# A STUDY OF SOLID WASTE DISPOSAL

## RESEARCH HOSPITAL AND MEDICAL CENTER
## KANSAS CITY, MISSOURI

A Problem Solving Project Report
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# INTRODUCTION

## General Information

Hospitals of this nation have no monopoly on problems in the field of waste disposal. This country's heritage of wastefulness is derived from an economic system that stimulates consumption to justify expanded production, thus leading to ever-increasing volumes of solid wastes. This propensity to consume, when compounded by the general lack of interest in the disposal of wastes, and especially of further investment in them, defines the first problem in the disposal of solid wastes.

The waste generation rate in the United States in 1965, excluding wastes produced and disposed of directly by industry, was estimated at 160 million tons. For a population of 200 million, this amounts to an annual production rate of 1600 pounds for every man, woman and child. By 1980 the projected estimate is 260 million tons.[1] This represents a rise from approximately 4.6 pounds per capita per day in 1965 to approximately 5.5 pounds per day in 1980.

Each year Americans dispose of 48 billion cans, 26 billion bottles and jars, 65 billion metal and plastic caps, plus more than one-half billion dollars worth of packaging material.[2] It also appears that waste production is increasing at the rate of 2 per cent per year; which, when compounded by the expected population growth, results in an annual increase of 4 per cent.[3]

Today's affluent society is the result of industry's ability to produce a multitude of consumer goods most of which are consumed or ultimately discarded. Yet, neither industry nor the consumer has given sufficient consideration to the disposal of wastes. The Committee on Pollution, National Academy of Sciences--National Research Council, spotlighted the problem by stating:

> Pollutants are the residues of the things we use and throw away . . . . As the earth becomes more crowded there is no longer an "away". One person's trash basket is another's living space.
>
> . . Our whole economy is based on taking natural resources, converting them into things that are consumer products, selling them to the consumer, and then forgetting about them. But there are no consumers--only users. The user employs the product, sometimes changes it in form, but does not consume it--he just discards it. Discard creates residues that pollute at an increasing cost to the consumer and to his community.[4]

The hospitals of this nation, perhaps more than any other industry, find themselves engulfed with ever-increasing amounts of waste for which some means of disposal must be provided. Few are able to adequately cope with the problem. Yet the hospital, as the prime provider of health care in the community, is morally obligated to insure that it has a waste disposal system free from health hazards. Waste disposal has long been relegated a place of low status within the hospital. Recently, however, two forces have impinged on the hospital to bring this subject to a new level of prominence: (1) modern technology or the so-called "disposable dilemma"; and (2) social legislation in the fields of air and water pollution and of waste disposal.

The increase in total solid waste per patient bed per day has been dramatic due to the increased use of disposables made of plastic, plastic coated papers and paper products. Solid waste quantities, in hospitals, rose 60 per cent between 1955 and 1965 and are expected to increase another 50 per cent by 1970.[5]

Ever increasing amounts of disposables are being used for housekeeping as well as for treatment and surgery. Cost factors continue to drop as better technological processes are developed and increased quantities are produced. Another vital development is the growing emphasis on sterility and infection control. Safety from transmission of disease is, and will be, the major factor forcing the introduction of disposables. Yet, little thought is given to the disposal of these materials.

If traditional handling and disposal methods continue, the very dangers that disposables are meant to avert--prevention of cross-infection--go up as the staff must deal with vast amounts of solid waste. Equally, more expensive manpower will be required to handle this increase.

The composition of disposables will determine new disposal methods. Former methods of waste destruction are not effective against plastic disposable materials, largely polyethylene and polypropylene, which are resistant to almost all organic solvents. It is for this and newer materials under development that waste disposal equipment must be designed.

Air pollution regulations have also added to disposal problems. Incinerators designed ten years ago no longer meet present standards or are unable to cope with the quantity and types of waste produced within the hospital today. Seldom can an old incinerator be updated to meet present standards. In addition, updating costs may be as expensive as the original capital costs of the incinerator.

The problems of increased waste production and incineration difficulties has led many hospitals to seek other methods of waste disposal. Without a thorough study it cannot be said that one disposal method is preferred over another. Each hospital must examine its present system in relation to other systems available in order to determine which system is best in its particular case.

## Conditions which Prompted the Study

On May 5, 1968, Kansas City, Missouri, placed its City Air Pollution Ordinance Number 34696 into effect (see

Appendix A). This law restricts incinerator operation to the hours between 10:00 A.M. and 4:00 P.M. It further requires that only multiple chamber (three chambers or more) incinerators are acceptable for refuse burning. A time limit has been set for modification to or rebuilding of existing incinerators which do not meet the standards outlined. In the case of Research Hospital and Medical Center their incinerator must meet the required standards by November 1, 1969.

The restricted burning hours coupled with the quantities of waste produced in the hospital has resulted in a necessity to overload the incinerator in order to dispose of each day's combustible waste. Overloading results in excessive smoke, fly ash and odor generation. The incinerator in its present state will not pass inspection. The Executive Director requested that a waste disposal method study be conducted in order to recommend a system that will economically handle the waste presently generated and at the same time pass present and future air and water pollution and waste disposal laws.

Statement of the Problem

The problem is to determine the best method of solid waste disposal for Research Hospital and Medical Center, Kansas City, Missouri.

## Objectives

The objectives of this study are:

1. To analyze the hospital's existing solid waste disposal system.

2. To discuss the various methods of solid waste disposal used in hospitals.

3. To discuss three alternatives to the present system.

4. To conduct a cost analysis of all four systems.

5. To evaluate the advantages and disadvantages of all four systems.

6. To conclude the best method of solid waste disposal for Research Hospital and Medical Center.

## Criteria

The criteria to be followed in concluding the solution to the problem are:

1. The system must handle all types (see Appendix B) of solid waste generated within the hospital.

2. The system should be closed from the point of entry to the point of uncontaminated end product.

3. It should be as automated as possible to reduce manpower costs.

4. It should be designed flexibly to expand as needed in the future.

5. The system must be designed and operated in such a manner as to be free of health hazards.

6. The system must meet present and expected air and water pollution and waste disposal laws.

7. The method chosen must be able to gain the support of the hospital staff.

8. The system must be economical in operation, consistent with the needs of Research Hospital and Medical Center and the above criteria.

## Factors Bearing on the Problem

Although incineration has been the most common means of waste disposal in larger metropolitan hospitals, the advent of more stringent air pollution regulations has resulted in other disposal methods being considered and, in many cases, adopted. Each individual situation must be evaluated and treated separately. At Research Hospital and Medical Center, consideration was given to the following factors:

1. Pathological type waste is best disposed of by incineration.[6] Grinding and burial, although less common than incineration, is also used.

2. The present incinerator was designed to burn 880 pounds of Type 1 waste per hour and 220 pounds per hour of Type 4 (pathological) waste with the pathological waste being consumed only when dry waste is being burned (see Appendix C).

3. The incinerator is located on "C" level of the

hospital, one floor below the loading dock. Ashes from the incinerator must be hand-hauled up to "B" level using a block and tackle. The ashes are then moved through the hospital laundry to the loading dock.

4. The incinerator is not equipped with an air pollution control device; consequently, air contaminants are allowed to pass up the stack into the ambient air.

5. The incinerator may be described as a single-flue, direct fed, combination Class III and Class VI incinerator (see Appendix D). It is not a multiple chamber incinerator and is not equipped with a secondary or after-burner.

6. Noncombustible waste is sorted from the waste to be incinerated. It is then stored in the charge room in two metal dumpsters each with a capacity of two cubic yards. No bulk reduction equipment is available to reduce the volume of this waste.

7. Garbage from the dietary department is largely disposed of in the kitchen area by grinding and removing as a water suspension in the sewer system.

8. Waste disposal is the responsibility of the housekeeping department of the hospital.

9. The hourly wage rate for waste-handlers at Research Hospital and Medical Center is estimated to be two dollars, including all fringe benefits.

10. The hospital waste disposal system must meet

Kansas City, Missouri, air pollution regulations on or before November 1, 1969.

## Assumptions

The following assumptions are to be considered as constants for the purposes of this study:

1. Sufficient funds are available in order to finance the recommended system.

2. The hospital will not increase in size within the next two years.

3. There will be an increase in the amount of solid waste generated within the hospital in the future due mainly to the increased use of disposables.

## Definitions

The terms as used in this study shall have the following meanings:

Air Contaminant--Any particulate matter, gas or vapor (exclusive of water vapor), including but not limited to smoke, charred paper, dust, soot, grime, carbon or any other particulate matter, or irritating odorous matter, fumes or gases, or any combination thereof contained in the ambient air.

Air Pollution--The presence in the ambient air of one or more air contaminants in quantities, of characteristics and of a duration which directly and proximately cause or contribute to injury to human, animal or plant life or health, or to property, or which unreasonably interfere with the enjoyment of life and use of property.

Air Pollution Control Device--Any method, process or equipment which removes, reduces or renders less obnoxious, air contaminants emitted into the ambient air.

Ambient Air--All space which lies outside of buildings or stacks.

Biological Wastes--Those wastes resulting directly from patient care activities, such as diagnostic procedures and treatment. They include materials of medical, surgical, autopsy and laboratory origin. Bandages, plaster casts, needles and syringes are examples of biological wastes.

Burning Rate--The amount of waste incinerated per unit of time, usually expressed in pounds per hour.

Charge Room--The room where refuse is stored prior to incineration. It is the room in which the charging chute is located.

Charging Chute--A vertical passage through which waste materials are conveyed from above to the primary combustion chamber of the incinerator.

Direct Fed Incinerator--Any incinerator meeting the requirements of Classes I, IA, III, IV, VI, or Class VII incinerators. The incinerator may be side, end or top charged.

Disposal Method--The ultimate means of rendering wastes inoffensive from public health and nuisance standpoints.

Flue Gas--All gases which leave the incinerator by way of the flue, including gaseous products of combustion, water vapor, excess air and nitrogen.

Fly Ash--Suspended ash particles, charred paper, dust, soot or other partially incinerated matter, carried in the products of combustion.

Garbage--The putrescible animal and vegetable wastes resulting from handling, preparation and consumption of food.

Incineration--The process of igniting and burning solid, semi-solid or gaseous combustible waste to carbon dioxide and water vapor.

Multiple Chamber Incinerator--Any structure used to dispose of combustible waste by burning, consisting of three or more refractory lined combustion chambers in series, physically separated by refractory walls, inter-connected by gas passage ports and ducts.

Pathological Wastes--All surgical and autopsy wastes including amputated limbs, tissues, organs, placentae and similar types of pathological material. Pathological wastes are of human or animal origin and should not be confused with biological wastes.

Scrubber--Any equipment for removing fly ash and other objectionable materials from the products of com-bustion by means of water sprays or wet baffles.

Waste--The useless, unused, unwanted or discarded materials resulting from normal hospital activities.

## Research Methodology

The research methodology followed in collecting and evaluating data were as follows:

1. Extensive examination of the present system of waste disposal at Research Hospital and Medical Center, including an inspection of the plant, to determine areas of possible relocation of existing solid waste disposal equipment, if required. The present system was also examined to determine whether or not updating of the present equipment was feasible.

2. Examination of existing laws in the field of air and water pollution and waste disposal, including investigation as to whether laws governing the disposal of pathological and other infectious waste material existed.

3. Interviews with hospital employees and others directly concerned with the problem in order to more fully understand the problems of waste disposal at Research Hospital and Medical Center and to obtain their thoughts and ideas on waste disposal systems.

4. Obtaining statistical data as to the types, quantities and weights of waste presently generated with a view to forecasting future requirements.

5. Correspondance with manufacturers of the various waste disposal systems to obtain technical and cost data on

the various systems available.

6. Intensive review of the literature with a view to gain a thorough understanding into and the advantages and disadvantages of each system in order to determine reliability and performance factors.

Literature Review

Literature in the field of waste management was reviewed with emphasis placed on waste disposal methods used by both industry and hospitals. No books are available dealing with solid waste disposal in hospitals per se, however, many articles have recently appeared in architectural and hospital journals on the subject. Only within the past three years has management become concerned with the disposal of solid wastes. Air and water pollution and waste disposal laws have finally brought waste disposal into prominence.

This writer, in his research, found three important facts that stand out above all others when researching the field of solid waste disposal: (1) technology in the field of solid waste disposal has failed to keep pace with advances in the fields of production, packaging and distribution of disposable items used in hospitals; (2) there no longer is an inexpensive method of solid waste disposal; and (3) until 1966 there was a general lack of comprehensive studies in the field of industrial and hospital waste disposal.

There is a serious and pervading need for precise, reliable data that can be utilized for specifying systems design, performance and management. Solid waste disposal techniques have been described as "horse-and-buggy systems with gasoline-engine propulsion."[7]

In general, hospital solid wastes are composed of: (1) rubbish, both combustible and noncombustible; (2) garbage; (3) ashes; and (4) special wastes, which by thier nature can be considered hazardous. These four classes of waste constitute the solid refuse generated by health care institutions (see Table 1).

TABLE 1

REFUSE MATERIALS BY KIND AND COMPOSITION

| KIND | | COMPOSITION | |
|---|---|---|---|
| Refuse (solid waste) | Garbage | Wastes from the preparation, cooking, and serving of food. | |
| | Rubbish | Combustible (primarily organic) | paper, cardboard, newspapers<br>wood, excelsior<br>cloth, bedding<br>leather, rubber<br>plastic refuse bags |
| | | Noncombustible (primarily inorganic) | metals, tin cans, metal foil<br>china, crockery, ceramics<br>glass, bakelite<br>plastic disposables |
| | Ashes | Residue from incinerator | |
| | Special Wastes | Hazardous wastes; infectious, pathological | |

Hospitals are generating ever-increasing quantities of wastes. According to one expert in the field, hospital waste production has increased from an average of nine pounds per patient bed per day in 1955 to nineteen pounds in 1965.[8] This tremendous increase has been attributed to the widespread conversion to the use of disposable items. So important have the use of "throw-aways" become that a still sharper increase in development and use can be expected in the future. Disposables have also changed the composition as well as the volume of waste generated.[9] Incinerators designed ten years ago are no longer capable of efficiently burning the types of waste generated today. Most incinerators cannot produce the temperatures needed to completely consume the thermoplastic plastics which make up the bulk of the plastic disposables. Small quantities pose no real problem, especially when introduced into the incinerator with large quantities of other combustibles. In large quantities, however, plastic often melts, forming a molten mass which tends to solidify on incinerator grates. Temperatures between 1,500 and 2,000 degrees Fahrenheit are required to insure complete oxidation.[10]

Disposing of plastics by dumping is one possible solution, however, for health reasons, refuse collectors should not be expected to handle this raw waste untreated. One of the advantages of plastics is the fact that they are impervious to almost all chemical substances. This is, perhaps, a disadvantage as far as disposal by dumping is concerned since little decomposition takes place. No suitable solvent has been found for the thermoplastic plastics which is universal or economically acceptable.

Hospitals generally dispose of their solid wastes using one of four methods: (1) incinerating within the plant; (2) hauling or transporting; (3) compacting; and (4) pulping.[11]

In addition to the above, most hospitals are equipped with garbage grinders which are used within the food service department to dispose of garbage as a water suspension in the sewer system. As this study is solely concerned with the disposal of refuse other than that disposed of within the kitchen area, no further discussion of this method will be undertaken in this study.

Baling with the use of portable baling presses is another method used by industry to dispose of solid waste. According to a major manufacturer of portable baling presses, the pressure generated by the hydraulic ram would burst polyethylene bags and thereby present a possible source of contamination (see Appendix E). The use of balers in hospitals is questionable and no further discussion is indicated.

Removal of solid wastes from the hospital is by far the most expensive part of any waste management system. As most waste removal contracts are negotiated on a volume basis, maximum use of bulk reduction is of primary importance to the efficient system. Noncombustible rubbish (mainly tin cans and glass bottles) is often disposed of without prior bulk reduction. The addition of a can and bottle crusher to the waste disposal system can result in reduced hauling costs and increased storage space within the hospital refuse room.

In solving a waste disposal problem it is necessary to know both the characteristics of the waste to be disposed of and the various methods available to dispose of the wastes, especially the newer and more complex systems. Once one is aware of the problem and the various methods necessary to solve it, it is then possible to overcome the present problems. There is no one system which is best in all situations. The use of systems and cost/benefit analysis should be one of the ingredients in deciding the best system. It is, however, only one ingredient in the decision making process. The final decision must also take into consideration the various alternatives, with their advantages and disadvantages in terms of esthetics, engineering, economics of operation and pollution. The final system is derived from the integration and evaluation of all the above factors.

## Footnotes

[1]U.S., Department of Health, Education, and Welfare, Proceedings: The Third National Conference on Air Pollution, Dec. 12-14, 1965 (Washington, D.C.: Government Printing Office, 1967), p. 281.

[2]Ibid., p. 272.

[3]Committee on Pollution, National Academy of Sciences--National Research Council, Report to the Federal Council for Science and Technology, Waste Management and Control (Washington, D.C.: National Academy of Sciences--National Research Council), p. 176.

[4]Ibid., p. 3-5.

[5]James Falick, "Waste Handling in Hospitals," Architectural and Engineering News, VII (November, 1965), 46.

[6]American Public Works Association, Municipal Refuse Disposal (Danville, Ill.: Interstate Printers and Publishers, 1966), p. 76.

[7]Committee on Pollution, Waste Management and Control, p. 19.

[8]John A. Holbrook, "Disposables Require New Disposal Methods," Modern Hospital, CVII (July, 1966), 126.

[9]Falick, "Waste Handling in Hospitals," 46.

[10]Ibid., 51.

[11]Wayne M. Foltz, "Choosing an Efficient Waste Disposal System," Hospitals, XLIII (February 1, 1969), 67-68.

## CHAPTER II

## DISCUSSION

The problems of solid waste management at the 517-bed Research Hospital and Medical Center encompass both the collection and disposal activities. As this assignment is concerned with the disposal aspect, it shall concentrate on this alone. The collecting, transporting, sorting and scheduling procedures are not reviewed in this study.

### The Present System

Direct observation revealed the present solid waste disposal system to be severely overtaxed to handle the volume of solid waste generated each day.

All solid waste generated in the hospital and student nurses residence is brought to the charge room on "B" level, two floors below ground level. Waste is collected using sixteen bushel capacity Rubbermaid refuse carts. These carts are stored, fully loaded, in the charge room prior to sorting and incinerating. The volume of waste and the number of carts filled each day causes severe overcrowding in the charge room. This problem is so serious that it was found practically impossible to move freely throughout the room.

A minor fire occurred in the charge room in early

March, 1969. As a result the hospital requested and obtained approval from Mr. Walter H. Franke, Chief of Technical Field Services, Air Pollution Control, Kansas City, Missouri, to carry out burning during and after the regulation six hour operating period. Although the hospital is presently burning during the daytime and early evening the incinerator is still overtaxed. Smoke, fly ash and odor are still a daily occurrance.

The incinerator is cleaned then preheated each morning, Monday to Friday, prior to charging at 10:00 A.M. At that time the incinerator is manually charged with combustible waste. Waste is then burned continuously until early evening.

Attempts are made to sort noncombustible waste from that burned, however, large amounts of metal and glass are introduced into the incinerator with the combustible waste. This results in added weight to the ash residue and makes proper cleaning of the grates difficult.

Noncombustible waste, sorted from the combustible refuse is placed into 2 two-cubic-yard dumpsters in the charge room. These dumpsters are filled and removed to the loading dock for pick-up three times a week. The dumpsters are not properly cleaned by the contractor and continually present an odor problem. Some method of replacing these dumpsters would be desirable.

A check was carried out on the incinerator to determine the degree of pollution output. The incinerator was cleaned then preheated for thirty minutes. It was then charged with two refuse carts (thirty-two bushels) of general hospital combustible waste. No air pollution was discernible. A further check was carried out after the incinerator had been operating for a period of three hours. From a vantage point approximately fifteen feet from the stack, an emission of fly ash was noticed shortly after charging. This was followed by intermittent discharges of dark smoke. Identical results were observed on three other occasions. It is concluded, therefore, that increased air pollution occurs as the quantity of ash residue in the burning chamber of the incinerator increases.

Pathological waste is disposed of in the incinerator with the normal combustible refuse. It is, however, introduced into the incinerator through a separate charging chute which brings it into direct contact with the gas flame. The combination of the heat generated by the burning refuse and that produced by the primary burner is used to oxidize the pathological waste.

Biological waste is sterilized prior to transportation to the charge room. It is then incinerated along with the general combustible refuse.

Waste Generation

In order to determine the best method of solid waste disposal for Research Hospital and Medical Center, it was considered necessary to obtain basic data as to the types, volume and weights of waste generated. This data would then form the basic inputs leading to the eventual solution to the problem.

Random inspection of the solid waste collected (see Appendix F) indicated that the hospital is principally generating Type 0 waste as described in Appendix B. Type 4 or pathological waste is also generated, however, the total amount is considered minute compared to the overall volume of refuse.

Data obtained through direct observation indicated that an average of 53.3 sixteen-bushel carts of solid waste is collected and brought to the charge room daily (see Table 2). This is equivalent to approximately 1070 cubic feet of solid waste.

The noncombustible waste sorted from the combustible refuse amounts to approximately 5 per cent (54 cubic feet) of the total refuse collected daily. This was determined by the fact that 2 two-cubic-yard (54 cubic feet) dumpsters are filled every two days and removed by local contractor.

Difficulty was experienced in obtaining accurate data on the weight of refuse generated. Due to the limited time available and the distance from the charge room to the scales, it was not possible to obtain a statistically significant sample of combustible and noncombustible waste. A limited number of carts were weighed with the resultant average computed weight of 4.96 pounds per square foot for combustible waste and 9.1 pounds per square foot for non-combustible refuse. This data, due to the limited sample, cannot be construed as being more than indicative. These weights do, however, compare favorably with those weights noted in the literature.[1] For the purposes of this study the weights used for combustible and noncombustible waste shall be 5 pounds per square foot and 9 pounds per square foot respectively.

TABLE 2

REFUSE GENERATION DURING A 24-HOUR PERIOD
FOR RESEARCH HOSPITAL AND MEDICAL CENTER

| Period | No. of Carts[a] | No. of Bushels | Cubic Feet[b] |
|---|---|---|---|
| First day | 56 | 896 | 1120 |
| Second day | 59 | 944 | 1180 |
| Third day | 55 | 880 | 1100 |
| Fourth day | 58 | 928 | 1160 |
| Fifth day | 52 | 832 | 1040 |
| Sixth day | 48 | 768 | 960 |
| Seventh day | 54 | 864 | 1080 |
| Eighth day | 51 | 816 | 1020 |
| Ninth day | 52 | 832 | 1040 |
| Tenth day | 48 | 768 | 960 |
| Total | 533 | 8528 | 10660 |
| Average | 53.3 | 852.8 | 1066.0 |

[a]Rubbermaid Truck Number 3685, 16-bushel capacity
[b]Bushel (U.S. Standard) = 1.25 cubic feet

Using the above data it is possible to determine the average daily generation of hospital solid wastes on both a volume and weight basis. Two units of measurement are commonly used for computing hospital waste generation: (1) the number of patients assuming a 100 per cent occupancy rate; and (2) the average equivalent population (per capita basis). The first measurement is more commonly used whereas the second, or per capita method, is considered more accurate, especially for planning purposes. The per capita measurement is secured by using an assumed "equivalent population," computed from the total of patients, plus staff members in full-time residence, plus the balance of the total number of employees times the assumed factor of 5/21. This factor is derived by considering the length of the average hospital employee's work week. The factor is based on the percentage of hours of this work week to the total hours in a seven day week, i.e., 40/7 x 24 = 5/21. Another approach is based on the number of meals taken on the premises by such employees. Assuming this is one each day, it would mean a factor of 1/3 x 5/7 or 5/21, on a weekly basis.[2] The assumed "equivalent population" for Research Hospital and Medical Center was computed to be:[3]

Number of hospital beds: 517
Number of employees in full-time residence: 43
Total number of employees less those in full-time residence: 1500

$$517 + 43 + (1500 \times 5/21) = \underline{917}$$ (see Table 3)

TABLE 3

DAILY AVERAGE PRODUCTION OF HOSPITAL WASTES
FOR RESEARCH HOSPITAL AND MEDICAL CENTER

| Waste Class | Average Weight per Capita[a] (lbs/day) | Average Volume per Capita[a] (cu ft/day) | Average Weight per Patient (lbs/day) | Average Volume per Patient (cu ft/day) |
|---|---|---|---|---|
| Noncombustibles[b] | 0.53 | 0.06 | 0.93 | 0.10 |
| Combustibles[c] | 5.52 | 1.10 | 9.79 | 1.95 |
| Pathological | | | 0.14[d] | |
| Total | 6.05 | 1.16 | 10.86 | 2.05 |

[a]Average equivalent population (per capita basis)
[b]Computed at 9.0 lbs/sq ft
[c]Computed at 5.0 lbs/sq ft
[d]see Footnote 1

By multiplying the total average weight of waste generated per capita per day times the equivalent population, it was determined that the hospital generates approximately 5,550 pounds of solid waste per day. On an average weight per patient bed basis the solid waste generation rate would amount to approximately 5,615 pounds Since these figures are relatively close, it is assumed that the solid waste generation rate at the present time is slightly less than 3 tons per day. This is considered normal since the weights of the garbage disposed of within the food services department and the ashes resulting from incineration were not included.

Observations and Comments

The regulation limiting incineration to six hours a day is included in most air pollution codes and is the maximum operating time recommended for hospitals by the Incinerator Institute of America.[4] This allows for proper cooling of the unit prior to ash removal and cleaning each day. The hospital's request to burn in excess of the six hour period was instituted to reduce the possibility of another fire in the charge room due to the build-up of refuse. By doing so, the hospital may have created another fire hazard by having to remove hot ashes from the incinerator.

Any future solid waste disposal method at Research Hospital and Medical Center should incorporate some method of reducing the bulk of noncombustibles generated. One of the best methods available at the present time is through the use of a crusher-destroyer unit. Most noncombustible waste is bulky and requires valuable storage space. In addition it increases hauling costs in many instances. Reducing the bulk of solid waste should be an essential part of any solid waste disposal system.

A unit which meets the requirements of the hospital is the Rescor Industries Model 2500-A Crusher-Destroyer. Noncombustible waste is placed into a hopper and is automatically fed into a high speed, chain actuated conveyor which forces the waste into contact with a heavy duty crusher plate. The waste is then crushed into a portion of its original size. The unit is capable of handling all sizes of cans and bottles including five gallon jugs.

The advantages of a crusher-destroyer unit are:

1. The unit is able to crush tin cans, bottles, jars, jugs and aerosols.

2. Original bulk is reduced by about 80 to 90 per cent.

3. The unit reduces hauling costs by reducing the bulk of waste to be carted away.

4. It increases valuable storage space in the charge room.

5. Improved sanitary conditions result.

The disadvantages of the unit are:

1. The unit is noisy while operating.

2. The unit should be cleaned daily by use of a hose to prevent odor formation.

3. It requires regular preventive maintenance.

The present system at the hospital requires that the 2 two-cubic-yard dumpsters, when filled, be hauled from the charge room to the loading dock. This procedure is carried out three times a week. The dumpsters are emptied and returned to the charge room. It is estimated that this procedure requires two men a minimum of five hours per week. With the installation of a crusher unit it is estimated that this can be reduced so that one man, using a sixteen bushel refuse cart, would require only two hours per week to accomplish the same task. In addition, a sixteen-bushel refuse cart is easily cleaned whereas with the present method little or no cleaning of the dumpsters is carried out. The odor problem in the chute room could be substantially alleviated with regular cleaning of the non-combustible waste storage containers.

A cost/benefit analysis of the present system as opposed to the installation of a crusher unit would appear as follows:

Present system

2 men x 5 hrs/wk x $2.00/hr x 52 wks
x 1.25 (fringe factor)

2 x 5 x 2.00 x 52 x 1.25 = $1300.00

Proposed system

1 man x 2 hrs/wk x $2.00/hr x 52 wks
x 1.25 (fringe factor)

1 x 2 x 2.00 x 52 x 1.25 = 260.00

Labor saving per year: ($1300.00 - 260.00) $1040.00

| | |
|---|---|
| Capital cost (including installation[a]) | $3500.00 |
| Depreciation (15-year life) | 6-2/3 % |
| Maintenance | 4 % |
| Operating expense | 4-1/3 % |
| Interest on investment | 5 % |
| Total | 20 % |

Total yearly cost of crusher (20% of $3500) $ 700.00

Total yearly saving ($1040 - 700) $ 340.00

[a]Includes provision for water and drain connections.

Although the cost/benefit analysis indicates a saving of 340 dollars per year to the hospital by installation of a crusher unit, the main advantage lies in the fact that the 2 two-cubic-yard dumpsters would no longer be required. Removal of the odor problem and increased storage space in the charge room will result if a crusher unit is installed. The effects of any saving in hauling costs, if any, cannot be determined. The Rescor Industries Model 2500-A Crusher-Destroyer is capable of crushing approximately two tons of solid waste per hour. It is considered that this unit is of sufficient size to serve the needs of the hospital over the foreseeable future.

## The Alternatives

In order to determine the best method of solid waste disposal for Research Hospital and Medical Center, it is necessary to evaluate the present methods of waste disposal available. Four such methods--refuse transported or open hauling, incineration, the compactor/container unit and the pulping unit system--will be discussed as alternatives to the present system.

### Refuse Transported or Open Hauling (see Appendix C)

According to this method all hospital refuse, except pathological waste, is brought to a central location at or near the loading dock and transferred to a large container or dumpster. Since the hospital is presently generating slightly under forty cubic yards of refuse daily, a container equal to or greater than that cubage would be required. The maximum container size which the hospital could accept, without major building modifications, is forty-two cubic yards. With a forty-two cubic yard container, a minimum of six pickups would be required each week.

The present contractor, American Container Service Corporation, could provide a container and arrange for refuse removal as often as required. Cost for this service would be approximately fifty dollars a pickup. The present incinerator would be retained for destruction of pathological waste and for use in emergencies.

The advantages of this alternative are:

1. No capital outlay is required.

2. No unwanted heat source is produced.

3. Air pollution, including odor, is considerably reduced.

4. The system can handle all types of refuse except pathological waste.

4. No sorting of refuse is required.

5. No maintenance or operating costs are involved.

6. The present incinerator is retained to destroy pathological waste and can be placed into service if required in an emergency.

The disadvantages of this method are:

1. Infectious waste disposed of by this method may present a health hazard.

2. Waste does not undergo any form of bulk reduction, therefore, this method requires frequent pickup of waste which make hauling costs relatively high.

3. All refuse must be carted to the loading dock through busy hallways on "B" level of the hospital.

4. The dumpster, unless properly cleaned by the contractor, will present an odor problem.

5. Installation may require minor modifications to the building.

6. The container size will substantially reduce valuable loading dock space.

Cost analysis.--

| | |
|---|---|
| Capital investment | nil |
| Yearly cost: (one 42-cubic-yard container × 6 pickups per week × 52 weeks × $50.00 per pickup). | |
| 1 × 6 × 52 × $50.00 | $15,600.00 |

The yearly cost to the hospital if it were to adopt the transporting or open hauling method of waste disposal is estimated to be $15,600.00. This figure should be taken to be the minimum cost per year.

Incineration (see Appendix H)

To adopt this method of waste disposal the hospital would have to replace the present incinerator with a Class III Incinerator (see Appendix D) with a capacity of 1,200 to 1,500 pounds of combustible waste per hour. The unit would require a primary and secondary burner, and a wet scrubber with an induced draft fan, in order to reduce air contaminants to a minimum. A unit of this size would be able to dispose of the combustible waste presently generated within the six hour period as set forth in the Kanasa City, Missouri, Air Pollution Control Code.

A unit of this size with the equipment specified is estimated to cost $25,000. The installation would require enlarging the present incinerator room on "C" level. This, together with installation of an automated ash removal system, would cost approximately $15,000. Total capital investment is, therefore, estimated to be $40,000.

The advantages of this course of action are:

1. Up to 90 per cent of the combustible refuse, including pathological and infectious waste, is disposed of on site. Therefore, hauling costs are lower because wastes are reduced to the minimum possible bulk before having to be transported away.

2. There is no necessity to cart refuse long distances, through busy hallways to the loading dock.

3. There is little or no odor produced in the area

of the loading dock.

4. The container size required to hold the ashes and noncombustibe waste is much less than that required by other systems.

5. The incinerator and crusher unit are able to take all types of waste produced by the hospital and reduce it to its minimum bulk.

The disadvantages of this method are:

1. A relatively high capital outlay is required.

2. Radiant heat transfers from the incinerator to the charge room and surrounding areas.

3. Air pollution, although considerably reduced, may still occur.

4. Maintenance costs, although lower than the other systems, can still be quite high.

5. Major alterations to the building will be required in order to install a new, and larger, incinerator.

6. Noncombustible waste must be sorted from the combustible waste.

7. Operating costs are extremely high. Gas, water and electricity consumption is continuous during operation.

<u>Cost analysis.</u>--

Capital investment:

| | |
|---|---|
| Incinerator: | $25,000.00 |
| Installation and ash removal system: | 15,000.00 |

| | | |
|---|---|---|
| Total capital investment: | | $40,000.00 |
| Yearly cost: | | |
| Depreciation (15-year life) | 6-2/3% | |
| Maintenance | 3% | |
| Operating expense | 6-1/3% | |
| Interest on investment | 5% | |
| | 21% | |
| Total yearly cost of operating incinerator (21% of $40,000) | | $ 8,400.00 |
| Add hauling costs ($140 per month x 12 months) | | 1,680.00 |
| Total yearly cost: | | $10,080.00 |

The minimum yearly cost to the hospital, if it were to replace the present incinerator with a new and larger model, is estimated to be $10,080.00.

<u>Compactor/Container Unit (see Appendix I)</u>

Using this method all hospital refuse, except pathological waste, is brought to a central location at or near the loading dock. The loose refuse is dumped into a large compactor unit and mechanically forced into an attached container. A minimum compaction ratio for this type of unit is estimated at three to one.

At the present rate of waste generation it is estimated that a minimum of ten pickups a month would be required if a forty-two cubic yard container is used. This means an average of two and one-half pickups per week.

Installation of a compactor/container unit of this size would require modification to the present building in order to fit the unit into the loading dock space. The use of a smaller size container is not considered because of the increased number of pickups required and the cost of hauling. Cost of building modifications are estimated at five thousand dollars. This cost could be amortized over a period of ten years.

The hospital has two possible courses of action if it were to adopt this system of waste disposal. The complete unit can be purchased and a contract entered into for hauling the refuse, or the unit can be rented from the hauling contractor with the contractor providing both the equipment and hauling services. The cost of a compactor/container, if purchased by the hospital, is estimated to be nine thousand dollars. Rental charges would amount to approximately 135 dollars a month. Cost of each pickup is estimated to be fifty dollars. The present incinerator would be retained for destruction of pathological waste and can be placed into full-time service if required.

The advantages of this course of action are:

1. Bulk reduction ratios of between three and six to one are obtainable. As a result, hauling costs are less than the open hauling method of waste removal.

2. No capital outlay is required if the complete unit is rented from the contractor.

3. No unwanted heat source is produced.

4. No sorting of refuse is required.

5. No maintenance costs occur if the unit is rented.

6. Operating costs are relatively low.

7. Air pollution is considerably reduced.

8. The present incinerator is retained to destroy pathological waste and can be placed into full-time service in an emergency.

The disadvantages of the method are:

1. Infectious waste disposed of may present a health hazard.

2. Refuse must be carted through busy hallways to the loading dock.

3. The container, unless properly cleaned by the contractor, will present an odor problem.

4. Installation will require major alterations to the building.

5. The size of the unit substantially reduces valuable space at the loading dock.

6. A relatively high capital investment is required if the unit is purchased.

Cost analysis.--

A. Unit rented:

| | |
|---|---|
| Capital investment: | nil |
| Building modification | $5,000.00 |

Yearly cost:

| | |
|---|---|
| Building modifications amortized over 10 years | $ 500.00 |
| Rental of compactor/container ($135 per month x 12 months) | 1,620.00 |
| Hauling costs (2.5 per week x 52 weeks x $50 per pickup | 6,250.00 |
| Total yearly cost to rent: | $8,370.00 |

B. Owned:

| | |
|---|---|
| Capital investment: | $9,000.00 |
| Building modificatios | 5,000.00 |

Yearly cost:

| | |
|---|---|
| Building modifications amortized over 10 years | $ 500.00 |

| | |
|---|---|
| Depreciation (10-year life) | 10% |
| Maintenance | 3% |
| Operating expense | 2% |
| Interest on investment | 5% |
| Total | 20% |

| | |
|---|---|
| Total yearly cost of owning compactor/container unit (20% of $9,000) | 1,800.00 |
| Hauling costs (2.5 per week x 52 weeks x $50 per pickup) | 6,250.00 |
| Total yearly cost | $8,550.00 |

On the basis of the above costs it would appear that the rental of a compactor/container unit would be more economical, however, rental charges can be expected to rise in the future during contract renegotiations. All factors must be weighed before deciding on renting or buying. Not allowed for in this study is the resale or scrap value of the equipment.

The Pulping Unit (see Appendix J)

Using this system a pulping unit would be installed in the charge room. The extractor unit would be installed at the loading dock and connected to the pulper by pipes running along the false floor between "A" and "B" levels.

The present system of hauling refuse the shorter distance to the charge room would be retained. There the refuse would be sorted with the nonpulpable waste being placed into the crusher unit. The pulpable refuse would then be placed into the pulping unit where it would be mixed with water and ground into a slurry before moving by pipe to the water extractor at the loading dock.

At the present rate of waste generation it is estimated that a fifteen cubic yard container would be required to maintain the present three pickups per week.

Capital investment, including installation of a 1,000 pound per hour pulper/extractor unit, is estimated at $30,000. This size unit is considered to be the maximum size unit required to economically dispose of the present waste output without increasing the number of waste handlers.

Cost of slurry removal, including rental of a fifteen cubic yard container, is estimated at $200.00 per month.

The present incinerator would be maintained for destruction of pathological waste and can be placed into full-time service in an emergency.

The advantages of this method are:

1. There is an 80 to 90 per cent reduction in refuse bulk, therefore, hauling costs are lower as waste is greatly reduced in bulk.

2. No unwanted heat source is produced.

3. Air pollution is considerably reduced.

4. There is no necessity to cart refuse long distances, through busy hallways, to the loading dock.

5. The possibility of an odor problem is considerably reduced.

6. Only minor alterations to the building are required during installation.

7. The container size at the loading dock is relatively small allowing more use of valuable space at that location.

8. The present incinerator is retained to destroy pathological waste and for use in emergencies.

The disadvantages of this system are:

1. The initial capital investment is relatively high.

2. Maintenance costs are higher than any of the other systems discussed.

3. Infectious wastes passed through the system may present a health hazard.

4. Refuse that cannot be pulped must be sorted from the pulpable waste.

Cost analysis.--

| | | |
|---|---|---|
| Capital investment (including installation) | | $30,000.00 |
| Yearly cost: | | |
| Depreciation (15-year life) | 6-2/3% | |
| Maintenance | 4% | |
| Operating expense | 4-1/3% | |
| Interest on investment | 5% | |
| | 20% | |
| Yearly cost of pulper unit (20% of $30,000) | | $ 6,000.00 |
| Add hauling costs ($200 per month x 12 months) | | 2,400.00 |
| Total yearly cost: | | $ 8,400.00 |

The minimum yearly cost to the hospital if it were to replace the present system with a pulping unit is estimated at $8,400.00.

## Summary

The study of any solid waste disposal system requires three important requisites: (1) basic data as to types, volumes and weights of waste generated; (2) a working knowledge of the disposal systems available on the market; and (3) investigation of any social legislation or other local factor which may place limitations on the use of one or more systems.

A good waste disposal system should consider bulk reduction; yet one of the most common methods of waste disposal is to have the bulk waste carried away by a contractor without undergoing any prior bulk reduction.

Hauling costs are normally determined by volume rather than weight. Uncondensed waste with empty boxes, tin cans and corrugated containers mixed with other waste products produces the most voluminous and, therefore, the most expensive waste to haul away. Transporting or open hauling of refuse is the most expensive method of waste disposal discussed.

Incineration is widely used to dispose of hospital waste and is the best method available for reducing waste bulk. Unfortunately, in this case the present incinerator operates at overcapacity most of the time and, in addition, does not meet present air pollution regulations. The cost of rebuilding or replacing the present incinerator to meet the present laws makes the choice of this method of waste disposal uneconomical.

Compaction is one of the most popular methods of waste disposal used in hospitals today. The major advantage in compacting waste is economy of operation. Also, if the unit is rented from the contractor, the hospital is freed of any maintenance and repair expense. The unit does, however, require considerable space and in this case modification to the building would be required in order to install the unit size required to handle the volume of waste economically.

Pulping is the newest method of waste disposal to enter the hospital field. The process reduces air pollution and squeezes refuse to one-fifth its original bulk. Cleaner and more odor-free operation are significant characteristics because waste is washed and aerated. The major disadvantage is the original capital investment required.

Footnotes

[1] Incinerator Institute of America, I.I.A. Incinerator Standards (New York: Incinerator Institute of America, 1968), p. 1968-4A; Committee on Hospital Facilities Engineering and Sanitation Section, "Hospital Solid Wastes and Their Handling," American Journal of Public Health, XLVI (March, 1956), 361.

[2] Committee on Hospital Facilities, Engineering and Sanitation Section, "Hospital Solid Wastes and Their Handling," American Journal of Public Health, XLVI (March, 1956), 361.

[3] Computed on the following basis: 517 patient beds, 43 in student nurses residence and 1500 full-time employees.

[4] Incinerator Institute of America, I.I.A. Incinerator Standards, p. 1968-4A.

[5] Ibid.

## CHAPTER III

## CONCLUSIONS AND RECOMMENDATIONS

Although cost is an important factor in selecting the best method of solid waste disposal for Research Hospital and Medical Center, freedom from health hazards, safety of operation and esthetic qualities rate higher in the final selection of the disposal method.

### Conclusions

1. The best method of solid waste disposal for Research Hospital and Medical Center is:

a. The installation of a pulping unit for disposal of pulpable waste.

b. The installation of a crusher-destroyer unit for bulk reduction of nonpulpable waste.

c. The retention of the present incinerator for disposal of pathological waste and for use in emergencies.

2. The adoption of the above method meets the present and any expected future Kanasa City, Missouri, Air Pollution Code.

3. The system is easily capable of handling all types of waste generated by the hospital.

4. The system can be expanded as needed in the future.

5. The pulped waste, being in a closed system from the charge room to the loading dock, is free of any health hazards.

6. The system should alleviate the overcrowded conditions in the charge room.

7. The present odor and heat problems in the charge room should be substantially reduced.

8. The system, although only semi-automated, lends itself to further automation in the future.

9. The system can be considered equally economical in operation as compaction and more economical than the other systems available on the market.

## Recommendations

Based on the preceding conclusions it is recommended that:

1. The hospital take immediate action to procure and install:

a. A pulping unit with a rating of 1,000 pounds per hour (SOMAT Model SSP-60B-JE, or equivalent).

b. A hydra-extractor with a rating of 1,000 pounds per hour (SOMAT Model CS-9-C or equivalent).

c. A crusher-destroyer unit (Rescor Industries Model 2500-A or equivalent).

2. Further studies be carried out to examine the processes of collecting, transporting, sorting and scheduling operations with a view towards increased automation.

3. Authority be requested from the Chief of Technical Field Services, Air Pollution Control, Kanasa City, Missouri, for the continued use of the present incinerator for the destruction of biological wastes. The burning of this waste would be carried out only after the incinerator had been properly cleaned, preheated and charged with combustible waste.

4. A contract be renegotiated with the present contractor, American Container Service Corporation, to remove the three 2-cubic-yard dumpsters presently in use and to replace these with one 15-cubic yard container.

# APPENDIX A

## SECOND COMMITTEE SUBSTITUTE FOR ORDINANCE NO. 34696

SECOND COMMITTEE SUBSTITUTE FOR ORDINANCE NO. 34696

AN ORDINANCE

AMENDING CHAPTER 18 OF THE GENERAL ORDINANCES OF KANSAS CITY, MISSOURI ENTITLED "HEALTH AND SANITATION", BY REPEALING SECTIONS 18.82 THROUGH AND INCLUSIVE OF 18.97 THEREOF AND ENACTING IN LIEU THEREOF NEW SECTIONS NUMBERED 28.82 THROUGH AND INCLUSIVE OF 28.98 OF LIKE SUBJECT MATTER.

BE IT ORDAINED BY THE COUNCIL OF KANSAS CITY:

ARTICLE III

Air Pollution

Section 28.82. Short Title--This article shall be known and may be cited as the Air Pollution Control Code.

Section 18.89. Incinerators. -

A. General provisions.

1. This regulation shall apply to all incinerators.

2. The amount of particulate matter emitted from any incinerator shall be determined according to the ASME Power Test Codes-PTC-27, dated 1957, and entitled "Determining Dust Concentration in a Gas Stream." In calculating the amount of particulate matter in a stack gas the loading shall be adjusted to 12 per cent carbon dioxide in the stack gas. Emissions shall be measured when the incinerator is operating at its maximum capacity or at any other burning rate during which emission of particulate matter is greater.

3. No person shall cause or permit the burning of refuse in any installation which is not designed for that purpose.

B. Restriction of Emissions of Particulate Matter from Incinerators.

1. No person shall cause or permit the emission of particulate matter from the stack or chiminey of any incineerator:

(a) In excess of 0.2 grains of particulate matter per standard dry cubic foot of exhaust gas.

(b) Greater than 60 microns in diameter; or

(c) Of a shade equal to or darker than that designated as No. 1 on the Ringelmann Chart, or of such opacity as to obscure an observers view to a degree equal to or greater than that designated as No.1 on the Ringelmann Chart.

A person may discharge into the atmosphere from any single source of emission for such reasonable periods of time as the Director may find to be required by the nature of the operations, air contaminants:

(1) Of a shade or density not darker than No. 3 on the Ringelmann Chart; or

(2) Of such opacity as to obscure an observer's view to a degree not greater than that designated as No. 3 on the Ringelmann Chart.

2. No incinerator shall be used for the burning of refuse unless such incinerator is a multiple chamber incinerator. Existing incinerators which are not multiple chamber incinerators may be altered, modified or rebuilt as may be necessary to meet this regulation. The Director may approve any other alteration or modification to an existing incinerator if such be found by him to be equally effective for the purpose of air pollution control as a modification or alteration which would result in a multiple chamber incinerator. All new incinerators shall be multiple chamber incinerators, provided that the director may approve any other kind of incinerator if he finds in advance of construction or installation that such other kind of incinerator is equally effective for purposes of air pollution control as an approved multiple chamber incinerator.

Existing incinerators which are not multiple chamber incinerators and do not otherwise meet the requirements of sub-section 1 of this provision shall be modified or rebuilt in compliance with this section in accordance with the following schedule:

| Rated Capacity | Latest Date for Compliance |
|---|---|
| 1,000#/hr or above | 12 months from effective date of regulation |
| 999#/hr or less | 18 months from effective date of regulation |

C. Permitted Hours of Operation. No person shall operate or cause or permit the operation of any incinerator at any time other than between the hours of 10:00 a.m. and 4:00 p.m. This restriction shall not apply to incinerators having a refuse burning capacity of one ton per hour or more.

# APPENDIX B

# CLASSIFICATION OF WASTES

## CLASSIFICATION OF WASTES

The types of hospital waste as described in this study shall be as defined by the Incinerator Institute of America. These definitions are commonly accepted throughout industry and are as follows:

_Type 0_--Trash, a mixture of highly combustible waste such as paper, cardboard, cartons, wood boxes, and combustible floor sweepings, from commercial and industrial activities. The mixtures contain up to 10% by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags and plastic or rubber scraps. This type of waste contains 10% moisture and 5% incombustible solids.

_Type_ 1--Rubbish, a mixture of combustible waste such as paper, cardboard cartons, wood scrap, foliage and combustible floor sweepings, from domestic, commercial and industrial activities. The mixture contains up to 20% by weight of restaurant or cafeteria waste, but contains little or no treated papers, plastic or rubber waste. This type of waste contains 25% moisture and 10% incombustible solids.

_Type_ 2--Refuse consisting of an approximately even mixture of rubbish and garbage by weight. This type of waste is common to apartment and residency occupancy, consisting of up to 50% moisture and 7% incombustible solids.

_Type_ 3--Garbage, consisting of animal and vegetable wastes from restaurants, cafeterias, hotels, hospitals, markets, and like installations. This type of waste contains up to 70% moisture and 5% incombustible solids.

_Type_ 4--Human and animal remains, consisting of carcasses, organs, and solid organic wastes from hospitals, laboratories, abattoirs, animal pounds, and similar sources, consisting of up to 85% moisture and 5% incombustible solids.

_Type_ 5--By-product waste, gaseous, liquid or semi-liquid, such as tar, paints, solvents, sludge, fumes, etc., from industrial operations.

_Type 6_--Solid by-product waste, such as rubber, plastics, wood waste, etc., from industrial operations.

APPENDIX C

LETTER FROM INCINERATOR MANUFACTURER

PLIBRICO COMPANY

PLIBRICO COMPANY • Refractory Engineers •

REFRACTORIES INCINERATORS ENGINEERING CONSTRUCTION

1800 N. Kingsbury Street • Chicago, Illinois 60614 • Phone: 312/549-7014 • TWX: 312/222-0689

March 13, 1969

Captain W. Cooper
721 Imlay St.
San Antonio, Texas 78209

RE: Incinerator for
Research Hospital
Kansas City, Mo.

Gentlemen:

This will acknowledge your letter of March 5th in which you request complete information on the incinerator installed for subject hospital.

We are in position to supply you with some of the information requested, but we are not in possession of all that is wanted because even though the engineering for the project was done by the Plibrico Company, in Chicago the actual installation and discussions with the architect were handled by our distributor in the Kansas City area. Our distributor is Plibrico Sales & Service Co., Div. of The Ferris Kimball's, 716 N. 6th St., Kansas City, Kansas 66101. We are mentioning this, so that if there is some information needed which we cannot supply you can contact Mr. Kimball who will be glad to cooperate if it is within his power.

We must also advise, the installation was made approximately 10 years ago and in order to supply you with somewhat meaningful answers we are going to have to take some liberties with todays incinerator classes and waste types.

The incinerator as installed was designed to burn 880 lbs. per hr. of dry waste and 220 lbs. per hr. of Pathological type waste with the Pathological waste being consumed only when dry waste was being burned. The dry waste at that time was rated at 6000 BTU's per pound whereas todays Type I Waste which would be most similar is rated at 6500 lbs. BTU's. Pathological waste is now termed Type IV waste so that the closest classification possible for the incinerator would be a combination of Class III and Class VI.

We no longer have a copy of the specifications and if any are available they would have to be obtained from Mr. Kimball or from the architect handling the project which is the firm of Gentry & Voskamp located in Kansas City. Operating instructions would have to be obtained from the job site unless Mr. Kimball happened to retain an extra set.

The gas burner has a minimum capacity of 800,000 BTU's per hr. and a maximum capacity of 1,200,000 BTU's per hr. and its present adjustment would be someplace between the two limits.

We doubt very much whether it is economically feasible to try to upgrade the present incinerator so that it will meet the present Air Pollution Control Code without the use of a gas washer or scrubber.

We feel, that if sufficient space is available adjacent to the incinerator that there is no reason a scrubber or gas washer cannot be installed in conjunction with the present incinerator so as to enable present emission limits to be met.

As a matter of fact, we feel sure, Mr. Kimball has been contacted by the Hospital to offer recommendations along these lines.

The maximum temperature in the incinerator is of course dependent on the amount of waste charged over a given period of time, but the design factors for the incinerator were based on a 1400°F temperature. There is no incinerator which is designed specifically for hospital only use, but rather the type of waste involved determines the proper unit. Several years ago the moisture content in hospital waste was considerably higher than it is today, and nowadays the majority of hospitals require a Type I Waste Incinerator or even a Type 0 Waste unit. Some of the incinerators incorporate a hot hearth to consume Pathological Waste such as is incorporated in the unit for Research Hospital, but in an increasing number of cases the hospital is installing a second unit designed solely for the pathological waste. This permits better efficiency of combustion. We are enclosing a copy of our general incinerator catalogue, and this will indicate the various designs which are available when hospital conditions so indicate.

All of the larger incinerators are erected at the job site, so there is normally not too much of a problem in this respect, and even if a so called portable incinerator is involved, this incinerator can be supplied on a knock down basis, so that the incinerator is assembled and lined at the job site. Therefore, in virtually any circumstances it is possible to install a new incinerator in an existing building.

It is of course impossible to supply you with pricing information on all capacities of incinerators, but using the 1100#/hr. capacity such as is involved with Research Hospital, an installation today incorporating an Incinerator Institute of America design and including a gas scrubber, induced draft fan, burners, controls, and necessary piping and wiring would cost in the $25,000.00 to $30,000.00 price range. The particular Air Pollution Control Code involved would of course dictate the sophistication necessary in the scrubber and the above figures an average emission limit.

We trust the above and enclosures will be of some help to you and we wish you every success with your thesis.

Yours very truly,

PLIBRICO COMPANY

K. W. Knoelk, Manager
Incinerator Division

KWK:ms

cc: Ferris Kimball - Kansas City, Kansas

APPENDIX D

CLASSIFICATION OF INCINERATORS

INCINERATOR INSTITUTE OF AMERICA

CLASSIFICATION OF INCINERATORS

The classes of incinerators as described in this study shall be those defined by the Incinerator Institute of America.

Class I--Portable, packaged, completely assembled, direct fed incinerators, having not over 5 cu. ft. storage capacity, or 25 lbs. per hour burning rate, suitable for Type 2 Waste.

Class IA--Portable, packaged or job assembled, direct fed incinerators 5 cu. ft. to 15 cu. ft. primary chamber volume; or a burning rate of 25 lbs. per hour up to, but not including 100 lbs. per hour of Type 0, Type 1, or Type 2 Waste; or a burning rate of 25 lbs. per hour up to, but not including, 75 lbs. per hour of Type 3 Waste.

Class II--Flue-fed, single chamber incinerators with more than 2 sq. ft. burning area, for Type 2 Waste. This type of incinerator is served by one vertical flue functioning both as a chute for charging waste and to carry the products of combustion to atmosphere. This type of incinerator has been installed in apartment houses or multiple dwellings.

Class IIA--Chute-fed multiple chamber incinerators, for apartment buildings, with more than 2 sq. ft. burning area, suitable for Type 1 or Type 2 Waste. (Not recommended for industrial installations.) This type of incinerator is served by a vertical chute for charging wastes from two or more floors above the incinerator and a separate flue for carrying the products of combustion to the atmosphere.

Class III--Direct fed incinerators with a burning rate of 100 lbs. per hour and over, suitable for Type 0, Type 1 or Type 2 Waste.

Class IV--Direct fed incinerators with a burning rate of 75 pounds per hour or over, suitable for Type 3 Waste.

Class V--Municipal incinerators suitable for Type 0, Type 1, Type 2, or Type 3 Wastes, or a combination of all four wastes, and are rated in tons per hour or tons per 24 hours.

Class VI--Crematory and pathological incinerators, suitable for Type 4 Waste.

# APPENDIX E

## LETTER FROM MANUFACTURER OF PORTABLE BALERS

## MAREN ENGINEERING CORPORATION

TELEPHONE 312 - 333-6250

MAREN ENGINEERING CORPORATION

P. O. BOX 143 • 16246 SCHOOL STREET • SOUTH HOLLAND, ILLINOIS 60473



March 20, 1969

Captain W. Cooper
721 Imlay Street
San Antonio, Texas 78209

Dear Captain Cooper:

We have received your letter relative to the request for information on portable baling presses in relation to their application for waste disposal.

At this time we are pleased to send through for your information, literature on the Maren 30, 42, 30-S and 42-S portable baling presses. You will note that these units are all steel welded construction and while they are truly portable, they are of some substance and weight. The pressure generated in these units is 10,000 lbs. of thrust and the pressure per square inch on the platen surface is approximately 17 lbs. per square inch.

We have had some interest evidenced to us by people in your field. However, todate it has been brought to our attention that most of these materials are collected in polyethelene bags and at that point, if they were placed in a baling press under compression, the polyethelene bag would literally burst and the materials, while they are definitely able to be compressed, would be a source of possible contamination.

It is apparent to us that no one has been able to say that a certain category of materials can be collected in a hospital and baled and disposed, without fear of contamination.

It is our thought that these materials could be handled in a portable baler and then the bales, as they are ejected, could be placed in polyethelene bags, wrapped, and then taken to a large municipal incinerator or land fill area.

The bales manufactured in this unit would be 30" x 30" x 20" or 42" x 30" x 20". These bales would, therefore, aggregate 10.5 or 14.5 cubic feet. The size of these bales would lend themselves to adequate protective covering.

Captain W. Cooper
721 Imlay Street
San Antonio, Texas

March 20, 1969



The reduction achieved in this type of material would average approximately 10 to 1 and the resultant cost reduction in handling of the baled materials would more than offset initial investment for the portable baling presses. Our experience has been that the reduction of the bulk of the materials at the source where they are generated is, at this time, the most economical means to follow.

We trust these observations will be of some assistance to you. If you have any further questions or feel that we can assist you in any way further, please don't hesitate to call on us.

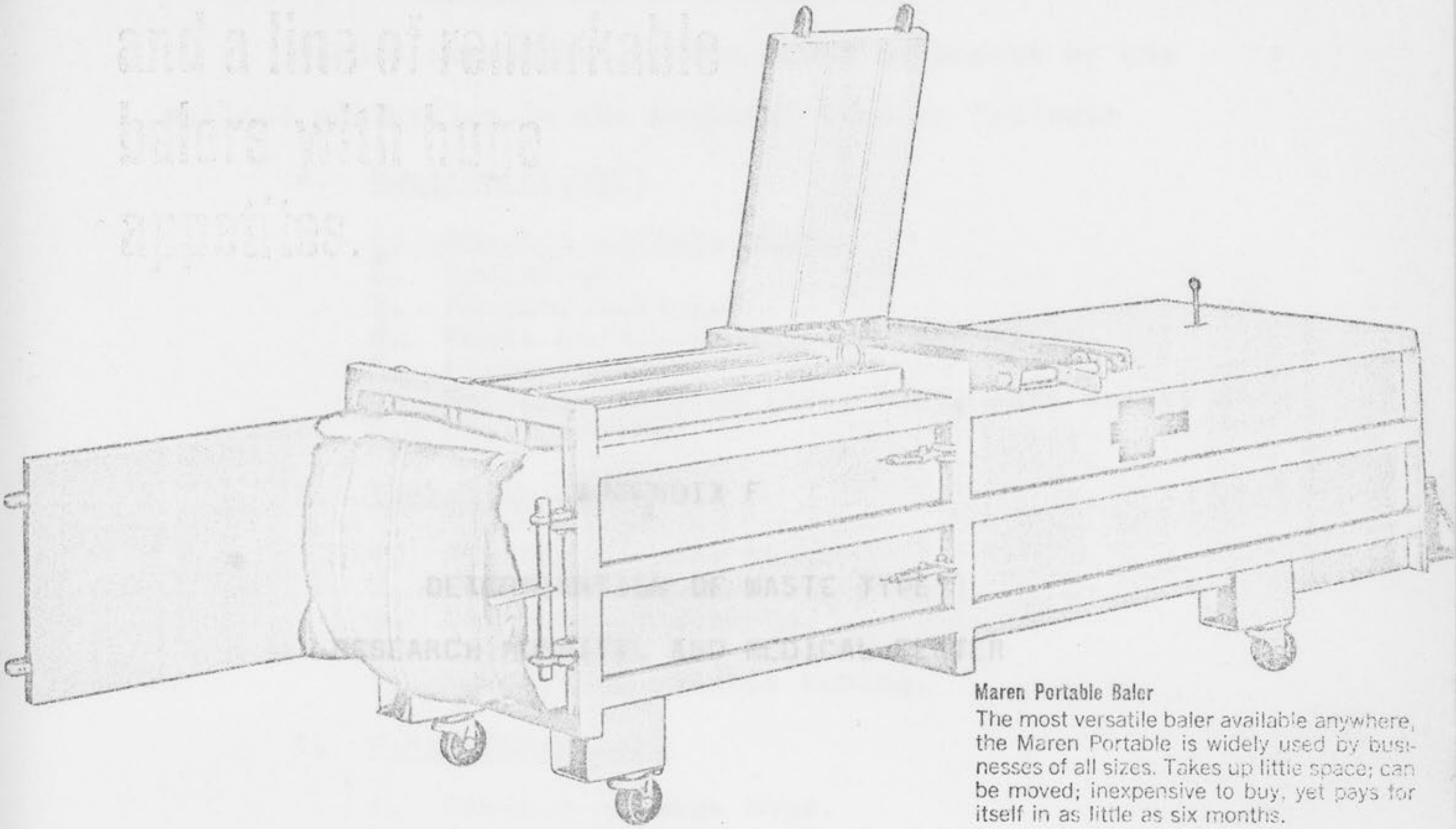
Cordially,

MAREN ENGINEERING CORPORATION

Andrew J. Pasztor

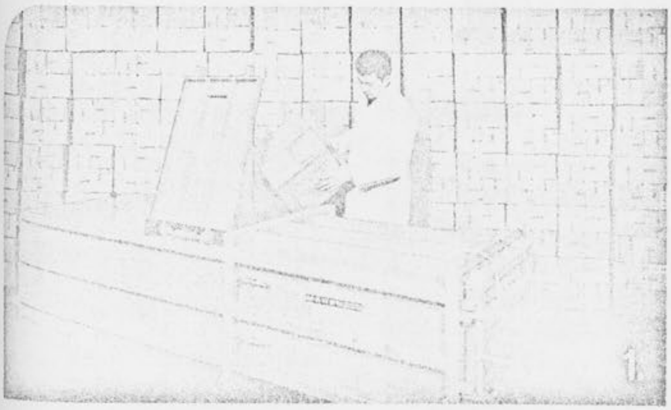
AJP/je
Enclosures

# They were assisted by MAREN ENGINEERING CORPORATION and a line of remarkable balers with huge appetites.



**Maren Portable Baler**

The most versatile baler available anywhere, the Maren Portable is widely used by businesses of all sizes. Takes up little space; can be moved; inexpensive to buy, yet pays for itself in as little as six months.



## Here's the way it goes...

In an actual demonstration, 99 corrugated boxes measuring 14"x14"x12" each, and occupying 132 cubic feet of space, are to be fed into a Maren Portable Baler.

After the hopper is filled, the spring-balanced lid is closed, and the hydraulically operated ram is set in motion by the operator, completing a compressive cycle every 15 seconds.

In short order, all 99 boxes have been crushed into a compact bale which is then speedily twine-tied by the operator in a semi-automatic procedure. Bale is pushed out by pressure of next bale being formed.

Now one bale contains all 99 boxes, weighs 131 pounds, measures 30" wide by 20" high by 42" long, or 15 cubic feet; just one *ninth* the original volume.

# APPENDIX F

## DETERMINATION OF WASTE TYPE

## RESEARCH HOSPITAL AND MEDICAL CENTER

## DETERMINATION OF WASTE TYPE

Random inspection of the waste generated by the various activities in the Hospital were as follows:

A. <u>Nursing Floors</u>

1. Plastic garbage bags.
2. Dressings.
3. Plastic tubing.
4. Waste paper, newspapers, magazines.
5. Flowers.
6. Solution bottles (IV., baby, soft drink)
7. Coat hangers.

B. <u>Operating Rooms</u>

1. Plastic garbage bags.
2. Solution bottles (IV, blood).
3. Disposable garments.
4. Dressings.
5. Rubber and plastic tubing.

C. <u>X-Ray Department</u>

1. Plastic garbage bags.
2. Bottles (plastic and glass).
3. Waste paper.

D. <u>Kitchen</u>

1. Garbage (small amounts).
2. Disposable services.
3. Cardboard boxes.
4. Plastic food wrapping.
5. Broken crockery.
6. Tin cans.
7. Cloth.
8. Glass bottles.
9. Plastic garbage bags.
10. Waste paper.

E. <u>Student Nurses' Residence</u>

1. Garbage.
2. Waste paper.
3. Tin cans (food and soft drink).
4. Glass bottles.
5. Plastic garbage bags.
6. Cloth.
7. Cardboard boxes.

F. Pharmacy

1. Cardboard boxes.
2. Solution bottles.
3. Drug bottles.
4. Plastic bottles and caps.
5. Waste paper.

G. Receiving and Stores

1. Cardboard boxes.
2. Steel strapping.
3. Waste paper.

H. Administration

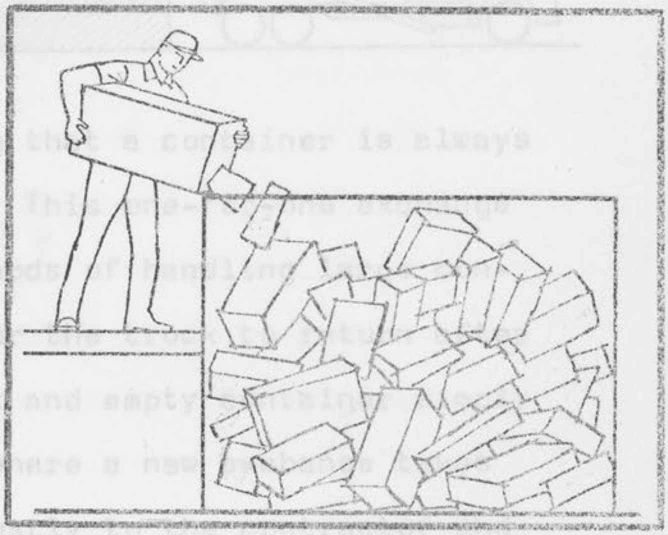
1. Waste paper
2. Plastic garbage bags.
3. IBM cards.
4. Carbon paper.
5. Cardboard boxes.

# APPENDIX G

## REFUSE TRANSPORTED OR OPEN HAULING METHOD

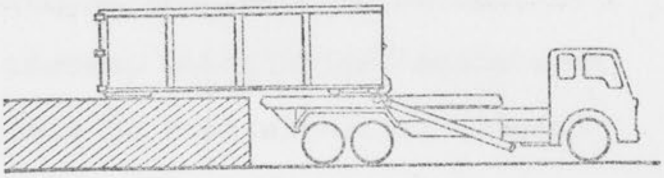
REFUSE TRANSPORTED OR OPEN HAULING METHOD

This method of waste disposal is one of the systems in popular use today. The system is simple to operate as far as the hospital is concerned and can be carried out by untrained personnel.



Refuse is picked up throughout the institution and brought to a central location whereit is transferred to a large metal container or dumpster. The size of the container depends on the amount of waste generated and the frequency with which the container is emptied or replaced. Containers or dumpsters range in size from the small one cubic yard size up to fifty cubic yards.

Normally these containers are rented from the contractor who also hauls the refuse away from the institution. Container size normally dictates the method by which the refuse is removed from the premises. The smaller containers are usually picked up and emptied directly into a vehicle with a larger capacity box, sometimes equipped with a compactor unit. The larger containers, i.e., those with a capacity of ten cubic yards and up, are too large to be handled as easily as the smaller units. Containers of this size are specially adapted to be truck mounted. A truck simply picks up the container, hauls it to its destination, dumps it and returns the empty. In many cases it is possible to arrange with the contractor to have a full container replaced with an empty one at the



time of pick up, thus insuring that a container is always available at the institution. This one-for-one exchange system is one of the best methods of handling large containers as there is no need for the truck to return after dumping the refuse. The truck and empty container simply move to a different location where a new exchange takes place. This system is less costly to the contractor and part or all of the savings is passed on to the hospital.

Refuse transporting is almost totally dependent on an outside contractor. There are very few institutions which own there own equipment and do their own hauling. The cost of operating by this method is the prime reason for its decline in popularity, especially in the larger metropolitan areas. Newer and more efficient systems are available today which have made the Refuse Transported or Open Hauling method of waste disposal inefficient and obsolete.

# APPENDIX H

# INCINERATION

INCINERATION

Disposal of wastes by incineration is, perhaps, the best method of disposing of and reducing volumes of hospital waste. In many states, pathological waste must, by law, be incinerated. This is done either in special pathological incinerators or in the main incinerator.

Waste disposal by incineration has lost popularity within the past few years because of the new air pollution regulations. These regulations have caused incinerators that were installed only a few short years ago to become outdated. Regulations specify certain design criteria and detail the maximum amount of polluants which can legally be discharged into the atmosphere. To meet these new laws incinerators must be installed with primary and secondary gas burners and air pollution control devices. The regulations combined with the equipment required to meet these laws has, in many cases, caused waste disposal by incineration to become uneconomical.

Future incinerators should be designed to operate at temperatures in excess of 2,000° F. Temperatures this high are capable of causing complete oxidation of most wastes, especially plastics. Few combustible flue gases and no odors escape. Air pollution control devices such as wet scrubbers would have to be installed in order to wash any particulate matter from the products of combustion.

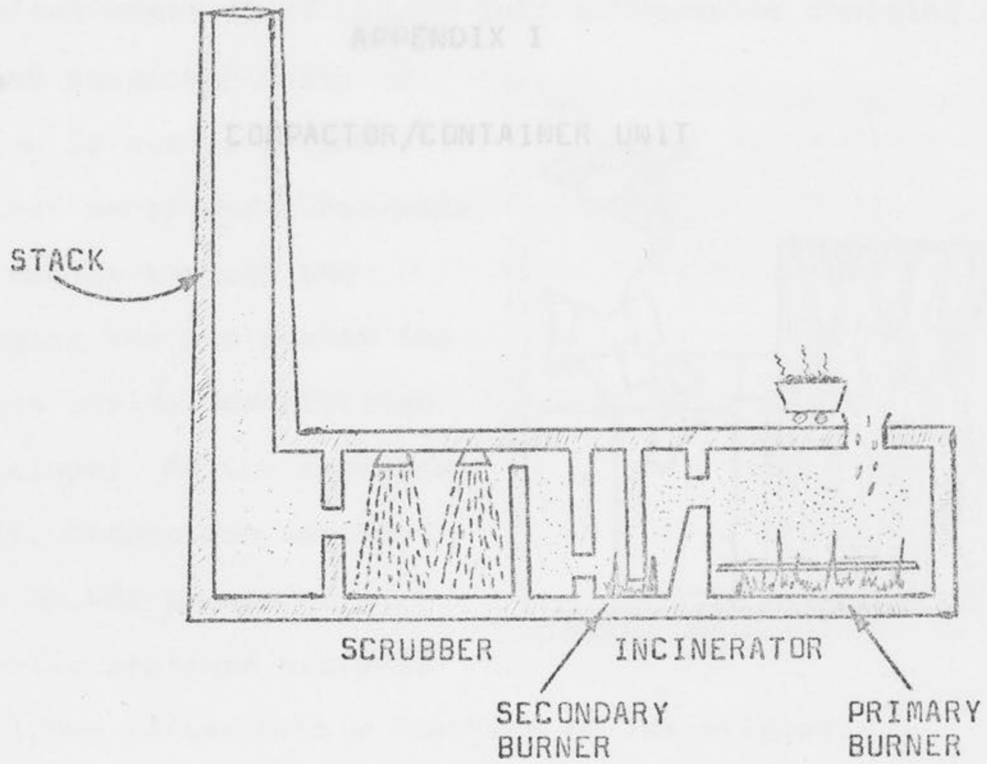
Certainly an incinerator as described above will be expensive to operate. To make this system economical the heat generated by the gas and refuse must be recovered and used for some purpose, i.e., to heat water, provide steam for kitchens and laundries, for absorption refrigeration or even for electric power. Waste is a natural source of heat energy which has been long overlooked. It is possible to design and operate small industrial incinerators which can economically dispose of wastes generated in our hospitals if the energy produced is put to some productive use.

Multiple chambers are required in an incinerator to slow the ash particles and allow them to settle out. A secondary or after-burner is used to completely burn the combustible gases produced in the primary chamber. The after-burner is placed in the secondary chamber of the incinerator.

Many air pollution control devices have been designed for use in incinerators. Bag filters and electrostatic precipitators will collect smoke particles and wet scrubbers will dissolve certain odorous and noxious gases. Bag filters and electrostatic precipitators are used only in large municipal type incinerators due to their size and the cost of their operation. Wet scrubbers are the main air pollution control devices used in the smaller industrial type incinerators. These scrubbers tend to saturate the hot flue gases with water vapor which condenses into visible steam when it contacts the cool air outside the stack. The public often confuses this harmless steam with smoke. Wet scrubbers also tend to interfere with the natural draft of the incinerator and therefore require the addition of induced draft fans to the scrubber unit.

Incineration of hospital waste, although recently losing popularity, will someday become an important, if not the preferred method of hospital waste disposal.

# MULTIPLE CHAMBER INCINERATOR *




* for illustrative purposes only

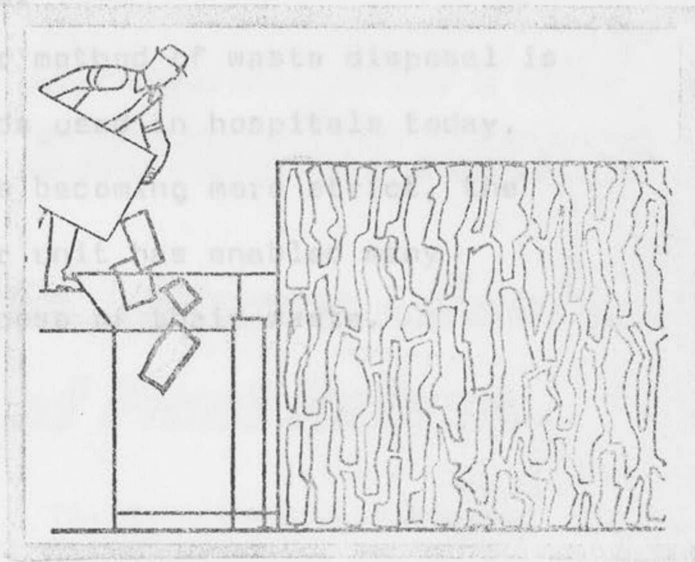
# APPENDIX I

## COMPACTOR/CONTAINER UNIT

COMPACTOR/CONTAINER UNIT

The compactor/container method of waste disposal is a direct modification of the Refuse Transported or Open Hauling Method. This method has the advantage in that it uses the principle of bulk reduction to gain the maximum use of the container.

Waste is brought to a central location in the hospital where it is dumped into a hopper or charging box of the compactor unit. A button is pushed on the control panel and a hydralic ram sweeps through the charging box and pushes the refuse inside the attached container. As the container fills, compaction begins. Over 40,000 pounds of hydralic pressure compacts the loose refuse into a fraction of its original volume. Depending on the density of the material, packing ratios of from three to six to one are achieved.

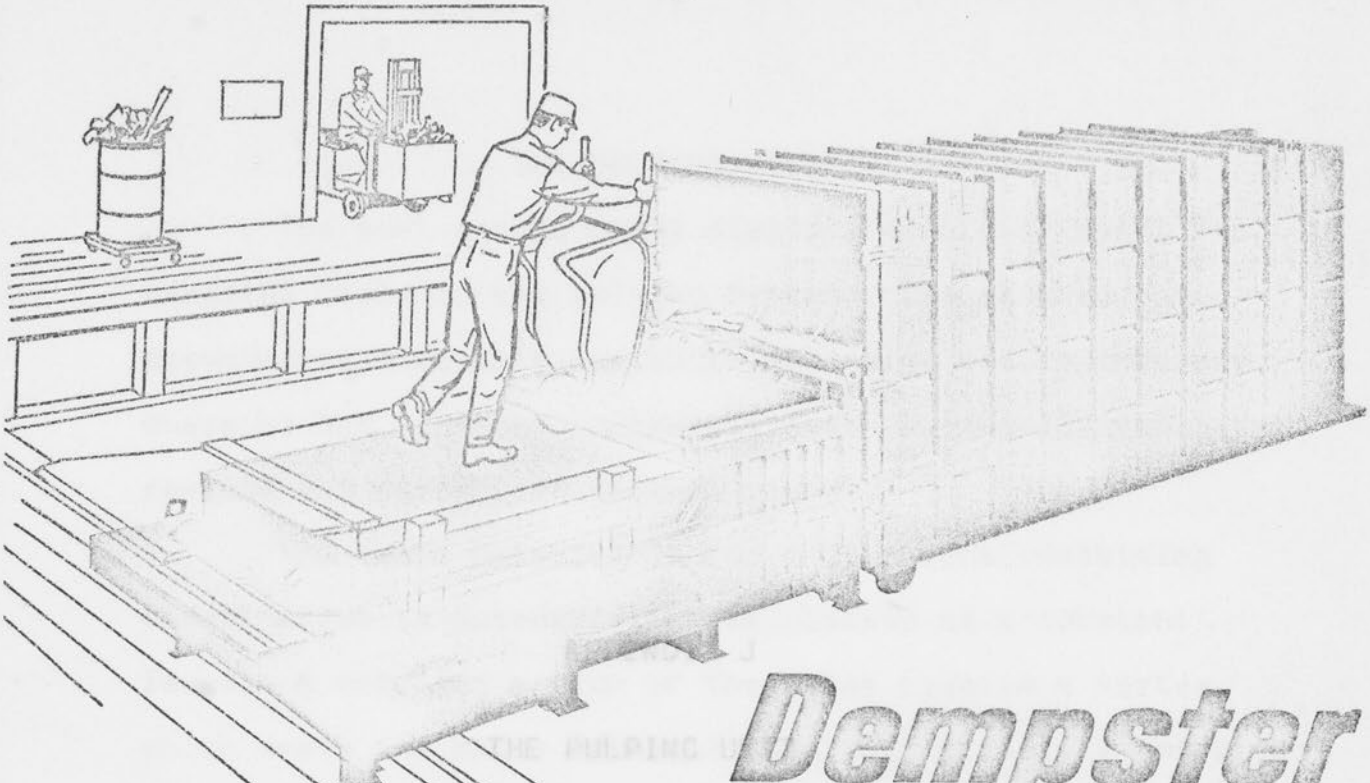


When the refuse container is full a truck-mounted handling unit unlocks the container, picks it up, hauls, empties, returns and locks the container to the compactor unit.

The use of a compactor/container unit decreases labor costs for refuse disposal and significantly decreases the amount of air pollution. Odor problems are reduced as the refuse is charged into closed containers. The placement of a deodorant spray near the hopper has also proved beneficial.

Compactor/container units range in size from ten to fifty cubic feet. The size of unit required depends on the volume of waste generated, the type of waste and the frequency of container pick up.

The compactor/container method of waste disposal is one of the most popular methods used in hospitals today. With air pollution regulations becoming more strict, the use of the compactor/container unit has enabled many hospitals to economically dispose of their waste.



# Dempster STATIONARY PACKER

## New System Compacts...Stores...Hauls... Hundreds of Yards of Plant Refuse...

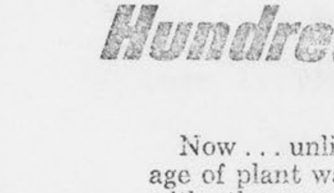
Now . . . unlimited ,out-of-sight storage of plant waste and refuse is yours with the new Dempster Stationary Packer System. Low cost containerized hauling, too! The Dempster Stationary Packer hydraulically pushes and mashes mountains of refuse into the large, enclosed container with tremendous force. Boxes, cans, cartons, paper, plastic, light scrap metal, broken skids, crates all are flattened and compacted into a tight economical load, easily picked up, hauled and dumped by the truck-mounted Dempster Dinosaur.

This efficient industrial packer assures maximum loads of both light and heavy industrial refuse for low cost operation.

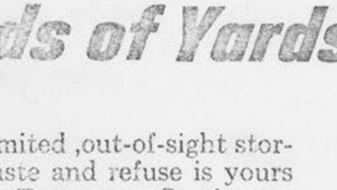
The big capacity hopper is easy to reach from your loading dock and hydraulic dumpers are available for emptying containers, bins and drums. Private Hauler Dinosaur Container Service is available in most cities. Write today for complete information.

**DEMPSTER BROTHERS, INC.**
**KNOXVILLE, TENN./DEPT.**

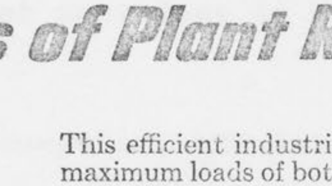
Refuse is dumped in hopper from dock.



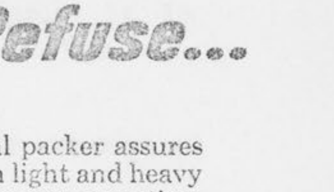
Packer plate pushes it into container.



Compacting refuse to high density.



Dinosaur hauls, empties and returns container.



# APPENDIX J

## THE PULPING UNIT

THE PULPING UNIT

The most recent waste disposal method to enter the hospital field is the pulping system. The process has proved itself capable and is in extensive use in industry where it has replaced incineration and materially reduced removal and carting of general wastes.

The waste material is fed into a tank containing water, which is automatically maintained at a constant level. A whirling motion of the water creates a vortex, which draws the waste material down into a rapidly rotating disc studded with tungsten carbide teeth. The disc grinds the material to a slurry, which is then pumped to a hydra-extractor or dewatering press. Here the slurry is squeezed upward by a helical screw where it emerges as a semi-dry pulp about eighty per cent less in bulk. It is then trucked away.

To minimize water consumption, the water squeezed out of the slurry is pumped back to the pulper for re-use. Water, when needed, is added at the pulper unit.

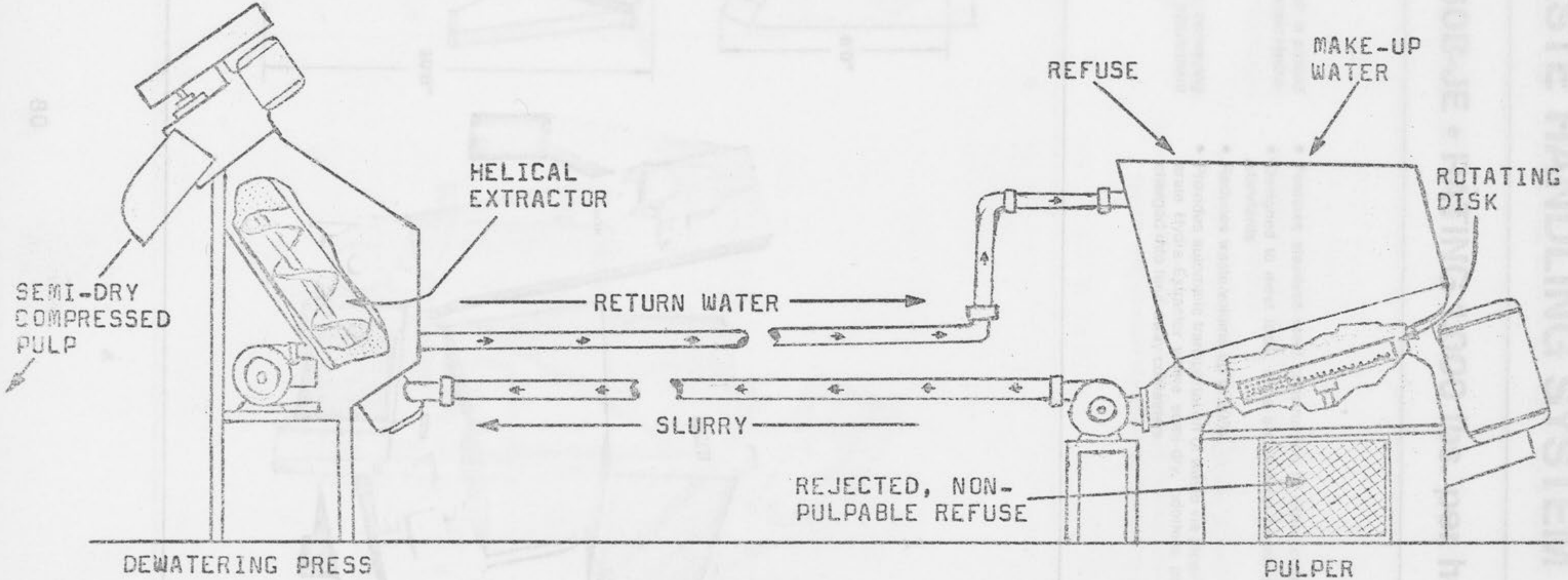
Nonpulpable objects are rejected to a bin located at the bottom of the pulper. The addition of a "junk extractor", an accessory, is recommended for hospital use.

The pulping unit has the advantage in that several waste pulpers can be added or combined with one hydra-extractor.

Cleaner and more odor free operation are significant characteristics because the refuse is washed and aerated. Although subject to considerable variation, the equipment and piping can be completely washed about once a week or as often as deemed necessary by the institution. The addition of a bactericidal solution to the water is recommended for hospitals.

The SOMAT Waste Handling System, manufactured by SOMAT Corporation, Pomeroy, Pennsylvania, is shown on the following pages.

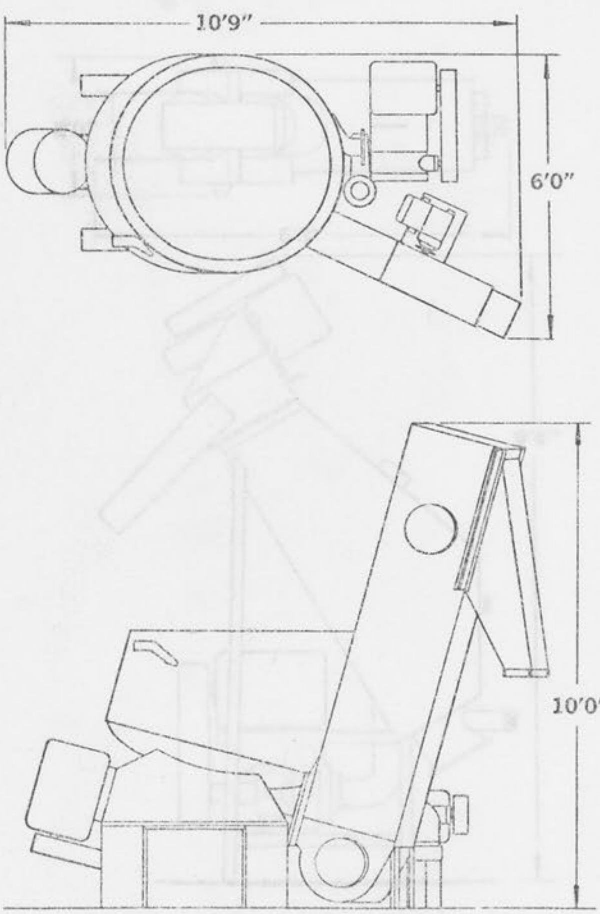
# SOMAT PULPER/EXTRACTOR SYSTEM

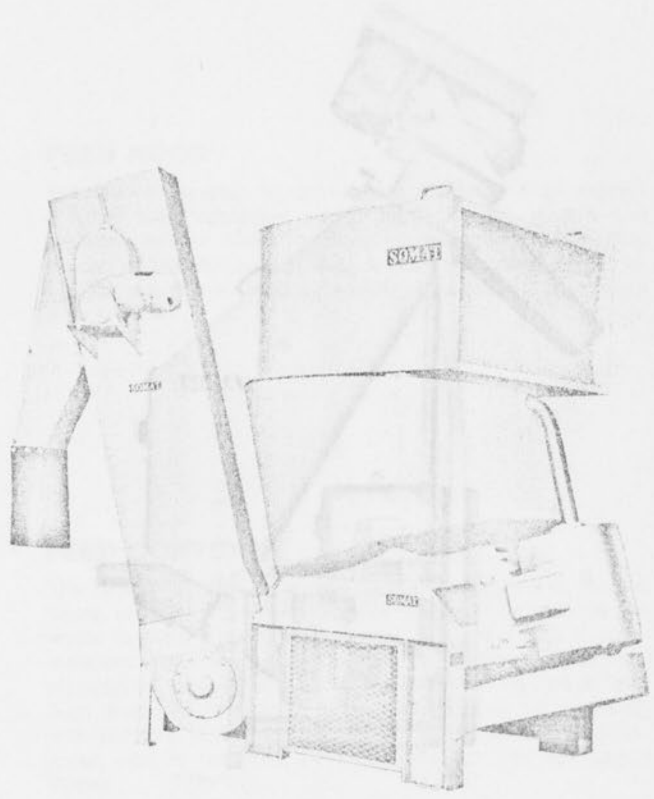


# HOSPITAL WASTE HANDLING SYSTEM

## SOMAT MODEL SSP-60B-JE • RATING 1,000 lbs. per hour

- Reduces general nursing floor waste to slurry which is picked up by a pump and pumped through pipeline to separate Hydra-Extractor.
- Designed specifically for hospital application.
- Can be fed via feed conveyor, chute, pneumatic conveying system, carousel, or manually for continual or intermittent operation.
- Features stainless steel construction in slurry chamber area.
- Designed to meet local, state and federal health department standards.
- Reduces waste volume up to 80%.
- Provides automatic transportation of waste via pipeline to separate Hydra-Extractor where semi-dry, odorless pulp is discharged into haul-away containers.



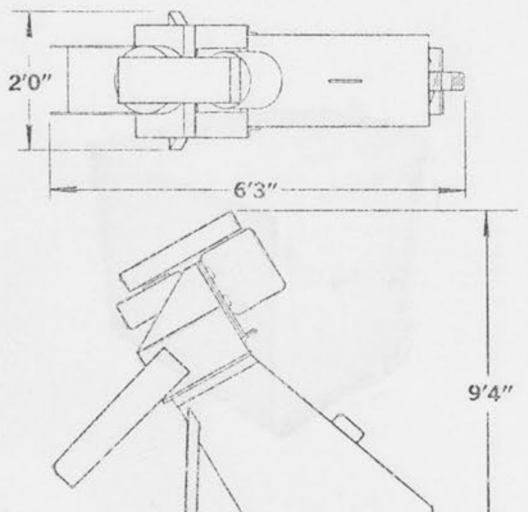


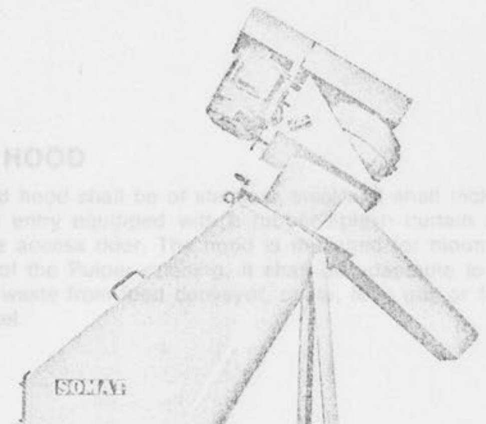

SOMAT®
SOMAT CORPORATION
Pomeroy, Penna. 19367
Telephone: (215) 384-7000

# HOSPITAL WASTE HANDLING SYSTEM

## SOMAT HYDRA-EXTRACTOR MODEL CS-9-C • RATING 1,000 lbs. per hour

- Receives slurry from SOMAT Pulper(s) totaling equal or less capacity, extracts excess water and discharges semi-dry odorless pulp.
- Can be located on loading dock or wherever convenient for discharge directly into haul-away container.
- Designed to meet local, state and federal health department standards.
- Pumps extracted water via pipeline to SOMAT Pulper(s) for re-use.
- Used with SOMAT Pulper(s) to provide closed-circuit system with no solid materials discharged to the sewer.



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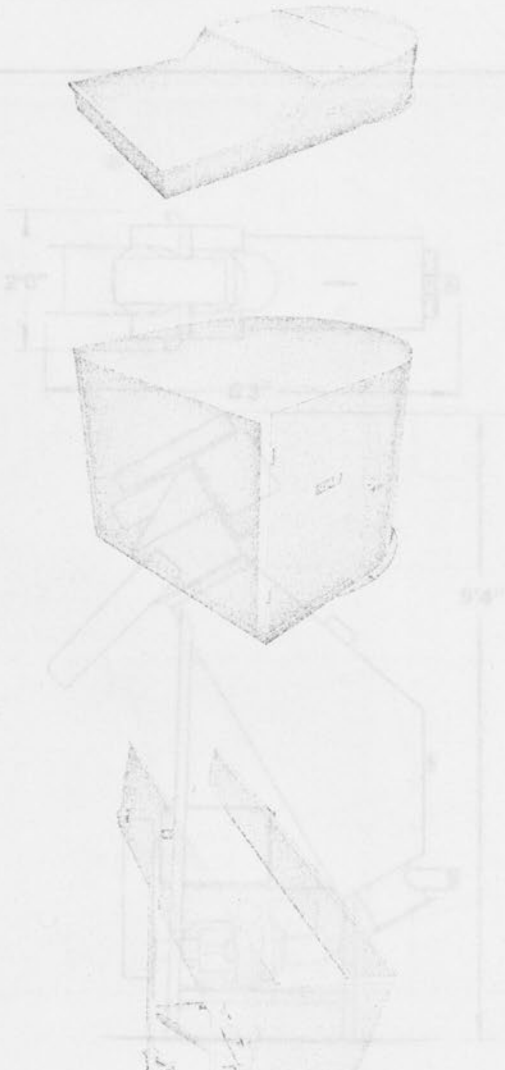
# GENERAL WASTE HANDLING SYSTEM

## SOMAT ACCESSORIES FOR GENERAL UNITS

The accessories shown here were designed specifically for SOMAT Waste Handling Systems being used for general waste. All the accessories listed are available for SOMAT Models CS-42B, CS-48B, CS-60B, CS-72B and CS-42-CC, with the exception of the Feed Tray which is used only with the CS-42B or CS-42-CC. The Pulp Screw Conveyor is designed for use with either SOMAT Model CS-9C or Model Twin CS-9C.



### FEED TRAY WITH COVER

The feed tray and cover shall be stainless steel construction and shall attach to the top of the SOMAT Pulper for use in collecting small amounts of waste prior to feeding the waste into the pulper. The cover shall be of hinged design and shall be equipped with a rubber splash curtain.

### FEED HOOD

The feed hood shall be of stainless steel and shall include a waste entry equipped with a rubber splash curtain and separate access door. The hood is designed for mounting on top of the Pulper opening. It shall be adaptable to receiving waste from feed conveyor, chute, feed tray or from floor level.

### FEED CONVEYOR

The heavy-duty feed conveyor shall be designed to receive waste material from feed level or trash chute, elevate the waste to the Pulper and discharge the waste into it automatically. The conveyor and supporting frame shall be constructed of heavy steel plate and shall be equipped with high sidewalls to prevent spillage. Unit shall be complete with suitably guarded drive motor, all controls and automatic start to integrate the feed conveyor and the Somat Pulper.



SOMAT
SOMAT CORPORATION
Pomeroy, Penna. 19367
Telephone: (215) 384-7000

# GENERAL WASTE HANDLING SYSTEM

## SOMAT HYDRA-EXTRACTOR MODEL CS-9C • RATING 1,000 lbs. per hour

- Receives slurry from SOMAT Pulper(s) totaling equal or less capacity, extracts excess water and discharges semi-dry odorless pulp.
- Can be located on loading dock or wherever convenient for discharge directly into haul-away container.
- Designed to meet local, state and federal health department standards.
- Pumps extracted water via pipeline to SOMAT Pulper(s) for re-use.
- Used with SOMAT Pulper(s) to provide closed-circuit system with no solid materials discharged to the sewer.

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# GENERAL WASTE HANDLING SYSTEM

## SOMAT MODEL CS-48B • RATING 1,000 lbs. per hour

- Reduces general waste to slurry which is picked up by a pump and pumped through pipeline to separate Hydra-Extractor.
- Designed specifically for office buildings, banks, industry, etc.
- Can be fed via feed conveyor, chute, pneumatic conveying system, or manually for continual or intermittent operation.
- Designed to meet local, state and federal health department standards.
- Reduces waste volume up to 80%.
- Provides automatic transportation of waste via pipeline to separate Hydra-Extractor where semi-dry, odorless pulp is discharged into haul-away containers.


A Separate Hydra-Extractor, and a feed hood tray or charging bin are required with this unit.



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ABSTRACT

A STUDY OF SOLID WASTE DISPOSAL

A Problem Solving Project Report Submitted to the Faculty of Baylor University in Partial Fulfillment of the Requirements for the Degree of Master of Hospital Administration

By Captain William T. Cooper, Canadian Armed Forces

August, 1970 88 Pages

A copy of this document may be obtained on loan from the United States Army Medical Field Service School, Brooke Army Medical Center, Fort Sam Houston, Texas.

This study examines a waste disposal problem faced by one hospital in order to determine the best method of solid waste disposal. To carry out the study it was necessary to examine the existing system and to determine the types, quantities and weights of waste generated daily. Also examined was the effect installation of a new system might have in relation to the present plant. Literature was reviewed to gain a working knowledge of solid waste disposal systems in use by hospitals. Correspondence was carried out with numerous manufacturers of waste disposal equipment to obtain specific data, including cost estimates. It was concluded that the combination of a pulping unit and a crusher-destroyer would be the best solution to the hospital's problem. It was recommended that the hospital take the necessary action to install the equipment and that further studies be carried out to examine the collecting, transporting, sorting and scheduling procedures with a view to increasing automation.