling plants, totalling 1980 TPD (1800 tpd), until 16 September 1979. At that time, the plants were transferred to SOGEIN, a public benefit corporation in which the majority interest is held by the City of Rome, with a minority interest held by Sorain-Cecchini, S.p.a.

SORAIN has operated the following plants in Italy from the dates indicated:

1964 Rome West	660 TPD (600 tpd)
1967 Rome East	1320 TPD (1200 tpd)
1972 City of Perugia	220 TPD (200 tpd)

SORAIN has designed the following plants outside of Italy, all of which have operated from the dates indicated:

1975 MSW Plant Rio de Janeiro (Brazil)	495 TPD (450 tpd)
1978 Pilot MSW Plant Kawasaki (Japan)	110 TPD (100 tpd)
1985 MSW Plant Oslo (Norway)	825 TPD (750 tpd)
1986 MSW Plant Guayaquil (Equador)	770 TPD (700 tpd)

DESCRIPTION OF THE SORAIN SYSTEM

General

The System receives, stores, and separates up to 1320 TPD (1200 tpd) of solid waste; and, then, recovers ferrous metals, aluminum,¹ film plastics, organics, and densified refuse derived fuel (DRDF). The technology utilized in the System has been used successfully in Italy since 1964, where three facilities are presently processing the municipal wastes of Rome and Greater Perugia. The high costs of fossil fuels, the economic advantage of recovering valuable material resources, and the desire to minimize the landfilling of waste, have resulted in the development of this System in Central Italy.

The waste is selectively fed into the system where it goes through a series of Primary and Secondary separating operations to sort the various components of the waste system into like fractions. These fractions are further processed to realize the optimum purity obtainable by physical sorting and then be distributed into five recovery lines. These five recovery lines further process their respective fractions to recover: ferrous metals, aluminum, film plastic, DRDF, and "organics" (which consist of such materials as hard plastics, organics, glass, ceramics, sand, and ashes). A sixth line removes the rejects (which consist of bulk items such as white metal, large pieces, etc). (Note: The SORAIN term "organics" includes small, heavy fractions of inorganics.)

In discussing the SORAIN System hereinafter, it is important to note that there are several alternatives available for material recovery. These alternatives have varied from plant to plant depending primarily on the local market for the recovered materials. Likewise, the materials recovered at a single plant have varied through the years, as markets for some recovered materials deteriorated and new markets for alternate materials were developed. The development of the Plastic Film Recovery Line is an example of a relatively new market. The paper products have been recovered both as cardboard and wood pulp or alternatively as DRDF. The "organic" fraction has been recovered as an animal feed, a high grade compost (Compost I) and a low grade compost (Compost II).

The basic SORAIN System described hereinafter is as proposed for all new installations, varying only when there is a special circumstance providing a market for a specific material recovery.

The operation of the Rome East (the oldest plant) is analyzed. Compost I, not Animal Feed, is now the prime recovery of the "organic" fraction. In the recently proposed SORAIN plants, about half are planning to recover the paper as pulp and cardboard, with the rest planning to recover DRDF.

Waste Receiving, Storage, and Charging (See Fig. 1)

(a) Receiving. All wastes are weighed upon arrival at the facility where weights are automatically recorded for invoicing and for basic system processing data. The vehicle then enters an enclosed tipping area and discharges the waste. The tipping area is entirely enclosed and under a slightly negative air pressure so as to preclude odors and/or dust/particulates escaping to the ambient atmosphere.

(b) Charging. Over-sized and/or nonprocessable materials are removed on the tipping floor and deposited in roll-off waste containers as reject fraction. Wheeled loaders (1) push the waste onto the Charging Conveyor (1). A Pick Up Device (2) which includes a bag breaker on the Charging Conveyor removes the bulk items for handling as reject fraction. The Leveling Device (3) meters the flow waste on the Charging Conveyor. Over-sized items not removed on the tipping floor or by the Charging Conveyor, are removed at the leveler.

(c) Primary Screen (4). The Charging Conveyor feeds the waste into this Primary Screen, in which the first separation takes place. The large fraction (nominal—8 in.), consisting mainly of paper, wood, and film plastic is discharged into the conveyor feeding the Large Breaker. The small heavier fraction, consisting mainly of organics, glass, ceramics, metal, sand, and ashes, drops onto a conveyor for further separation of the heavy fraction.

Primary Separation—Large Fraction (See Fig. 2)

(a) Large Breaker (5). The large fraction is fed into the Large Breaker. This rotary machine, set to operate at 10–20 rpm, reduces the large fraction items and breaks any large plastic bags. It will stop automatically, reverse, and reject any item it cannot break.

(b) Large Air Classifier (6). The somewhat homogenized output of the Large Breaker is fed into the Large Air Classifier, in which the lighter fraction (sheetpaper, and film plastic) is separated from the heavier fraction (cardboard, bound paper, wood, and rags). Each of these fractions are fed onto separate conveyors for secondary separation.

¹ Because of the insignificant amount found in the Italian waste stream, aluminum is not separated at the Rome plants.

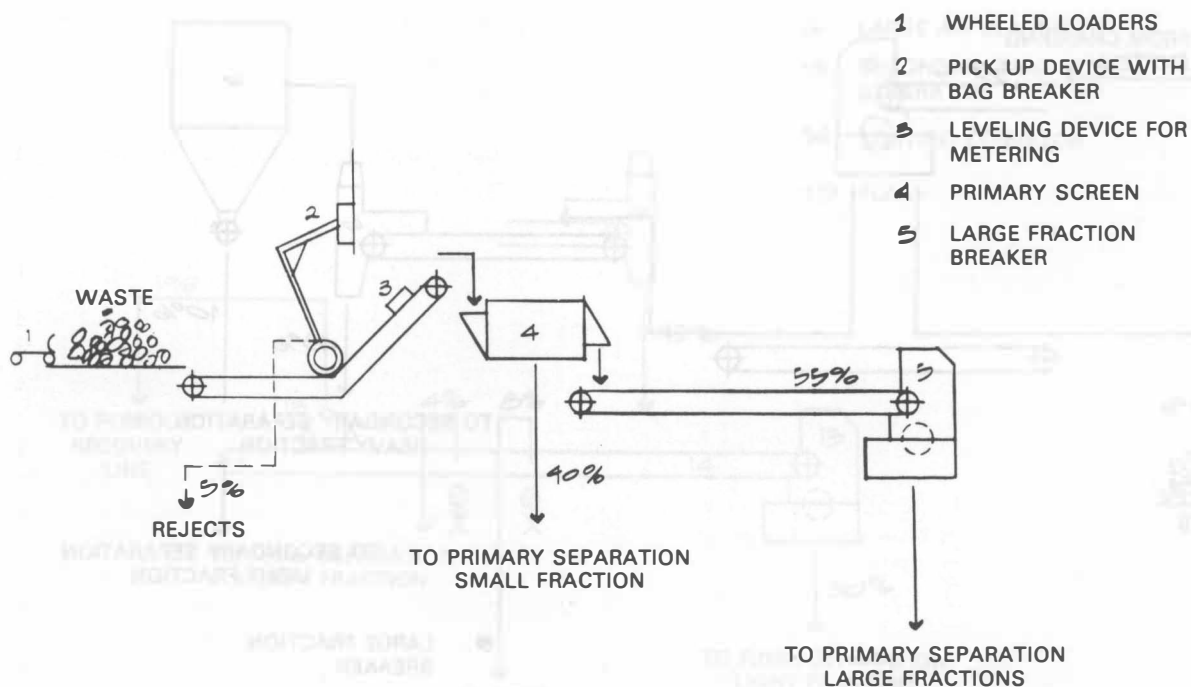


FIG. 1 CHARGING SYSTEM

Primary Separation—Small Fraction (See Fig. 3)

(a) Primary Magnetic Separator (10). The small heavier fraction, separated at the Primary Screen, is passed through the Primary Magnetic Separator, which removes the ferrous metals, which are conveyed to the Ferrous Recovery Line. The remaining small heavier fraction is conveyed to the Small Breaker for secondary processing.

(b) Small Breaker (11). The small fraction output of the Primary Screen is fed into this Small Breaker. It further breaks down this fraction, tears the small plastic bags, and homogenizes this fraction. The output of this breaker is fed into the Secondary Screen.

(c) Secondary Screen (12). This screen further separates the fraction of the Small Breaker into a large light fraction (nominal—4 in.) consisting mainly of film plastic, paper and wood; and, a small fraction consisting mainly of organics, glass, sand, ashes, and aluminum. The lighter fraction output is deposited onto a conveyor leading to the DRDF Resource Recovery Line. The heavier fraction output is deposited onto a conveyor leading to the Organics Collection Area.

Secondary Separation—Heavy Fraction (See Fig. 4)

(a) Secondary Magnetic Separator (13). The heavier fraction rejected in the Large Air Classifier is conveyed under a magnetic cross conveyor. The ferrous content is removed by an electromagnet and deposited on a conveyor leading to the Ferrous Recovery Line. The remaining heavier fraction is conveyed to the Eddy Current Separator.

(b) Sorting Conveyor (14). Following the removal of the metals, the heavier fraction is processed along a Sorting Conveyor where cardboard, missed recovery items, and rejects are sorted by inspectors or hand operated semi-automatic devices. The cardboard is placed upon a conveyor leading to either the Cardboard Recovery Line or the DRDF Recovery Line. Other items are picked for recovery and placed in container for delivery to their respective recovery lines or the reject conveyor. The remaining mass, consisting mainly of paper, is conveyed to the Flail.

(c) Flail (15). The output of the Sorting Conveyor, after removal of cardboard, other salvageable items, and certain rejects, consists mainly of paper. This residual paper fraction includes bound paper and residual

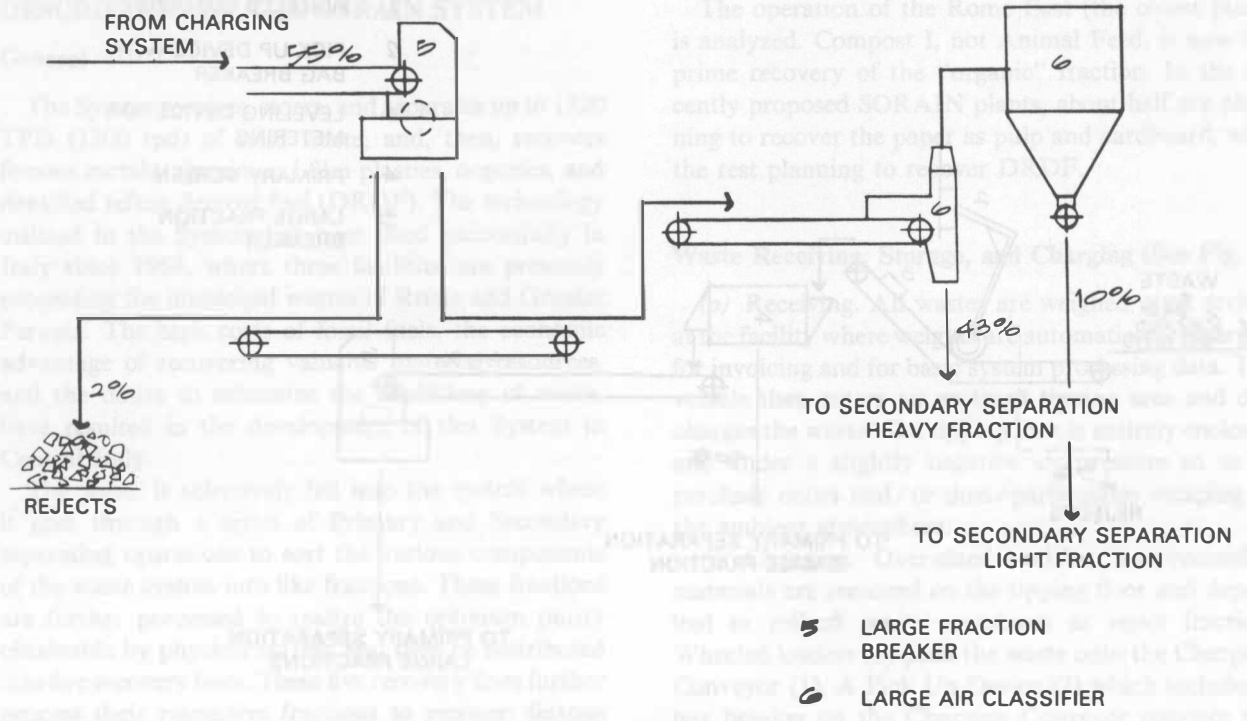


FIG. 2 PRIMARY SEPARATION LARGE FRACTION

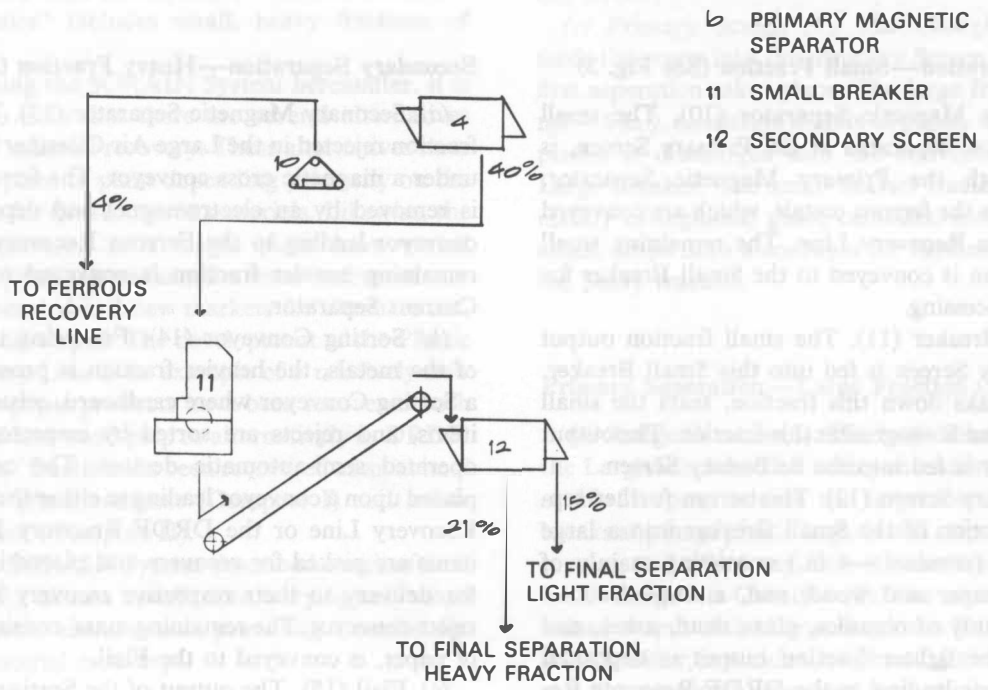


FIG. 3 PRIMARY SEPARATION SMALL FRACTION

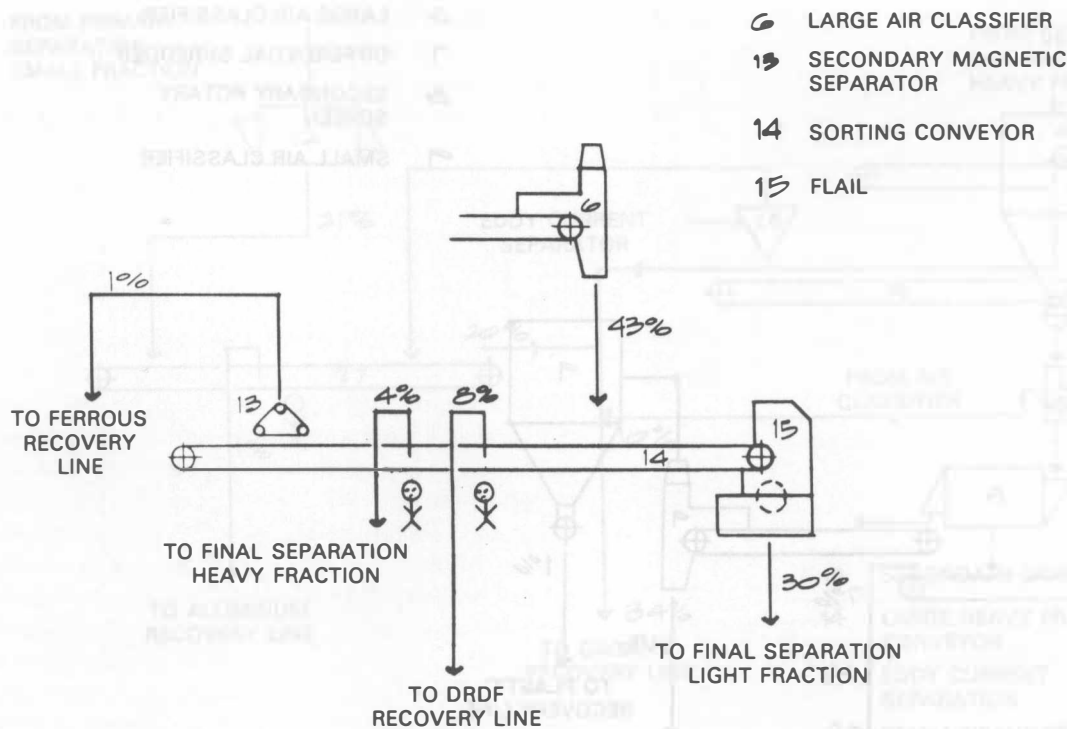


FIG. 4 SECONDARY SEPARATION HEAVY FRACTION

cardboard and is processed in this grateless Flail to breakdown into a light fraction. It is then fed into a Secondary Air Classifier.

Secondary Separations—Light Fraction (See Fig. 5)

(a) Differential Shredder (7). The light fraction, consisting of paper and plastic film is fed into the Differential Shredder. The shredder breaks the paper, but not the plastic film, and then drops it on a conveyor, which feeds the entire output into a rotary screen.

(b) Secondary Rotary Screen (8). This Rotary Screen makes a preliminary separation (nominal 10 in.) of the paper and plastic film fed into it. A substantial amount of the plastic film is removed at this screen. The heavy fraction remaining is fed onto a conveyor which takes this fraction to an air classifier.

(c) Small Air Classifier (9). This Small Air Classifier further separates additional plastic film, which is dropped onto a conveyor leading to the Plastic Recovery Line. The remaining fraction consisting mainly of paper, but including some rag fragments, is dropped onto a conveyor leading to the DRDF Recovery Line.

Final Separation—Heavy Fraction (See Fig. 6)

(a) Eddy Current Separator (25). The remaining heavier fraction, from which the ferrous metal has been removed, is conveyed through an Eddy Current Separator where further nonferrous metal, primarily aluminum, is removed. This device uses the Eddy Current Principal to set up a force, which separates the aluminum from the fraction. The remaining fraction is then dropped upon a Sorting Conveyor.

(b) Large Heavy Fraction Conveyor (14). After passing by the Eddy Current Separator, the Large Heavy Fraction Conveyor carries the remaining organics to the Organic Resource Recovery Line.

(c) Small Heavy Fraction Conveyor (27). The Small Heavy Fraction Conveyor carries the small heavy fraction from the secondary separation of the heavy fraction and the small heavy fraction from the DRDF Air Separation, after the ferrous metals have been removed.

Final Separation—Light Fraction (See Fig. 7)

(a) Secondary Air Classifier (16). This Secondary Air Classifier receives the light fraction output of the Flail and the small fraction from the Primary Screen.

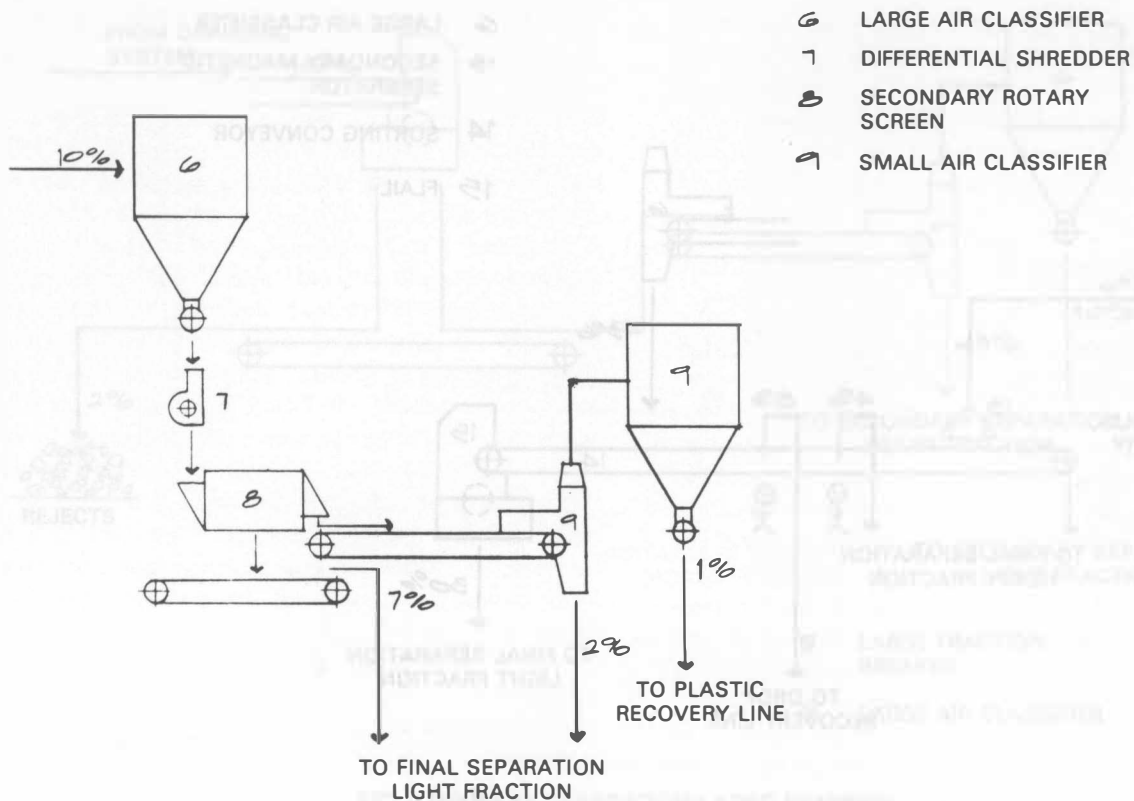


FIG. 5 SECONDARY SEPARATION LIGHT FRACTION

This classifier removes all paper, which is deposited on a conveyor leading to the RDF Resource Recovery Line.

(b) DRDF Air Classifier (20). This DRDF Air Classifier finally separated the DRDF fraction, which is dropped into a conveyor leading to the DRDF Densifiers in the DRDF Recovery Line. The remaining small fraction is conveyed to the Organics Recovery Line.

(c) DRDF Magnetic Separator (21). This DRDF Magnetic Separator finally separates any ferrous metal from the DRDF Conveyor Line. Any ferrous metal moved is conveyed to the Ferrous Metal Recovery Line (less than 1%).

Ferrous Recovery Line

(a) Ferrous Metal Separation Points: The ferrous metals are separated from the other material recovery fractions at three points: the Primary Magnetic Separator (10); the Secondary Magnetic Separator (13); and the DRDF Magnetic Separator, which are con-

veyed to the Ferrous Recovery Line where the Abrader further breaks down the ferrous fraction and the final magnetic separator further separates said ferrous fraction from non-ferrous fractions.

(b) Ferrous Abrader: This Abrader is a specially designed hammermill with its own particular grate, which cleans the ferrous fraction through friction and densifies it through compression. Alternately, the ferrous fraction may be cleaned by "firing", a process in which the fraction is run through a fuel-oil fired kiln. A system of "washing" the ferrous has been tested. However, the Abrader with an electromagnetic separator is emerging as the preferred technology.

(c) Final Magnetic Separator. A Final Magnetic Separator separates the ferrous metals at the output conveyor of the Abrader, removing (purifying this fraction) the nonmetals loosened by the Abrader. These nonmetals (primarily paper) are conveyed to the DRDF Densifiers.

(d) Ferrous Metal Storage: The Densified Ferrous Metal (DFM) has a specific gravity of approximately 3.0 or 200 lb/ft³. The DFM is stored in bins.

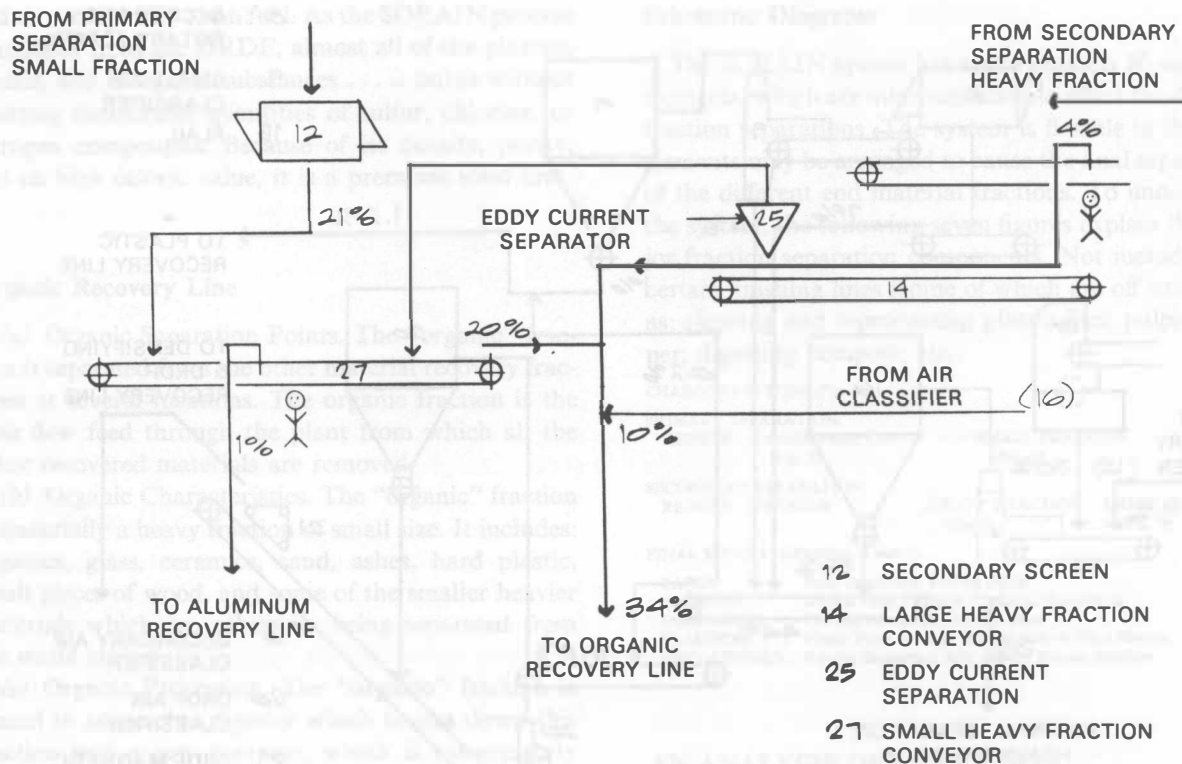


FIG. 6 FINAL SEPARATION HEAVY FRACTION

Aluminum Recovery Line

(a) Aluminum Separation Points. The aluminum is separated from the other fractions on the Metallic Feed Conveyor (17) and the Inspection Conveyor. Eddy Current separation is used to enhance said separation.

(b) Aluminum Crusher. The aluminum fraction is passed through an Aluminum Crusher where the aluminum is densified (flattened) to reduce voids.

(c) Aluminum Storage. The aluminum as stored has a specific gravity of approximately 1.0 or 62 lb/ft³.

Plastic Recovery Line

(a) Plastic Separation Points. The film plastics (primarily polyethelene) are separated from the remaining material recovery fractions at two points: the Small Air Classifier (9); and, the Secondary Air Classifier (16) from which they are conveyed to the Plastic Recovery Line.

(b) Plastic Shredder and Storage Silo. The film plastic is fed into the Plastic Shredder where the film is

broken into small (one square inch or less) flakes for further processing. Because the cycles of the Plastic Processing Line are not of the same duration these unwashed flakes are stored in a Storage Silo, awaiting further processing.

(c) Plastic Prewasher and Plastic Washer. The plastic flakes are cleaned by a series of washing cycles in the Plastic Prewasher and Plastic Washer. The impurities are removed by a combination of dissolution, floatation, and floccation.

(d) Water Treatment Plant. The water used in the washing process is treated in a small, on-site Water Treatment Plant (100 gal/hr). A small amount of make up water (about 10 gal/hr) is needed to compensate for the evaporation. There is no effluent from the Water Treatment Plant. The dried solids are added to the DRDF, and are subsequently consumed in the Incinerator-Boiler.

(e) Dryer and Storage Silo. After washing the plastic is air dried in the Plastic Dryers, the (hot) air output from the Dryers is exhausted to the combustion air of the Incinerator-Boiler; and, thus not released to the

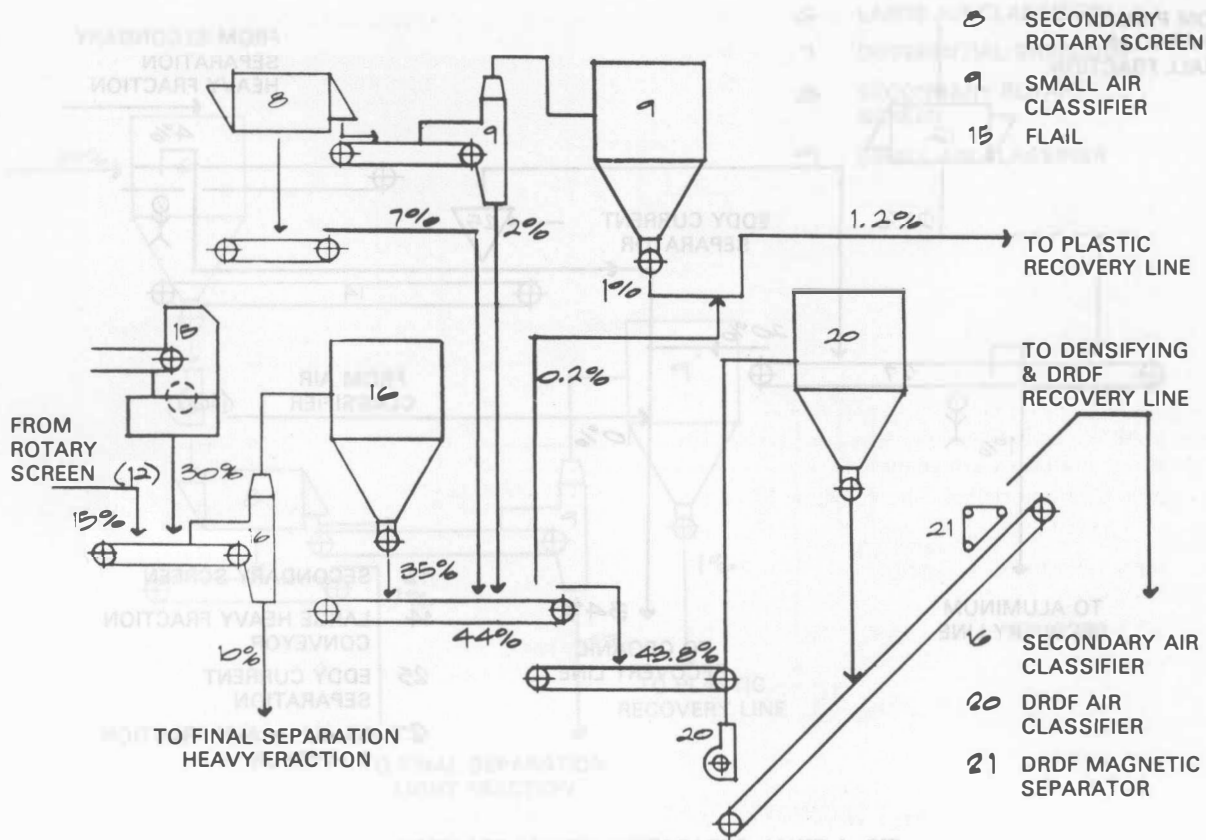


FIG. 7 FINAL SEPARATION LIGHT FRACTION

ambient atmosphere. Because the cycle of the Extruder (Pelletizer) is not of the same duration as the Dryers, the cleaned flaked plastic is stored in the Clean Plastic Storage Silo, awaiting further processing.

(f) Extruder (Pelletizer). The cleaned plastic flakes are removed from the Clean Plastic Storage Silo and are fed into a vat, where the plastic is elevated to a temperature above its melting point. The liquid plastic is then fed through a strainer where any foreign matter, not removed in washing, is filtered out. The liquid plastic is then fed into the Extruder (Pelletizer) which cools the plastic, ejecting standard polyethylene, plastic pellets (in the configuration which is the standard for the plastic industry).

(g) Plastic Pellet Storage. The plastic pellets are stored in a Silo from which they are either bulk shipped or bagged and shipped to plastic film manufacturers, which use recycled plastic.

DRDF Recovery Line

(a) DRDF Separation Points. The DRDF is separated and conveyed to the DRDF Recovery Line: from the DRDF Air Classifier (20); from the DRDF Magnetic Separator (21); and, if there is no Cardboard Recovery Line, from the Cardboard Recovery Conveyor (14).

(b) Densifier. The separated DRDF fraction is then conveyed to a Densifier, where the DRDF is pressed into fine, but concentrated flakes.

(c) DRDF Storage. The DRDF has a specific gravity of approximately 0.6 or 38 lb/ft³. DRDF is stored in the DRDF Silo, from which it is conveyed to the Incinerator-Boiler.

(d) DRDF for Sale. The DRDF may be used either as the fuel for the Incinerator-Boiler or it may be sold as clean DRDF fuel, which is both a concentrated fuel

mixed with water. For handling purposes, it is sold as a pulp with a moisture content of between 63 and 68%. The weights indicated in the table are based on 12% moisture, which is the standard in the industry. However, at either location, all the paper is converted into DRDF, which is the preferred methodology.

(c) Metal (Ferrous) Fraction. The ferrous metal is magnetically separated. It is fired to remove paper and/or paint. The ferrous metal is compressed into blocks approximately 1 in. x 1 in. x 2 in. However, at other locations the ferrous metal is densified by the abraded and handled as a metal gravel; accordingly, it is not fired, which is the preferred methodology.

(d) Plastic (Film) Fraction. The plastic film (polyethylene) is separated from the light fraction, cleaned, pelletized, and sold. It is used to make plastic pipe for irrigation and plastic refuse bags.

(e) Organic (Feed) Fraction. The most profitable organic fraction called for the removal of certain of these organics as an animal feed, which was sterilized by high temperature pressurized steam and subsequent pelletized. In 1980, a change in Italian law required the recovered organic feed pellets to be mixed with additional fodder on a ratio of 2:8. This had the effect of eliminating this profitable market.

(f) Organic (Compost I) Fraction. This is a high quality compost from which is marketed as a soil conditioner. It includes the former organic (feed) fraction.

(g) Organic (Compost II) Fraction. The quality of this compost is such that it cannot be sold. It has been given away to salvage operators, processed in the incinerator, and/or landfilled with certain of the residual fractions.

(h) Glass (Test) Fraction. For four years SORAIN operated a pilot program to separate the glass from the Organic (Compost II). It had a capacity of 10 TPD and used an optical sorting system. The program was abandoned when it was determined that the recovery cost far exceeded the revenues which could be expected.

(i) DRDF Fraction. RDF production began in 1977. Experiments were conducted creating RDF in the form of both pellets and fluff. These programs were abandoned because the RDF pellets were too expensive, and because the fluff was too difficult (bulky) to store and transport. Subsequently, SORAIN developed a densified RDF (DRDF) which has the advantages of being economical to produce and, because it is densified, relatively easily to both store and transport. Test programs are underway to use the DRDF in the cement industry. This DRDF fraction is an ecologically pure fuel, in that it not only has an extremely low sulfur content, but also practically no chlorine, due to

the prior removal of the hard plastics (PVC, PET, etc.).

(j) Materials (Total) Recovered. The Materials (Total) Recovered indicate the total tonnage which is normally recovered; however, a varying proportion of the Organic (Compost II) is consumed in the incinerator and/or landfilled in accordance with varying marketing conditions for the use of same.

(k) Incineration Fraction. The Incineration Fraction for the years 1975 to 1978 is primarily the separated combustible fraction remaining after the basic separation processes. Subsequent to the abandonment of the Glass (Test) program and the Organic (Feed) program (circa 1980), substantial portions of the Organic (Compost II) have been processed in the incinerator.

(l) Steam Sold. The quantity of steam sold is based upon the market for same at a nearby rendering plant. The incinerator boiler is capable of producing almost four times this amount, the better part of which had been used in the Organic (Feed) Processing Line and is currently being used in the Plastic (Film) Processing Line (at Perugia).

A review of the above 10 years (decade) of operations indicates considerable flexibility in recovery of the material fraction. The SORAIN process can be adjusted to meet varying input waste characteristics and output material fractions. For examples: if there was no market for Paper (Pulp) that fraction could be diverted to the DRDF Line; the very profitable Plastic Film Material Recovery Line was developed to remove the Plastic Film, because it contaminated the Paper (Pulp) Line; the program for the separation of glass was tested, found uneconomical, and abandoned. When the Organic (Feed) market was no longer available, the process was modified to increase the quantity and quality of Organic (Compost I), which is a high grade soil conditioner.

In the United States, the characteristics of the input waste and the markets for the recovered materials would differ somewhat from those in Italy. Therefore, in addition to the ferrous metal, aluminum would be recovered; the paper category, which is pulped in Italy, would be recovered as DRDF; and, the remaining fraction would be recovered as an organic soil conditioner.

The environmental exposures for the SORAIN System are minimal. There are no effluents (air or water) transmitted from the plant, except for the incinerator flue gases which are scrubbed. The only in-plant environmental considerations are dust and odors, both of which are minimized by internal enclosures and air cleaning equipment.

TABLE 1 ROME-EAST—DECADE 1 JANUARY 1975 TO 31 DECEMBER 1984
RECOVERY OF MATERIAL FRACTIONS—ANNUAL
(In Thousands of Metric Tons)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1. INPUT WASTE	327.0	338.0	347.0	344.0	297.0	286.0	270.0	275.0	280.0	285.0
<u>FRACTIONS</u>										
2. PAPER (PULP)	19.6	20.2	20.0	20.5	20.8	19.2	18.6	18.4	18.5	18.2
3. METAL (FERROUS)	11.2	11.4	11.5	11.1	9.1	8.4	7.8	8.1	8.1	8.4
4. PLASTIC (FILM)	—	—	.4	1.4	2.1	1.7	1.6	1.9	2.1	2.0
5. ORGANIC (FEED)	82.0	85.0	87.0	86.0	68.0	51.0	—	—	—	—
6. ORGANIC (COMPOST I)	65.0	63.0	66.0	65.0	67.0	75.0	79.0	78.0	78.0	77.0
7. ORGANIC (COMPOST II)	81.0	85.0	88.0	82.0	107.0	109.0	123.0	127.0	130.0	132.0
8. GLASS	Test	Test	Test	Test	—	—	—	—	—	—
9. DRDF	—	—	—	Test	Test	—	1.2	1.1	1.6	1.8
10. MATERIALS (RECOVERED)	185.0	188.1	194.6	188.6	212.8	218.4	231.2	234.5	238.3	239.4
11. INCINERATION FRACTION	140.0	140.0	145.0	150.0	160.0	160.0	160.0	160.0	160.0	160.0
12. STEAM SOLD	50.0	50.0	50.0	48.0	46.0	45.0	60.0	58.0	60.0	60.0
13. LANDFILLED RESIDUE	47.0	48.0	45.0	46.0	52.0	54.0	53.0	54.0	53.0	54.0
13.1 FROM 11	42.0	42.0	43.5	45.0	48.0	48.0	48.0	48.0	48.0	48.0
13.2 FROM 2 and 9	5.0	6.0	1.5	1.0	4.0	6.0	5.0	6.0	5.0	6.0

In the past, the MSW of Europe differed somewhat from the MSW in the United States. The main difference has been that MSW in the United States has had a higher percentage of paper and cardboard content, while European MSW has had a higher percentage of organic matter. Hereinafter is a table showing the waste composition of Rome for the years 1962 and 1985. Please note the trends in the first two lines (organic matter and paper and cardboard):

Fraction	Percent 1962	Percent 1985
Organic Matter (Kitchen Waste)	45	33
Paper and Cardboard	12	22
Glass	3	7
Ferrous Metals	4	4
Fines (less than 1 in.)	20	12
Plastic, Film	Not Present	1
Plastic, Hard	Not Present	2
Textiles	2	2
Miscellaneous (Unclassified)	14	14
Total	100%	100%