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Advances in Small-Scale Refuse Incinerators

Seminar Proceedings

Solid Waste Management Branch
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ADVANCES IN SMALL-SCALE REFUSE INCINERATORS

Seminar Proceedings

Sponsored by

Environment Canada
and
Newfoundland Department of Provincial Affairs and Environment

Held

April 6, 1976
St. John's, Newfoundland
and
April 8, 1976
Gander, Newfoundland

ABSTRACT

A one-day seminar was held on April 6 in St. John's and again on April 8 in Gander, Newfoundland. The subject, ''Advances in Small-Scale Refuse Incinerators'', was specifically requested by the Newfoundland Department of Provincial Affairs and Environment as a potential solution to solid waste problems presently experienced in the province.

Subjects included Incinerator Design, Costs and Benefits, Federal and Provincial Air Pollution Standards and detailed descriptions of the common small-scale incinerators in use today.

No doubt the reader will find the subject matter is applicable to many other parts of rural Canada and it is for that reason that these proceedings are made available to all who are interested.

RÉSUMÉ

Les 6 et 8 avril, à Saint-Jean et à Gander respectivement, a eu lieu un séminaire sur les progrès réalisés dans les techniques des petits incinérateurs, à la demande expresse du ministère des Affaires provinciales et de l'Environnement de Terre-Neuve, en vue d'une solution possible aux problèmes causés par les déchets solides, auxquels on a faire face dans cette province.

Parmi les sujets abordés, citons la conception des incinérateurs, le rapport coûts-avantages, les normes fédérales et provinciales élaborées contre la pollution atmosphérique, ainsi que la description détaillée des petits incinérateurs actuellement en service.

Il est évident que le lecteur pourra estimer que la question est aussi d'actualité pour de nombreuses autres régions rurales du Canada; c'est la raison pourquoi le présent document est rendu accessible à toutes les personnes intéressées.

FOREWORD

Sponsored jointly by Environment Canada and the Newfoundland Department of Provincial Affairs and Environment, the one-day seminar "Advances in Small-Scale Refuse Incinerators" was given in St. John's and Gander.

Speakers were provided by Environment Canada's Solid Waste Management Branch and Federal Activities Environmental Branch as well as one representative of Newfoundland's Department of Provincial Affairs and Environment.

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CHAIRMAN'S OPENING REMARKS

Mr. L.P. Fedoruk
Atlantic Region, Environmental Protection Service
Environment Canada
Halifax, Nova Scotia

Good morning. I'm Lawrence Fedoruk and I will be your Chairman today. We will be talking about Advances in Small-Scale Refuse Incinerators a little later but before I go into the topic, the Deputy Minister for Provincial Affairs and Environment would like to say a few words - Mr. Gerry Malone.

WELCOMING ADDRESS

Mr. G.B. Malone
Deputy Minister
Newfoundland Department of Provincial Affairs and Environment
St. John's, Newfoundland

My Minister, the Honourable A.J. (Hank) Murphy was to be here this morning, but unfortunately he was called away for a cabinet meeting. He asked me to come and say hello to you, and for those from out of the province to extend a welcome to the province of Newfoundland. Our department, Provincial Affairs and Environment, has developed an extremely close liaison with the Environmental Protection Service of Environment Canada and we have found that the degree of collaboration that has been reached has been very helpful in the development of environmental programs in industry. The object of working together, of course, is to cut down on the number of visits and to coordinate our activities so that when we are working together to present seminars like the one you are sitting in on this morning we feel that these are good things. We hope that you get something from it and we would like at this time to thank you for attending.

Some of the municipalities that are invited here this morning all have problems of waste, solid waste disposal, and our department and the federal department are helping the councils to wrestle with these. We expect that the councils representing 5,000 or greater population, particularly those with surrounding suburban populations near-by would cooperate in a joint disposal system. We hope that today's seminar may help speed up the awareness and interest in such systems and it is hoped that other councils will benefit from the suggestions on the principles of environmental control, volume reduction, combustion, landfilling, etc. that will be touched upon by the speakers today.

Solid waste managment is one of the principal concerns of the Department of Provincial Affairs and Environment, and occupies a lot of our time and attention. What we are trying to do of course, is to respond to the desires of communities regarding their needs with respect to waste disposal while at the same time ensuring that the quality of the environment is maintained or possibly improved. The Waste Material Disposal Act for 1973 was our Bible the legislation under which control is exercised over the collection and disposal of waste, in unincorporated areas in particular.

In recent years there has been a growing public resistance to the landfill method of solid waste disposal. This is especially a problem in the St. John's urban region where suitable land sufficiently remote from populated areas is not readily available. Although sanitary landfills can be operated satisfactorily, the Avalon Peninsula topography provides something less than an ideal condition, and I guess anyone who is familiar with Robin Hood Bay is certainly aware that the situation out there is less than ideal.

Incineration seems to us to be a viable alternative. A simple teepee burner has adequately served the needs of some rural areas in the Province. I believe that there are over twenty of these burners. Where the load is small and the disposal site is isolated these teepee burners are effective for a short period of time, after which maintenance expenses tend to escalate.

For larger urban centers more sophisticated and expensive equipment is required and these incinerators would be expected to employ adequate pollution control equipment to meet the provincial requirements. We are just getting into this area and we are just at the kindergarden stage of development with it. We have a lot to learn and we are very anxious to see how things develop.

Most attempts at incineration give rise to air pollution complaints but where the volume of waste to be burned is not great and the incinerator is properly sited, complaints can be kept to a minimum. The minor problem of air pollution is much more tolerable than a poorly operated landfill system, in our experience.

I hope that the session that you are attending today will be interesting, and everybody will get something out of it. Hopefully the municipalities that are in attendance will be able to go away from the seminar with some ideas that they did not have before they came. And hopefully, we can all work together to improve the environment and to develop methods of waste disposal in Newfoundland that will be acceptable and tolerable and, at the same time, within reasonable cost. Thanks again for having me here and welcome to the seminar.

CHAIRMAN'S REMARKS

Mr. L.P. Fedoruk

Our first speaker, Dale Cameron, graduated in engineering from the University of Waterloo in 1973, and joined the Federal Activities Environmental Branch of Environment Canada in Ottawa. He's been involved in providing an advisory service for federal facilities on the evaluation of a small incinerator and the development of guidelines for solid waste disposal and wastewater treatment.

DEFINITION OF TERMS

D.B. Cameron
Federal Activities Environmental Branch
Environment Canada
Ottawa

I'm going to try to provide you with an explanation of some terms you're likely to hear at various times during the seminar. I hope that those of you who may already have had contact with the incineration field will bear with us. Hopefully, for you, there will be some points of interest in the slides which accompany my definitions.

The basis for satisfactory incinerator operation is the proper analysis of the waste to be destroyed, and the selection of the proper equipment to best destroy that particular waste.

The Incinerator Institute of America has developed a waste classification system for use in the design and therefore the selection of incinerators (Figure 1).

There are six main types of waste:

Type 1 – Rubbish
Type 2 – Refuse
Type 3 – Garbage, that is food wastes
Type 4 – Pathological wastes
Type 5 – By-product wastes from industrial operations
Type 6 – Solid by-product wastes from industrial operations.

Each of these classifications is further broken down into non-combustibles (like glass, tin cans, metal), moisture content, combustibles and heat values.

A typical municipal waste consisting of residential wastes, institutional wastes as in schools, hospitals and office buildings, and commercial wastes as in restaurants, stores and markets falls into the range between Type 1 and Type 3.

You will note on this chart that heating values are measured in BTU's. A BTU (British Thermal Unit) is a measure of heat and is the amount of heat necessary to raise one pound of water one °F.

For comparison, a gallon of oil weighing approximately 10 lbs gives off 160,000 BTU's when it burns. Heating values for municipal waste range from 3000 BTU's per lb. to 6,000 BTU's/lb. Now that we know what the wastes are that a municipality would normally wish to dispose of, we may look at the subject of incineration itself.

An incinerator (Figure 2) is a combustion apparatus in which solid and semi-solid wastes are ignited and burned to carbon dioxide, water vapour and a solid residue containing little or no combustible material. There are 4 main types of incinerators of interest in this seminar.

- Multiple Chamber Incinerator
- Pit Incinerators
- Conical or Teepee Burners
- Controlled Air Incinerators

The multiple chamber incinerator is a structure consisting of three or more refractory-lined combustion chambers in series, physically separated by refractory walls and interconnected by gas passage ports or ducts.

The charging door is simply a closure for the primary combustion chamber loading entrance through which the refuse is fed into the incinerator. It can be a vertically operated charging door of the guillotine type, a simple hinged door, or a door which slides horizontally. In large installations, say 50 tons/day and over, the charging system may be more complex and consist of a hopper, a charging chute and a guillotine-type of sliding door (Figure 3). The grate is the surface that supports the waste material during the combustion process. It is usually located in the primary combustion chamber and designed to permit removal of ash and unburned residue. Grates may be horizontal, inclined, stationary or movable or combinations of these types.

Projections, called rabble arms, rotate slowly stoking or mixing the waste. Sections of the grate on the outer edge of the chamber periodically drop away to permit the ash to drop out of the chamber. This is called a dumping grate.

Examples of the inclined moving grates are these 3 types (Figure 4).

- The reciprocating grate in which sections slide in and out causing the waste to move down the incline.
- The rocking grate which achieves the same operation by an alternating up and down motion of neighboring sections.
- The travelling grate which resembles a conveyor belt system.

The primary combustion chamber, or ignition chamber as it is sometimes called, is simply the chamber in which the waste is burned. Waste is ignited, usually by means of ignition burners in the wall of the ignition chamber. The burning waste is often referred to as the fuel bed. Air must be supplied to the incinerator for combustion and cooling air supplies may be classified according to their point of introduction or use. Overfire air is supplied beyond the fuel bed through wall ports in the primary combustion chambers. Its purpose is to aid in combustion of gases produced in the fuel bed. It is also sometimes called secondary air. Underfire air is supplied beneath the grate to support combustion of the fuel bed. The term primary air is also used for this supply. The introduction of air into the incinerator may be accomplished by three methods.

The term draft is used to identify the air pressure difference between the interior of the incinerator and the outside air. Natural draft is the pressure difference created by the stack because of its height and the temperature difference between the flue gases and the atmosphere. In induced draft systems, the pressure difference is created by the action of a fan installed between the incinerator and the stack exit. Such a fan is called an induced draft fan. Similarly, in a forced draft system the pressure difference is created by the action of a fan forcing air into the incinerator through air ports. The flame port is a small port in the curtain wall through which the flames and products of combustion from the burning refuse must pass. A mixing chamber is usually placed between the primary combustion chamber and the secondary combustion chamber. It serves to mix the gases produced during the burning of the waste and provide increased combustion of these gases. Heat may be added here by a secondary burner to aid in combustion.

The secondary combustion chamber reduces gas velocity, allows the larger particles to settle out and provides time for combustion of the gases to reach completion.

The breeching or flue connection is the connecting duct between the incinerator and the stack. The stack of course, is the passage for conducting the flue gases to the outside atmosphere. The damper is a manually or automatically controlled device to regulate the draft or the rate of flow of air or combustion gases. They may be of four different configurations:

1. A barometric damper
2. A butterfly damper
3. A guillotine damper
4. Sliding damper

Most of the terms used in describing multiple chamber incinerators also apply to the other types of incinerators to be considered at this seminar. There are however special concepts and terms for each of the remaining three incinerators. The Pit incinerator is one of the simplest incinerators to be developed in many years (Figure 5).

The unit as originally conceived was to burn high density/low ash material such as wood waste. There are two types of pit incinerators, the open pit shown here and the closed pit.

The open pit unit consists, as the name suggests, of a large box-like structure open at the top except for a screen. Waste is brought up to the ramp and simply dumped into the top of the pit. This may be a direct dump from the collection truck or a front-end loader may be used. Air is supplied over the top of the burning refuse, similar to the overfire air of the multiple chamber incinerator. Air is also supplied at the base of the burning waste similar to the underfire air of the multiple chamber units. Power is required for blower operation but there are no burners to consume fuel.

An air manifold at the top supplies air for turbulence and combustion through a set of nozzles. The closed pit unit is also a large pit but has a closed canopy on the top and a rectangular stack. Air is supplied as in the open pit over the top and through the fuel bed at the bottom. The pit can be loaded by means of a front end loader which simply pushes refuse into the gap between the canopy and the pit. The end walls of the pit can slide sideways on the projecting steel beams to permit ash removal by the front end loader after a cooldown period. Some have an air manifold connected to a blower. These units are rugged, inexpensive to operate and have few maintenance problems, however their flue gas discharges into the air are not capable of meeting most air pollution regulations.

Controlled air incinerators are a relatively new type (Figure 6). The term controlled air indicates that air is supplied in a predetermined amount by a positive means such as a blower. Because the air supply can be closely controlled, combustion is much better than in other types of incinerators and pollution control regulations can usually be met. These units may also be referred to as starved-air incinerators. Without getting into the detailed chemistry of the combustion process, basically this refers to the fact that there is a certain quantity of air required to burn a specific amount of waste. That amount of air is called theoretical air. If less air than this theoretical amount is supplied the unit is being starved of air. Conversely if more air is added than the theoretical air the condition is one of excess air. These units can be either batch-fed, that is, loaded once or twice per day or, as in this more recent design, continuously fed by a ram feed system.

This unit also has a heat recovery system consisting of a boiler which is heated by means of the hot flue gases drawn through it by an induced draft fan.

These units normally have the following components (Figure 7):

1. a ram feeder in larger units,
2. a waste combustion chamber which doubles as a storage chamber in smaller batch-fed units,
3. an ignition burner,
4. an afterburner section usually located in the stack, and
5. the air supply equipment consisting of blowers, air manifold lines and air introduction ports in the afterburner section.

Conical or Teepee Burners (Figure 8) will probably be the most familiar type of incinerators to people living in lumbering areas. They were first developed in the Northwestern part of the United States for the burning of sawdust and wood wastes. They usually consist of a sheet metal shell supported by a steel frame. The general design is a truncated cone with a large spark screen on top. The unit is a single chamber and waste is either brought in through a side door or fed through an inlet part way up the outside. The waste is burned on an earthern floor (called hearth burning) with combustion air usually coming in tangentially at the bottom of the unit.

Air is introduced by a fan through a duct system with vents around the bottom. Some units have large charging doors that allow the use of a front end loader for charging. Recent attempts have been made to reduce the air pollution emissions by adding control devices such as electrostatic precipitators and wet scrubbers.

Since I have just mentioned the primary reason why new types of incinerators are being developed and existing ones are being improved, that is air pollution emissions, I'll just discuss briefly some of the terms associated with air pollution discharges regardless of the type of incinerator used.

First we have *particulates* which are the primary concern when discussing incinerator stack discharges. They are simply particles in the flue gas such as soot and fly ash. Incinerators built today and in recent years cope with this problem by high combustion efficiency, control of combustion air, and particulate collection equipment notably electrostatic precipitators and gas scrubbers.

Another term sometimes tossed around when discussing stack emissions is the *Ringlemann number.* Grey or black smoke is judged by comparing it with the so-called Ringlemann Chart. The chart contains squares having different shades going from a value of 0 (indicating a clear emission) to 5 (which is completely black).

I hope this has provided you with a feel for the subject of incineration and will help with the understanding of later discussions in the seminar.

FIGURE 1 CLASSIFICATION OF WASTES

CLASSIFICATION OF WASTES:

Type I Waste

Rubbish, consisting of combustible waste such as paper, cartons, rags, wood scraps, sawdust, foliage and floor sweepings from domestic, commercial and industrial activities.

Type II Waste

Refuse, consisting of an approximately even mixture of rubbish and garbage by weight.

Type III Waste

Garbage, consisting of animal and vegetable wastes from restaurants, cafeterias, hotels, hospitals, markets and like installations.

Type IV Waste

Human and animal remains, consisting of carcasses, organs, solid organic wastes from hospitals, laboratories, abattoirs, animal pounds and similar sources.

Type V Waste

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

Type VI Waste

Solid by-product waste, such as rubber, plastics, wood waste, etc., from industrial operation.

Type Waste	Non-Combustibles	Moisture	Combustibles	Heating Values
I	10%	25%	65%	6500 BTU/#
II	7%	50%	43%	4300 BTU/#
III	5%	70%	25%	2500 BTU/#
IV	5%	85%	10%	1000 BTU/#
V	Considered according to waste analysis.			
VI	Considered according to waste analysis.			

FIGURE 2 COMPONENT PARTS OF AN INCINERATOR

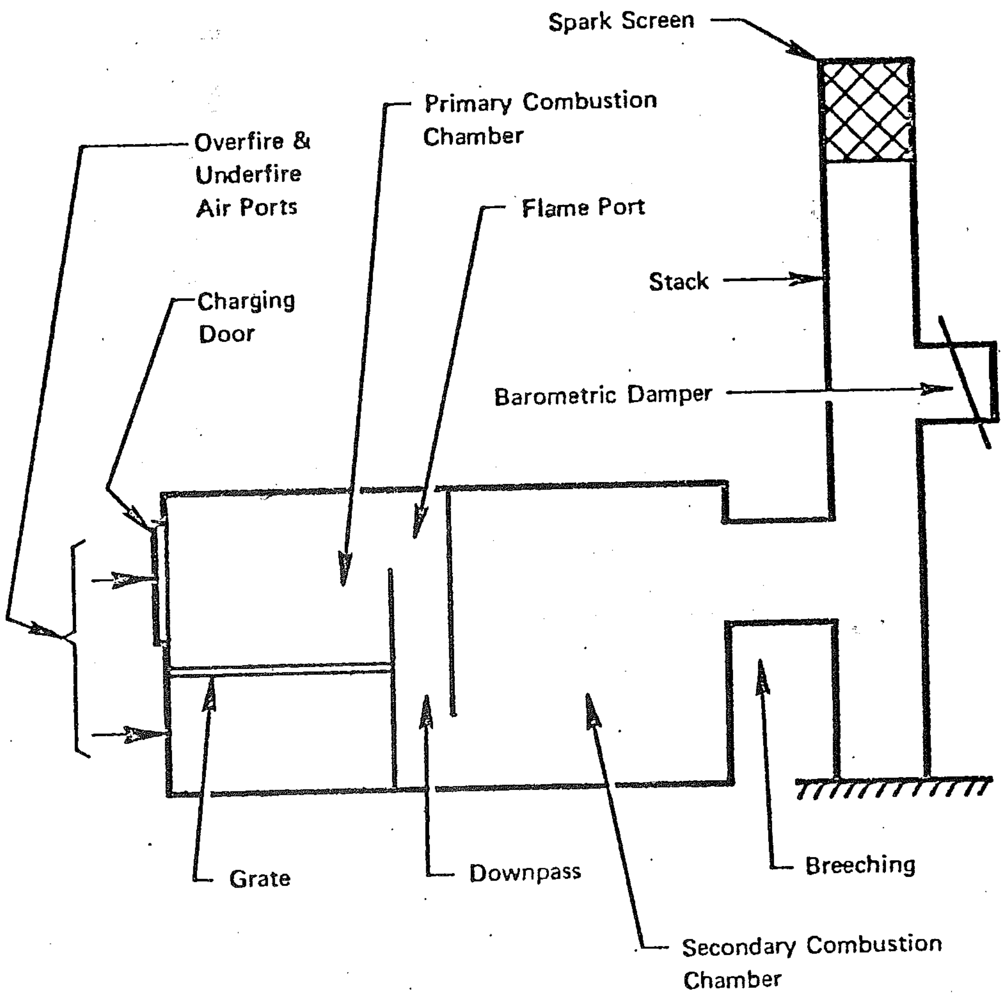


FIGURE 3 **CIRCULAR FURNACE, SOURCE: DeMarco *et al., Incinerator Guidelines-1969,* p.27.**

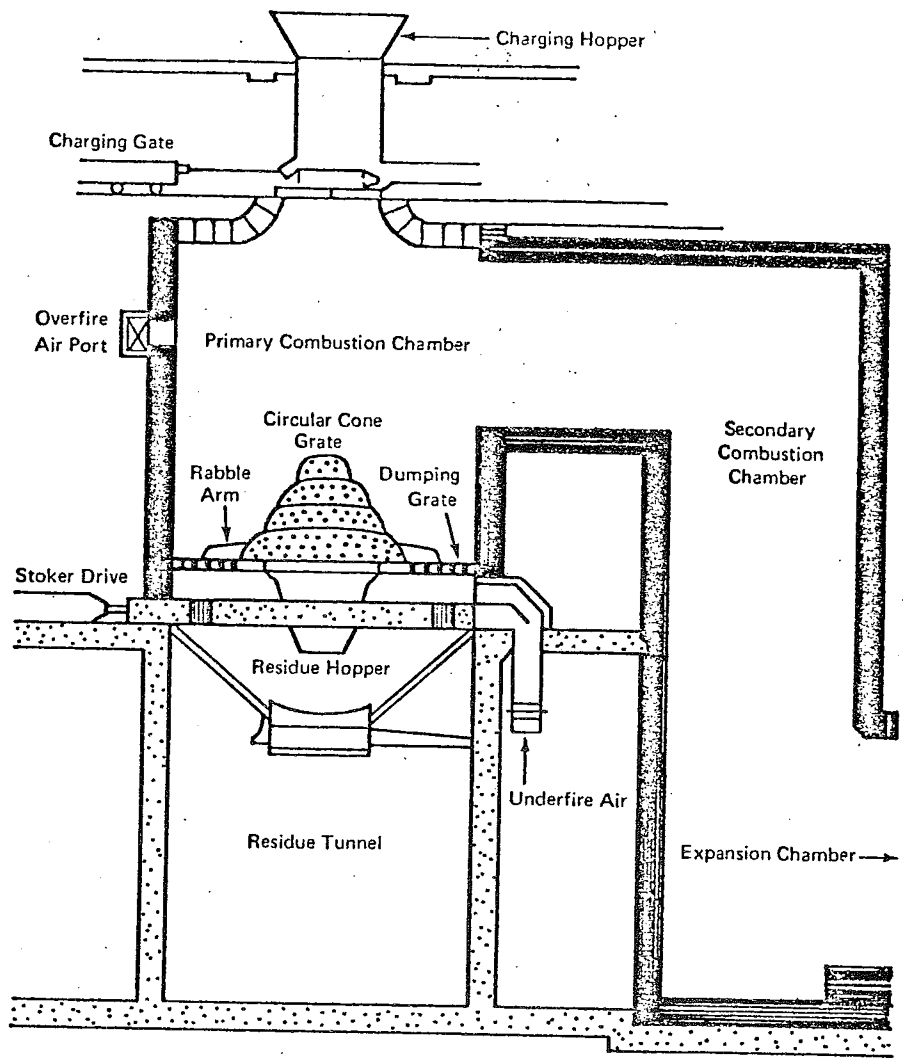


FIGURE 4 **TYPES OF GRATES FOR CONTINUOUS-FEED FURNACES. SOURCE: DeMarco *et al., Incinerator Guidelines-1969,* pp.30-31.**

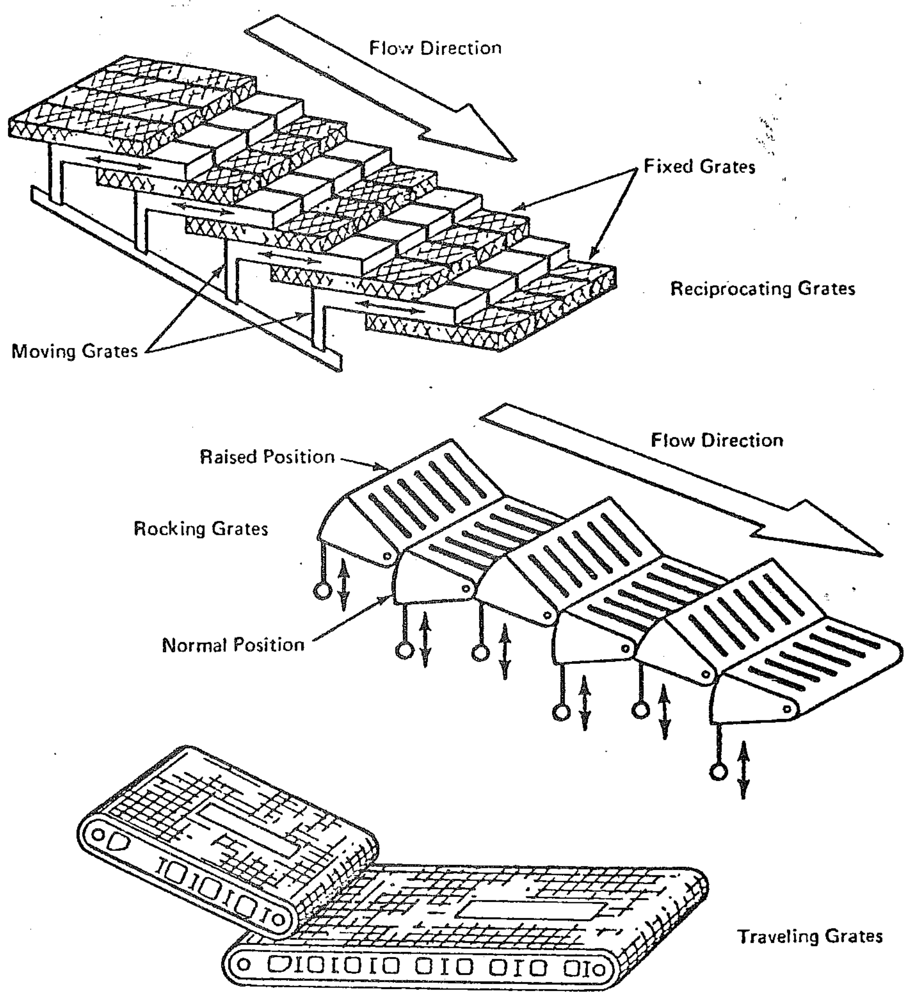


FIGURE 5 OPEN PIT INCINERATOR

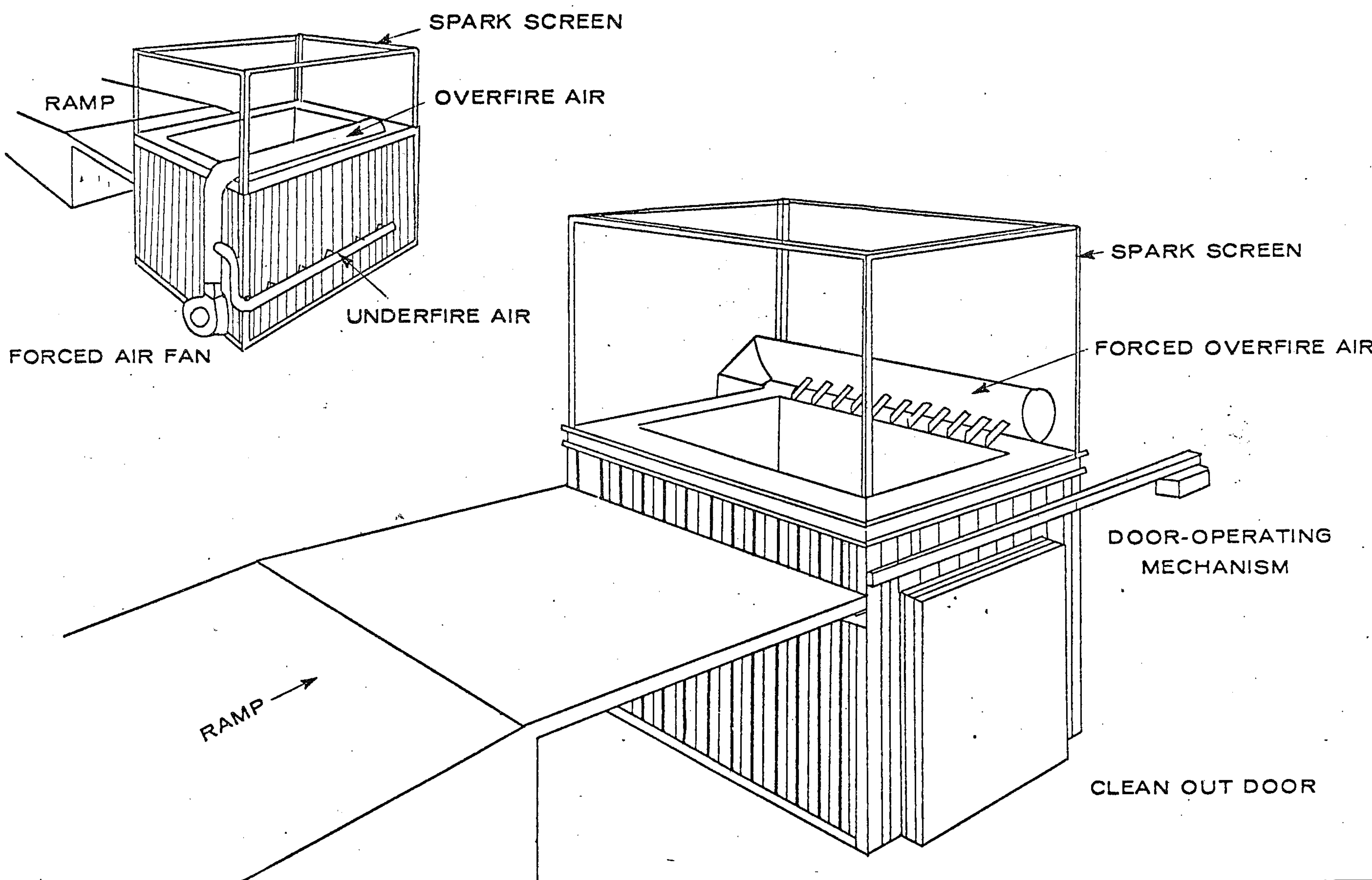
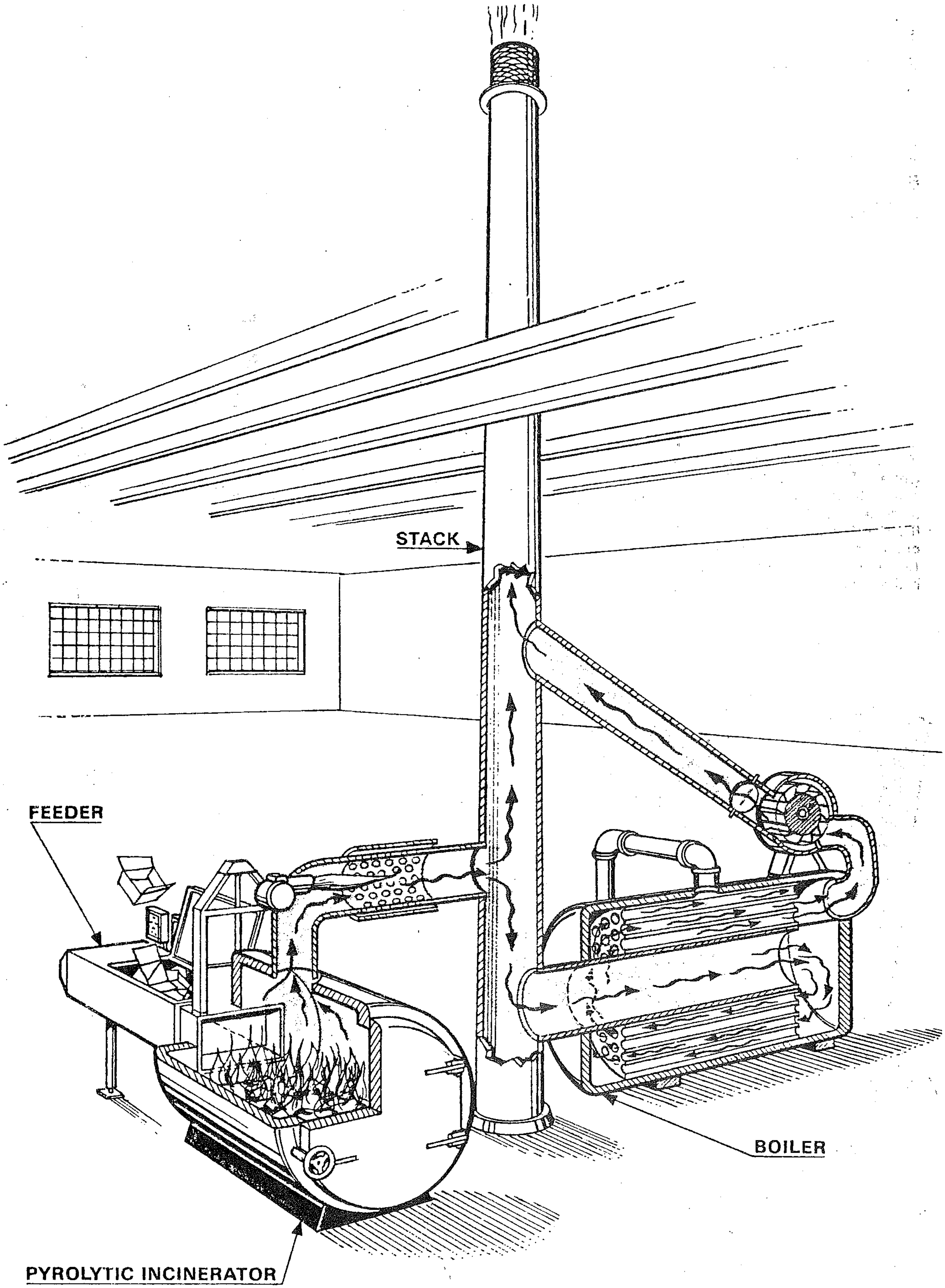


FIGURE 6 FLU GAS TO STEAM HEAT RECOVERY SCHEMATIC



1. Programmer
2. Reactor burner
3. Blower
4. Ignition
5. Primary chamber
6. Reactor section
7. Temperature controller

This cutaway drawing illustrates the CAB Series of DUO-FLOW incinerators available in a choice of five capacities from 200 to 1000 cu. ft. Also available is the RB Series, of cylindrical design, in a choice of four capacities from 20 to 100 cu. ft. The operating principle is the same.

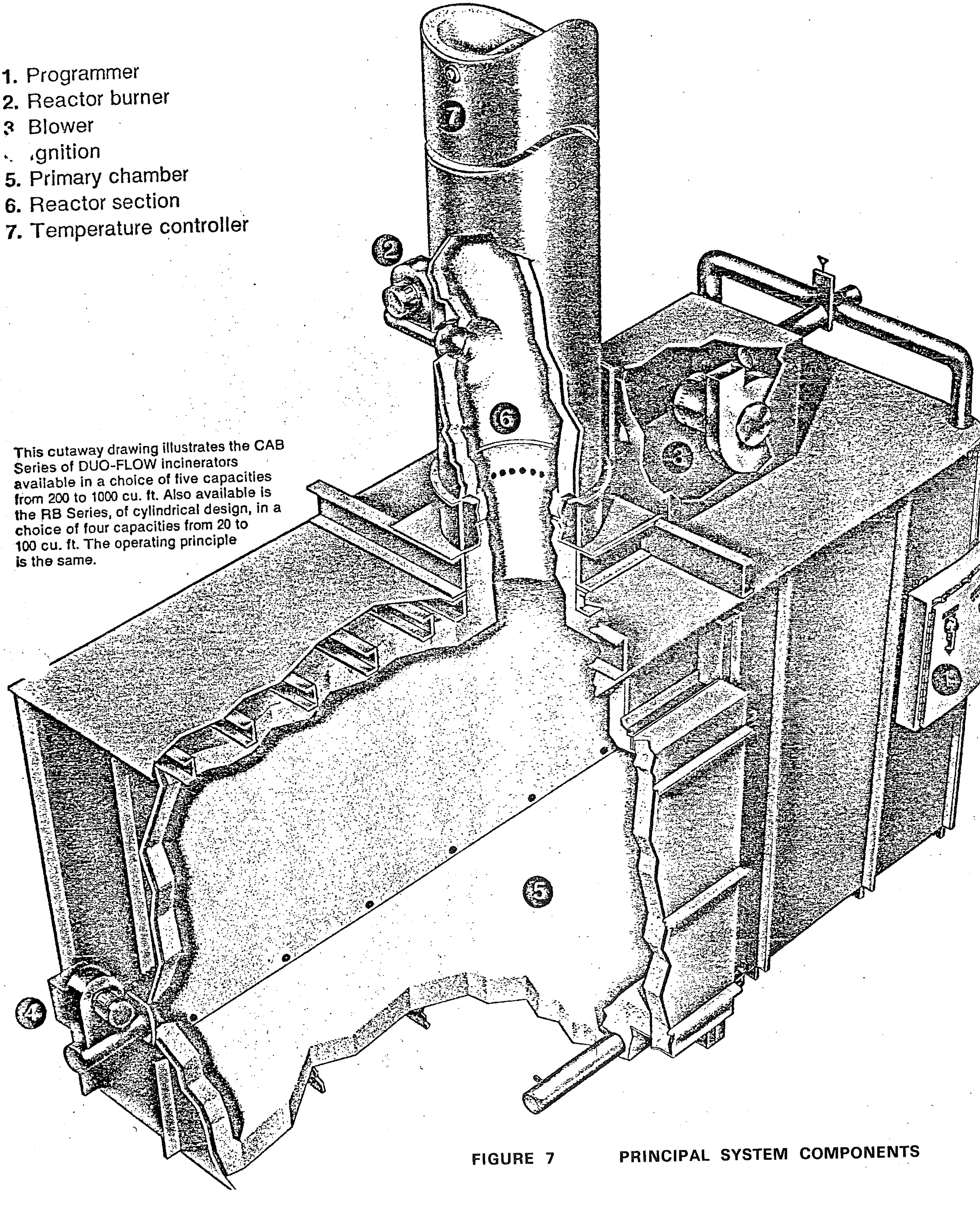
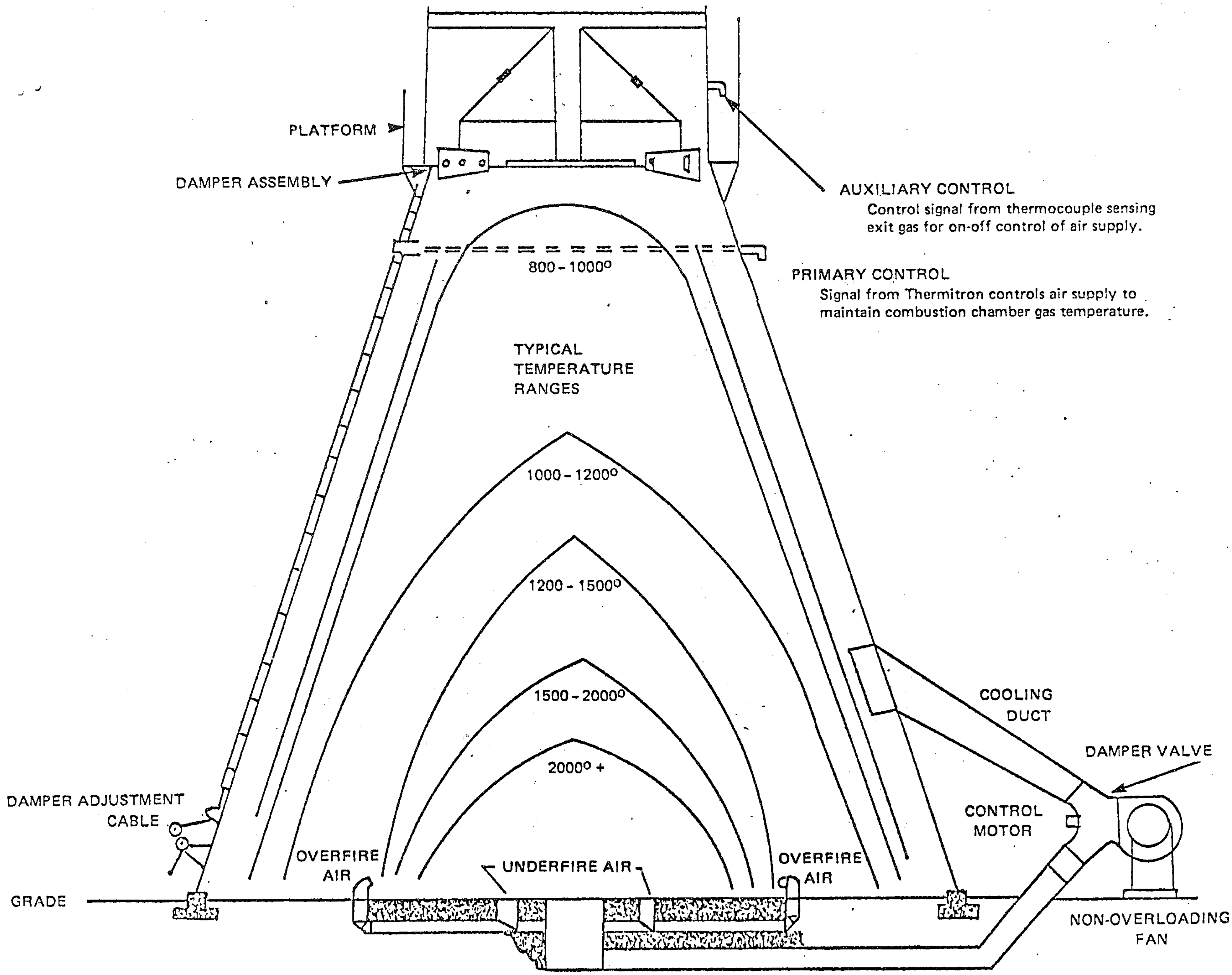


FIGURE 7 PRINCIPAL SYSTEM COMPONENTS

FIGURE 8 MODIFIED CONICAL INCINERATOR



CHAIRMAN'S REMARKS

Mr. L.P. Fedoruk

If you have any questions please hold off until Dave Campbell has gone through his talk. Dave will be discussing the evolution of incinerator design.

Dave Campbell graduated from Queen's University in 1967 in Chemical Engineering. By the time that Ontario was taking action on air pollution, Dave was employed by a Toronto based Incinerator Manufacturer in design and trouble-shooting. Dave joined the Federal Activities Environmental Branch of Environment Canada in 1972. He's been a technical advisor on effluent control, on the development of new technology, regulations and guidelines.

EVOLUTION OF INCINERATOR DESIGN

D.C. Campbell
Federal Activities Environmental Branch
Environment Canada
Ottawa

This section of the seminar will deal with the evolution of incinerator design, particularly in the past 8-10 years. The attention will be focused on four main types of incinerators:

(A) The Three Chamber Incinerator
(B) The Pit Incinerator
(C) The Conical or Teepee Incinerator
(D) The Controlled Air Incinerator

These incinerators will be analyzed by their (1) Design Configuration (2) Accessory Equipment (3) Operation (4) Advantages and, finally, (5) Disadvantages.

At this point, I would like to carry you back in time to the days when the mini-skirt was at its height of fashion - the beginning of 1968. I was first introduced to incinerators at this date when I became part of an incinerator-design team for a refractory manufacturer based in Toronto.

The single chamber incinerators of the 1930's were all but banned in Ontario by the late 60's and had been replaced by the three chamber incinerators. Single-chamber incinerators are still being sold in some areas of Canada today such as in the north and in some apartment buildings.

(A) THREE CHAMBER INCINERATORS

Design Method

In 1968 three chamber incinerators were designed according to the I.I.A. Design Manual produced by the Incinerator Institute of America.

The province of Ontario published their own design manual in 1970 (Criteria for Incinerator Design and Operation) which uses many of the same terms and factors as the I.I.A. manual. Both of these design manuals are based on a waste classification as shown in Figure 1.

The Incinerator designer, technical representative or consultant would arrive at your facilities and conduct an analysis of the quantity and quality of your wastes. This waste would fall into one of these six categories and the incinerator would be labelled as such, e.g. Type 2 waste incinerator - (similar to municipal waste). The waste analysis is completed using charts such as Figure 2.

In the special case where your facility has not as yet been built - such as a proposed hospital, the incinerator would be designed using charts such as Figure 3.

Now that the designer has established your waste type and quantity he is then able to complete the design configuration.

1. **Design Configuration**

The configuration of a three chamber incinerator is shown in Figure 4. The designer would take your daily quantity of waste and divide by the hours of operation to arrive at the hourly capacity of the incinerator. As an example, suppose you generated 4200 lbs per day of type 2 waste and you wanted to burn for 7 hours per day. This would then dictate a

$$\frac{4200 \text{ lbs/day}}{7 \text{ hrs/day}} = 600 \frac{\text{lb}}{\text{hr}} \text{ incinerator.}$$

The whole incinerator is then designed based on the rate of burning (600 lbs/hr) and the type of waste (type 2).

The grates are sized using charts or equations to burn 600 lbs/hr. The waste rate is then converted into a volume of flue gas at 1600°F and the flame port, mixing chamber, combustion chamber, breeching and stack are sized using this volume and the velocities specified in the Design Manual (Figure 5).

The larger incinerators are designed using the same basic tools although some of the factors will be different - particularly the grate burning rates - from 20 to 40 lbs per square foot per hour for the smaller units (100 to 2000 lbs/hr) and upwards of 60 lbs per square foot per hour for the larger municipal incinerators. The larger units will also have some method of particulate emission control such as scrubber or electrostatic precipitator (Figure 6).

2. Accessory Equipment

2.1 ***Primary Burners*** - used to ignite and dry the wastes. Types 1,2,3,4,5,6, wastes.

2.2 ***Afterburners*** - employed to heat the gases and particulates from the ignition chamber to higher temperatures to ensure complete combustion Types 1,2,3,4,5,6 wastes.

2.3 ***Overfired Air*** - introduced by fan or by natural draft to promote combustion. (Approximately 200% of theoretical air) Types 1,2,3,4,5,6 wastes.

2.4 ***Underfired Air*** - introduced by fan or by natural draft to promote combustion (Approximately 30% of theoretical air). Types 1,2,3,4,5,6 wastes.

2.5 ***Mixing Chamber Air*** - introduced by fan or by natural draft to complete combustion of gases and particulates (Approximately 60% of theoretical air). Types 1,2,3,4,5,6 wastes.

2.6 ***Flyash Screen*** - located in breeching or on the stack to breakup particulates.

2.7 ***Refractory Damper*** - usually located in the breeching and is used to block the flow of gases.

2.8 ***Barometric Damper*** - located in the breeching or stack and is used to damper variations in draft due to variations in gas flows and gas temperatures.

2.9 ***Stack*** - a hot air column which provides draft to the incinerator due to the buoyancy of hot gases.

2.10 ***Induced Draft Fan*** - a fan which supplies draft to the incinerator to pull the gases through the chambers.

2.11 ***Scrubbers*** - usually made of stainless steel and employ water to remove gases and particulates from the flue gases.

2.12 ***Electrostatic Precipitators*** - used on large incinerators to remove particulates.

3. Operation

The general operational procedure for the 3 chamber incinerator is as follows:

3.1 The operator opens the charging door and with a shovel, rake, and hoe-cleans out the ashes from on top of the grates and from the ash pit. The ashes are generally shovelled into ash cans and trucked to the landfill site. In large units the ashes are collected from a trench at the base of the grates.

3.2 The operator then turns on the burner(s) and preheats the incinerator for approximately one hour.

3.3 The operator then begins to charge the incinerator. The recommended procedure for the smaller units is that 1/4 of the hourly capacity is charged every 15 minutes. i.e. if it was a 400 lb/hr incinerator he would charge 100 lbs every 15 minutes. If a 4000 lb/hr incinerator, he would charge 1000 lbs every 15 minutes. In the smaller units he would charge by hand; in the larger units he may fill a ram charger by hand or a charging hopper by crane.

3.4 The waste burns in the ignition chamber. The gases generated pass through the flame port and the combustion is completed in the mixing chamber and settling chamber. The large flyash particles drop out in the settling chamber.

3.5 At the end of the operating day the incinerator is shut down.

4. Advantages

Simple to operate and repair.

5. Disadvantages

Very operator-dependent. Can be overcharged and under charged.

(B) THE PIT INCINERATOR

1. Configuration

There are two basic models being marketed in Canada. The Open Pit Incinerator and the Closed Pit Incinerator (Figure 8).

The closed pit incinerator differs in that it has a stack and flyash screen on the fire box whereas the open-pit has a flyash screen *only* on the fire box. The basic fire box is 8′ wide by 11′ deep. The length of the fire box varies as the rated capacity.

LENGTH	WIDTH	DEPTH	RATED CAPACITY
8 ft	8 ft	11 ft	2 tons/hr
12 ft	8 ft	11 ft	3 tons/hr
16 ft	8 ft	11 ft	4 tons/hr
20 ft	8 ft	11 ft	5 tons/hr

2. Accessory Equipment

2.1 ***Fan.*** A manifold across the top of one side of the incinerator blasts high velocity air through a series of nozzles across the top of the fire. This screen of air serves to knock down flyash as well as promote rapid combustion. A smaller manifold may be installed at the base of the fire box on both sides to supply underfire air.

2.2 **Charging Doors.** Some models are equiped with motor operated charging doors to minimize tramp air inclusion during burning.

2.3 ***Front End Loader.*** The incinerator is generally charged with a front end loader.

3. Operation

At the beginning of the day the operator opens the side clean out door. If there are two clean out doors the ashes will be pushed out using a large hoe attachment on the front end loader; if not, the hoe will be used to drag the ash from the pit. The operator may then spread a layer of gravel on the floor to prevent slagging on the refractory.

The pit is then filled 2/3 full of solid waste. The waste is ignited using a match. Oil may be spread on the waste to initiate the burning. Shortly after the fire has started the fan is turned on and the incinerator is charged regularly using the bucket of the front end loader.

4. Advantages:

- simplicity of operation
- relatively low cost
- few moving parts

5. Disadvantages:

- high particulates emissions
- gaseous pollution

(C) THE CONICAL OR TEEPEE INCINERATOR

1. Configuration

The teepee burner (Figure 9) is so called because of its similarity in shape to an Indian teepee. The size of a burner may vary from 10 feet in diameter by 12 feet high to 90 feet in diameter by 97 feet high. A typical size for a teepee burner is 52 feet in diameter by 57 feet high. The base of the teepee burner is normally secured to a concrete ring foundation, and the walls are usually 16-gauge steel. Many teepees have an inner-wall liner of corrugated steel for protection from heat. The 15- to 20-foot diameter dome of the teepee is normally equipped with 2-1/2 mesh steel wire for collection of the particles of fly ash. A large number, e.g., 50 to 75, adjustable- or fixed-draft doors about 10 inches wide by 20 inches high are located at the base of the burner to provide overfire air for combustion. Most teepee burners are also equipped with forced-draft blowers and underground piping to the burner grate. Double doors large enough for a dump truck to pass through provide access for charging the teepee with combustible waste and for removing ash.

2. **Accessory Equipment**

2.1 ***Charging System*** - a steel conveyor belt or a bulldozer with a moveable blade or an elevated truck chute.

2.2 ***Underfire and Overfire Air*** - combustion air is generally supplied by a forced air fan and by louvers on the walls.

2.3 ***Auxillary Burners*** - some teepees may have an auxillary burner tied to temperature controllers.

2.4 ***Control Systems*** - the modified conical burners may have a control system to operate the burner(s), air supply, and a dome damper system.

3. **Operation**

Three methods are used for charging refuse to the teepee burner (1) by steel conveyor belt, (2) by bulldozer with a movable blade, and (3) by elevated truck chute.

The fastest charging, requiring the least operating personnel, is the elevated truck chute method. The incoming truck loaded with refuse backs onto an elevated platform to the teepee charge chute and dumps the refuse onto the chute and into the teepee. Incoming truck loads of refuse may vary from one to four per hour.

A typical operating schedule observed is from 7:00 a.m. to 6:00 p.m., 6 days per week. The first operation of the day is removal of the ash residue from the previous day. The ash is loaded on a truck and hauled to a landfill. Ash removal from the teepee may take from 30 to 60 minutes. After the teepee is charged with municipal-type refuse, the charge is ignited, and the underfire air blowers are turned on.

The more popular type of charging observed was the dozer method. The incoming truck dumps the full load of refuse in front of the open doors of the teepee. A large dozer pushes the refuse onto the burning pile in the center of the teepee. The dozer blade is raised vertically as the dozer moves forward. At most of the dozer-fed teepees, the large dozer was operating about half and the large double doors were open approximately three-fourths of the operating day. A smaller dozer was usually used while the large dozer was serviced or repaired.

The typical conveyor-feed system for a teepee includes both a covered 4-foot-wide conveyor belt and a receiving house, perhaps, 40 by 60 by 20 feet high. The base of the loading house is often 10 to 15 feet above the floor of the teepee burner. The belt conveyor enters the teepee about half-way between its base and dome and extends into the center of the teepee. Incoming trucks unload refuse onto the floor of the receiving building. A small dozer pushes refuse onto a separate floor conveyor which transfers the refuse to the inclined conveyor feeding the teepee. This type of charging system offers a better controlled, uniform feed. The large unloading doors on the teepee are closed during charging and burning to afford better control of overfire air entering the louvers at the base of the teepee.

Although the charging of refuse may stop at about 5:00 p.m., the burning continues at a reduced rate for another 8 to 12 hours. The forced-draft blowers are left operating to provide the necessary underfire air to complete combustion. Although the ash residue is normally removed each morning, in some teepee burners ash is removed only once or twice a week. In most of the ash unloading operations, no unburned garbage was detected.

4. **Advantages**

- inexpensive
- simplicity of operation

5. **Disadvantages**

- very operator-dependent
- air pollution source
- low temperature combustion generates excessive smoke.

(D) THE CONTROLLED AIR INCINERATOR (STARVED AIR)

The controlled air incinerator was first introduced into Canada in 1970. It was designed and tested by the design team of which I was a part and the first unit to be installed in an operating facility was at Maple Leaf Gardens in Toronto.

This type of incinerator is recommended by Environment Canada at the present time as the best practicable technology in the incineration field.

At the present time there are two basic models being marketed in Canada. The Batch Charged Controlled Air Incinerator and the Continuously Charged Controlled Air Incinerators.

Batch Charged Controlled Air Incinerators

1. **Configuration**

The batch charged units were the first to be marketed in Canada. They are generally for waste loads between 200 lbs per day and 5 tons per day, although sizes as large as 20 tons per day have been marketed in the U.S. They are called "Batch" because they are designed to hold the total daily waste generated by a site in one charge.

As an example, suppose a site generated 5 tons per day of type 2 waste with a density of approximately 5 lbs per cubic foot. The volume of the 5 tons of waste would be

$$\frac{5 \text{ tons} \times 2000 \text{ lbs/ton}}{5 \text{ lbs/cubic foot}} = 2000 \text{ cubic feet}$$

Therefore, the primary chamber would be a refractory lined box with a capacity of 2000 cubic feet. The stack would be sized to burn this waste in a period of about 4-8 hours.

2. Accessory Equipment (Figure 10)

2.1 ***Control Panel*** - the incinerator is turned on at this panel and a programmer inside controls the combustion operation.

2.2 ***Afterburner*** - the afterburner preheats the stack and burns the gases to complete the combustion.

2.3 ***Blower*** - the blower supplies combustion air to the primary chamber and the reactor section through nozzles.

2.4 ***Ignition Burner*** - the ignition burner ignites the refuse and assists the combustion by drying the wet wastes.

3. Operation

3.1 The operator cleans out the ashes from the previous day's operation. The ashes may have to be ''wet-down'' with water prior to removal from the incinerator.

3.2 The incinerator is then left open for the next 8 hours during which time it is slowly loaded with waste as it arrives on the disposal site.

3.3 At the end of this loading period the operator seals the charging door and presses the start button on the panel initiating the following sequence which occurs automatically:

3.3.1 The afterburner ignites and preheats the stack for 1/2-1 hour.

3.3.2 At the end of the preheat period the ignition burner is started which in turn ignites the waste in the chamber. This burner will remain on for approximately 15 minutes with dry waste, however, with wetter wastes the ignition burner will be set for longer periods to dry the waste.

3.3.3 The combustion air fan starts at approximately the same time as the ignition burner. This fan supplies less than the required air for combustion in the primary chamber resulting in the generation of a pyrolysis gas. Hence the term ''starved-air'' incinerator is often used. This gas is drawn into the stack where it is mixed with high velocity air in excess of that required for complete combustion. It then encounters the afterburner which burns the gas to carbon dioxide and water vapor. The afterburner is temperature controlled at 1600°F and with dryer wastes this burner will be automatically shut down due to temperatures in excess of 2000°F during the first hour of burning. As the temperatures drop in the stack the afterburner will be re-ignited.

3.3.4 In a typical burn the afterburner will be shut off automatically after about 6 hours. The combustion air fan will remain on for about 15 hours to cool the incinerator down for the next day.

3.3.5 The cycle then repeats the next day.

4. Advantages

- minimum operator attendance during loading and not required during burning,
- very low particulate and gaseous emissions due to controlled air supply and combustion rate
- very simple operation

5. Disadvantages

- complex for repairmen other than from manufacturer
- relatively expensive
- limited capacity

Continuous Charged Controlled Air Incinerators

1. Configuration

The continuous charged controlled air incinerator differs very little from the batch-charged unit. The main configurational difference is that the continuous charged incinerators tend to be horizontal cylinders in shape to minimize restriction to charging the waste.

2. Accessory Equipment

The accessory equipment on the continuous charge incinerators is the same as the batch units except for the following differences;

2.1 ***Ram Charger*** - these incinerators are generally loaded using a compactor charger. This device minimizes the tramp air intrusion into the incinerator and maximizes the quantity of waste burned in a given volume of furnace.

2.2 ***Heat Recovery Modules*** - these incinerators offer an option of a heat recovery module installed on top of the charging cyclinder.

2.3 ***Bobcats*** - the larger systems are generally charged with small "Bobcat" tractors.

3. Operation

3.1 The basic operation of these units is the same as the batch charged incinerators. The major difference is that they are ram charged continually during the day and allowed to burn down during the night. There also tends to be a higher degree of control on the after burner and the air supply because continuous operation better utilizes the heat from the waste resulting in a cutback on auxillary fuel use. The volume of the unit is also better utilized because continuous charging and burning releases the volatiles immediately leaving the fixed carbon to burn more slowly during the day and night.

3.2 The main operational difference between the continuous and the batch units is the use of module combinations to burn upwards of 100 tons per day. This is also the major advantage of the one system over the other.

FIGURE 1 CLASSIFICATION OF WASTES TO BE INCINERATED

Classification of Wastes Type	Description	Principal Components	Approximate Composition % by Weight	Moisture Content %	Incombustible Solids %	B.T.U. Value/lb. of Refuse as Fired	B.T.U. of Aux. Fuel Per Lb. of Waste to be included in Combustion Calculations	Recommended Min. B.T.U./hr. Burner Input per lb. Waste
*0	Trash	Highly combustible waste, paper, wood, cardboard cartons, including up to 10% treated papers, plastic or rubber scraps; commercial and industrial sources	Trash 100%	10%	5%	8500	0	0
*1	Rubbish	Combustible waste, paper, cartons, rags, wood scraps, combustible floor sweepings; domestic, commercial, and industrial sources	Rubbish 80% Garbage 20%	25%	10%	6500	0	0
*2	Refuse	Rubbish and garbage; residential sources	Rubbish 50% Garbage 50%	50%	7%	4300	0	1500
*3	Garbage	Animal and vegetable wastes, restaurants, hotels, markets; institutional, commercial, and club sources	Garbage 65% Rubbish 35%	70%	5%	2500	1500	3000
4	Animal solids and organic wastes	Carcasses, organs, solid organic wastes; hospital, laboratory, abattoirs, animal pounds, and similar sources	100% Animal and Human Tissue	85%	5%	1000	3000	8000 (5000 Primary) (3000 Secondary)
5	Gaseous, liquid or semi-liquid wastes	Industrial process wastes	Variable	Dependent on pre-dominant components	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey
6	Semi-solid and solid wastes	Combustibles requiring hearth, retort, or grate burning equipment	Variable	Dependent on pre-dominant components	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey	Variable according to wastes survey

*The above figures on moisture content, ash, and B.T.U. as fired have been determined by analysis of many samples. They are recommended for use in computing heat release, burning rate, velocity, and other details of incinerator designs. Any design based on these calculations can accommodate minor variations.

FIGURE 2 B.T.U. VALUES

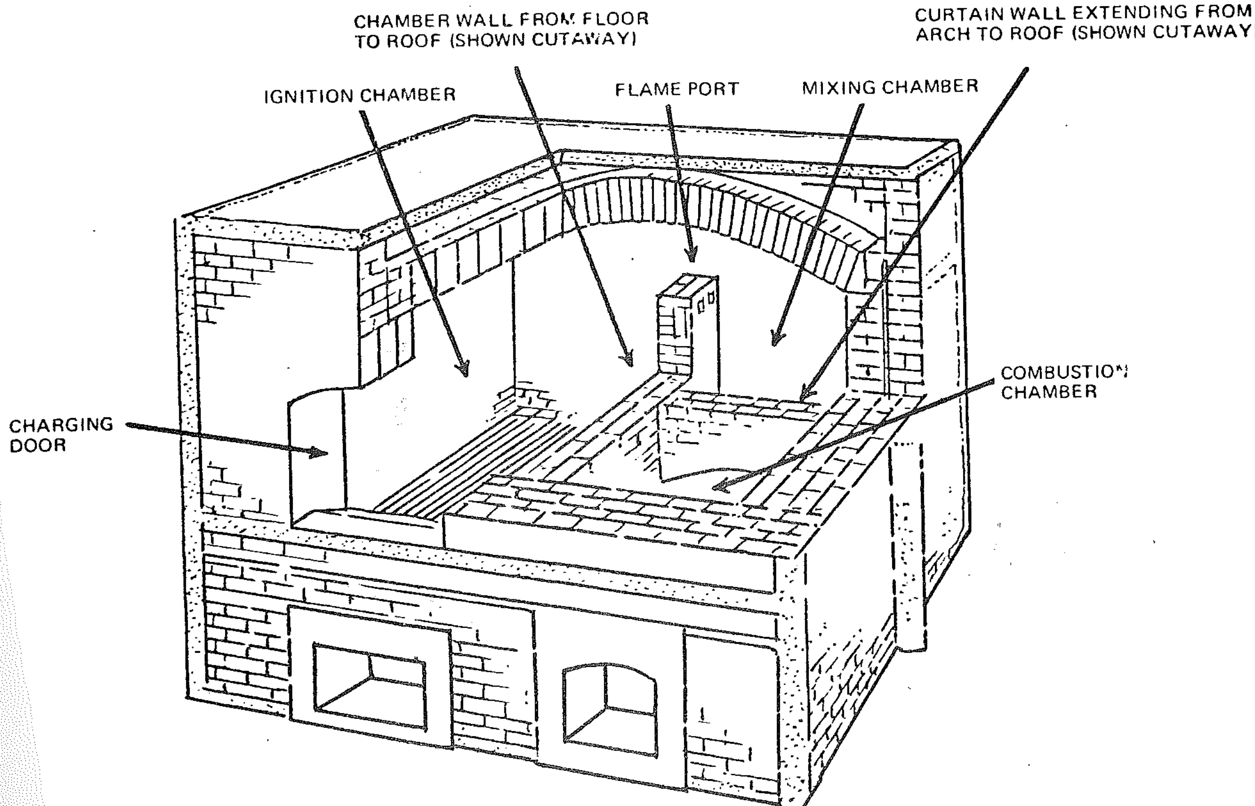
Waste	B.T.U. value/lb. as fired	Wt. in lbs. per cu. ft. (loose)	Wt. in lbs. per cu. ft.	Content by weight in percentage	
				ASH	MOISTURE
Type 0 Waste	8,500	10		5	10
Type 1 Waste	6,500	10		10	25
Type 2 Waste	4,300	20		7	50
Type 3 Waste	2,500	35		5	70
Type 4 Waste	1,000	55		5	85
Kerosene	18,900		50	.5	0
Benzene	18,210		55	.5	0
Toluene	18,440		52	.5	0
Hydrogen	61,000		.0053	0	0
Acetic acid	6,280		65.8	.5	0
Methyl alcohol	10,250		49.6	0	0
Ethyl alcohol	13,325		49.3	0	0
Turpentine	17,000		53.6	0	0
Naphtha	15,000		41.6	0	0
Newspaper	7,975	7		1.5	6
Brown paper	7,250	7		1.0	6
Magazines	5,250	35		22.5	5
Corrugated paper	7,040	7		5.0	5
Plastic coated paper	7,340	7		2.6	5
Coated milk cartons	11,330	5		1.0	3.5
Citrus rinds	1,700	40		.75	75
Shoe Leather	7,240	20		21.0	7.5
Butyl sole composition	10,900	25		30.0	1
Polyethylene	20,000	40-60	60	0	0
Polyurethane (foamed)	13,000	2	2	0	0
Latex	10,000	45	45	0	0
Rubber waste	9,000-11,000	62-125		20-30	
Carbon	14,093		138	0	0
Wax paraffin	18,621		54-57	0	0
1/3 wax-2/3 paper	11,500	7-10		3	1
Tar or asphalt	17,000	60		1	0
1/3 tar-2/3 paper	11,000	10-20		2	1
Wood sawdust (pine)	9,600	10-12		3	10
Wood sawdust	7,800-8,500	10-12		3	10
Wood bark (fir)	9,500	12-20		3	10
Wood bark	8,000-9,000	12-20		3	10
Corn cobs	8,000	10-15		3	5
Rags (silk or wool)	8,400-8,900	10-15		2	5
Rags (linen or cotton)	7,200	10-15		2	5
Animal fats	17,000	50-60			0
Cotton seed hulls	8,600	25-30		2	10
Coffee grounds	10,000	25-30		2	20
Linoleum scrap	11,000	70-100		20-30	1

The above chart shows the various B.T.U. values of materials commonly encountered in incinerator designs. The values given are approximate and may vary based on their exact characteristics or moisture content.

FIGURE 3 SELECTION AND SIZING GUIDE

Classification	Building Type	Design Requirements For Waste Type	Approximate Quantities of Waste Produced
Industrial Buildings	Process Plants	5, 6	Survey must be made
	Factories	1, 2, 3	Survey must be made
	Warehouses	1, 2, 3, 5, 6	2 lbs/100 sq.ft./day
Commercial Buildings	Office Building	1	1 lb/100 sq.ft./day
	Department Stores	2, 3	4 lb/100 sq.ft./day
	Shopping Centres (excluding food stores)	2, 3	Survey must be made
	Supermarkets	3	9 lb/100 sq.ft./day
	Restaurants	3	2 lb/meal/day
	Drug Stores	2, 3	5 lb/100 sq.ft./day
	Banks	1	Survey must be made
	Food Markets	3	4 lb/25 sq.ft./day
Residential	Apartments	2	5 lb/bedroom/day
Schools	Without Cafeteria	1	10 lb/room + ¼ lb/pupil/day
	With Cafeteria	2	8 lb/room + ¼ lb/pupil/day
	Universities	1, 2, 3, 4	Survey must be made
Institutions	Hospitals General Waste	2, 3	8 lbs/bed/day
	Hospitals Pathological Waste	4	5 lbs/bed/day
	Residences	2	3 lbs/person/day
	Rest Homes	2	3 lbs/person/day
	Homes for Aged General Waste	2, 3, 4	5 lbs/person/day
Hotels	Hotels – 1st Class	3	5 lbs/room/day
	– Medium Class	3	5 lbs/room/day
	Motels	1	2 lbs/room/day
Miscellaneous	Dog Pounds	4	Survey must be made
	Vet. Hospitals	4	Survey must be made
	Crematoria	4	Survey must be made

FIGURE 4 CUTAWAY OF AN IN-LINE MULTIPLE-CHAMBER INCINERATOR



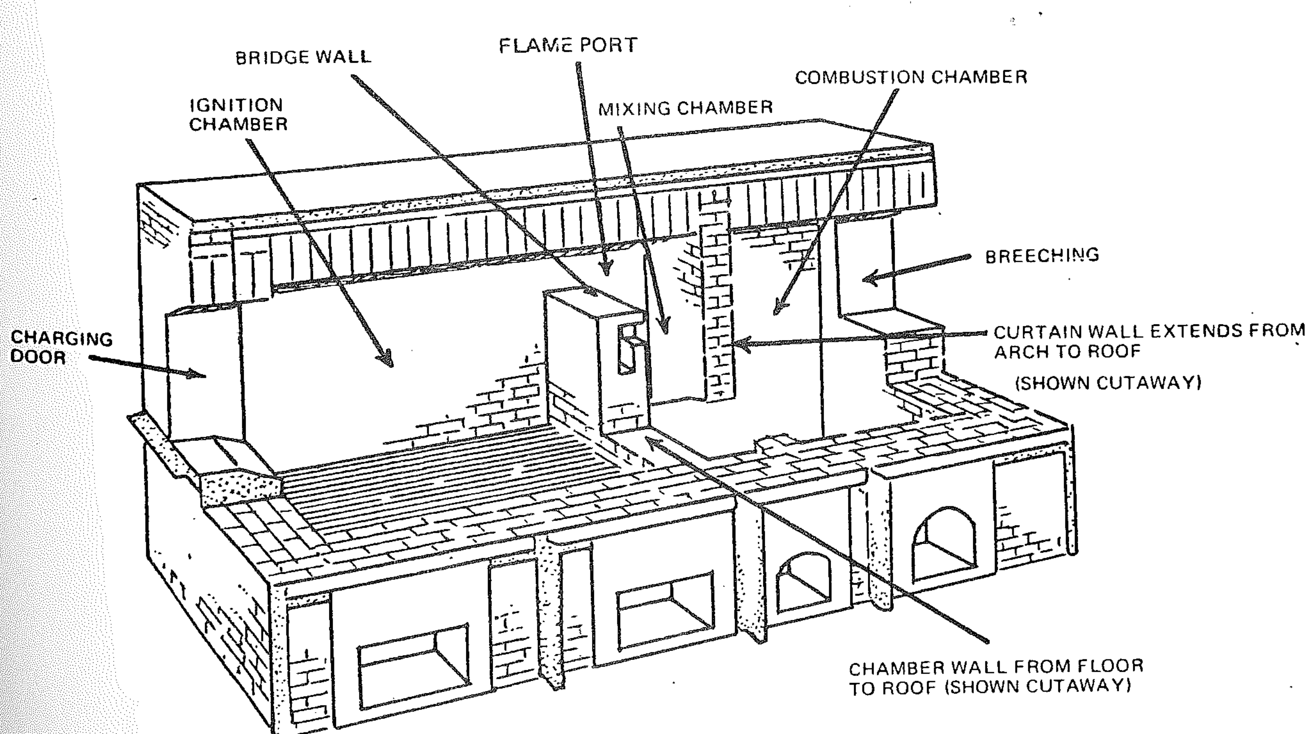


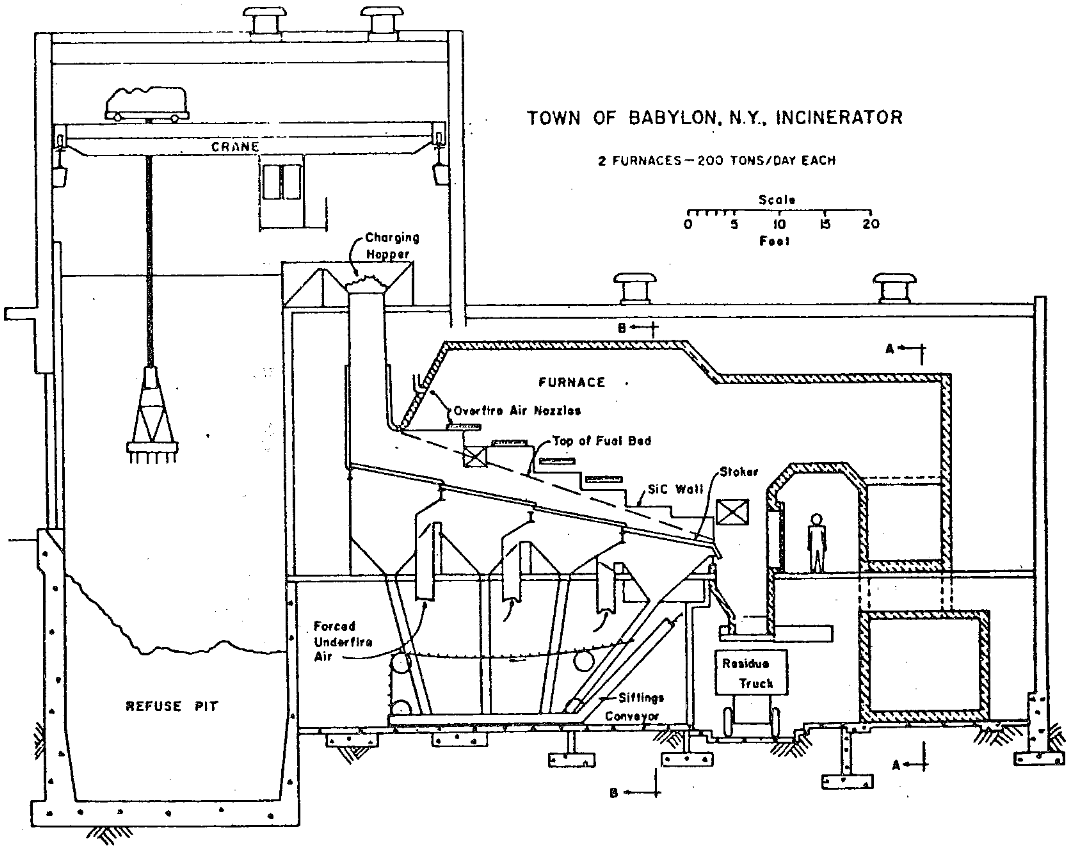
FIGURE 5 COMBUSTION AIR

(i)	Total Air requirement (batch charging operation)	Sufficient air (calculated on the basis of heat balance) to maintain a temperature of 1600°F in the mixing and combustion chambers
(ii)	Air Distribution	Ports controllable up to:—
	Overfire Air Ports (ignition chamber)	70% of total air requirement
	Underfire Air Ports (ignition chamber)	10% of total air requirement
	Mixing Chamber Air Ports	20% of total air requirement
(iii)	Port Sizing:— Nominal inlet velocity pressure	0.1 in. water gauge
(iv)	Air Inlet Port Oversize Factors:—	
	Primary Air Inlet	1.2
	Underfire Air Inlet	1.5 for over 500 lb/hr to 2.5 for 50 lb/hr
	Mixing Chamber Air Inlet	2.0 for over 500 lb/hr to 5.0 for 50 lb/hr

Temperatures, Gas Velocities and Retention Time;

(i)	Ignition Chamber Temperature:—	1600°F plus or minus 10%
(ii)	Mixing Chamber Velocities:—	
	Flame Port @ 1600°F	55 ft/sec plus or minus 20% (45 ft/sec — 65 ft/sec.)
	Mixing Chamber @ 1600°F	35 ft/sec plus or minus 20% (28 ft/sec — 42 ft/sec.)
	Curtain Wall Port @ 1600°F	25 ft/sec plus or minus 20% (20 ft/sec — 30 ft/sec.)
(iii)	Combustion Chamber:— Minimum Gas Retention Times	
	Rubbish (Type 1 waste)	0.3 second
	Refuse (Type 2 waste)	0.5 second
	Garbage (Type 3 waste)	0.5 second
	Maximum Velocity at 1600°F	8.5 ft./sec.

FIGURE 6 CROSS-SECTION OF TEST FURNACES AND PLANT



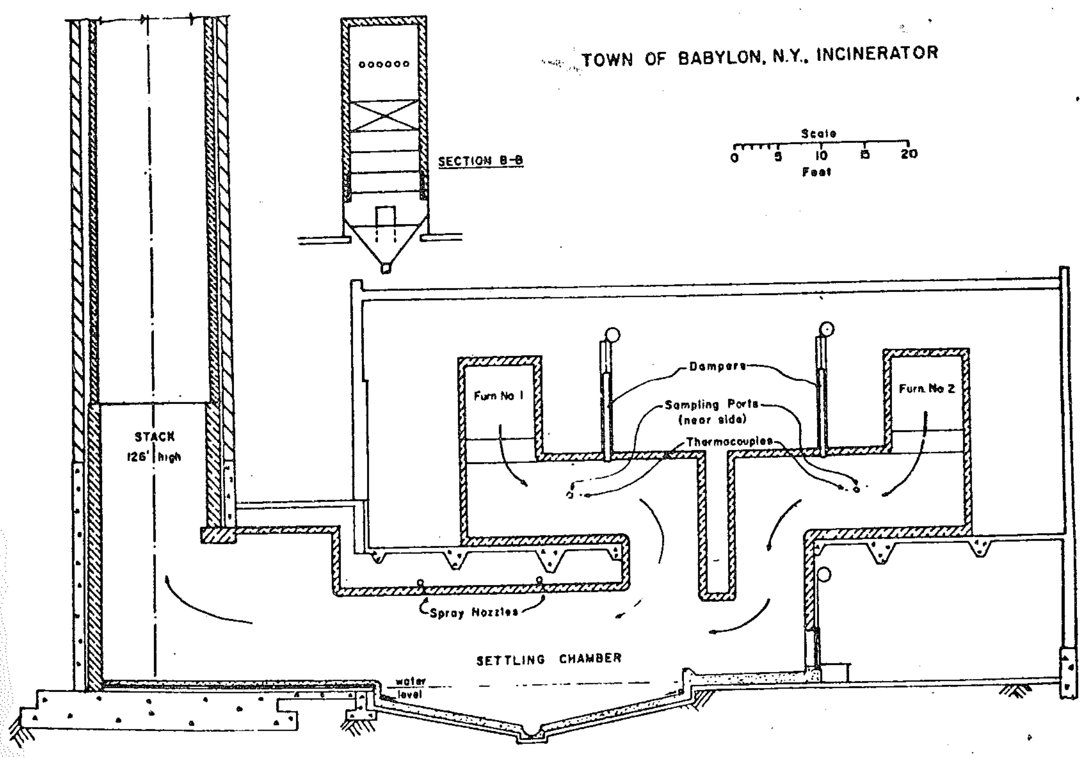


FIGURE 7 CLASSIC TYPES OF INCINERATORS

COMPONENT PARTS OF AN INCINERATOR

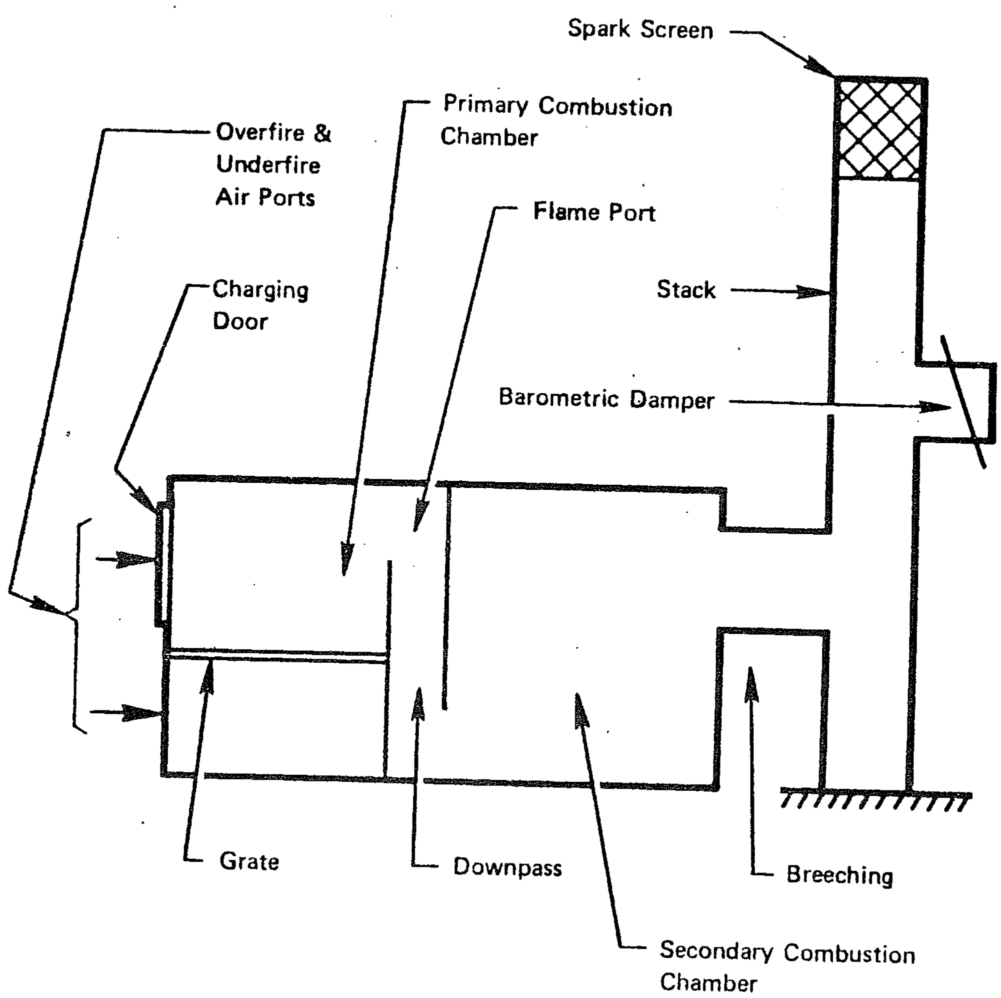


FIGURE 8 OPEN PIT INCINERATOR (PLIBRICO CANADA, LIMITED)

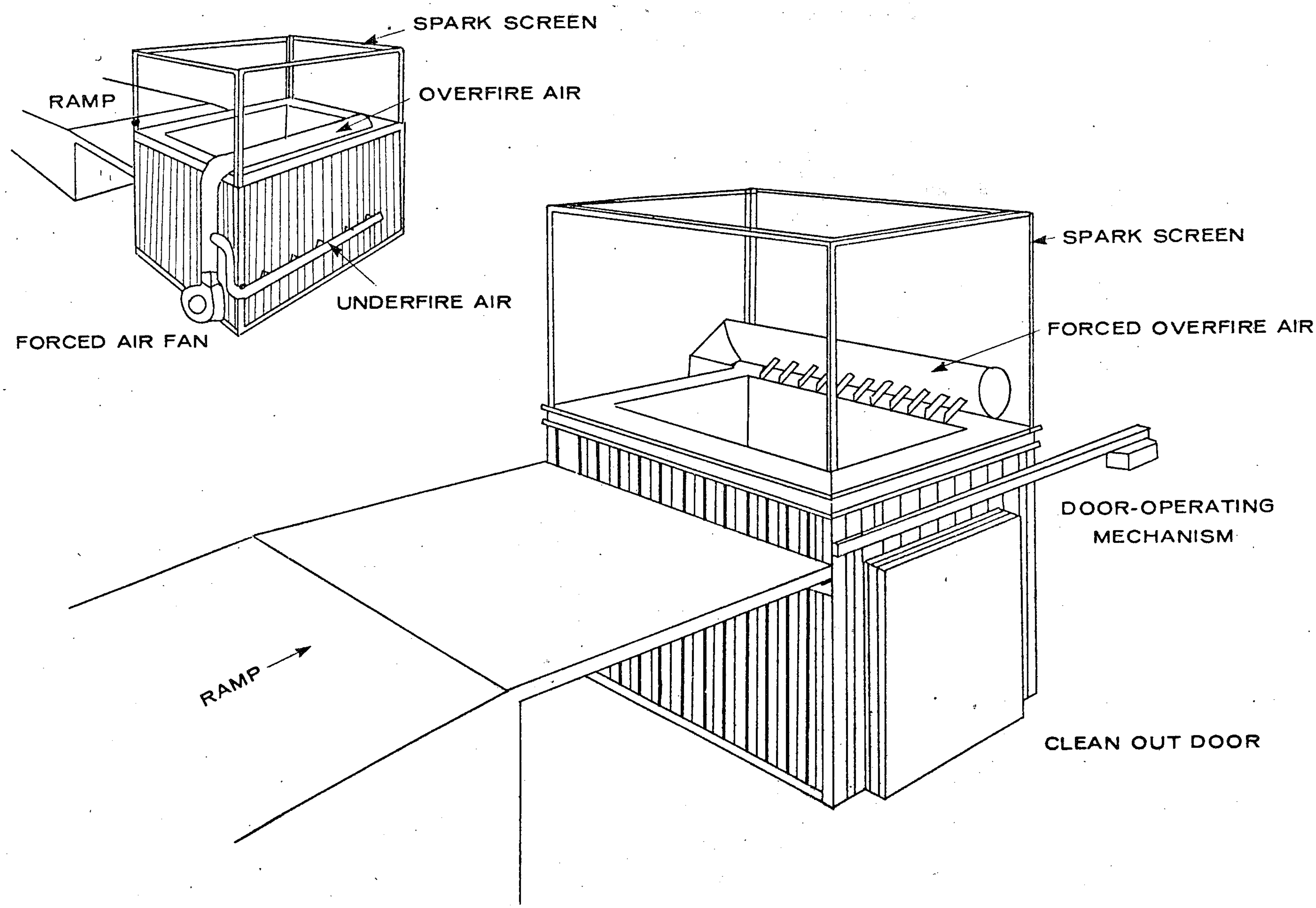
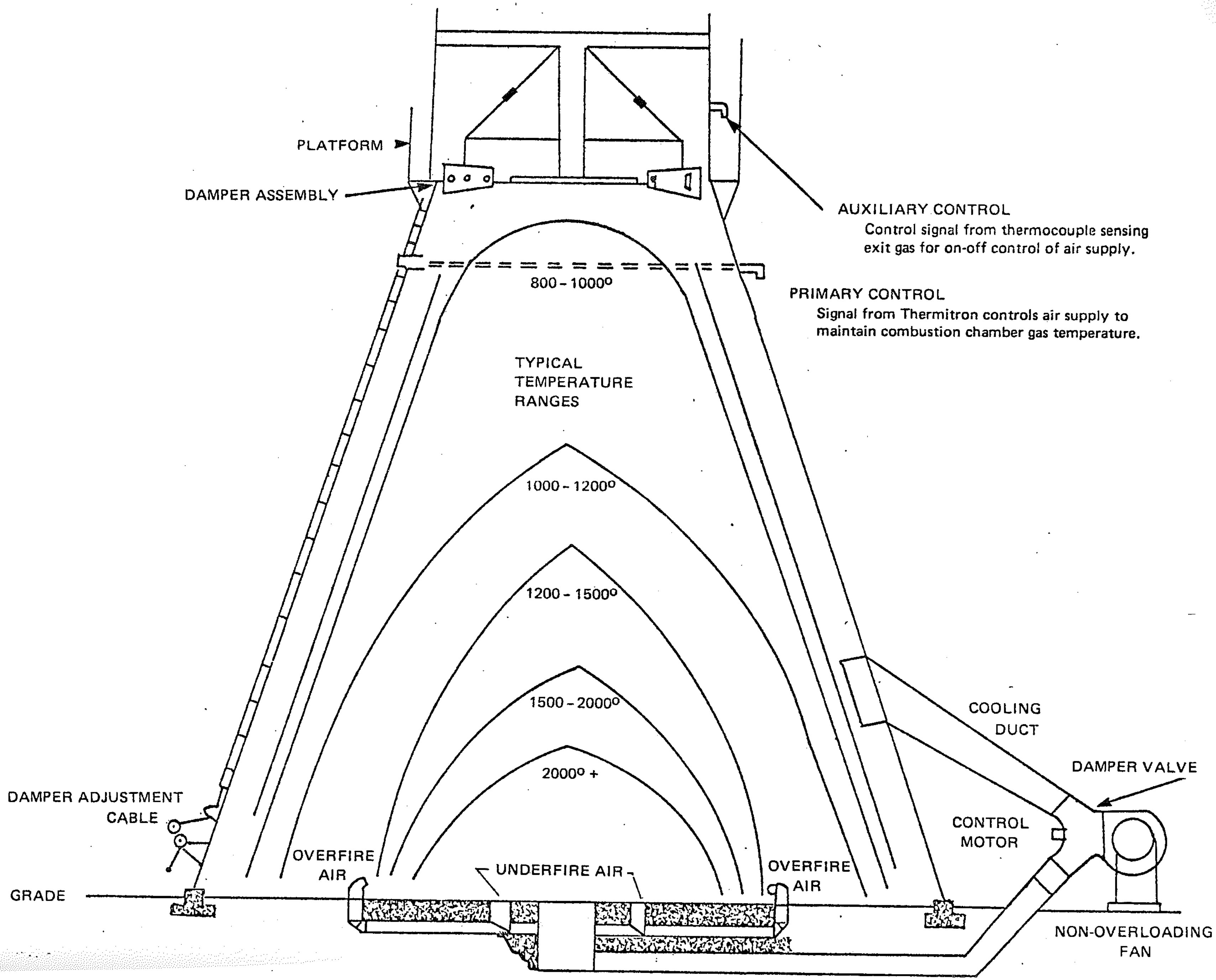


FIGURE 9 MODIFIED CONICAL INCINERATOR (LAMB–CARGATE)



1. Programmer
2. Reactor burner
3. Blower
4. Ignition
5. Primary chamber
6. Reactor section
7. Temperature controller

This cutaway drawing illustrates the CAB Series of DUO-FLOW incinerators available in a choice of five capacities from 200 to 1000 cu. ft. Also available is the RB Series, of cylindrical design, in a choice of four capacities from 20 to 100 cu. ft. The operating principle is the same.

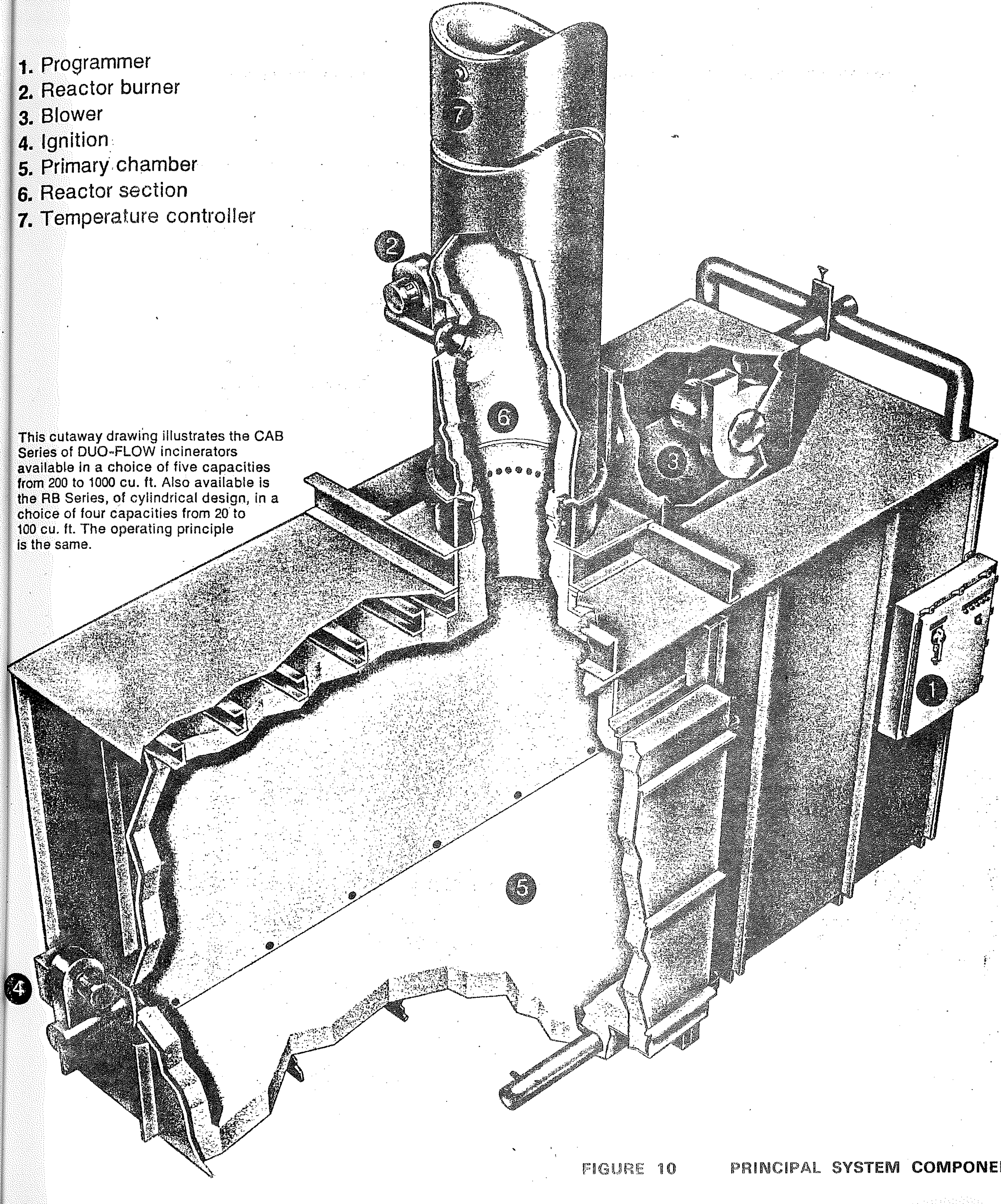


FIGURE 10 PRINCIPAL SYSTEM COMPONENTS

QUESTION PERIOD: DEFINITION OF TERMS AND EVOLUTION OF INCINERATOR DESIGN

Question: **(Mr. R. Pritchard, Alberta Environment, Edmonton)** I wonder if you would give us any information on water wall incinerators.

Answer: **(Mr. Campbell)** The water wall is usually a wall of water, where the particulates impinge on this water wall. It's not a very effective way of eliminating particulates. The design principle has the hot gas come through a flame port area, it impinges on a wall of water, then the particulates, the large particulates, are wetted down. Then they have to make another bend. As the gas flows through this bend the wet particulates will drop out in the water. So in principle its just a minimum type of scrubber the very minimum. There is very little pressure loss through the water wall. I've never seen a water wall meet an emission standard, at least not the present ones.

Question: **(Mr. W. Haynes, Newfoundland Department of Provincial Affairs and Environment, St. John's)** As you were showing the modules you were saying they were 12 and a half tons each. Was that on a full 24 hour day period?

Answer: **(Mr. Campbell)** The slide that you were looking at was an 8 to 10 hour day. The people would come in and clean that thing out in the morning. They would then charge it for a full day's operation, for 8 to 10 hours, then they would let it burn down during the night. They, however, can be operated for longer periods. We are sizing one now for Toronto International Airport that will be continuously fed over a 24 hour period.

Question: **(Mr. K.A. Childs, Environment Canada, Ottawa)** Dave, you showed us 8 module units having 100 tons per day capacity. At what point do you choose between modules and the conventional type of incinerator rated at 100 tons a day?

Answer: **(Mr. Campbell)** What that comes down to is cost and we shall be touching on that later. With the modular concept you can locate 2 plants in one city if you wish. You can have one on one side of the city which will service half of the city and the other one could service the other half of the city.

Comment: **(Mr. Childs)** And now you have two citizens groups.

Comment: **(Mr. Campbell)** Well that's a problem. You've seen the emissions. When we went into these facilities they were running at their 100 ton load. You couldn't see anything, except for one stack which was close to a number one Ringlemann.

Question: **(Mr. Childs)** Would you have to put any additional structures around the building?

Answer: **(Mr. Campbell)** Yes, we would close them in because the controls are designed for 70 degree Farenheit and not 20 below. It's a very good idea, I'd like to see more use of them, as a lot of other people would.

Question: **(unidentified)** Can anything at all be done about the pollution from conical incinerators?

Answer: **(Mr. Cameron)** Not to bring it within the regulations. There has been a study done by our air pollution people in Ottawa, on a modified wood waste conical (it was not burning municipal waste) and even modified for wood waste they were not meeting the regulations.

Question: **(Mr. Carl Strong, Newfoundland Department of Provincial Affairs and Environment, St. John's)** What temperature would you reach in the conical one where there is no introduction of blown air?

Answer: **(Mr. Campbell)** I'd guess at the most, 700 to 800 degrees. All you are doing is closing in an open burning pile and they don't burn very well.

Question: **(Mr. Strong)** And the pit incinerator where air is introduced through nozzles - does blockage occur in the nozzles to produce uneven distribution of air?

Answer: **(Mr. Campbell)** Yes. These nozzles can actually burn right off. Sometimes you can run these incinerators at very intense heat. I do not have any figures on the frequency of burning out of the nozzles. The ones that were designed by the company that I worked for had them enclosed in refractory. Some other types have them sitting on top of the fire box, in which case they are exposed to the heat.

Question: **(Mr. Strong)** And I imagine an open pit incinerator is less susceptible to explosions than other types of incinerators.

Answer: **(Mr. Campbell)** I've never had any experience with explosions in pit incinerators, but there is no containment of them so they should be the minimum. I've seen a controlled air incinerator, totally confined, explode. Not blow up, but I've seen a fire ball go up a stack. I've also seen pressurized cans explode in a three chamber incinerator which just moves the door out a bit. I think the pit incinerator will be the least susceptible to explosions because of the nature of its design.

Question: **(Mr. Strong)** Was it luck that this fireball went up the stack while you were there or is it a frequent occurence?

Answer: **(Mr. Campbell)** Yes very lucky. It really scared me. I've not seen the like of it.

Question: **(Mr. Haynes)** What about lubricating oil in the pit incinerator? Could you burn lubricating oil in the pit incinerator successfully?

Answer: **(Mr. Campbell)** If handled properly, yes. If you put a whole bunch in there at once you'd have an extremely hot fire going and you'd probably find yourself relining your incinerator, because you'd burn out your refractory. But if you did it on a basis where you didn't affect the fire that greatly then you'd probably be able to do it. Virtually anything will burn in it. The one we were showing you was in British Columbia, where the waste is very wet. You know its raining there all the time, and it is wet garbage they are burning there. It is not operated that frequently either. Still, the emissions weren't that bad.

Question: **(Mr. Haynes)** Have you ever seen a truck backing into a pit incinerator and catch fire while it is dumping? Or does the air blanket tend to keep the fire away from the truck that's backing in and dumping?

Answer: **(Mr. Campbell)** Hopefully, the truck doesn't dump directly into the pit. I've never seen that type of operation to tell you the truth. If that operation does exist it exists when the designer, or the manufacturer or the air pollution control agency is not there. In other words, the manager is doing this on his own, because normally that's not how you're supposed to do it. You're supposed to charge on a regular rate using a front end loader. The other way the incinerator would have a tremendous charge, a whole truck load and you'd have a lot of smoke going up the stack.

Comment: **(Mr. Strong)** Because of the thickness of the steel plating on our teepees we have had to replace the entire unit about every four years. They burn out - they are not lined with refractory.

Question: **(Mr. Roger Saunders, Department of Provincial Affairs and Environment, Deer Lake)** What difficulties can be expected in finding parts for controlled air incinerators?

Answer: **(Mr. Campbell)** When you do your costing you have to allow for replacement parts - buy spare parts at the time of original purchase.

Comment: **(Mr. T.P. Hynes, Newfoundland Department of Provincial Affairs and Environment, Deer Lake)** And you must allow for trained people to repair them.

Question: **(Mr. Saunders)** What is the life expectancy of controlled air incinerators?

Answer: **(Mr. Campbell)** They are designed for 15 years.

COSTS & BENEFITS

D.B. Cameron
Federal Activities Environmental Branch
Environment Canada
Ottawa

I will first indicate which type of incinerator would likely be suited to a community based on the population of the community. In order to determine the size of an incinerator suited to a community's needs, it is necessary to determine the amount of waste being produced by that community. This can be done either by direct measurement, the most accurate means, or by using a relationship which has been determined through other studies in the area or for other communities having the same basic characteristics.

In larger cities of Canada and the United States, the relationship, called a solid waste generation rate has been estimated to be 5 pounds per person per day.

This rate includes all sources of solid waste in a community. For example if your municipality had a population of 2300 then using this generation rate the amount of waste your community would have to dispose of would be approximately 11,500 pounds/day or 5.75 ton/day. This figure of 5 pounds per person per day is not necessarily the generation rate in your community, and, in fact, I am aware of one solid waste study conducted in Newfoundland for a number of communities where the average generation rate was determined (by measurement) to be approximately 3.7 pounds per person per day.

Another point to be noted here is that the solid waste generation rate is increasing in North America by about 4% to 5% per year. Therefore, if we look at that community having 2300 people generating 5.75 tons/day in 1976, if there is no population increase in the next 10 years in that community, the waste that will be produced in the 10th year will be 8.51 tons/day (Figure 1).

I bring this out to show that when making an incinerator selection, you must consider that the incinerator will probably have a 15 to 20 year life and should be capable of handling waste quantities expected in the future and not just those of 1976. Otherwise, you are going to have an incinerator which is overloaded after 4 or 5 years and will no longer give a good operation. There will be air pollution problems as well as poor volume reduction resulting in higher residue disposal costs. Figure 2 summarizes the types of incinerators we are discussing today. It shows the range of population and solid waste quantities for which each type would normally be practical. The relationship between population and quantity generated is 5 lbs per person per day. Since we were advised to discuss incinerators for populations from 1000 to 60,000 the chart uses 60,000 as an upper limit. However, I would like to make it clear that there are incinerators in operation which dispose of much larger waste quantities, for example a 900 ton/day incinerator in which there are 3 furnaces each disposing of 300 tons per day.

Multiple-chamber incinerators can be constructed in any size right up to the 150 tons/day units.

Pit incinerators are built in sizes ranging from 15 tons/day to 80 tons/day. You can reach the 150 tons/day level by using more than one unit. This is usually referred to as a modular system as Dave mentioned where each unit is a self-contained module and can be operated separately.

Controlled air incinerators have been separated into two types here. The *batch-fed units* which normally must hold the whole days waste are limited to the range 50 pounds/day to 5 tons per day. You can readily see that if you had 30 tons of waste to dispose of, and it all had to be loaded in the primary chamber before the incinerator was started up, you would need a huge primary combustion chamber as well as a much larger afterburner and stack for the increased flue gas quantities. The *continuous feed units* can be built to handle a much larger daily load, up to 25 tons/day in a single unit. These units may also be purchased as a modular system. For example, 8 of the 25 ton/day units would provide a 200 ton/day total capacity as in one of the installations discussed by Dave. The *conical or Teepee burners* are available in sizes ranging from 12.5 tons/day to 100 tons/day. I suppose these could also be duplicated or triplicated to increase the total capacity in modular fashion. For each of these types, I will try to provide costs which represent the total cost of obtaining a complete system assuming that a municipality is starting with an open dump. Therefore the costs as presented will normally include the following items:

1. Land development costs. Development costs are those associated with clearing, providing all-weather roads on the site, fencing, and residue disposal areas.
2. Building costs for housing the incinerator in most cases or at least the controls which are apt to be damaged by weather, and building costs for storing and repairing equipment such as front-end loaders.
3. The incinerator itself and its associated equipment such as front-end loaders, power supply, water supply and fuel supply, and pollution control equipment in some cases.

The costs further assume that no unusual site development problems will be expected and the construction can be accomplished with conventional equipment and materials.

Capital costs associated with multiple-chamber incinerators (Figure 3) vary from around one hundred thousand dollars for a one ton per day unit to two million, five hundred thousand dollars for a one hundred and fifty ton per day unit.

On a dollar per ton basis then, you could say, the larger units are a better buy. That is, for the one ton per day unit the dollar per ton cost is one hundred thousand dollars. For the 150 ton per day unit the dollar per ton cost is $16,700 approximately. Of course, it is likely that a one ton per day unit could be incorporated into an existing building but at very little cost reduction The air pollution control equipment required to bring emission levels into agreement with Federal requirements represents almost half the installation cost and is included here. Operating costs will normally be in the range of $8.00/ton to $15.00/ton.

The pit incinerator costs are dependent on the type of pit operation. That is, if it's open pit or closed pit. The closed pit costs are typically as shown in Figure 4. Buildings may in some cases be considered an unneeded extra, however in Newfoundland's climate it would be advisable to at least have the controls and blower components protected. The other advantages to having a building are comfort for the loader operator, site cleanliness and storage for the loader and possibly the collection vehcile. The per ton capital costs then are twelve thousand eight hundred ($12,800) dollars for 12.5 tons/day, forty-eight hundred ($4800) dollars for 50 tons/day and three thousand ($3000) dollars for 80 tons/day the absolute maximum single unit capacity. Operational costs are normally of the order of about $3/ton to $4/ton.

The open pit units have capital costs as shown in Figure 5. Again, the per ton capital costs are around $2,000/ton when operating at capacity. Their operating costs are about $3/ton.

I must confess that for the conical or teepee burners we have had to update some cost figures obtained from a 1968 report on the state of the art of teepee burners (Figure 6). There is not a lot of recent data available on these units primarily due to the fact that they do have heavy emissions associated with their operation and are therefore not too popular with regulatory or licensing agencies. However, our cost updating puts these units in a dollar per ton capital cost range from a maximum of $8160/ton for 12.5 ton/day units to $2040/tons for 100 ton/day units. The operator can expect to have a higher residue disposal cost with these units than with the others described here and may also have the additional handling operations associated with separating bulky or slow burning items such as tires from the waste loads. The operating costs would probably be in the area of $3.00/ton.

Controlled air incinerators of the batch-fed type can usually be located in an existing structure without too much difficulty. At least, the controls can be protected from the elements. Therefore, costs for these units do not include building costs (Figure 7). Also, such units are usually manually fed and therefore do not have additional loader costs.

The capital cost/ton varies from $21,200 for a 3 ton/day unit up to the $12,130 for a 200 pound per day unit. What may not be immediately obvious is the fact that units of this size would be most suited for on-site disposal of waste at large complexes like airports, hospitals, and manufacturing or processing plants. As such, considerable cost may be sacrificed for the convenience of easy disposal but savings should also be considered in the collection and transportation costs which may no longer apply. Operating costs, due primarily to fuel and power consumption can be in the order of $14/ton. The continuous feed controlled air units will have costs varying from $12,600/ton to $18,400/ton (Figure 8). Modular systems have been developed to such a point now that it is possible to obtain complete plans for all elements of the system from the incinerator manufacturer. Average operating and maintenance costs for these units are around $14.00/ton. It is difficult to provide costs for an area which does not have very much actual operating data as in Newfoundland. The operation and maintenance costs for the more complex controlled-air units could be significantly higher in Newfoundland particularly if representatives of the manufacturer have to be called in.

A comparison of the costs (Figure 9) shows that the total disposal costs per ton, are highest for the batch-fed controlled air units, followed by the continuous feed controlled air, the multiple chamber, the closed pit, open pit and then the teepee.

The costs for the continuous feed controlled-air units can change drastically for the better if a nearby plant or building complex can be sold steam from an optional heat-recovery system. I haven't covered these benefits here but, suffice it to say, the evaluation of what type of unit is to be selected should include a study of potential heat-recovery, steam sale revenues. This is a very site-specific economic evaluation.

At the bottom of Figure 8 I have included a rough estimate of sanitary landfill costs for a properly designed and operated landfill operation- -less than five dollars per ton. If suitable soil conditions are available and transport distances are not too great from the collection point, this may very well be your best alternative. If, however, you are looking at 1 or 2 feet of cover material on rock or 20 to 25 mile haul distances you should likely be at least considering a look at incineration.

FIGURE 1 ESTIMATE OF MUNICIPAL SOLID WASTE QUANTITY

POPULATION: 2300

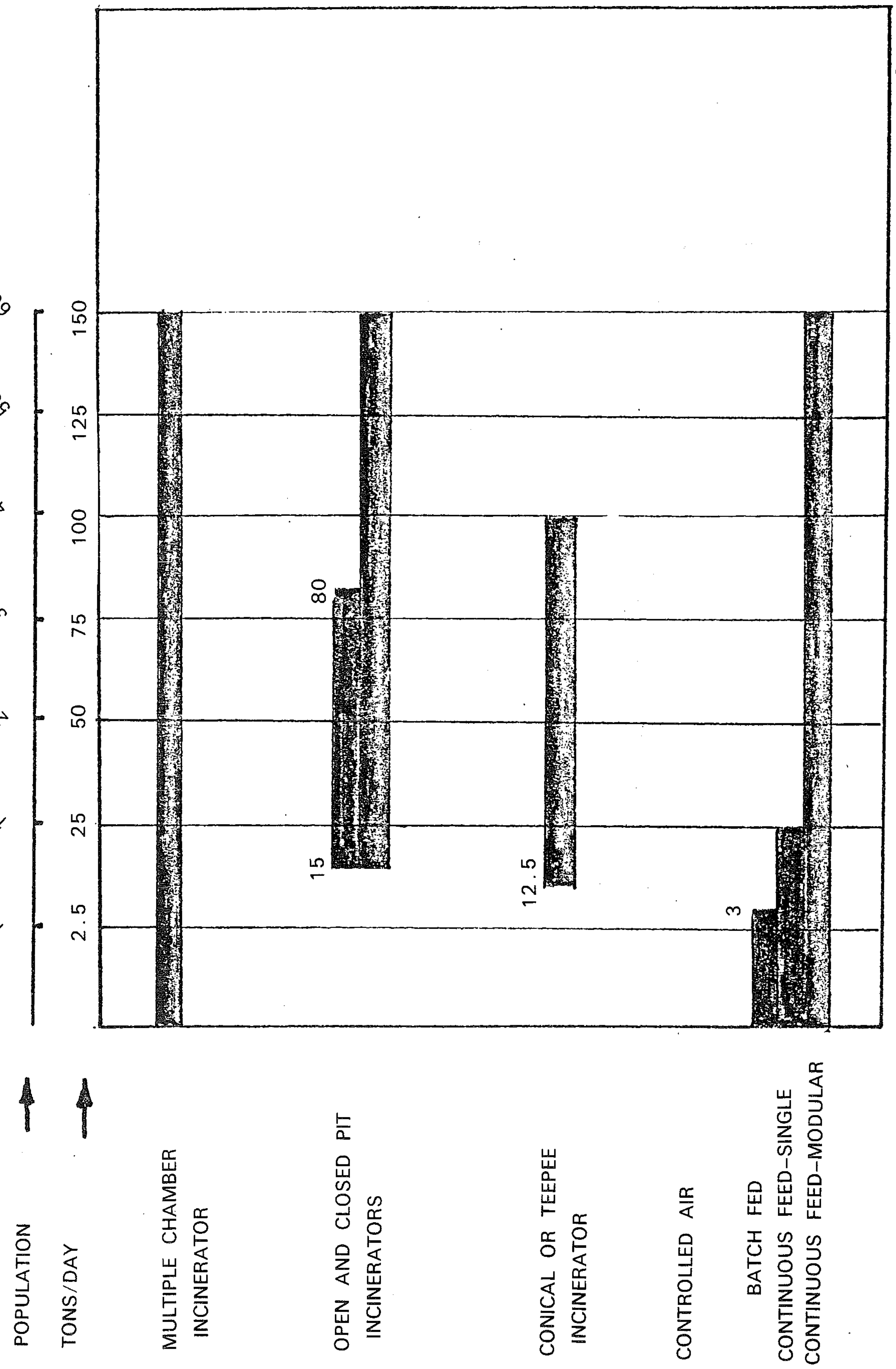
GENERATION RATE: 5 POUNDS/PERSON/DAY

$$\text{TOTAL ESTIMATED QUANTITY} = \frac{5 \times 2300}{2000} = 5.75 \text{ TONS/DAY}$$

ANNUAL INCREASE OF 4%

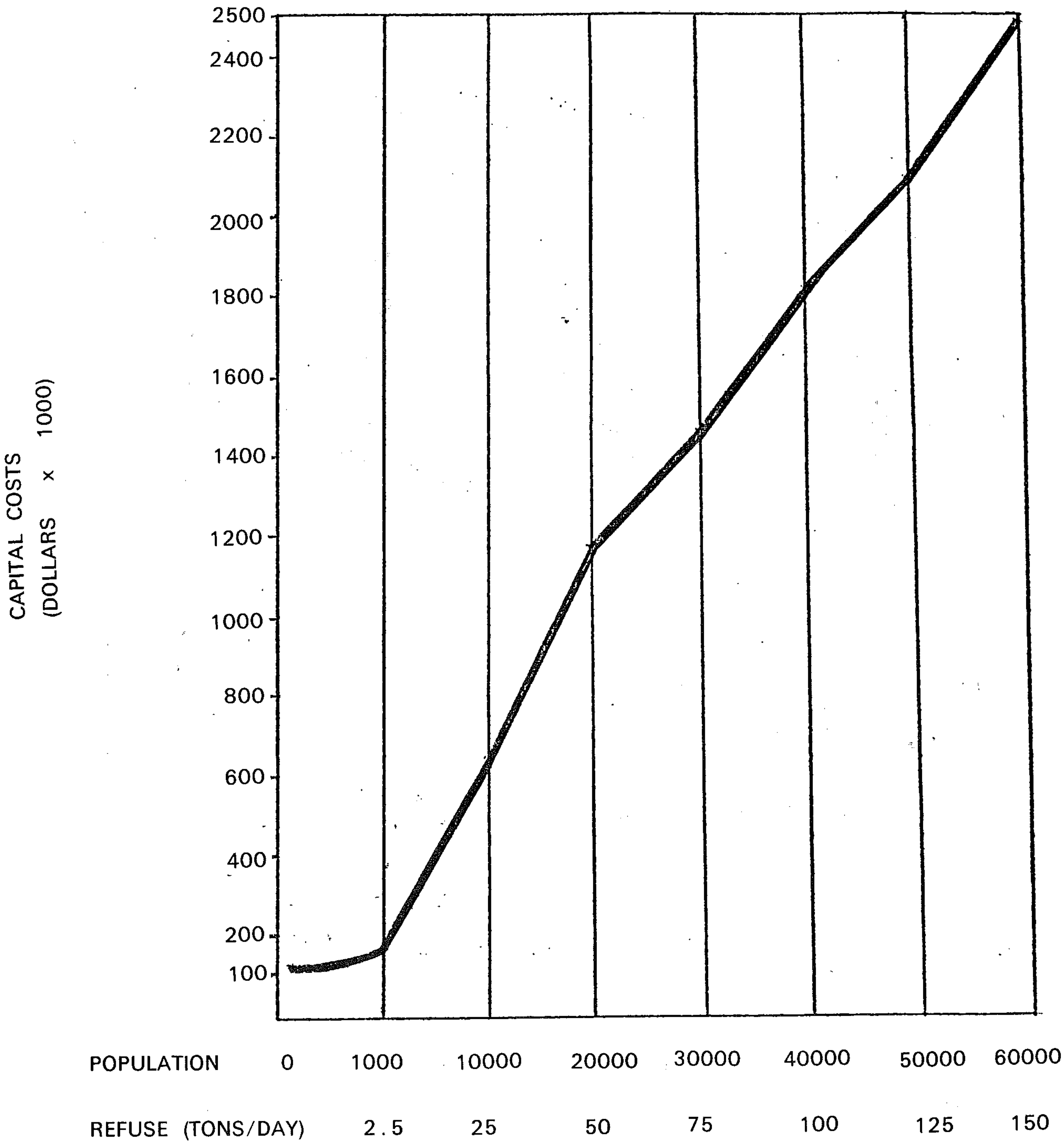
YEAR		WASTE QUANTITY
1976:	–	5.75
1977:	(.04 x 5.75) + 5.75	= 5.98
1978:	(.04 x 5.98) + 5.98	= 6.22
1979:	(.04 x 6.22) + 6.22	= 6.47
1980:	(.04 x 6.47) + 6.47	= 6.73
1981:	(.04 x 6.73) + 6.73	= 7.00
1982:	(.04 x 7.00) + 7.00	= 7.28
1983:	(.04 x 7.28) + 7.28	= 7.57
1984:	(.04 x 7.57) + 7.57	= 7.87
1985:	(.04 x 7.87) + 7.87	= 8.18
1986:	(.04 x 8.18) + 8.18	= 8.51

FIGURE 2



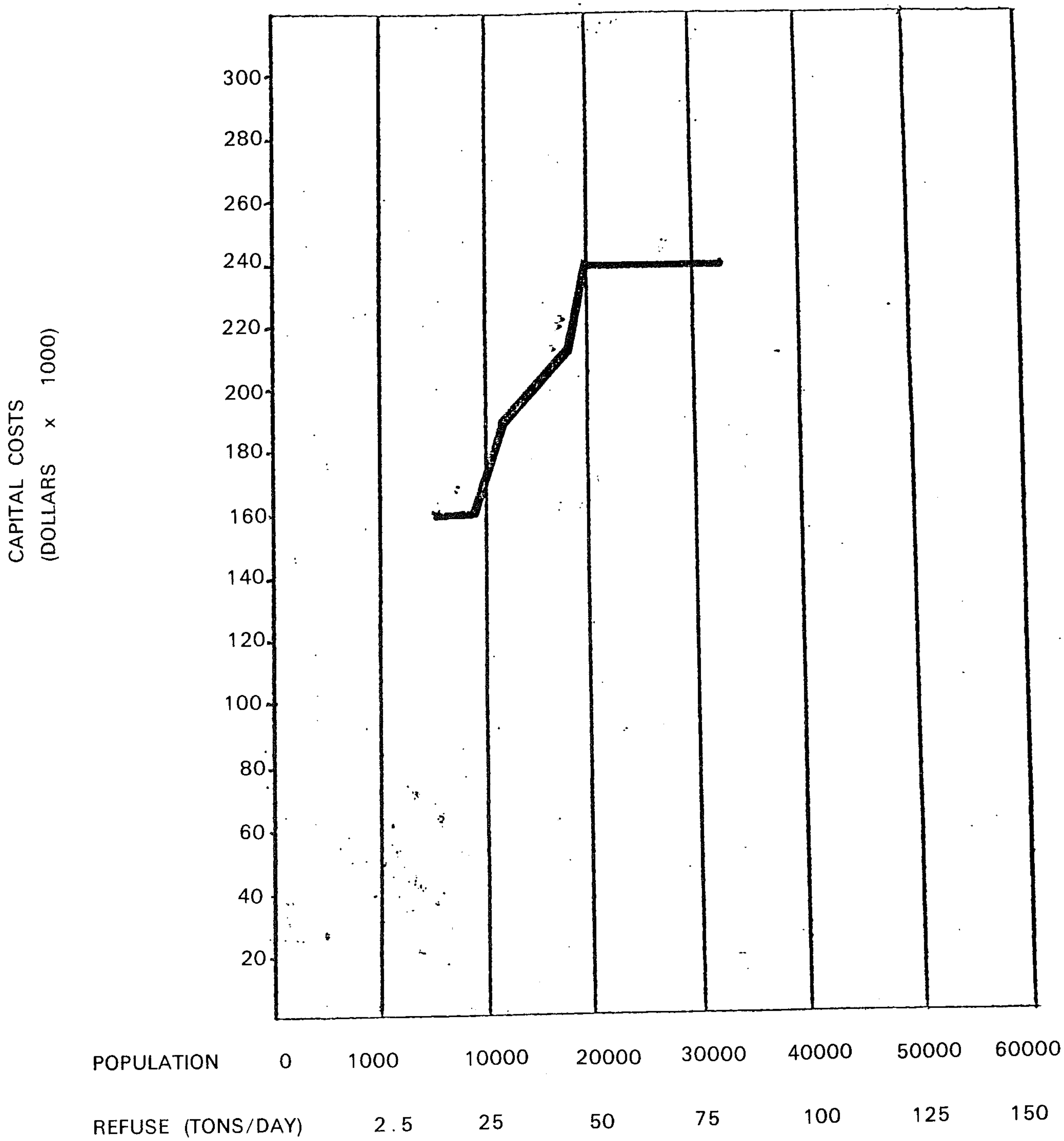
POPULATION
TONS/DAY
1000
10,000
20,000
30,000
40,000
50,000
60,000
2.5
25
50
75
100
125
150
MULTIPLE CHAMBER INCINERATOR
OPEN AND CLOSED PIT INCINERATORS
15
80
CONICAL OR TEEPEE INCINERATOR
12.5
CONTROLLED AIR
BATCH FED
CONTINUOUS FEED-SINGLE
CONTINUOUS FEED-MODULAR
3

FIGURE 3 MULTIPLE CHAMBER INCINERATORS



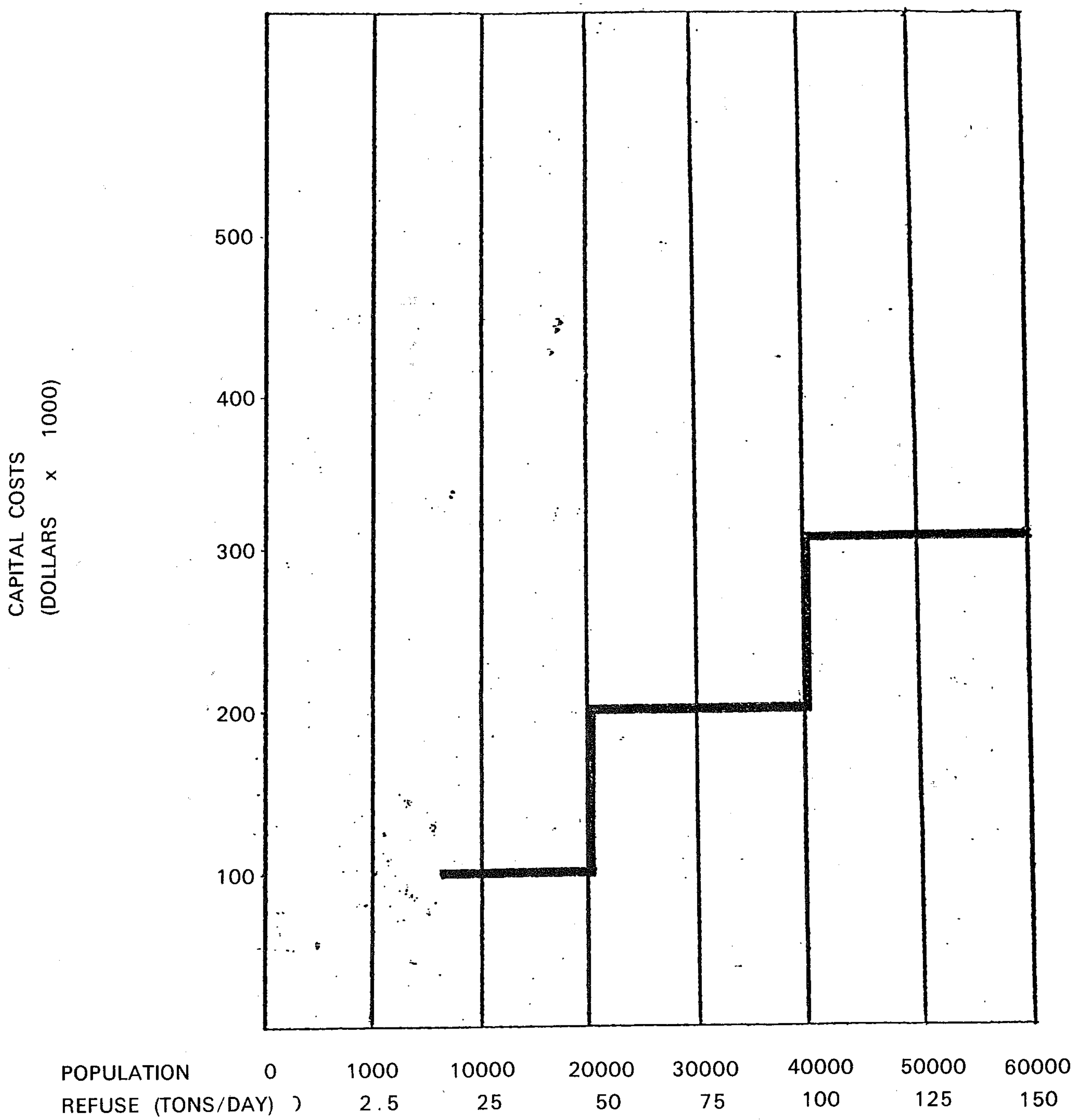
COSTS INCLUDE ALL EQUIPMENT, BUILDINGS, CONSTRUCTION, UTILITIES, BUT NOT LAND COSTS. AIR POLLUTION EQUIPMENT INCLUDED.

FIGURE 4 PIT INCINERATORS – CLOSED PIT



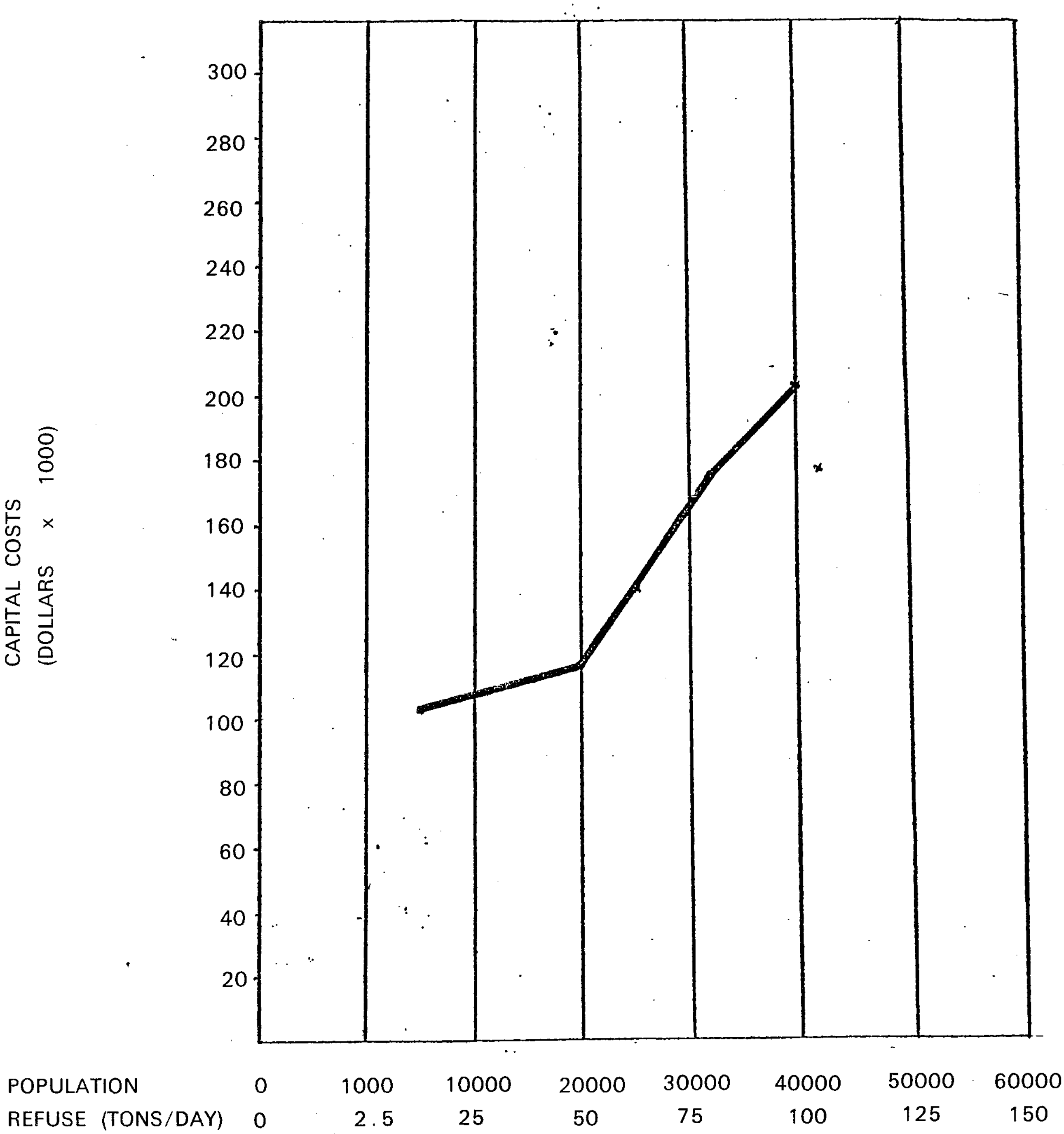
COSTS INCLUDE FOUNDATIONS, BUILDING, UTILITY SUPPLY
LOADER EXTRA ($10,000–$20,000)

FIGURE 5 **PIT INCINERATORS – OPEN PIT**



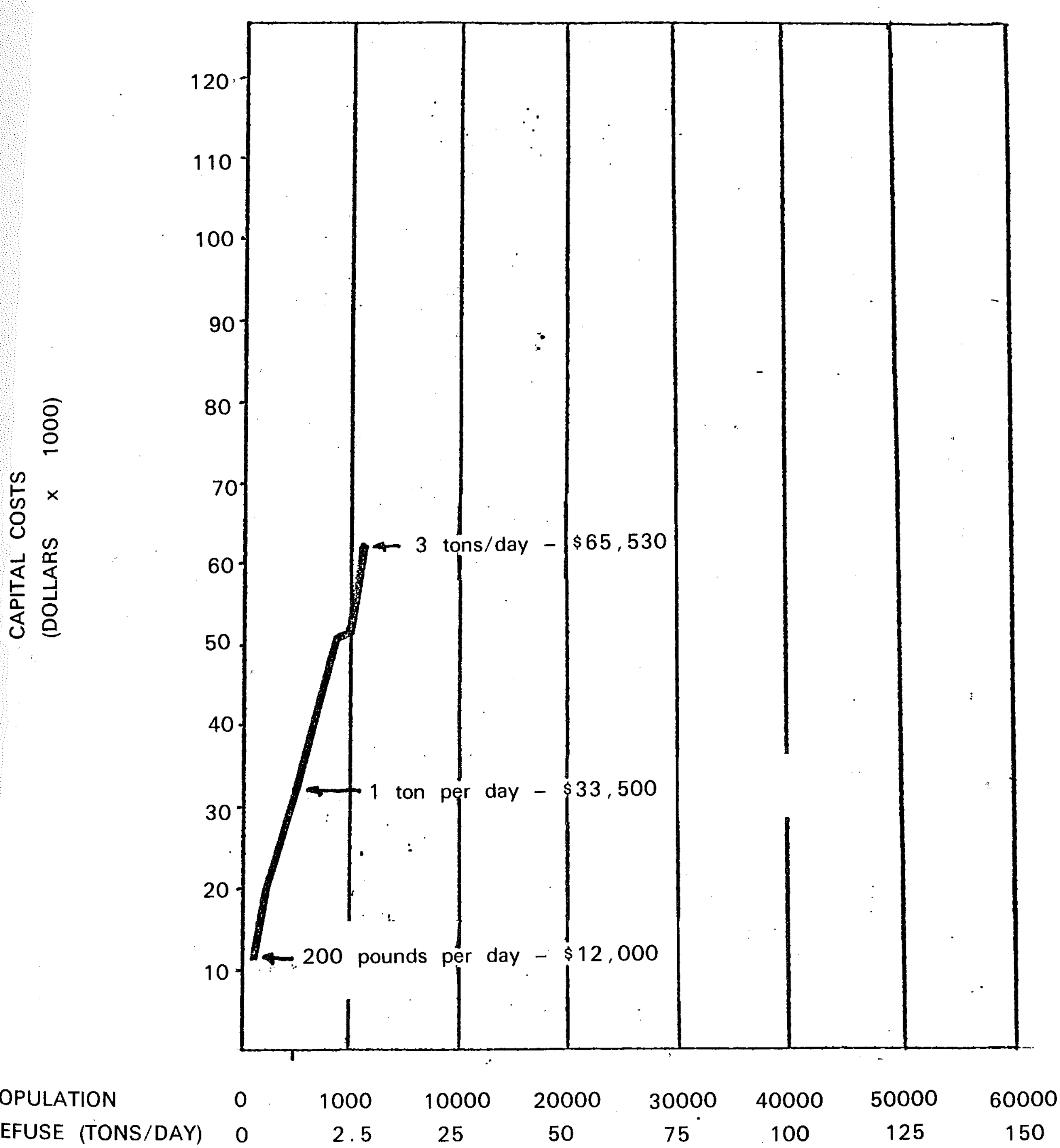
THE BASIC UNIT IS A 5 TON/HR. PIT COSTING $100,000 INSTALLED AT THE SITE. THIS PROVIDES MAXIMUM OF APPROXIMATELY 50 TONS/DAY (10 HOURS OF OPERATION) ADDITIONAL CAPACITY IS OBTAINED BY ADDING A SECOND AND THIRD UNIT AT COST OF $100,000 EACH TIME. FOUNDATION AND GRADING WORK IS NOT INCLUDED IN COSTS (ADDITIONAL $30,000)

FIGURE 6 **TEEPEE OR CONICAL BURNERS**



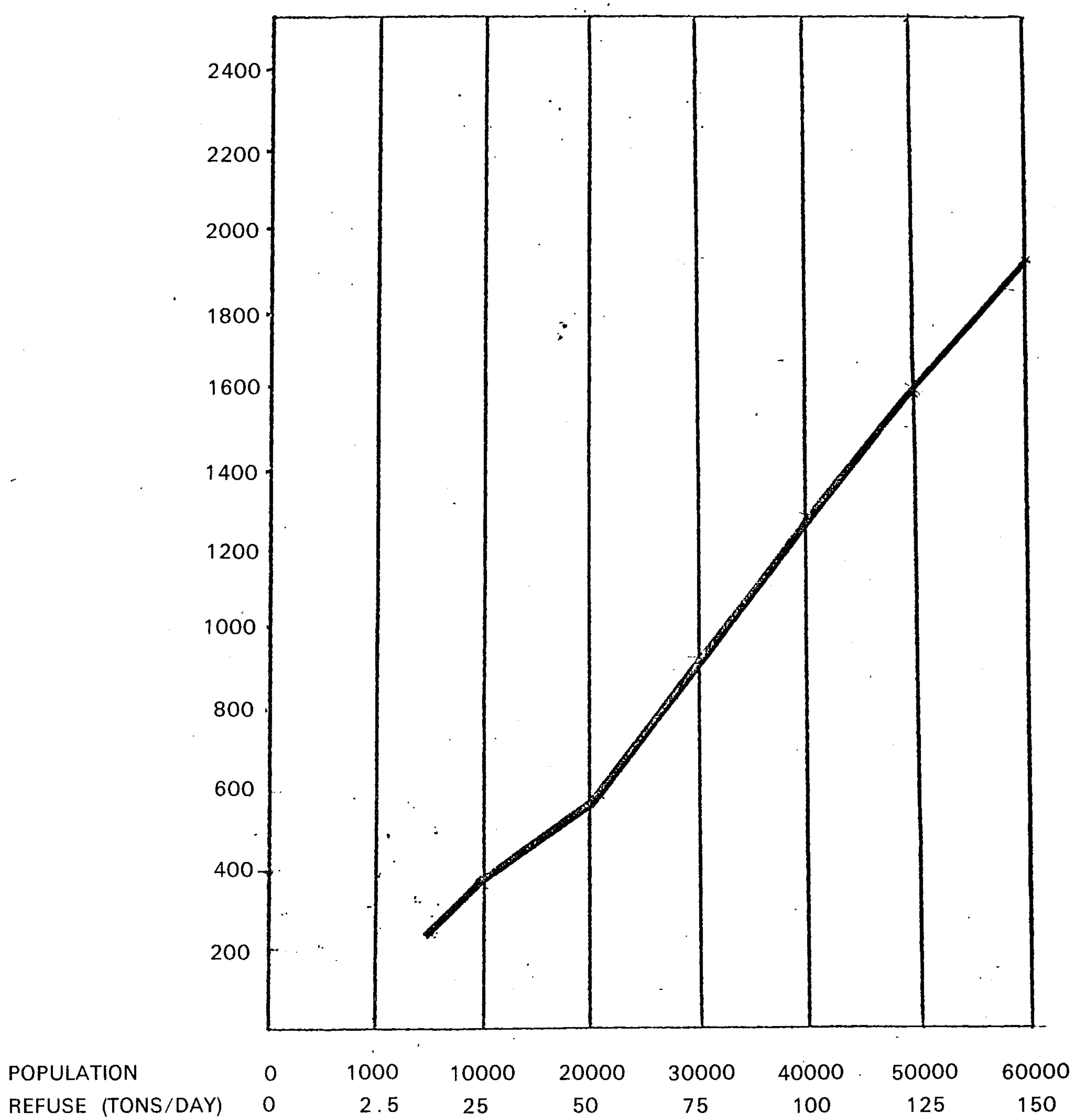
LOADER COSTS NOT INCLUDED

FIGURE 7 CONTROLLED AIR INCINERATORS - BATCH FED



THESE COSTS ARE ONLY FOR THE INCINERATOR AND ITS CONTROLS. THEY DO NOT INCLUDE PROTECTIVE BUILDINGS ALTHOUGH SUCH BUILDINGS SHOULD BE PROVIDED BY PURCHASER.

FIGURE 8 CONTROLLED AIR INCINERATORS - CONTINUOUS FEED



INCLUDES BUILDING, SITE DEVELOPMENT, LOADER COSTS.

FIGURE 9

COST COMPARISONS

	Amortized capital cost $/ton	Average operating and maintenance $/ton	Total cost $/ton
Multiple chamber	6.85	11.00	17.85
Open pit	.86	3.00	3.86
Closed pit	1.96	3.50	5.46
Conical or teepee	.82	3.00	3.82
Controlled-air batch fed	13.68	14.00	27.68
Controlled-air continuous feed	6.55	14.00	20.55
Comparison - landfill			<$5.00/ton

QUESTION PERIOD: COSTS AND BENEFITS

Comment: **(Mr. Pritchard)** I would like to comment, if I may, on your cost estimates. I'm not saying that this will seriously affect the relative cost estimates. I think something which must be considered in the incinerator's cost is handling of the ash because it's a cost which is frequently overlooked. Having an incinerator does not eliminate the need for a landfill of some kind. The ash that is produced by incineration is biologically inert but it is by no means chemically inert. It still contains all the chemical elements minus some carbon, hydrogen, and oxygen that were in the original refuse before it was burned. So, from the point of view of water pollution or groundwater pollution, the handling of the incinerator ash is an important problem.

Comment: **(Mr. Fedoruk)** Just a follow up to that it should be emphasized that incineration is a *process.* You're processing your garbage. It's not a disposal method per se. What you end up with is volume reduction. You still have something to get rid of.

Question: **(Mr. Hynes)** What is the smallest unit of closed pit? The ones you talked of seem too large for our needs.

Answer: **(Mr. Cameron)** 12 1/2 tons is the smallest.

Comment: **(Mr. Campbell)** If you asked to have a smaller one desinged for your needs you could get it. Of course, the cost per ton would increase.

Comment: **(Mr. Saunders)** You know, there are so many teepees in Newfoundland because there is so much rock. We can't use landfills. Most communities look at things from a cost point of view. Pollution control is nice but the first question I get is "What's the cost?"

CHAIRMAN'S REMARKS

Mr. L.P. Fedoruk

Some special small-scale units will be discussed by Art Burgess, an Electrical-Mechanical Engineer who graduated from Nova Scotia Tech. in 1947. Art had a total of 24 years industrial experience before joining Environment Canada in 1974. He joined the Solid Waste Management Branch where he's been involved in technology development related to refuse processing.

SOME SPECIAL SMALL-SCALE REFUSE INCINERATORS

Mr. A.E. Burgess
Solid Waste Management Branch
Environment Canada
Ottawa

This presentation is mainly intended to provide operating results of 3 incinerators which are in the course of being evaluated by the Environmental Protection Service. In addition to talking about these specific units I will make reference to other types of units which are occasionally used and about which we often get inquiries.

Since this morning's presentations provided considerable background on the science of incineration I will not include definition of terms or operating principles but will cover the special features and available operating results of the subject incinerators only.

The three incinerators being studied by E.P.S. are listed as follows:

1. a 12 1/2 ton/day controlled air unit now operating at the village of Lake Cowichan, Vancouver Island, B.C.
2. a 90 ton/day modified pit type incinerator installed at the village of Ste. Eustache, Québec
3. a 500 lb/day controlled air combination solid waste/sewage unit now being evaluated at the Bedford Research Institute in Halifax, N.S.

The other incinerators about which I will be saying a few words are the simple pit and teepee types which are occasionally used in some areas of Canada although to a decreasing extent as improved incinerator designs are developed and as air pollution regulations become more stringent.

LAKE COWICHAN INCINERATOR

Of the three studies referred to, the one that appears to be most relevant to the needs of Newfoundland is that of the controlled air incinerator at the community of Lake Cowichan, B.C. It is relevant because (1) it is the first controlled air incinerator used by a municipality in Canada, (2) it is a successful operating unit (3) it meets provincial air emission standards and (4) it is suitable for communities with populations up to 10,000 of which there are a great number in Newfoundland. Quite fortunately the study of this incinerator has been completed and I have a draft copy of the final report by Allan M. McCrae consulting engineer from which I have taken extensive reference data for this presentation.

Some of the results of the study to which I will refer are as follows:

1. A description of the events leading to the decision to use incineration rather than sanitary landfilling for disposing of municipal wastes at Lake Cowichan.
2. Measurement of the weight and volume reduction efficiencies of the incinerator
3. Measurement of the stack particulate emissions rates
4. Description of the quality of the residue
5. Calculation of the disposal cost per ton of waste by this process
6. Reference to the operating and maintenance problems encountered
7. Other reference data that might be relevant to other communities which might be considering the installation of a similar incinerator.

The chronological development of this incinerator installation is shown in figure No. 1 which shows an elapsed time of 2 1/2 years from the original planning study or 18 months from the call for tenders to the time of completion. This might be considered quite expedient compared to the time it takes some authorities to plan and complete similar solid waste management projects.

The Cowichan Valley Regional District which is the authority that owns and operates the incinerator is one of the 28 regional districts into which the inhabited part of B.C. is divided.

Within the Cowichan Regional District there are four municipalities each with their own local government with populations totaling 27,000.

The Cowichan Valley Regional District however, has overall responsibility for the municipality waste disposal function for the four municipalities. They are presently utilizing 4 disposal sites of which 2 are modified landfill, one is an open pit incinerator installed in 1969 and the fourth is the new incinerator at Lake Cowichan as described herein.

Previous to the installation of the incinerator, municipal wastes, from the village of Lake Cowichan and the surrounding region with a total population of 6,500, were disposed of at a dump operated by the village, on property leased from a private logging company. Refuse was dumped and burned then pushed over the dump bank.

By 1972, the dump site had little remaining capacity and it was appreciated that the disposal method was no longer acceptable. A search for a site for a sanitary landfill operation indicated that one could not be found to satisfy normal landfill specifications and also be provided with an all weather access.

After further study of alternative disposal methods it was decided to go to incineration. A site was selected and application made to the Provincial Pollution Control Branch for a permit to install and operate the proposed system.

While the application was being considered, contract documents were drawn up and tenders called. Five quotations were received ranging in price from $89,000 to $288,000 of which the lowest was accepted.

The plant was delivered in January 1975, accepted in March and since that time has been serving the Village and surrounding area in a consistent and reliable manner.

The unit was sized to satisfy the needs of the Village and surrounding area including projected load increases up to the year 1982 which are anticipated from population and waste generation increases. Solid waste generation rates for the present were estimated from a review of a number of studies carried out in B.C. and for the future from American technical references. Typical waste generation rates for other B.C. communities are shown in Table No. 1.

Disposal Standards

Included in the tender document were the disposal standards required by the B.C. Pollution Control Branch for incinerators as follows:

Opacity - Maximum Ringelman No. 1 with permissable variance to Ringelman No. 2 for 5% of the operating time

Particulate emission - 100 grains per standard cubic foot corrected to 12% carbon dioxide

The permit issued by the PCB stipulated the further requirement that the minimum gas temperature be 1800°F in the secondary combustion chamber.

These conditions are most economically met by the use of a controlled air incinerator which minimizes particulate emissions without the need for auxiliary cleaning devices. This type of incinerator, as seen in figure No. 2, is provided with two combustion chambers each equipped with a burner and an auxiliary fuel supply. The waste is ignited and heated in the primary chamber, by controlling introduction of air and therefore controlling the temperature. This results in very low velocities so that the ash particles are not entrained and carried to the upper chamber. Only smoke and very small particles pass into the upper chamber.

Here the smoke is reheated by the secondary burner and additional air introduced so that the very fine and hot smoke particles are oxidized rapidly to produce essentially harmless carbon dioxide and water vapor.

After this reaction additional air is introduced through the upper air inductor to reduce the temperature of stack gases before they exit into the atmosphere.

Evaluation Study Procedures

Since the incinerator was sized to dispose of the quantities of wastes expected to be generated in 1982, it is over-sized for the present amount of wastes available from the area served. As a result it operates at capacity on Tuesdays and Wednesdays only and at reduced capacity on Thursday and Fridays. The plant does not operate nor are wastes picked up on weekends and Mondays, however individuals may deliver wastes any day of the week.

The study project monitored the plant for 8 days in total, that is, on Tuesdays and Wednesdays for four weeks -- one in October, one in November and two in December. Processes monitored were as follows:

Quantity of wastes processed
Characterization of wastes incinerated
Ambient conditions
Incinerator plant operation – temperatures,
burner cycles, changing schedules
Fuel and power consumption
Stack emissions
Residue quantity and quality

The quantities of waste were weighed for each days burn during the testing periods. This was done by the Regional District collection trucks at weigh scales at a nearby asphalt plant since weigh scales were not available at the incinerator site.

Waste characterization was completed on 26 samples weighing from 65 lbs to 272 lbs each with 3 or 4 samples being taken on each of the test days. The results of this characterization are shown in Table No. 2 which also includes characterization of wastes done in other studies in other areas in B.C. The proportion of paper products is lower than what normally might be expected and is probably due to the fact that the collection area is isolated from major urban areas and the consumption of newspapers is lower than normal. It is also probable that any newsprint that is available is mostly used for fire starting. The food wastes are higher than normal, however, if paper waste was added to raise its proportion to the usual percentage of 50%, the food waste would be suppressed to 26 percent which is close to the typical value.

Residue

Various measurements were taken on the residue cleaned from the incinerator on the morning following each test day. The quantity, both volume and weight, were measured and the quality of the residue assessed. These factors are required to determine the combustion efficiency and to predict the potential effect of the residue on the landfill site. The reduction ratios are shown in Table No. 3. The average volume reduction of 93% and weight reduction of 72% are comparable to the efficiency of large municipal incinerators. Unburned combustibles average about 1% but seem to be greater when the first loads are high in moisture and tend to remain in the front bottom corner of the primary chamber below the level of the front burner, and become insulated by subsequent charges.

The residue from the incinerator is disposed of by landfilling in a coarse, porous, gravel - the only type of soil available in the area. It is not known if groundwater from the landfill area migrates 350′ to a nearby creek or 3,300 feet through an outwash to Lake Cowichan.

Emissions

The most important characteristics of an incineration process for most regulatory authorities and for public acceptance are the smoke opacity and the concentration of particulates in the gaseous emissions.

The PCB standards previously mentioned were exceeded by all tests completed during the 4 week test period-see tests 1 to 24 in figure 3. Some of the apparent reasons for the high emission rates are listed as follows:

1) The beginning of testing coincided with a change in weather condition from an unusually dry summer and fall to the normal heavy winter rains. Adjustments in operating methods to accommodate the wastes with a higher moisture content took a couple of weeks.

2) Lacquering of the burner nozzles, restricting efficient burner operation.

3) A new burner nozzle did not seat properly resulting in an oil leak and in unburned oil.

4) A choke ring was missing from one of the burners.

It should be noted that the last 4 tests, shown on the figure were taken a month or so after the regular 4 week test period and after all possible improvements were made in the system. These meet the necessary Pollution Control Branch requirements.

It appears that with improved maintenance to ensure good performance of all components satisfactory particulate emission results can be achieved in regular operation. With more experience the owner will be better able to operate the plant to its best advantage.

Costs

The total cost of the installation was $201,600 including all site development costs and all auxiliary equipment and exclusive of the cost of land (see Table #4 for details). The 1974 price shown for the incinerator at $88,500 would be considerably higher today - probably in the order of $120,000. It is interesting to note that the total cost of the installation is over twice the cost of the incinerator and this is on a site which has been very easy to grade and level.

The cost of incineration including capital and operating costs is shown in Table #5. Total annual cost at present is $64,210 or $29.27 per ton. At the full rated capacity of 72 tons per week the cost would be $18.48 per ton.

Fuel consumption at 7.56 gals/ton and at a price of $.378 per gallon amounts to $2.86 per ton and is within the range predicted by the incinerator manufacturer.

Summing up, we can state the following about the use of the Lake Cowichan controlled air incinerator.

1. There has been good public acceptance of incineration and it is generally preferred by most residents of the area over open dumping.

2. The performance of this incinerator is considered to be as efficient in terms of weight and volume reduction, and probably in stack emissions as any of the large municipal type incinerators.

3. Although the cost of disposal is high it is probably no higher than that of a large municipal incinerator built at today's costs. It appears, however, to be less costly to use sanitary landfill if a suitable site can be found close to the community.

4. One of the main problems with this type of incinerator, which in fact seems to be common to all municipal incinerators, is in controlling stack emissions to permitted levels for extended periods of times. High levels of maintenance and operating efforts are required to keep particulate emissions to a minimum.

STE EUSTACHE INCINERATOR

The second incinerator which is being evaluated is a 90 ton/day modified pit type incinerator installed at Ste Eustache, Québec, about a year ago.

This unit consists basically of the following main components:

1. 2 pits each capable of burning 45 tons over a 10 hour period at temperatures of 1500°F.

2. A common chamber between the two pits through which the gases pass and in which there is fallout of the heavy particulate.

3. A cooling tower into which air is infiltrated and water sprayed to reduce the gas temperatures to 500°F.

4. A dry cyclone scrubber for removing the middle sized particulates.

5. A 350 H.P. fan to pull the gases through the above mentioned equipment and out the stack.

6. A stack to meet local code requirements.

7. Miscellaneous - ductwork, blowers, water pumps, auxiliary oil burners, etc.

These major components are shown in figure No. 4.

This incinerator is different from other pit type incinerators in Canada in that it is provided with an induced draft system which directs the combustion products through a cooling tower and a dry cyclone scrubber before being expelled through a stack.

This plant was purchased and installed in 1974/75 and cost about $1,000,000 to complete.

The weight and volume reduction efficiency of this incinerator is comparable to that of a controlled air incinerator.

Although the stack particulate emissions at 4.4 lbs per ton of waste burned is acceptable for existing incinerators, it has recently been legislated in Québec that new incinerators must not exceed 2 lbs per ton.

Five people, working one shift per day five days a week, are required to operate the plant.

The cost per ton of waste disposed for this plant, not including the cost of land, is roughly calculated to be between $10.00 and $11.00 which makes it quite attractive costwise.

This incinerator disposes of the wastes from several municipalities in the Ste Eustache area as well as from the nearby new Mirabel international airport. With a daily capacity of 90 tons it might be considered of ample size for a community of 60,000 to 100,000 people.

A BATCH CHARGED COMBINED SOLID WASTE/SEWAGE SLUDGE INCINERATOR LOCATED AT THE BEDFORD RESEARCH INSTITUTE IN HALIFAX, N.S.

This unit has been designed for the sequential incineration of solid waste followed by sewage waste in a combined single charge dual chamber controlled air incinerator.

The solid waste compartment has a capacity of 100 cu. ft. and will hold 400 lbs at 4 lbs per cubic foot density.

The sewage compartment was designed for burning atomized sewage sludge at a rate of 20 gallons per hour after being pre-treated by a macerator. A schematic view of this incinerator is shown in figure No. 5.

The purpose of this unit is to serve as a development model for the incineration of combined sewage and solid wastes for use on vessels, northern workcamps or in northern communities. It may have some relevancy to the disposal of wastes in remote areas of Newfoundland and Labrador as well.

Two series of tests are being conducted on this incinerator:

1. The first series are intended to demonstrate the automatic operation whereby the operator loads the solid waste incinerator and the sewage storage tank, then presses a button on the control panel which starts incineration of the solid waste, after which the sewage waste is incinerated, at the completion of which the unit is to shut down. In this particular operation, the sewage waste is first macerated and atomized to facilitate the burning in the sewage waste incinerator chamber.

2. A second series of tests are being conducted to determine the capabilities of a typical controlled air incinerator in burning honey bag wastes mixed with municipal solid wastes in one chamber.

The purpose of the tests is to establish the usual performance characteristics of the incinerator such as volume and weight reductions, stack emission quantities, costs and quality of residue for the two operating conditions mentioned above.

At this point in the test program it appears that the sewage burning arrangement in a separate chamber is impractical to use because of the problem of clogging of the spray nozzle. No firm performance measurements have been made of the sewage burning process in the separate combustion chamber because of the frequent stoppages of the operation due to spray nozzle clogging. It is questionable if this type of sewage incineration will be viable for most locations envisaged for this type of incinerator.

The burning of solid wastes in the other chamber is completed with results that are comparable to the incinerator at Lake Cowichan with 73% weight reduction, and 2% unburned materials and stack emissions being approximately the same.

The second series of tests in which solid wastes and honey bag wastes were burned in combination in the same chamber indicate that this procedure does not have much promise as an economical method of disposing of these wastes except possibly for special locations such as on ships.

Test results indicate that in ratios of 80% solid wastes and up to 20% honey bags the same results can be achieved as for the burning of solid wastes alone in respect to weight reduction and stack emission, however, the unburned fraction increases to 5% which is mainly material that has been wetted by the human wastes. Fuel consumed in this operation is high, however, with 30 gallons of oil at a cost of $12.00 being required to burn 300 lbs of refuse and 60 lbs of honey bag wastes.

Although there is an urgent need for a viable disposal system of this type, particularly in northern areas where the ecological and health factors are especially critical, considerable development work is still required in this area to produce an acceptable unit that is sufficiently reliable and efficient in fuel consumption.

TEE-PEE INCINERATOR AT CHARLOTTETOWN

It has been suggested that some of the operating history of the tee-pee incinerator used by the City of Charlottetown from 1961 to 1975 might be of interest to some of those present today.

The unit consisted essentially of a lined conical structure, approximately 60 ft in diameter and was provided with a simple type of over and under fired air system where one pipe directs air up the center of the waste pile and another pipe directs air over the top of the waste pile.

Since only dry cellulose materials would burn in this unit it was necessary to separate out mixed loads that would not readily burn and dispose of them in an open dump at the far end of the same property. This portion amounted to about 50% of the total.

Thus we had two waste streams - one going to the incinerator which smoked heavily and the second going to an open dump which burned continuously and smoked ever more heavily.

In spite of the select high BTU material going into the incinerator a burndown of only 50% was being achieved even with continual stoking by the small caterpillar tractor which operated inside the tee-pee at regular intervals. Doors on opposite sides of the tee-pee were kept open to improve ventilation during these sorties inside by the tractor operator.

Although the incinerator and facilities were owned by the city of Charlottetown the operation of the site was contracted out at a cost of $50,000 per year which amounts to about $2.00 per ton.

When this site was recently closed down because of the smoke problems and generally deplorable conditions, sanitary landfilling was introduced. This is costing $150,000 a year or approximately $5.00 per ton.

Tee-pee burners of improved design having mechanical charging systems, underfire air grate systems, afterburners and other combustion gas cleaning systems, are being experimetned with, however, I have no specific test results available for this presentation.

PIT TYPE INCINERATORS

Although simple pit type incinerators with their high particulate emissions are being used less and less because of tighter air pollution standards their use is still permitted in several provinces for certain requirements.

For instance, it is still permitted for the burning of brush, wood wastes, and in certain remote areas for the burning of municipal wastes where it is seen as an improvement over open burning. It is particularly attractive from a cost point of view. Typical disposal costs are in the order of 4 to 5 dollars a ton with this unit.

The incinerator consists of a refractory lined steel pit with a clean out door at one end, an overfired and underfired forced air system, a tipping ramp and some kind of a hood/and or spark screen over the top.

A typical incinerator is shown in the attached figure No. 6.

Although the weight reduction accomplished by this unit is about as good as that of the controlled air incinerator the stack emissions are high and are usually not less than 8 to 10 lbs per ton of waste burned. This is 4 to 5 times the quantity usually accepted for incineration of municipal wastes. Installations of this type should be considered as temporary and kept in service only until such time as an improved type of disposal system can be funded.

TABLE 1 COMPARISON OF WASTE GENERATION RATES

Authority (1)	Nature (2)	Population (3)	Generation Rate LBS/CAP/DA (4)
1. Lake Cowichan and Region	urban–rural	6,500	1.86
2. Oak Bay	urban	18,500	3.21
3. Esquimalt	urban	13,000	7.00
4. Central Saanich	rural	5,100	0.93
5. North Saanich	rural	4,000	0.93
6. Sidney	urban	5,200	5.00
7. Sooke	rural	4,900	1.00
8. Powell River	urban	13,700	1.41
9. Duncan	urban	4,400	1.68
10. Coquitlam	urban		1.14

TABLE 2 COMPARISON OF REFUSE COMPOSITION

Item	Category Sampling Season	This Study Mean Winter	Saanich Ref. (B)	Victoria Ref. (B)	Vancouver Ref. (B)	Typical Ref. Year
1.	Paper Products	36.8	32.5	31.5	36.4	40–55
2.	Food Wastes	33.4	31.0	20.0	25.0	15–25
3.	Metals	9.8	13.0	13.5	8.2	7–9
4.	Glass Ceramics	8.1	14.5	12.0	7.2	7–10
5.	Dirt, Rocks, Ash	1.4	2.0	18.0	3.6	
6.	Rubber	0.4				
7.	Leather	0.2			4.7	2–4
8.	Plastics	3.5	3.5	3.0		
9.	Textiles	3.0	3.5	1.5		2–3
10.	Wood	1.0	Trace	0.5	14.9	5–10
11.	Fines 1/2'' Minus	2.5				
A	Non-combustibles	19.1	29.5	43.5	19.0	16.5
B	Combustibles	80.9	70.5	56.5	81.0	80.5

TABLE 3 QUANTITIES OF RESIDUE AND INCINERATION REDUCTION RATIOS

	Refuse Processed		Residue		Reduction Residue – Refuse	
Test Day	Volume Cubic Feet	Wet Weight Pounds	Volume Cubic Feet	Weight Pounds	Volume Percent	Weight Percent
1. Oct. 28	1,550	16,320	119.8	4,020	7.73	24.46
2. Oct. 29	2,356	22,490	214.3	6,790	9.00	30.19
3. Nov. 11	2,418	NA	121.6	–	5.00	–
4. Nov. 12	2,480	27,120	165.0	5,610	7.06	20.69
5. Dec. 2	2,480	24,400	145.9	5,630	5.88	23.07
6. Dec. 3	2,728	17,960	156.4	5,950	5.73	33.13
7. Dec. 9	2.790	24,420	129.9	6,410	4.66	26.25
8. Dec. 10	2,666	26,780	210.0	10,290	7.88	38.42
TOTALS	19,460	159,490	1,262.9	44,700	6.49	28.03

SUMMARY: Average Volume Reduction – 93%
Average Weight Reduction – 72%

TABLE 4 COWICHAN VALLEY REGIONAL DISTRICT

COWICHAN LAKE INCINERATOR - CAPITAL COST STATEMENT
TO DECEMBER 31, 1975

CAPITAL COSTS

Construction	-	Incinerator	$ 88,500
	-	Foundations	13,900
	-	Site Grading and Paving	5,300
	-	Office and Garage	13,300
	-	Accessory Building	32,000
	-	Engineer	21,000
Other Costs	-	Fencing	6,500
	-	Gas Tank	500
	-	Power Service	2,500
	-	Water Supply	1,800
	-	Tractor	10,200
	-	Office Equipment	500
Financing	-	Interest of Temporary Borrowing	5,100
	-	Miscellaneous	500
			$ 201,600

TABLE 5 INCINERATION COSTS

Description	Total $	Annual $ per year	Present Operation $ per ton @ 42 tons/wk	Rated Capacity $ per ton @ 72 tons/wk
Capital Costs:	$201,600			
Amortization of Capital Cost	–	20,200	9.14	5.40
Fuel Oil 1975[A]	–	6,270	2.86	2.86
Electrical Power[B]	–	700	0.32	0.32
Labour, Administration, Overhead, Miscellaneous	–	28,440	13.00	7.61
TOTALS	201,600	55,610	25.32	16.19

[A]Fuel Year Av. 7.56 gal/T, @ $0.378/gal

[B]Electrical Power 10.1 KWH/T @ $0.0315

'IGURE 1 CHRONOLOGICAL DEVELOPMENT OF THE LAKE COWICHAN INCINERATOR

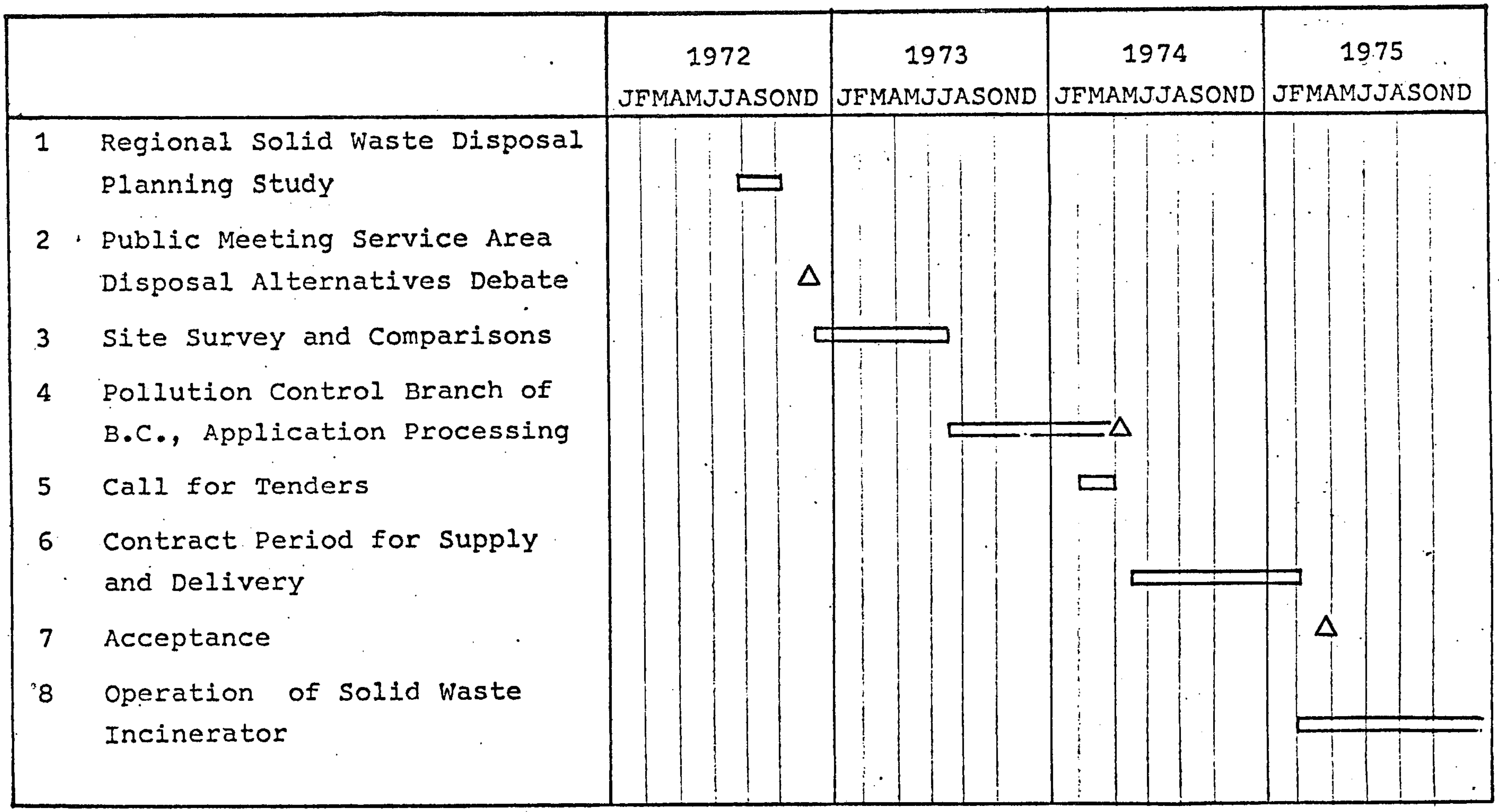
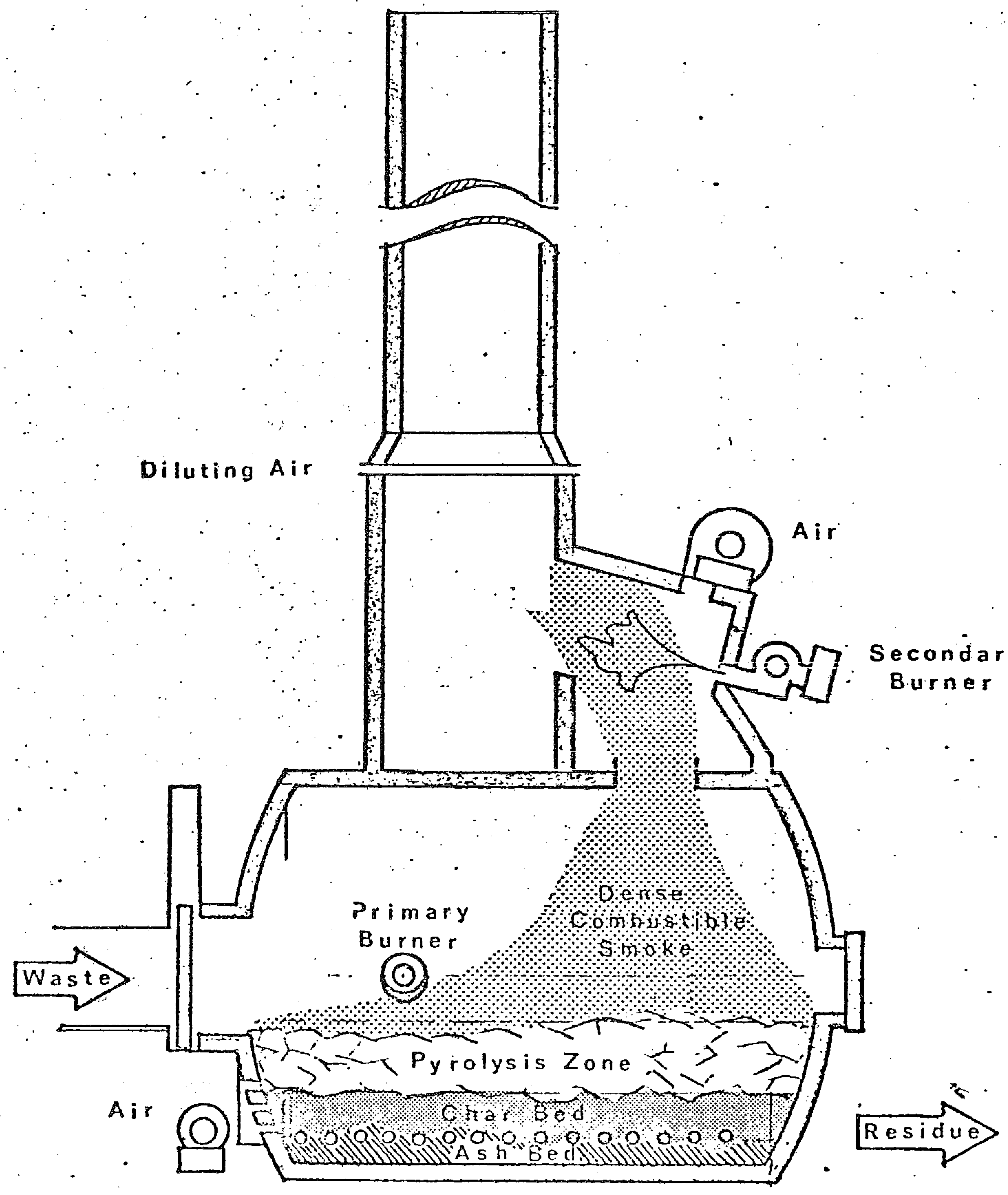


FIGURE 2 CONTROLLED AIR INCINERATION PROCESS



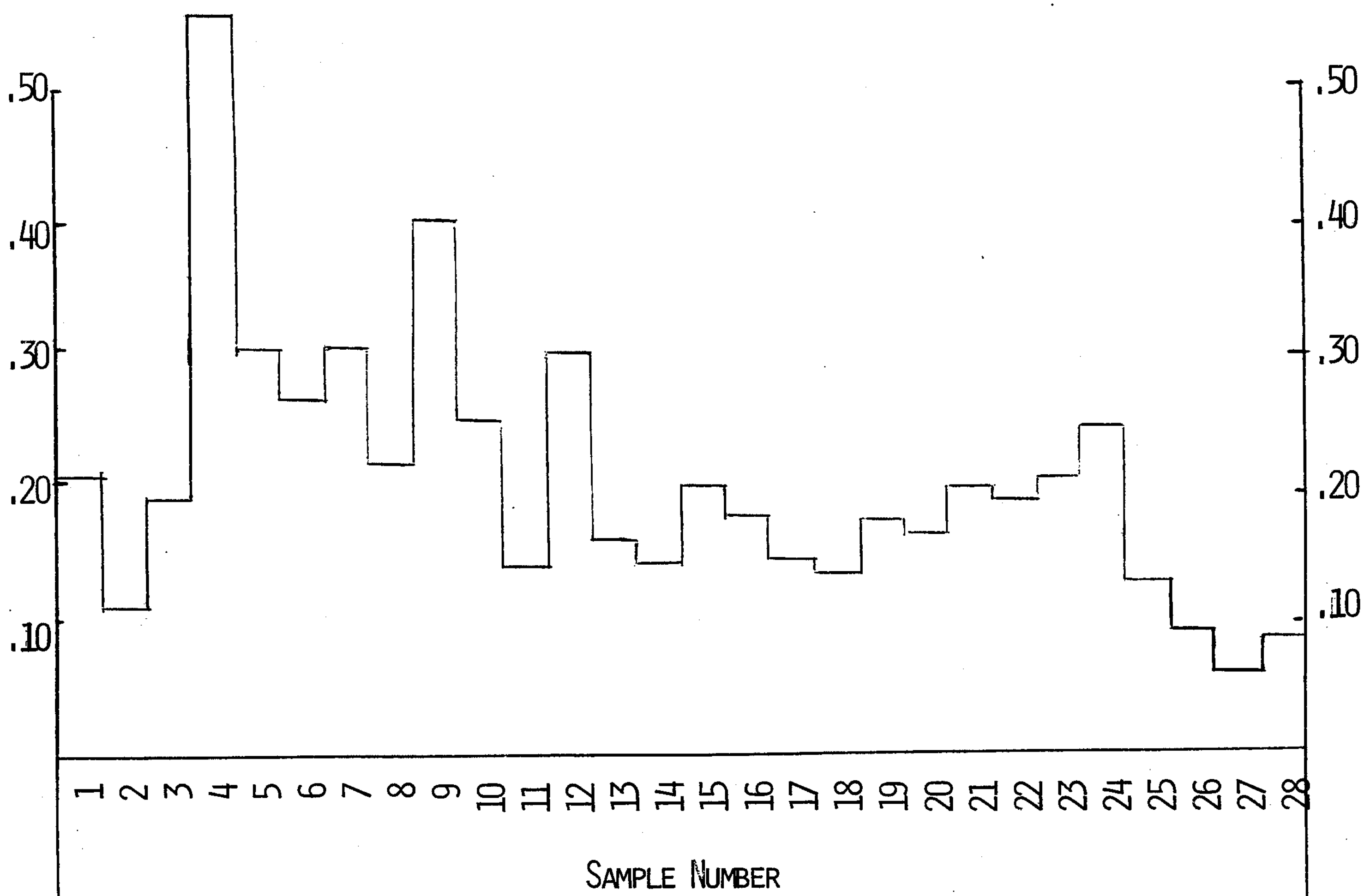
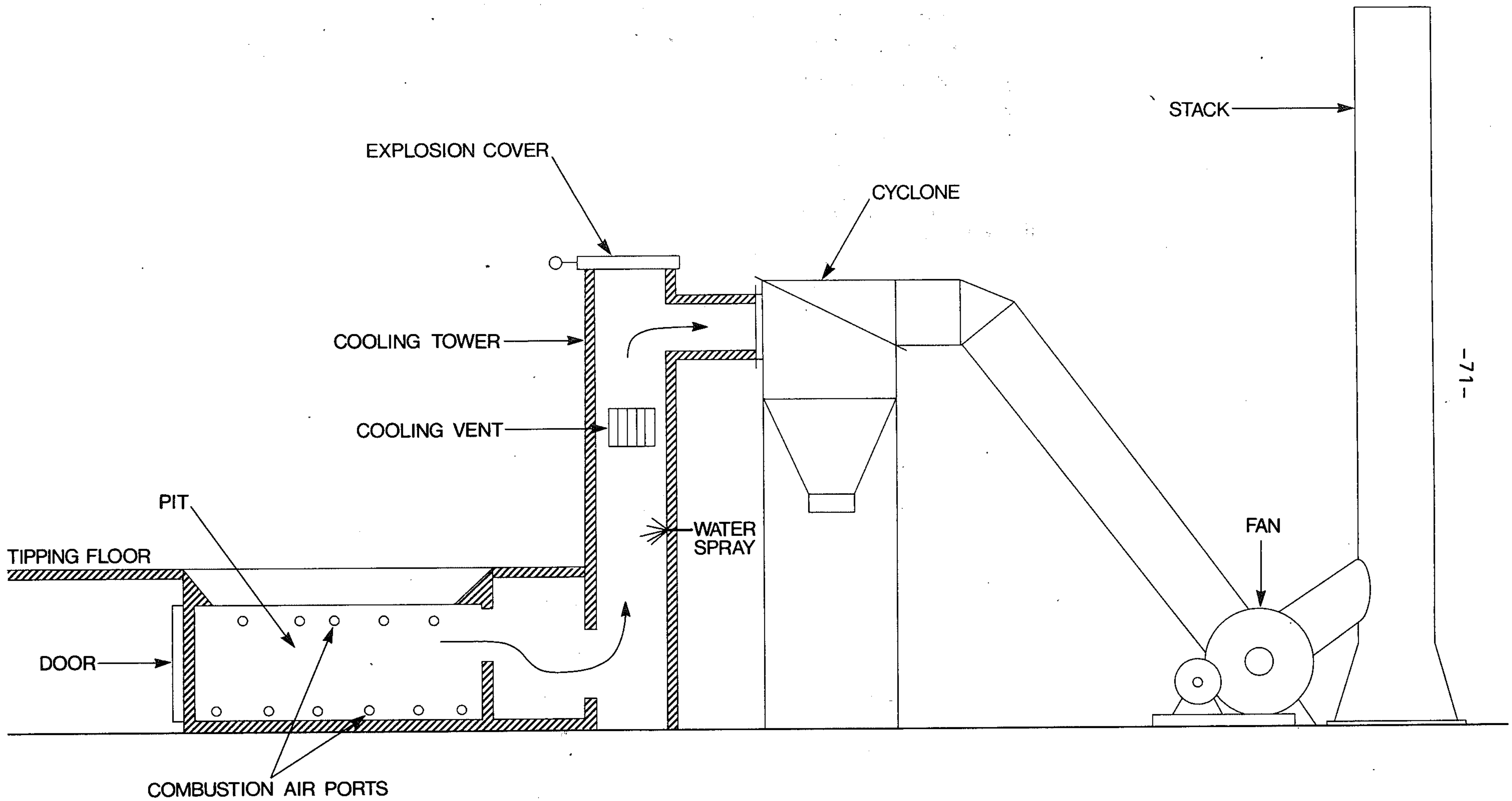
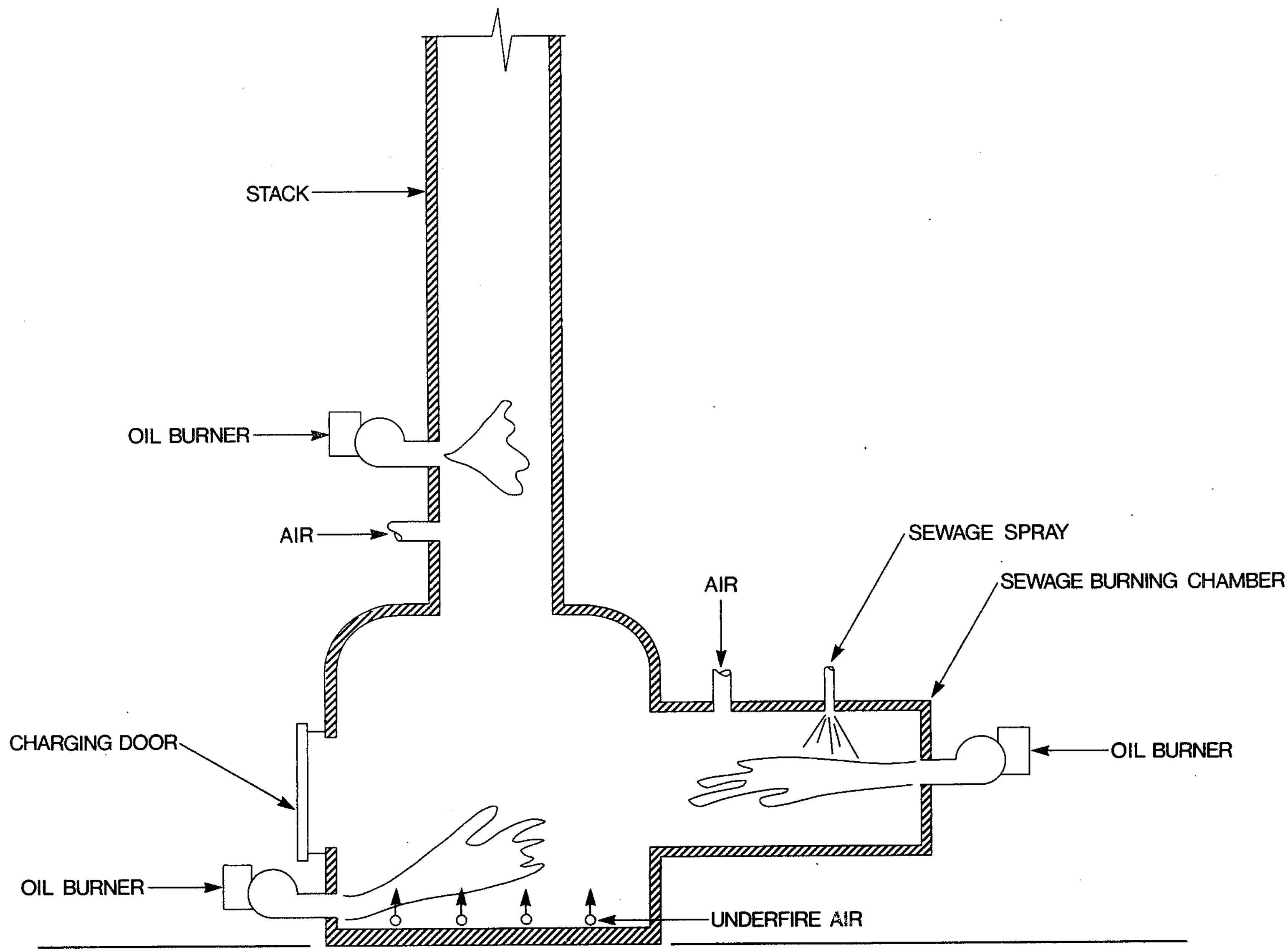


FIGURE 3 PARTICULATE GR/SCF @ 12% CO_2



ST. EUSTACHE INCINERATOR
FIGURE No. 4



COMBINATION SOLID WASTE/SEWAGE SLUDGE INCINERATOR
FIGURE No. 5

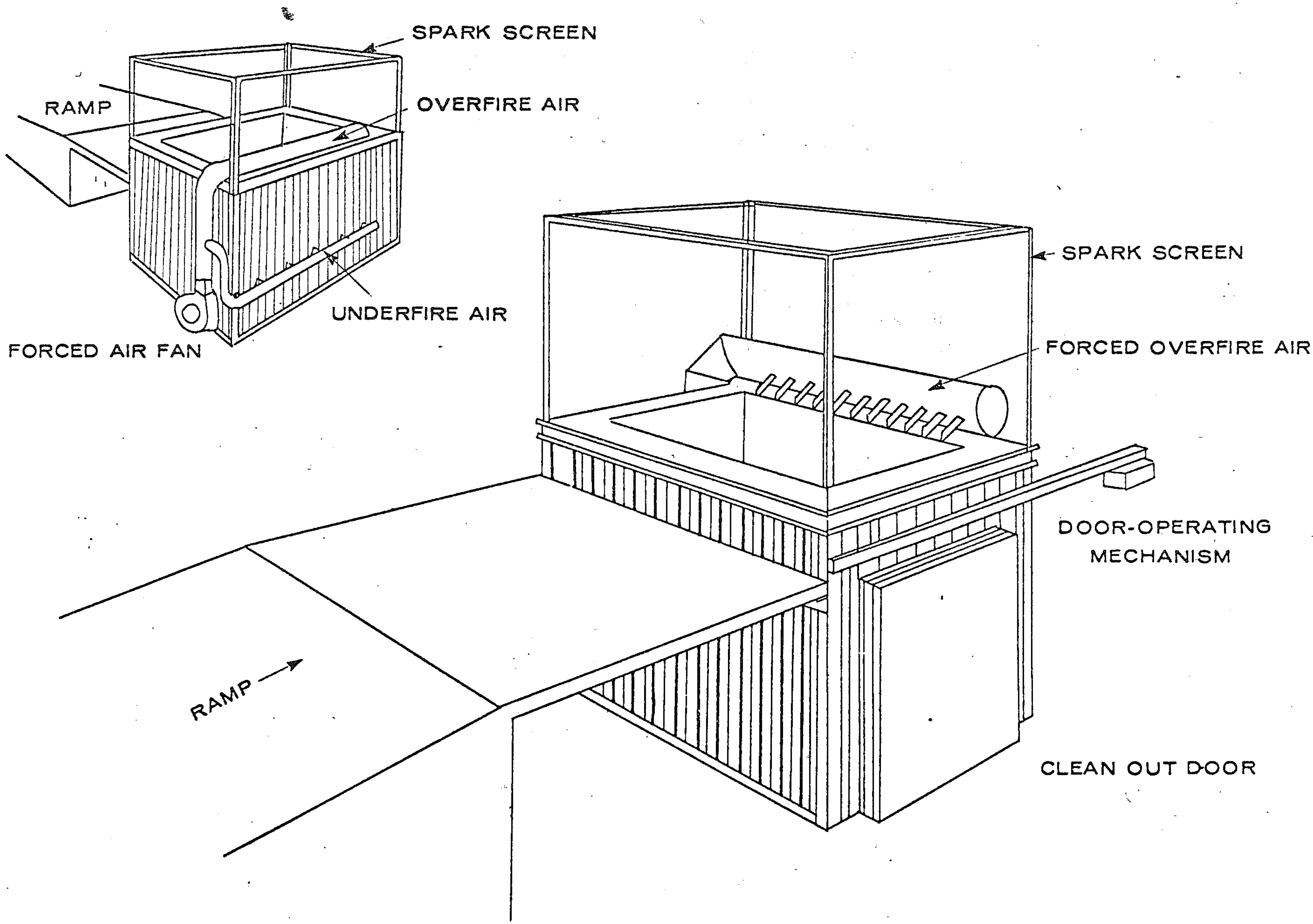


FIGURE 6 **OPEN PIT INCINERATOR**

QUESTION PERIOD: SOME SPECIAL SMALL-SCALE REFUSE INCINERATORS

Question: **(Mr. Pritchard)** In your presentation you referred to a particulate emission level of about 4 pounds particulates for each ton of refuse. I wonder if you could relate that to the Federal Standards which you refer to, in the example on Lake Cowichan.

Answer: **(Mr. Burgess)** Those are provincial standards. The Cowichan regulations say 0.1 grain per standard cubic foot at 12% carbon dioxide. Now that relates to the two pounds per ton which now is standard in Quebec, exactly. It is the same thing.

Question: **(Mr. Strong)** In the British Columbia unit you've shown a table showing the various stages from 1972, till 1975. The longest period there, was for the British Columbia Pollution Control Branch to process the application-between 10 to 12 months. Any particular reason for that?

Answer: **(Mr. Burgess)** No. I would say that this is very good for most government operations.

Question: **(Mr. Strong)** I noticed the tender call was about 4 months before the application was processed and concluded about 1 month before. Did that cause any problem?

Answer: **(Mr. Burgess)** I really don't know the specifics of that; I came in after the fact. In spite of the 4 months that you mentioned and the one year getting approval it would be pretty hard for processing of this type to proceed in a more expedient manner for something new in the municipal waste disposal area. It's probably something like 8 months for delivery of an incinerator. I would say there weren't any major hold-ups in any points that they couldn't live with.

Question: **(Mr. Childs)** Neither you, nor Dave, nor Dale has mentioned problems of refractory cracking due to this business of cycling-heating during the day, cooling overnight. It seems to me that the pit incinerators I knew of were always having refractory problems. Do any of you want to talk about that?

Answer: **(Mr. Campbell)** I'll give you an example. Back in 1945 they installed an incinerator, in Maple Leaf Gardens. When we came in to install a controlled air incinerator, the same refractory was in there. Now because people like to come in and change their refractory the craftsmen don't spend as much time. They come in and slap on refractory - so it falls out. But they sell refractory so its OK. It's the quality of the labor but its really not the labourer's fault. They want it done quickly and it falls out fine.

Question: **(Mr. Childs)** Are you telling me that this rapid cycling has nothing to do with it?

Answer: **(Mr. Campbell)** I'm sorry that does have something to do with it, but the craftsman is mainly the one who is responsible.

Comment: **(Mr. Childs)** You have introduced a practical point, that is with this high mortality rate in refractory you almost need two units, one to operate while the other is being relined. How long does it take to reline?

Answer: **(Mr. Campbell)** It depends on how large is the unit.

Question: **(Mr. Brian Power, Newfoundland Department of Provincial Affairs and Environment, St. John's)** You said for the Lake Cowichan incinerator the incinerator itself was about 45% of the total cost. Is this an average type of percentage for all incinerator installations?

Answer: **(Mr. Burgess)** I would say for a small municipal incinerator of that size and that type, yes. Certainly you don't use that to get approval of Treasury Board for money, though because it is site specific. You could have wide variance depending on where its located. It could be solid rock and you would have to blast.

Question: **(Mr. Power)** How about a larger installation, like serving a community of 100 thousand people?

Answer: **(Mr. Burgess)** There are some economies of size as far as the facilities are concerned. The building wouldn't have to be 8 times as large for 8 modules as for one. You wouldn't need 8 times the number of vehicles and you would not need 8 times the fencing or 8 times the area of property. So, I would say that you are effecting considerable economy by going to a multiple unit. I think the largest, the highest ratio of cost of installation versus cost of unit would be as a single unit.

Question: **(Mr. Saunders)** Can fuel oil be injected in place of the sewage in the Bedford incinerator?

Answer: **(Mr. Campbell)** No. If you're going to use fuel oil the spray nozzles should be properly designed for that type of liquid.

Question: **(Mr. Retis Hancock, Town Manager, Bishop's Falls, Newfoundland)** Would a teepee that's installed now meet provincial standards?

Answer: **(Mr. Strong)** It depends upon the location. We can hardly approve of present ones now, so we would have to look at the location.

Question: **(Mr. Hancock)** I was led to believe we couldn't get a teepee at all.

Answer: **(Mr. Strong)** We encouraged Bishop's Falls to improve their dump operation instead of installing a teepee.

Comment: **(Mr. Hynes)** A teepee would definitely be an improvement over the dump.

Comment: **(Mr. William Baird, Town Engineer, Gander, Newfoundland)** Two teepees went into operation in Gander in 1973 and we've had extensive repairs made to them already.

FEDERAL GUIDELINES AND LEGISLATION

D.C. Campbell
Federal Activities Environmental Branch
Environment Canada
Ottawa

The Federal approach to air pollution abatement from incinerators comprises a two pronged attack encompassing reduction of emissions of pollutants from the source (the incinerator) and the reduction of the concentration of the air pollutants contacting the receptor.

These are generally called (A) an Emission Standard and (B) an Ambient Standard. We are going to discuss these two approaches under the headings of (1) CONTENT and (2) COMPLIANCE.

(A) AIR POLLUTANT EMISSION STANDARD

(1) Content

Environment Canada has recently issued a *draft* guideline entitled, *''Proposed National Emission Guidelines for Packaged Incinerators''* for comments by Provincial Air Pollution Control Agencies and Incinerator Manufactures. This guideline *proposes* the following emission limits (Figure 1):

1.1 RECOMMENDATION FOR EMISSION LIMITS

1.1.1 ***New Installations.*** Incomplete combustion is the prime reason for most of the air pollutants emitted by packaged incinerators. These combustible emissions include organic particulate matter, carbon monoxide, hydrocarbons, organic acids, and ammonia. Rather than set an emission limit for each pollutant, particulate matter can be considered representative of combustion performance. An incinerator which complies with a particulate emission limit can be considered to be emitting a minimum of the other related pollutants.

Particulate matter emitted from a packaged incinerator will be composed of both organic particulate and incombustible particulate. The incombustible portion results from entrainment of ash particles in the combustion gases. Incinerators designed on the controlled air principle have been shown to emit a minimum of both types of particulate. On this basis, a particulate emission limit for new sources of 1.5 pounds of particulate per ton of waste burned is recommended. This figure is approximately equivalent to 0.06 grains per standard cubic foot of flue gas corrected to 12% CO_2 or 0.12 pounds of particulate per 1000 pounds of dry flue gas at 50% excess air. These relations depend on waste composition and so are not exact.

Analysis of emissions tests conducted by manufacturers of controlled air incinerators indicated that eighty percent of the tests were less than 1.5 lb particulate per ton of waste when the waste was either basically cellulose or high heating value industrial waste. With pathological waste, fifty percent of the particulate emission tests were less than 1.5 pounds per ton of waste.

When particulate emissions are below this level, there are no visible emissions and consequently, zero opacity is the recommended requirement for visible emissions for new installations.

1.1.2 Existing Installations. In the late nineteen sixties, new packaged incinerators were predominantly multiple-chamber types, manufactured according to the Los Angeles design criteria or some variation of it. Since that time there has been a shift away from the multiple-chamber style with the controlled air design being preferred. Consequently, existing installations may be either type. Emission guidelines for existing units are based on the performance of properly designed and operated multiple-chamber incinerators. Because of the large number of existing incinerators, the enforcement of a particulate emission limit by stack testing would be costly and a time consuming process. Instead, particulate criteria based on visible emissions is the recommended approach. Acceptable performance for existing incinerators is twenty percent opacity, measured by averaging 24 discrete visual observations taken over a six minute period (Figure 2) where 20% Opacity = 1 Ringlemann.

1.1.3 Restricted Materials. Some waste materials form noxious gases upon combustion. The two main materials are polyvinyl chloride (P.V.C.) which forms hydrogen chloride and rubber which forms sulphur dioxide. Incinerators which burn these wastes do not represent a large segment of the incinerator population and therefore the specializaed technology for removing these pollutants from the flue gas has not been investigated and an emission limit for hydrogen chloride and sulphur dioxide has not been proposed. Nevertheless, it is desirable to have some criteria which establishes when special treatment of the flue gas is necessary and when it is not.

P.V.C. should be eliminated as much as possible from waste to be burned in incinerators lacking HCl controls. However, even with careful segregation it is not always possible to eliminate it entirely. Consequently a small residual amount, 0.25 percent PVC, should be permitted. Incinerators which burn wastes with greater than 0.25 percent P.V.C. should be equipped with flue gas scrubbing systems; otherwise, no special measures are necessary to control hydrogen chloride other than ensuring that the P.V.C. concentration in the waste never exceeds 0.25 percent.

Sulphur dioxide emissions from combustion of rubber can be controlled in a similar manner. But since the sulphur content of rubber is considerably lower than the chlorine content of PVC, the recommended upper limit for rubber concentration is 20 percent. Incinerators which burn waste with a rubber concentration greater than 20 percent should be equipped with flue gas desulphurization equipment.

RESTRICTED MATERIALS

1. POLYVINYL CHLORIDE -- HYDROGEN CHLORIDE GAS
2. RUBBER -- SULPHUR DIOXIDE GAS

(2) Compliance

2.1 NEW INCINERATORS

Before a new incinerator is built the air pollution control agency should make an assessment of the proposed installation and determine whether the unit will be able to comply with the particulate emission limit. This can be done on the basis of the manufacturer's previous installations. The manufacturer should supply the results of a particulate emission test carried out on a similar incinerator of his manufacture. The incinerating capacity may be different but the design should be the same. It should be charged in the same manner (manually or with a mechanical loader) and the waste used during the emission test should be reasonably similar to that at the proposed installation. If the emission test carried out on the previous installation shows that the particulate emission rate is less than 1.5 lb/ton of waste and if there is sufficient similarity between the two units, then construction may proceed. To make this assessment of similarity the air pollution control agency will normally require:

1) plans and specification of both units,
2) description of the waste in both cases, and
3) the complete emission test report including test procedures and apparatus.

The two incinerators need not be identical. There will be differences in size, auxiliary fuel usage and waste composition. The pollution control officer will have to exercise judgement in assessing how these differences will affect emissions. In most cases the wastes can be considered similar if both fall into one of three categories based on moisture content and heating value. The first category includes highly volatile wastes with high heating value, low moisture content and low density such as dry paper and wood, textiles, plastic and oily solid wastes. The second category comprises primarily cellulosic waste with moisture content varying from 10 percent to 60 percent. The third category includes waste with low heating value and high mositure content such as pathological waste and wet sludges.

If the manufacturer has not conducted an emission test under sufficiently similar conditions, the air pollution control agency may allow the unit to be installed on the condition that an emission test be conducted within 90 days of startup. If successful, the test can be used for approval of future installations.

Before permitting a new packaged incinerator to operate on a regular basis, the owner should conduct an operational test or ''test burn'' within 90 days of startup (Figure 4). This test would be coincident with the particulate emission test if such a test is necessary. The test burn will allow the pollution control officer to monitor the performance of the incinerator under what will be normal operating conditions, so that he may:

1) ensure that the unit has been built in accordance with the approved plans and specifications,
2) ensure that proper operating procedures are followed,
3) observe the flue gas to make sure that there are no visible emissions and
4) inspect the waste for restricted materials and conformance with type specified.

If the officer is satisfied with the operation of the incinerator a permit to operate is issued and periodic spot checks on the flue gas opacity are made to detect violations.

2.2 Existing Incinerators

With existing incinerators a somewhat different approach is necessary. A stack test for particualte matter is not a good method of enforcing an air pollution regulation on existing packaged incinerators. The tests are expensive in relation to the value of some older incinerators and there is a question as to who should pay for tests. But more important still is the fact that a stack test only measures emissions over the test period which may be a few hours. This short period may not be representative of typical emission performance. Air pollution violations often result from operating conditions such as overcharging, wrong waste types, improper air adjustments, stoking and poor maintenance. The owner of an offending incinerator will be very careful to ensure that none of these conditions occur during a stack test. Consequently, the test results may not reflect the conditions which initiated the enforcement action and in fact this test may be used as a defence against future violations.

2.3 Particulate Emission Tests

Particulate emission tests should be conducted according to a recognized standard reference method. One example is "Standard Reference Method for Source Testing: Measurement of Emissions of Particulates from Stationary Sources" published by Environment Canada as Report EPS 1-AP-74-1. Any test to be used for official purposes should be witnessed by a pollution control officer who will ensure that sampling procedure and technique are satisfactory. For compliance purposes, most pollution control agencies consider only dry, filterable particulate. This is material which is collected at a temperature above 250°F in the nozzle, probe, cyclone and filter of the Environment Canada or similar type sampling train. The particulate emission limit of 1.5 pounds per ton of waste, recommended for new packaged incinerators, is based on dry filterable particulate only.

The particulate emission limit is referenced to a ton of waste burned rather than the more common basis of a cubic foot of gas corrected to 12 percent CO_2. The reason is related to the difficulty in accurately determining the average CO_2 content of the flue gas. With packaged incinerators it is fairly simple to weigh the waste charged and to measure the time between ignition of the first charge and burnout of the last charge. The average burning rate can then be calculated in terms of tons of waste burned per hour. The particulate emission test yields results expressed as pounds of particulate per hour. Dividing the emission rate by the burning rate normalizes the emission rate in units of pounds of particulate per ton of waste burned.

It is important to measure the burning rate accurately. Because of the nature of the process it is impossible to make an accurate determination of the burning rate over the short period of time that the flue gas is being sampled. The recommended approach is to measure the average burning rate over the complete burning cycle, from ignition of the first charge to burnout of the last charge. It is not sufficient to record the weight of the material charged during the emission test and then estimate the weight of material left unburned at the end of the test period and subtract it from the charge.

For compliance purposes the particulate emission rate in terms of pounds of particulate per ton of waste should be determined three times and the average should be less than the specified limit of 1.5 lb/ton of waste. The sampling period of each repetition should not be less than 60 minutes and at least 30 dry s.c.f. of flue gas should be sampled each time. The determination of molecular weight should be made from an integrated gas sample, not a grab sample.

It is possible to make all three sampling repetitions during one burning cycle. In such a case, the average burning rate would be the same for each repetition. If particulate sampling is conducted on more than one burning cycle, as will normally be the case, the average burning rate should be determined for each cycle.

2.4 Visual Emission Tests

Visual emission tests are recommended for approval of new installations and for day-to-day enforcement purposes on all units. There are two principal measurement methods in use. Smoke density can be determined with the aid of the Ringlemann Smoke Chart described in the U.S. Bureau of Mines Information Circular 8333. Alternatively, the degree to which emissions reduce the transmission of light and obscure the view of an object in the background is called opacity and can be determined by a qualified observer according to standard procedure such as "Standard Reference Methods for Source Testing: Measurement of Opacity of Emissions from Stationary Sources" now in preparation by Environment Canada as Report EPS 1-AP-75-2. The opacity method is preferred to the Ringlemann Chart because of increased accuracy and reproducibility.

(B) AMBIENT AIR STANDARD

(1) Content

The federal Government has promulgated an Ambient Air Quality Standard (Figure 5). In the incineration field the concentration of major interest is that of the suspended particulate matter. This draft shows an annual and a 24 hour concentration for suspended particulates, however, the incinerator designer and the Air Pollution Abatement Agency will require a one hour average concentration for their deliberations. This one hour average value is usually assumed to be in the area of 100 μgms/m^3 of suspended particulates.

The designer will use diffusion equations to size his stack height in order that the downwind ground level concentration of suspended particulates is less than 100 μgms/m^3.

(2) Implementation

We have defined an emission standard in the previous section which in this case is the concentration of particulate matter *emitted* from the incinerator stack.

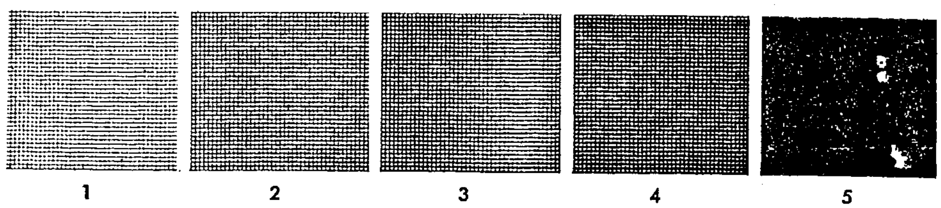
The ambient air standard in this case is the maximum hourly concentrations of particulate matter downwind of the stack at the point where it first contacts a receptor.

During the evaluation of the incinerator the designer and/or the Air Pollution Abatement Agency will first ensure that the emission standard is met by the methods described in the previous section. He will then ensure that the ambient air quality standard is attained by raising the incinerator stack height until the suspended particulates have diffused enough in the downwind air stream such that the concnetration that contacts a receptor is less than 100 $\mu gms/m^3$.

FIGURE 1 RECOMMENDED EMISSION LIMITS AND ENFORCEMENT ACTION

	Emission Limit		
Pollutant	New Installation	Existing Installation	Enforcement Action
Particulate Matter	1.5 pounds of particulate per ton of waste burned		determined prior to construction from emission test of similar incinerator or determined after construction by emission test of actual unit, conducted within 90 days of startup.
	0% opacity	20% opacity	measured within 90 days of startup of new installation, then used for day to day compliance check on both new and existing units.
Hydrogen Chloride	limit PVC in waste to 0.25% or install scrubber		check waste at new installations and spot check all units. provide individual approval of scrubbers.
Sulphur Dioxide	limit rubber in waste to 20% or install scrubber		check waste at new installations and spot check all units. provide individual approval of scrubbers.

FIGURE 2 DEPARTMENT OF TRANSPORT SMOKE CHART



CANADA

DEPARTMENT OF TRANSPORT SMOKE CHART

Instructions for Use on Reverse Side

CARTE DES FUMÉES – MINISTÈRE DES TRANSPORTS

Méthode d'utilisation au verso

81-0007

INSTRUCTIONS FOR USE

1. Hold chart at arm's length.
2. View smoke at approximately right angles to line of travel of smoke.
3. Match shade of smoke with nearest shade on chart.

MÉTHODE D'UTILISATION

1. Tenir la carte au bout du bras.
2. Observer la fumée à peu près à angle droit avec la ligne de déplacement de la fumée.
3. Trouver la nuance de la fumée qui se rapproche le plus de l'une des nuances représentées sur la carte.

FIGURE 3 PARTICULATE MATTER SAMPLING TRAIN

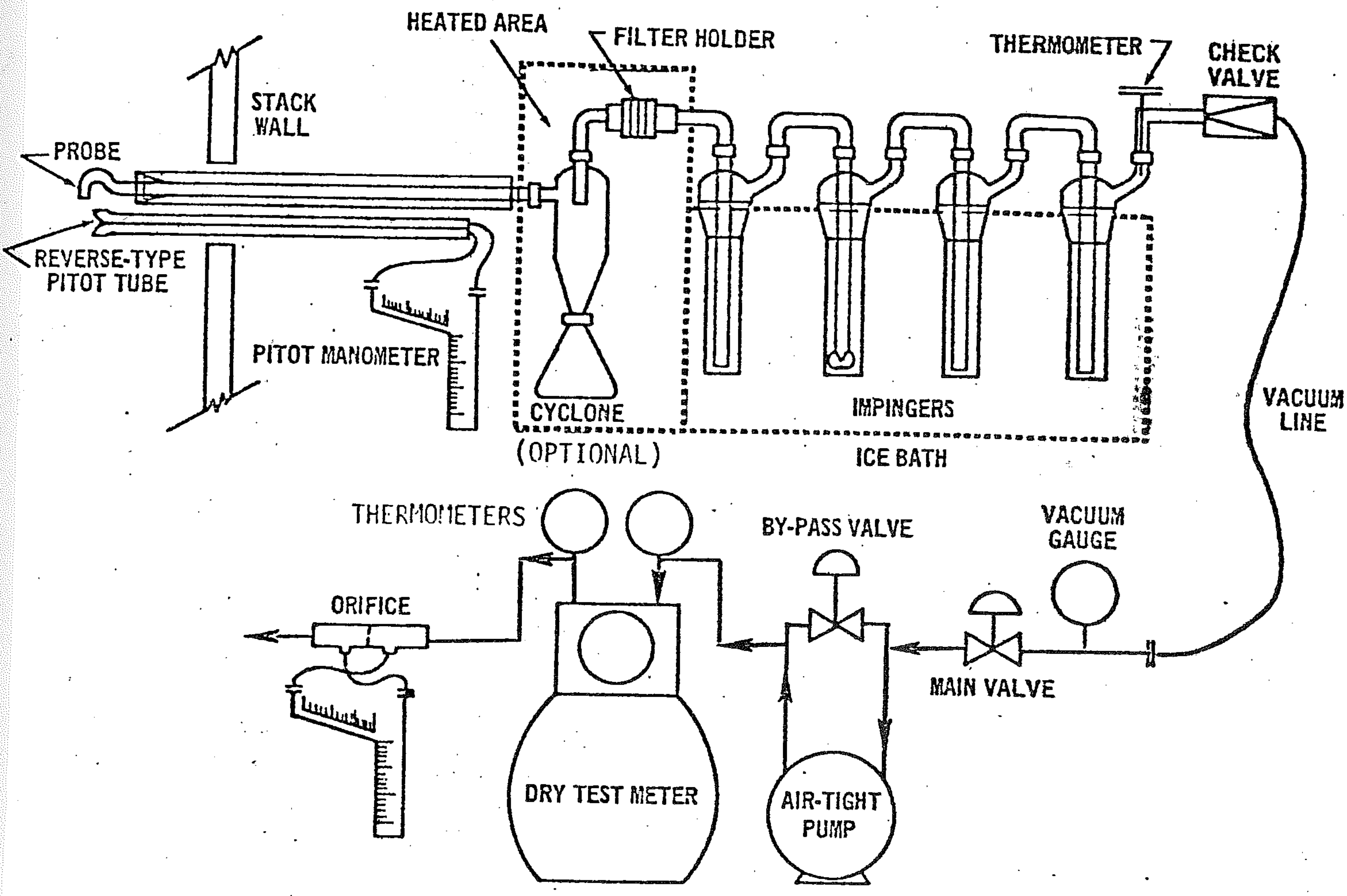


FIGURE 4 EMISSIONS FROM PACKAGED INCINERATORS*

	Controlled Air	Multiple Chamber	Single Chamber
Particulate Matter (dry filterable) lb/ton	1.2	2.3	15.3
Particulate Matter (condensible) lb/ton	0.5	2.0	8.5
Particulate Matter (total) lb/ton	1.7	4.3	23.8
Carbon Monoxide lb/ton	Neg.	3.5	197 to 991
Organic Acid (acetic) lb/ton	N.A.	0.8	<3
Aldehydes (formaldehyde) lb/ton	N.A.	0.18	5 to 64
Hydrocarbons (methane) lb/ton	Neg.	<1	N.A.
Nitrogen Oxides lb/ton	3.2	2.1	<.1

* From emission test reports on file with Combustion Sources Division and from Reference 4 and 5

Neg. – Negligible

N.A. – Not Available

FIGURE 5 SCHEDULE I

COLUMN I Air Contaminants	COLUMN II Concentrations	COLUMN III Range of Quality
1. Sulphur Dioxide	(a) 0 – 30 μg/m³ annual arithmetic mean	Desirable
	(b) 0 – 150 μg/m³ average concentration over a 24 h period	
	(c) 0 – 450 μg/m³ average concentration over a 1 h period	
2. Sulphur Dioxide	(a) 30 – 60 μg/m³ annual arithmetic mean	Acceptable
	(b) 150 – 300 μg/m³ average concentration over a 24 h period	
	(c) 450 – 900 μg/m³ average concentration over a 1 h period	
3. Suspended Particulate Matter	0 – 60 μg/m³ annual geometric mean	Desirable
4. Suspended Particulate Matter	(a) 60 – 70 μg/m³ annual geometric mean	Acceptable
	(b) 0 – 120 μg/m³ average concentration over a 24 h period	
5. Carbon Monoxide	(a) 0 – 6 mg/m³ average concentration over an 8 h period	Desirable
	(b) 0 – 15 mg/m³ average concentration over a 1 h period	

QUESTION PERIOD: FEDERAL GUIDELINES AND LEGISLATION

Question: **(Mr. Fedoruk)** Do you take emission standards or the ambient air standard as the more strict case? If you attain emission standards, do you automatically attain ambient air?

Answer: **(Mr. Campbell)** No. Maybe I didn't draw that out. The first step is to attain the emission standard on a new installation. You are assuming that the fellow has 1.5 pounds per ton or less and from that point you start raising the stack height to meet the downwind concentration or the ambient standard. Now he, with that emission standard might with a very short stack meet the downwind. At the same time if he had a large installation then he might need 200 or 300 feet of stack to meet the downwind. It would depend on the size. Some of the small units are acceptable with very short stacks and the larger units might take very tall stacks.

Comment: **(Mr. Power)** The ambient air quality would also depend on what other type of industry or services are in the area. You might have another building nearby throwing something out of their stack. So your ambient really would be cumulative.

Answer: **(Mr. Campbell)** Unfortunately right now we are not at the stage where we are taking background ambient levels into account. Now, it is obvious, a person would say that's stupid and I agree. We should take the background ambient level, subtract it from our code value and then design for the difference. So far we haven't done that. I think its mainly because we haven't accumulated enough data. For the large city we should have a background particulate level. Say that particulate level is 10 micrograms per cubic meter. Then you should subtract that from 100 and you should design a stack for 90 micrograms which is stricter by 10. Maybe if we have all the data from St. John's, from Vancouver, from Toronto, Calgary, then we can start getting into that field.

Question: **(Mr. Strong)** I'm not an air quality person, but you said only the starved air incinerator would meet the Federal air quality guidelines. Wouldn't almost any 3 compartment incinerator, or a sophisticated incinerator with an electrostatic precipitator meet the requirements?

Answer: **(Mr. Campbell)** Yes. That gets into the larger range. I said all of the 3 chamber-actually all the incinerators would meet the standard, if they want to go to fuel gas cleaning. Now the controlled air ones will meet it without any precipitators or things like that. So there is your option. If you were building a unit here in St. John's, if you went to the modular controlled air unit, the continuous charge one, you would not need precipitators to meet the standard. But if you went into a large municipal unit you would need precipitators to meet the standard.

Question: **(Mr. R.T. Matthews, Department of Provincial Affairs and Environment, St. John's)** I wonder how federal guidelines compare with U.S. guidelines.

Answer: **(Mr. Campbell)** We deal very closely with them. We tend to be stricter than them. It seems to be the history of regulation. They always start in Los Angeles for some reason. I do not know why, but everyting seems to start in California and as it comes north it becomes more strict. The national emission guidelines for packaged incinerators were done by people in Ottawa. They did a survey of all the different emission tests from all the different types of incinerators, the controlled air, the three chamber, etc. and then they settled on the controlled air, as being the most exemplary piece of equipment. They set the guidelines according to the controlled air incinerator. For example referring back to the level of 1.2 pounds per ton for the controlled air 80% of the controlled air incinerators were under that level. So that is how they set it.

Question: **(Mr. Matthews)** The reason I asked was to determine how much equipment of U.S. manufacture which meets their guidelines would not conform to Canadian standards.

Answer: **(Mr. Campbell)** For an example, the continuous charge units are really an American manufacture and they meet the guidelines. You can buy an American manufactured open pit incinerator or an American teepee incinerator which would not meet the guidelines. You would have to put some sort of scrubbing device on it. The Americans have similar types of guidelines. They might be a little less strict but they are in the same area.

The approach with the federal guidelines tries to push people into finding a better quality incinerator rather than going for the open burning dump or the open pit and the teepee incinerator. We would like people to move toward these controlled air units and that's the whole gist of this performance here today. I think if you look at the cost data you can see where you can fall. If you can put heat recovery on some of these units, if you can find the situation adaptable, then those controlled air numbers will look pretty good. You will also be meeting a good ambient air and emission standard.

CHAIRMAN'S REMARKS

Mr. L.P. Fedoruk

Our mext session is on Provincial regulations, guidelines and requirements. Brian Power will be giving the paper. Brian is a chemical engineer who graduated in 1972 from Nova Scotia Tech. Having served as a meteorologist with the Atmospheric Environment Service in Gander he joined Provincial Affairs and Environment in 1974. He is involved in the control of air pollution from all sources and industrial waste water pollution abatement.

PROVINCIAL REGULATIONS, GUIDELINES AND REQUIREMENTS FOR INCINERATORS

B.F. Power
Department of Provincial Affairs and Environment
St. John's, Newfoundland

My topic covers the Regulations, Guidelines and Requirements which the Dept. of Provincial Affairs and Environment expects to be followed with respect to solid waste management which, of course, includes refuse incineration. I will briefly review our legislation, our requirements for waste management, our proposed air regulations and how they would be applied to incinerators.

A selection of material has been distributed to you, the attendees. It includes:

(1) The Dept. of Provincial Affairs and Environment Act.
(2) The Waste Material Disposal Act
(3) The Department's Water Regulations
(4) A list of standard stipulations for a Waste Disposal Site Certificate of Approval. Some or all of these stipulations would be used for each site approved.
(5) An Application for a Certificate of Approval.
(6) 2 sheets giving minimum requirements for incineration and landfill site construction and operation.
(7) A blank copy of the Notice which must be published for each site proposal.
(8) Two brochures prepared by the Department - one on provincial government action and the other on Newfoundland industry and environment.

This material is meant for you own interest and reference. I shall refer to parts of this information throughout the next few minutes.

Our Department has two Acts which govern waste management and disposal, a set of water regulations and a drafted set of air regulations. We are anxiously waiting for these air regulations to be promulgated by Cabinet.

Under Section 26 of the Dept. Provincial Affairs and Environment Act, the construction, extension or change of any works, (which could pollute air, water and/or land,) cannot be undertaken until Ministerial approval has been granted.

Section 13 of the Waste Material Act requires that Ministerial approval be obtained prior to the establishment, alteration, enlargement or extension of a waste management system or a waste disposal site. Section 17 of this same Act outlines the information needed on the application for Certificate of Approval and also the prerequisites to applying.

The application is a fill-in-the-blank form. The information required includes:

(1) The size of the community to be serviced.

(2) Distances from the proposed site to water bodies, roads, houses, businesses, aircraft runways and cemeteries.

(3) Vehicles and accessory equipment for collection, handling at the site, fire fighting and snow clearing.

(4) Details of construction - including tree screens, access roads, fencing and firebreaks.

(5) Size and type of operation.

(6) Anticipated schedule dates and life of the site.

The information obtained in this application will be reviewed by the Land and Water Branch of the Department under the supervision of our chief engineer, Wyn Haynes.

In order for Approval to be recommended to the Minister our minimum requirements would have to be met. These are shown schematically on these two sheets. These requirements are based on experience obtained by our own Dept. Provincial Affairs and Environment, the preceding Mines and Resources and Clean Air, Water and Soil Authority and other provincial environmental authorities in Canada.

Very generally, the proposed site would have to be *at least:*

(1) 500 ft. from the nearest pond, stream or other water course.

(2) 1 mile from the nearest residence.

(3) 1000 ft. off the main road and out of sight from the road.

(4) must have 100 ft. of cleared area (or firebreak) between the fence around the site and the vegetation line.

These requirements are for landfilling operations and simple teepee incinerators. Should the more sophisticated incinerator be proposed for an area (along with the associated control equipment) these requirements would be reconsidered.

As described in the Waste Disposal Act, Section 17, a notice of the site proposal must be published in a local newspaper having general circulation in the affected community. This notice is expected to precede the application to the environment.

The general procedure to be followed in setting up a Waste Disposal Site can be summarized as follows:

(1) The community should determine a location and method for disposal. This could entail a feasibility study by the community, using either their own staff, employing a consultant or seeking advise from government. The approach, of course, would depend on the size of the operation and the potential complications in getting a satisfactory operation.

(2) Publish a notice of the proposal.

(3) Apply to Dept. Provincial Affairs and Environment for approval.

(4) Written objections from the community would be received by the Deputy Minister at anytime prior to the expiry of seven days after the date of last publication of the notice.

(5) Application and objections (if any) would be reviewed and a recommendation submitted to the Minister.

(6) If approved, a Certificate of Approval would be issued with stipulations concerning both the construction and operation. (Standard stips. have been handed out).

(7) Construction of the site.

(8) Operation.

Up to this point we have gone over th authority of the Department and the environmental requirements expected for each disposal site, be it landfill or incineration.

Let us now review our drafted air regulations, which we are presently using as guidelines and then discuss how they would be applied to incineration sites. As mentioned these regulations are awaiting promulgation by Cabinet.

They are designed to control all stationary sources of air pollution. They are written such that air pollution can take one or more of three forms.

(1) ***Odour pollution.*** Odours, while being very easy to smell, are extremely difficult to measure. To my knowledge there is no effective, reproduceable method of quantifying odours. Therefore, to regulate odours there is a general clause which states that no person shall cause air pollution or permit air pollution to be caused. Air pollution is defined as the presence in the air of any air contaminant. A portion of the definition of air contaminant includes: any odourous substances which may cause harm or discomfort to any person, adversely affect the health or impair the safety of any person.

(2) ***Visual pollution.*** Everybody has probably seen a stack belching out black smoke. It can happen for short periods of time when starting up a furnace or for extended periods of time if the furnace is in need of repair or if the air fuel ratio is off and has to be changed manually.

This form of pollution is regulated using a chart for comparing the opacity of the plume - Opacity is defined as the degree to which a visible emission obstructs the passage of light. This chart is called a Smoke Density Cahrt and has sometimes been referred to as Ringleman Chart. It has five blocks consisting of varying numbers of black dots. The first block is equivalent to a reduction in visibility of 20%, the second 40%, the third 60%, the fourth 80% and the fifth 100%. The inspector, who would have to be trained in taking these readings, would look at the plume at its point of emission and compare with the chart. If there was steam also being discharged, then the reading would be taken at a point where the inspector feels the steam has dissipated. Steam is not considered a pollutant.

The regulations limit the opacity of a plume to 20% or density # 1. However, there are two conditions under which greater opacity is allowed. For 4 minutes in any half hour period, smoke may have an opacity of 40% or density #2. For 3 minutes in any quarter hour period up to one hour after the new fire is started, smoke may have an opacity of 60% or density #3. These two conditions allow for soot blowing and for startup problems.

(3) ***Specific emitted contaminants.*** This is the main part or the guts of the regulations. This limits the concentrations of certain pollutants to levels in the ambient or surrouunding air which is considered harmful to man or beast or vegetation or properties. The contaminants listed are the ones known to be emitted from industry in the province and from the burning of fuel. They include carbon monoxide, fluorides, hydrogen sulfide, oxides of nitrogen, sulfur dioxide, suspended particulate matter and others.

There are two ways which are being used to determine whether a process is polluting or is likely to pollute. The obvious one is by actually sampling the air and analyzing for the contaminants. The second method, to be employed during the design stage of the process or in picking sites for sampling, is by calculating their emissions using computer programs called Air Dispersion Models. They are not exact but do give a good indication of what can be expected.

Again the limits for contaminants are based on what is measured on the ground or in the ambient air. They are not based on the concentrations as they leave the stack. Ours are general air quality standards expected to be met by all new works as they come on-stream and by all existing works within a period of time after the regulations become law. The amount of time given to any works to come into compliance will be negotiated by the Department and the individual works.

The move towards setting specific regulations for specific industries is being made by Environment Canada and by some of the provinces. This may happen in Newfoundland in the future - but only if the general ones prove to be ineffective.

In the meantime, the Minister will have the authority to specify the total allowable quantity of any air contaminant that may be emitted by any stationary source. This will be a section in the regulations.

For the smaller teepee incinerators - presently serving the needs of many small communities and likely to do so for many years - it is possible that the odor, smoke density and air quality criteria may be exceeded. However, by locating the sites in areas remote from residences and community activities (and this can be done in most instances) and by keeping the burner in good repair and maintaining good operation of the site; the odors, smoke and dustfall can be kept to a minimum.

Also based on information presented today it appears that the open pit incinerators are in the same economical range as the teepee, while apparently giving cleaner emissions. This is something that communities should consider if contemplating incineration. The Department will be looking for more detailed information on these systems.

For large municipal incinerators, such as those seen today, air pollution control equipment is essential. They are meant to be located close to the source of waste and also close to buildings and services that can use the energy that they produce. Many of these incinerators have been designed to comply with stringent standards set by U.S. Environment and state Environments.

Should such an incinerator be proposed for a community in Newfoundland, our Department would have to assess this proposal in light of its potential to pollute.

For odour control we would be looking at the temperatures and length of the gas path to ensure sufficient combustion time. For type 2 waste, which is composed of 50% rubbish and 50% garbage, 1000°F and contact time in the high temperature zone (after burner section) of 0.5 - 0.75 seconds is desirable. For food wastes and pathological wastes higher temperatures (around 1800°F to 2200°F) are needed. Determining the amount and type of waste to be incinerated would be one of the first steps in designing the incinerator.

For smoke control we would be looking towards proper management of fuel and air ratios and velocities high enough to ensure thorough mixing through turbulence in the combustion zone.

Looking at the specific pollutants in our regulations - sulfide dioxide would probably not be a concern as there is little sulfur in municipal waste, using excess air in the process and ensuring sufficient combustion time will keep carbon monoxide production to a minimum, nitrogen oxides would not be a concern, and all other gases would be in trace amounts which would not cause a concern. The contaminant which would need controls would be suspended particulate matter or the fine fly ash which would be entrained in the exhaust gases. Again the degree of control would depend on the size and location of the incinerator. Types of controls would be:

(1) *Cyclones* - good for large particles but inefficent for the below 10 micron particles.

(2) *Scrubbing systems* - can have efficiencies as high as 95% plus and can also eliminate odours that may get through the incineration. However, the scrubber water would probably need treatment - at least settling ponds and probably pH adjustment.

(3) *Electrostatic precipitators* - a dry collection method which has shown efficiencies of 98% plus and is becoming popular with modern incinerator installations.

These are the types of controls that would be expected in order to comply with our suspended particulate regulation of 120 μgrams/m^3 of air based over a 24 hour period.

In conclusion, it is felt by the Department that large scale incineration can be used and can meet our environmental standards. However, the decision as to whether or not a municipality goes the incineration route remains with the municipality. Our role is to make certain that sufficient controls are employed to maintain the quality of the environment in its vicinity.

QUESTION PERIOD: PROVINCIAL REGULATIONS, GUIDELINES AND REQUIREMENTS FOR INCINERATORS

Question: **(Mr. Cameron)** Will you be having a monitoring program . . .

Answer: **(Mr. Power)** We haven't, not for the teepee burners. We know that they are in excess. But if we had a large incinerator set up in St. John's we would monitor it. We have our inspectors and our officers who are looking after the other disposal sites. There are officers throughout the province, and they each have their own district. They are in very close contact, especially in the unincorporated areas. If they have any problems they just close the site.

Question: **(Mr. Strong)** I'm just curious about which equation applies to incinerators in Newfoundland. The Holland . . .?

Answer: **(Mr. Power)** It depends where we get the equation. We've been using the Briggs in the past. These dispersion equations are difficult to use in Newfoundland because we are surrounded by the sea. You are looking at a one hour period where one assumes a constant weather condition. You just don't get that here, the terrain is also very hilly and these things are designed for flat terrain. They will give you a very good answer out on the prairies but they kind of fall down here.

Question: **(Mr. Childs)** Do you have provision in your set for public hearings?

Answer: **(Mr. Power)** Yes. Actually they have to give notice before they apply to us.

Question: **(Mr. Childs)** Then what happens?

Answer: **(Mr. Power)** Ok. The minister or the deputy minister will review the application, objection or complaint. That could take the form of a public hearing which it has in the past.

Comment: **(Mr. Haynes)** We are generally the defendants, not the municipality. We are trying to support the municipality and suggest what they should do and the municipality publishes what they are going to do. As a usual thing there is a rash of objections, particularly at any landfill site and that's one of the reasons we are becoming interested in incineration. Of course, we have very little soil in Newfoundland. It's almost impossible to find a decent landfill. When the public starts to object, the municipality not being highly organized as they are elsewhere, look to the government for support. The way it is supposed to work is the municipality picks its own site then Environment comes in and approves it. Once we have said "right, here is the site", we will approve it and we can see that the Department of Transportation will approve because the road access is good and the Department of Forestry approves because there is not much timber that will be damaged, various other departments will get involved in some cases, Health, Agriculture in some cases if its on agricultural land. Then, having found that out the municipality goes ahead and publishes in the paper and the objections come out. And we find once the objections come up that all the other departments except Environment withdraw. Even the municipality withdraws its support where originally they selected the site. The reason I think this happens is there are very small communities in Newfoundland and everybody in the municipality knows their councillors and they are related to everybody in the community. It's a small community and they have lived there for years. They don't want to have a big fight inside their own community so therefore, they think government now can take the lead and push these things. And it's unfortunate in that case.

If we were to establish an Environmental Hearing Board, the board should be composed of neutral people who really are not tied to the government so they can be neutral in their arbitration. It doesn't really make any difference, even if we have a neutral board, if they decide against or for a particular site, it would make no difference who decided it the people would still be against it.

Comment: **(Mr. Childs)** All this has happened. The classic one in Ontario, around metro Toronto, concerns the Pickering sites. The Environmental Hearing Board has been damned. They took the heat off the professional staff of the province.

Question: **(Mr. Haynes)** One thing I would like to know. Dale had some figures on the board today showing that the open pit was about $3.86, I think for operating cost and the teepee was $3.82. I get the impression that the open pit is certainly an improvement on the teepee. I wonder how reliable those figures are. Is this a general figure or could the open pit go higher than that?

Answer: **(Mr. Cameron)** As I was saying, I'm not too familiar with the teepee burner operation. The best I could do was a 1968 report with updated cost figures. Basically the operating equipment would be the same though.

Comment: **(Mr. Haynes)** It seems the ideal for solid waste would be if one could have some type of solid waste incineration that could be introduced in stages just as you do with sewage treatment. When you haven't a great deal of money you like to take one step at a time. If only the incinerator business could be the same where instead of going to something completely new and discarding anything you've already put in. We could improve it and add something to it. Now possibly we could by going to things like scrubbers on the stack and precipitators later on. This would be a tremendous help to provinces like ourselves to be able to do in stages. But all these different types seem to be so different so that when you put it in you're stuck with it and then you have to eliminate that completely and build something completely new. That's costly.

Comment: **(Mr. Campbell)** You might start with one controlled air module and then add heat recovery if you can find a site where you can supply the steam for some facility. If you're going to go for best cost you're not going to get any further than an open pit or a teepee incinerator.

Comment: **(Mr. Haynes)** Ititially we want the lowest cost. At the present time we have very limited funds to deal with some of the things we heard today. In fact we may have to slow down introduction of our own regulations. I don't think we can afford to introduce types of incinerators that will meet our own regulations and you have to be very careful about that.

Comment: **(Mr. Childs)** Heat recovery, surely, is only feasible in perhaps 3 places on the island.

Comment: **(Mr. Haynes)** Its certainly true that the teepee is an improvement over the awful open dumps. The open pit, I think, is an imporvement over the teepee. It looks to me today that it is better than the teepee. I think incineration looks very attractive for St. John's. The landfill idea has been turned down by the people in the area. It looks to me they have to go to incineration.

Another thing we would like to see is, the federal people getting into helping the province with solid waste disposal, financially. They help us at the present time, through DREE and CMHC with water and sewage services and here is another service which has become most necessary and slowly as federal guidelines are tightening, I think that the province very shortly will be approaching Ottawa for help to obtain money on solid waste. At the present time as far as I am aware there is no means for the federal government to help us except for studies. Is that correct?

Answer: **(Mr. Childs)** Yes, although after the St. John's experience, we are having a second look at funding studies in the absence of an enforcement mechanism. As a matter of fact in Ontario since 1971 or 1972, they spent 800 thousand dollars (and they're spending 50,50) so 1.6 million dollars have been spent on regional studies and they haven't implemented one yet. And they have the enforcement. I am really beginning to question the value of these studies unless there is political courage to implement them.

Comment: **(Mr. Haynes)** I know you are referring directly to the Ruby Line study on which a lot of money was spent by government and it got nowhere. However there has been a very successful one where the federal government were putting quite a lot of money into it and that is in Terra Nova National Park where they had a very good study done and now that has been implemented.

Comment: **(Mr. Fedoruk)** There is a special circumstance here that Terra Nova Park was an existing federal facility and the money that was used to develop the solid waste management scheme for that area, came through the federal activities program not through the solid waste program. It's because there was a federal facility there. Now, Gros Morne National Park is a different animal because it's a new facility and they have to incorporate any environmental scheme, be it solid waste or waste water or whatever, within their own program and not through the federal activity program. The Federal activity program is purely for cleaning up *existing* federal facilities. If it's a *new* facility they have to look after it themselves.

Comment: **(Mr. Haynes)** I would like to see the federal government getting into an incinerator, say, in Conception Bay Center, where we have a population of 20 thousand. I think that once the province saw what a well operated incinerator could do then they might well take off on their own. At the present time, except for one or two people in this room, few people are aware that an incineration system exists which could produce such good results.

Question: **(Mr. Burgess)** I want to mention one source of funding which may be worth investigating. You have mentioned DREE and I think you are on the right track. Their general development agreements cover, as you said, water and sewage supplies and other services which can be extended to cover solid waste. I can cite one case in particular where DREE money was used for an incinerator and that was in St. Eustache. It was a regional plan and it has some DREE money in there.

CLOSING REMARKS

Mr. L.P. Fedoruk

I would like to thank the speakers for taking the time to come to Newfoundland and put on the seminar, Dave, Dale, Art - Brian didn't have to come very far. I feel that today was an excellent seminar. We did not receive any negative reaction, so I am assuming it is all positive.

Comment: **(Mr. Strong)** I have a positive reaction. I think it was an excellent seminar. Before it started I had a small fear that even though it was entitled Advances in Small-Scale Refuse Incinerators, that ''small'' would not be small enough. I would like to thank the speakers. I think they all adapted themselves particularly well to the Newfoundland situation. Very good.

ATTENDEES

Mr. G.B. Malone, (Welcoming Address)
Deputy Minister,
Dept. of Provincial Affairs &
Environment,
Elizabeth Towers,
St. John's, Newfoundland.

Mr. Lawrence Fedoruk, (Chairman)
Environmental Protection Service,
Environment Canada,
Halifax, Nova Scotia.

Mr. David Campbell, (Speaker)
Federal Activities
Environmental Branch
Environmental Protection Service
Environment Canada,
Ottawa, Ontario.

Mr. Dale Cameron, (Speaker)
Federal Activities
Environmental Branch
Environmental Protection Service
Environment Canada,
Ottawa, Ontario.

Mr. A.E. Burgess, (Speaker)
Solid Waste Management Branch,
Environmental Protection Service,
Ottawa, Ontario.

Mr. Brian F. Power, (Speaker)
Environmental Management and
Control Division,
Dept. of Provincial Affairs and
Environment,
Elizabeth Towers,
St. John's, Newfoundland.

Mr. R.C. MacKenzie, (Co-Organizer)
Solid Waste Management Branch,
Environmental Protection Service,
Environment Canada,
Ottawa, Ontario.

Mr. Carl W. Strong, (Co-Organizer)
Environmental Inspection Supervisor,
Environmental Management and
Control Division,
Dept. of Provincial Affairs and
Environment,
Elizabeth Towers,
St. John's, Newfoundland.

Mr. James Arklie,
Town Manager, Council Office,
P.O. Box 490,
Botwood, Newfoundland.

Mr. William Baird,
Town Engineer,
Council Office,
Town of Gander,
Gander, Newfoundland.

Mr. J.C. Chakraburtty,
FENCO Consultants Limited,
58 Kenmount Road,
P.O. Box 1406,
St. John's, Newfoundland.

Mr. Kenneth Childs,
Head, Solid Waste Appraisal,
Solid Waste Management Branch,
Environmental Protection Service,
Environment Canada,
Ottawa, Ontario.

Mr. Richard D. Conway,
Environment Officer,
Environmental Management and
Control Division,
Dept. of Provincial Affairs and
Environment,
Provincial Building,
Grand Falls, Newfoundland.

Mr. F.M. Corbett,
Environment Officer,
Environmental Management and
Control Division,
Dept. of Provincial Affairs and
Environment,
Elizabeth Towers,
St. John's, Newfoundland.

Mr. Peter D. Crocker,
Office of the City Engineer,
City Hall,
New Gower Street,
St. John's, Newfoundland

Mr. Norman R. Genge,
Town Manager,
Council Office,
P.O. Box 190,
Wabush, Labrador,
Newfoundland.

Mr. Harold Goodyear,
Works Superintendent,
Town of Gander,
Gander, Newfoundland.

Mr. Isaac Gosse,
Town Manager,
Town Council Office,
P.O. Box 190,
Torbay, Newfoundland.

Mr. W. Conway,
Town Council Office,
Holyrood, Conception Bay,
Newfoundland.

Mr. Wilmore Grander,
Council Office,
Gambo, Newfoundland.

Mr. Retis Hancock,
Town Manager,
Council Office,
P.O. Box 310,
Bishops Falls, Newfoundland.

Mr. W.R. Haynes,
Chief Environmental Engineer,
Dept. of Provincial Affairs and
Environment,
Elizabeth Towers,
St. John's, Newfoundland.

Mr. Wilfred Hicks,
Town Council Office,
Bonavista, Newfoundland.

Mr. Thomas P. Hynes,
Environment Officer,
Environmental Management and
Control Division,
Dept. of Provincial Affairs and
Environment,
P.O. Box 88,
Deer Lake, Newfoundland.

Mr. B. Keough,
Dept. of Municipal Affairs and
Housing,
Confederation Building,
St. John's, Newfoundland.

Mr. William Mills,
Town Council Office,
P.O. Box 1118,
Marystown, Newfoundland.
AOE 2MO

Mr. R.C. Pottle,
Environment Officer,
Environmental Management and
Control Division
Dept. of Provincial Affairs and
Environment,
Elizabeth Towers,
St. John's, Newfoundland.

Mr. Robert Pritchard,
Waste Management Branch,
Alberta Environment,
10040, 104th Street,
Edmonton, Alberta.
T5J 0Z6

Mr. Allen Steeves,
Newfoundland Design Associates,
Eastern Canada Savings & Loan
Building,
95 Bonaventure Avenue,
St. John's Newfoundland.

Mr. Alfred Sullivan, Mayor,
Town of Goulds,
P.O. Box 47,
Goulds, St. John's West,
Newfoundland.

Mr. R.T. Matthews,
Environment Officer,
Environmental Management and
Control Division,
Elizabeth Towers,
St. John's, Newfoundland.

Mr. A.J. Rendell,
Town Council Office,
P.O. Box 280,
Labrador City, Newfoundland.

Mr. Samuel Rideout,
Town Foreman,
Council Office,
P.O. Box 310,
Bishops Falls, Newfoundland.

Mr. Roger A. Saunders,
Environment Officer,
Environmental Management and
Control Division,
Dept. of Provincial Affairs and
Environment,
P.O. Box 88,
Deer Lake, Newfoundland.

Mr. F. Eric Stentaford,
Environment Officer,
Environmental Management and
Control Division,
Dept. of Provincial Affairs and
Environment,
Provincial Building,
Grand Falls, Newfoundland.

Mr. Francis Waddleton,
Trepassey Town Council Office,
Trepassey, Newfoundland.

Mr. James G. Thomas,
Environment Officer,
Environmental Management and
Control Division,
Dept. of Provincial Affairs and
Environment,
P.O. Box 88,
Deer Lake, Newfoundland.

Mr. Wayne Tucker,
Environment Officer,
Environmental Management and
Control Division,
Dept. of Provincial Affairs and
Environment,
Elizabeth Towers,
St. John's, Newfoundland.

Mr. H.F. Wong,
Environmental Protection Service,
Environment Canada,
P.O. Box 9367
Pleasantville,
St. John's, Newfoundland.

Mr. Maxwell Way,
Town Council Office,
Bonavista, Newfoundland.

Mr. Wilson Weir,
Dept. of Municipal Affairs and
Housing,
P.O. Box 331,
Gander, Newfoundland.

Special Arrangements by:
Mr. Bill Duggan,
Memorial University Extension
Service,
Memorial University of
Newfoundland,
St. John's, Newfoundland.

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