DESIGN CASE STUDY OF A

MUNICIPAL SOLID WASTE DISPOSAL SYSTEM

THE EVOLUTION OF A
MUNICIPAL SOLID WASTE DISPOSAL SYSTEM:
A DESIGN CASE STUDY

BY

OSBORNE RAYMOND LOVE

A Thesis

Submitted To The Faculty Of Graduate Studies

In Partial Fulfillment Of The Requirements

For The Degree

Master of Engineering

McMaster University

July, 1971

MASTER OF ENGINEERING (1971)
(Mechanical)

McMASTER UNIVERSITY
Hamilton, Ontario

TITLE: The Evolution of a Municipal Solid Waste Disposal System: A Design Case Study

AUTHOR: Osborne Raymond Love, B.A.Sc.,
(University of British Columbia)

SUPERVISOR: Dr. G. Kardos

NUMBER OF PAGES: viii, 194

SCOPE AND CONTENTS:

A record of the design evolution of a municipal solid waste disposal system has been made. The record was arranged chronologically on a process basis.

The author has presented his analyses of the design influences. Emphasis has been put on the major influences. Observations and analyses of a more general nature, plus personal views of the case study method are also given.

Recommendations for further study of this project are provided in a test proposal outline for the system.

RELEASE AUTHORIZATION

We have read the case study entitled:

"The Evolution of a Municipal Solid Waste Disposal System:

A Design Case Study"

submitted by Osborne R. Love, and hereby authorize the use of this material for teaching purposes at McMaster University, other schools and organizations, and in printed case books.

[illegible]
Signature

President
Position

July 23, 1971
Date

[illegible]
Firm

TABLE OF CONTENTS

TABLE OF CONTENTS

cont'd. **Page**

APPENDICES

LIST OF ILLUSTRATIONS

Appendix 10 contains a Photographic Record of Construction

ACKNOWLEDGEMENTS

The preparation of this thesis required the co-operation of many people. Many responded generously to the author's requests. He wishes to thank Messrs. F. Ferguson, H. Ragetlie, and A. Brown of Gordon L. Sutin and Associates Ltd., T. Melnechenko and J. Young of Babcock and Wilcox Canada Ltd., H. Van Hille of Consoer, Townsend Associates as well as Professors G. Kardos and R. Newcombe of the McMaster University Mechanical Engineering Department.

The author especially wishes to thank Gordon Sutin for his tolerance of many unannounced visits and interruptions over the past three years.

Many others not mentioned also contributed to this study. Their inputs are also appreciated. The author acknowledges the sacrifices of his wife Sally during its preparation.

Finally, the author accepts full responsibility for the presentation of what he believes factual information and its analysis as contained in this study.

Osborne R. Love

I. OBJECTIVES OF THIS CASE STUDY

In an order of ascending importance the objectives of this case study were:

1. To summarize the chronological evolution of a municipal solid waste disposal system on a process basis,
2. To record key influences (economic, technical, aesthetic and political) on the design,
3. To present analyses of their effects on the design evolution,
4. To interpret the effects of design decisions upon the processes, and
5. To present personal observations and analyses on the project and the case study method.

The author did not intend this report to investigate the relative merits of different pieces of equipment intended to perform the same function. Only those choices as major effects or causes of key influences were studied in any detail.

This report also did not investigate the structural problems which developed during the erection phase of this disposal system.

II. INTRODUCTION

Present public reaction to environmental pollution is very great. The magnitude of this problem is now being realized by the general public. One reference gives the annual U.S. production of refuse at 3.5 billion tons per year. Its disposal employs a work force of 300,000 men--expected to treble by 1980--plus a budget of $4.5 billion. After education and highway costs, it is the largest American municipal expense. Eighty percent of this disposal bill is attributed to transport costs.

The public is beginning to realize it must pay for proper waste disposal. The smaller per-capita refuse generation of past years cannot be now as easily hidden. Ontario Minister of Energy and Resources Management George Kerr estimates by 1975 for Hamilton area pollution control alone investment will be $100 million.

Like many cities Hamilton suffers a disposal problem with its solid wastes. By 1960, the City government realized its one incinerator which was built in 1931 was over-taxed as well as worn-out. The City was also critically short of suitable land fill capacity.

This old incinerator, located on Depew Street in the north end, was designed to process 80 tons during a 9 hour shift. By 1960, 200 tons per 16 hour day were being forced through it. Its operation required a large number of staff and its maintenance cost was becoming prohibitive.

By the summer of 1969, the City only expected to have the use of this incinerator for one more year. In 1957 it had sold the 36 acre site on which the incinerator stands to the Steel Company of Canada which owned the surrounding area. The Steel Company for $285,000 bought the land rights on condition they could take possession only after at least one years notice from any time after 1967. The City received such notice in June 1969.

From June 30, 1970 until the new Solid Waste Reduction Unit (often referred to hereafter by the acronym "S.W.R.U.") was operational, the City then expected to be without incineration capacity. Gordon L. Sutin and Associates Ltd. (often referred to hereafter as "the Firm") whom the City had previously retained as consultants recommended the four Tollemache pulverizers selected for the S.W.R.U. be temporarily installed, two each at the Upper Ottawa Street and Longwood Road sites to extend the lives of the land fills.

Stelco in June 1970 advised the City that as it would not immediately require the site, they could use the incinerator longer. It is of interest to note the City was required to shut down one of the two furnaces at the Depew Street unit if the Air Pollution Index rose too high.

The three City sanitary land fills generally are acknowledged as efficient operations. One of these, the Upper Ottawa Street site, was visited, and Figures II-1 to II-4 are photographs taken by the author. Vermin are few, and burning is done only on Sunday nights, under favorable weather conditions. There are thirteen scrap pickers licenced to operate there. By 1975 it is expected that this site will be full at its present rate of use. It may be difficult to replace as Ontario Water Resource Commission approval must be obtained for new land fill sites. Neighbouring Saltfleet township was refused a land fill site permit after the land was purchased for this use.

It is against this background of the state of refuse disposal that the design development for the S.W.R.U. will be studied. It is an attempt to present a study of a design during its development, for a politically-sensitive customer.

Fig. II-1 Typical Collection Truck

Fig. II-2 Dumping

Fig. II-3 Solid Waste as Received

Fig. II-4 Compacted Fill

Four Views of the Upper Ottawa St. Land Fill

July 1969

III. BACKGROUND TO THE DESIGN

Despite the need for good data to aid the incinerator designer, little exists. The A.S.M.E. Incinerator Division assumed this status only in 1967-1968. They acknowledge the influence of strong public pressure for better solid waste disposal. As the chairman of the Mid-West Area section of the Division, Mr. Carl Bowen (Partner-Consoer, Townsend and Associates, Consulting Engineers, Chicago, U.S.A.) remarked to the author, he believes a useful design code will require much development. The Division is still primarily focused on incineration rather than on a systems approach.

Modern incinerators date back less than a century. The first municipal type was built by Alfred Fryer at Nottingham, England, in 1874. Canada's first was in operation at Quebec in 1906. Even then the importance of a high combustion temperature and provision for fly-ash control were recognized for complete and clean operation. Until World War II, even maintaining burning was a problem. In wet weather the garbage fuel was often too moist to burn. J. W. Stephenson believes the change in refuse composition

"...has probably affected incinerator design requirements more than any other single factor".[1] Presumably he also considered the requirements for better pollution control. The major post war developments were mechanical stokers and continuous feeds. Stephenson concludes "...the present concept of incineration will approach its ultimate development during the next ten years".

The Firm became aware of Hamilton's needs indirectly. A wood burner to destroy demolition scrap lumber from civic urban renewal projects was needed. From the August 1960 Report on "Refuse Collection and Disposal in Hamilton", prepared by the Canadian-British Engineering Consultants of Toronto, and their own investigations, they realized the urgency of a solution to the general solid waste disposal problem.

It took a long time to get construction underway on the S.W.R.U. since the recognition of the problem a decade ago.

In August 1960, the Canadian-British report was received by the City. It recommended the purchase of land-fill and incinerator

---

[1] Stephenson, J. W., "Incineration--Past, Present and Future", American Society of Mechanical Engineers, Paper 69-WA/Inc-1, 1969.

sites, with an immediate start to the construction of an incinerator. These consultants issued a tender for an incinerator, and a bid from Francis Hankin and Co. Ltd. was selected. This incinerator was never built. The contract was awarded to Hankin but it was later cancelled upon a decision to revert to land fill--it has been reported that Hankin received $95,000. Their design was traditional.

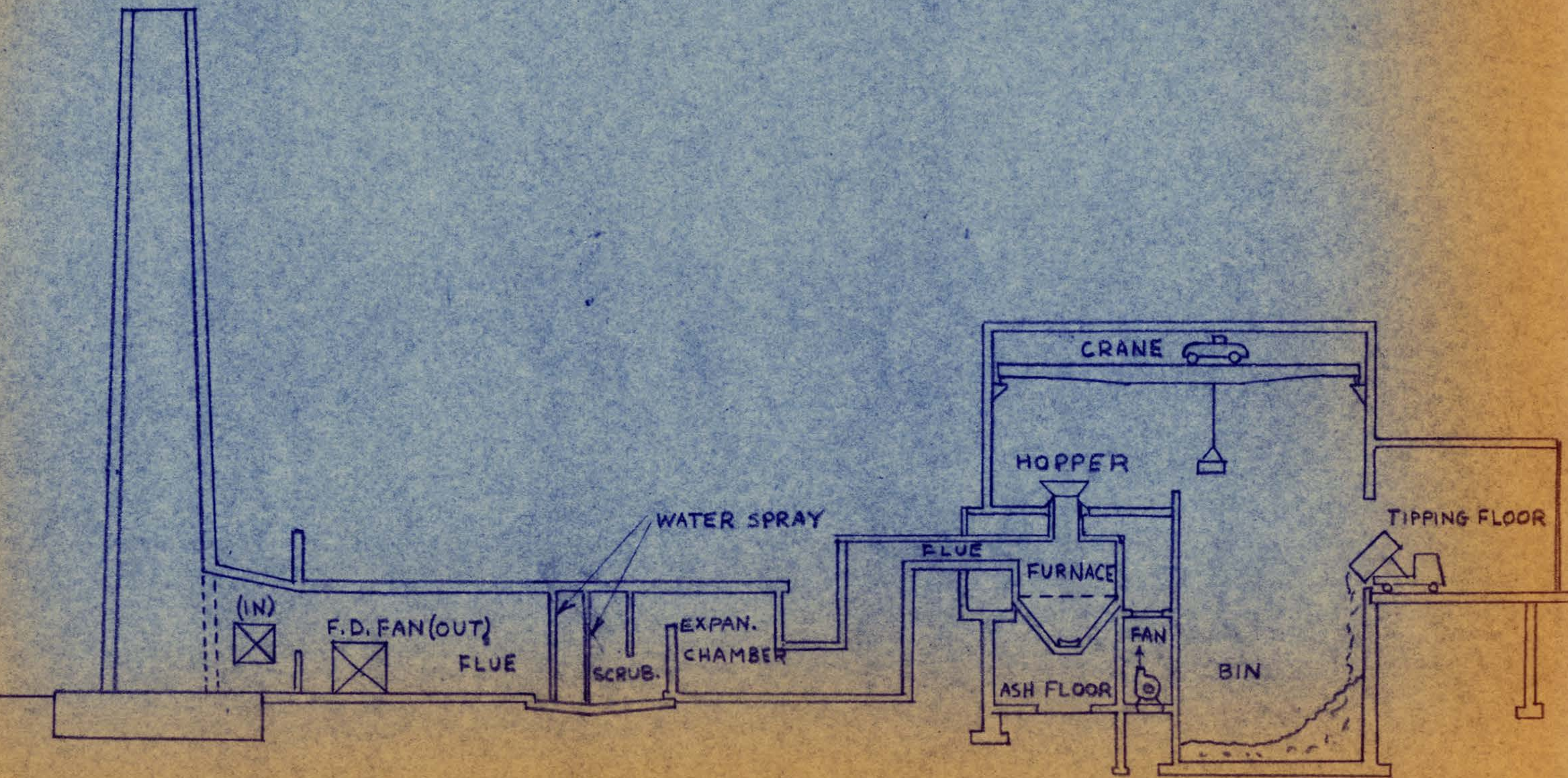
Toronto's Dufferin Street incinerator uses the same processes and equipment planned for Hamilton. It first was fired May 24, 1968. After the author's visit to it, Mr. Sutin remarked that it was forty years old the day it opened, in reference to its traditional design. It needs considerable manpower plus some 2.5 million gallons per week of non-recycled water. It has traditional overhead cranes to supply furnace feed hoppers with the refuse. Each hopper is charged twelve times hourly, twenty-four hours a day for a five day a week operation. The exhaust gases are sent through a water scrubber before entering the 180 foot stack. Figures III-1 and III-2 show exterior views, while Figure III-3 is a simplified sectional view.

By 1967, Hamilton citizens living on the Mountain near the Upper Ottawa Street land fill were mounting pressure against the land fill operation. In August the City hired the Firm to up-date

Fig. III-1   Note plume

Fig. III-2

Views of the Dufferin St. Incinerator, Toronto.   August 20, 1969



NOT TO SCALE

FIG. III-3 DUFFERIN ST. INCINERATOR (SIMPLIFIED) the 1960 Report. Their report was issued on November 16, 1967, making a number of recommendations regarding acquiring land fill sites and building incinerators. It agreed also with the statements in the 1960 report that a solid waste disposal crisis was imminent in Hamilton. One of its interesting recommendations was that the City should begin the immediate construction of a 300 ton per 24 hour day incinerator near the Queen Elizabeth Way-Provincial Highway 20 intersection. It also noted that 64% of the city disposal costs evolved from transportation of refuse. Apart from the increased use of packer trucks, little could be recommended to reduce haulage costs. The collection system was judged handicapped by long hauls, although it was well-organized and competently staffed. This Report was accepted by the City.

As an outgrowth of the November 1967 report, the City awarded the Firm a contract for engineering services for an "East Hamilton Municipal Refuse Incinerator" in January 1968. This culminated in the important "Preliminary Engineering Report" dated July 31, 1968. The author feels the Firm's efforts in the period January-July 1968 were well spent.

This is discussed in more detail in Section XII. Basically, the Firm carefully examined existing incineration stations, and equipment and produced this important Report.

A new refuse analysis was conducted by the City in early 1968 at the request of the Firm and under its guidance. This sampling updated the earlier knowledge of civic refuse characteristics. The Analysis is tabled in Appendix 2.

Stricter pollution control regulations made the Firm recognize that efficient solid waste disposal operations would be needed. Its opinion was that the prime function of an incinerator was to reduce the volume of waste, thereby extending the life of land fill sites. Burning seemed the best method to achieve high volume reduction.

As prime consultant, the Firm then retained Consoer, Townsend and Associates of Chicago and Walter, Eull and Elliot Ltd. of Hamilton as sub-consultants on process engineering and mechanical-electrical services respectively.

Mr. Sutin realized the necessity of gaining knowledge of current practice. In the spring of 1968 he toured many European incinerator installations at his own expense. European units have generally been designed to meet stringent pollution control laws. They are generally well in advance of North American designs in this aspect.

As a result of this tour, Mr. Sutin made a number of observations which would affect his later S.W.R.U. design. European units achieved good results, but only with high capital and operating costs. The method of loading the furnaces with overhead cranes is an expensive one. Odour and vermin attraction seemed less when the material was crushed or shredded and its volume was also reduced. Burners of the fixed grate variety gave a poor burn-out and needed a high labour content for their use although their first cost was low. Oscillating-type grates were also expensive to buy and operate but their burn-out was better. Air pollution control in European incinerators was far advanced as electrostatic precipitators are widely used. Finally, he recognized that high pressure steam production was the best means to cool the gases going to these precipitators.

The Firm decided to approach the Incinerator design as a manufacturing operation--a factory would be designed whose prime function was to reduce the volume of solid wastes as cleanly as possible. The production of useful by-products was to be a secondary goal. The three design work areas were defined as:

1. materials handling

2. process engineering

3. disposal of by-products (heat, scrap and ash).

The "Preliminary Engineering Report" contains thirteen specific conclusions and five recommendations. They are all presented in Appendix 3. All were accepted, and have received attention during the subsequent design work.

As a means for solid waste disposal, the Firm deemed only incineration as practical at this time. The typical composting plant must be subsidized as the humus produced has little demand, and high haulage costs develop in its disposal. High pressure compaction systems also were rejected as being in the experimental stage. Only an incinerator could provide an inert, inorganic residue. Thus a specific recommendation was made that--"The City should proceed immediately...(with)...a 600 ton per 24 hour day..." unit.

Mr. Sutin told the author he believed the incinerator manufacturers could not fill this need. They could supply the furnace and boiler but not a systems engineered S.W.R.U. Also, he believes that the Unit which his firm designed will provide a useful life of forty years before excessive maintenance costs occur.

Cost estimates and a number of general arrangement drawings concluded the "Preliminary Engineering Report".

Section V, entitled "Evolution of the Contract", provides an outline of developments following the acceptance of the "Preliminary Engineering Report" by the City. It should be noted that except for the deletion of a sifting conveyor and certain redundant conveyors there have been only minor process changes. The shredders, boilers, stacks, etc., have all been re-positioned since the Preliminary drawings to improve materials handling. These are not process changes. By July 1969, the material handling system design was finalized, but equipment selection continued until spring 1971.

IV PROFESSIONAL BACKGROUNDS OF PRINCIPAL DESIGNERS

1. Gordon L. Sutin and Associates Ltd.

Mr. Sutin, born 1928, is a 1949 University of Toronto graduate in "Engineering and Business". Since graduation he has been involved in the construction business. For two years he sold construction machinery in Toronto. From 1951 to 1953 he was a field engineer on church construction projects with the Fassel and Baglier Construction Ltd. He then worked as a project engineer (estimating, supervising and client liaison) from 1953 to 1955 with Tatti Construction Co. Ltd. in Hamilton, Ontario. He then directed his efforts to the housing and alteration side of the construction business. In 1957 he formed "Construction Supervision Services" which did cost estimating, building design and supervising of both commercial and industrial construction. His present firm evolved from this in 1961, which he formed in partnership with Mr. Ron Hayes. This present firm resulted from requests for building designs submitted to the previous company.

The S.W.R.U. design is the largest project to date of the firm. They have designed and built a number of apartment blocks, but only one project which involved considerable process design. This was a large meat-packing plant for which the proposed land could not be properly zoned. It therefore was not built.

2. Consoer, Townsend and Associates

This Chicago-based firm has been engaged in the analysis and design of a variety of public works projects for over fifty years. It is a stable, conservative company employing a staff of about 350. It ensures its projects are operating properly before publicizing them. Normally this firm would be the prime consultant on a project of this nature.

The Firm's chief contact with Consoer, Townsend is Mr. Herman Van Hille, Chief-Solids Waste Division. This gentleman has had a long and varied engineering career. For a number of years he was a naval engineering officer. In addition he has for 25 years been involved with the design of incinerators including a period as president of a firm designing and building incinerators. With justified pride he states that his older projects still meet and in many cases exceed stricter new pollution control regulations.

3. Some of the others who influenced the design or who otherwise contributed to this thesis are listed in Appendix 5.

V. EVOLUTION OF THE CONTRACT

Detailed design began on the S.W.R.U. following the acceptance by the City of the "Preliminary Engineering Report".

As project process consultants, Consoer, Townsend and Associates aided the Firm in preparing the Preliminary Report. They were retained as process consultants with a fee set as a percentage of the cost of the portion of the design which they performed.

It was realized early that the critical delivery items were the boiler and auxiliary equipment which included air pre-heaters, burners, stokers, electrostatic precipitators, etc., as listed in Appendix 6. The requirements for boiler performance with respect to burn-out and pollution control meant the post shredder storage-to-boiler system had to be tendered together. Their specifications were jointly prepared by the Firm and by Consoer, Townsend for issuance by the City on March 13, 1969. Babcock and Wilcox Canada Ltd. was the successful bidder. As the owner's engineer, the Firm transmitted all boiler contract correspondence between Consoer, Townsend and B W.

The larger General Contract specifications were prepared in three parts:

Part 1 "Architectural and Structural Specifications"

Part 2 "Mechanical-Electrical Specifications"

Part 3 "Process Equipment Specifications"

each with related sets of drawings. The last part was not available for about two weeks after the tenders were called by the City on December 2, 1969. It was awarded to Pigott Construction Co. Ltd.

Appendix 6 presents a survey of the specifications for both the contracts. Copies of the tender forms for both are included in Appendix 7. A list of sub-consultants, contractors and sub-contractors for the Unit follow in Appendix 8.

VI. RESPONSIBILITIES OF THE CONTRACTORS

Appendix 6 is a survey of the contract specifications. Basically the general contractor has the responsibility for meeting costs and construction schedules. It co-ordinates the efforts of all concerned. The Firm is to supply continuing engineering services. It must issue approvals for design changes and keep control of the critical path net-work. Finally it must issue the acceptance of the Unit by the owner to the General Contractor.

VII EVOLUTION OF THE SYSTEM WITH AUTHOR'S COMMENTS

There are several objectives intended for this section of the report.

Firstly, the factors which influence each process or operation are presented. An attempt was made to indicate the relative importance of these factors as they influenced the design decisions.

Secondly, the author's comments follow these presentations of design influences and decisions. They show the justification and consequences of decisions, and whether all influences were considered by the Firm.

The S.W.R.U. system is investigated on a process-by-process basis. The presentation of comments for the entire system in one separate section was felt to have provided an unwieldly presentation. Observations and analyses of a more encompassing nature are provided in Section X.

Sub-section M contains a number of fold-out design evolution diagrams, plus a process flow diagram. All may be consulted during the study of this section.

A. Site Selection

The City provided the S.W.R.U. site on expropriated land near the Queen Elizabeth Way-Provincial Highway 20 intersection. This is illustrated in Figure VII-A-1. The adjacent area is generally undeveloped and zoned for industrial use.

The Firm is reasonably content with the site. They hope that eventually the S.W.R.U. will be part of a regional solid waste disposal system with shredding stations elsewhere supplying refuse to such units for incineration. Mr. Sutin feels the S.W.R.U. is well placed to serve both east Hamilton and the Burlington-Waterdown areas. As will be discussed later, he felt that shredding stations at the Upper Ottawa Street and Longwood Road sites could supply this Unit.

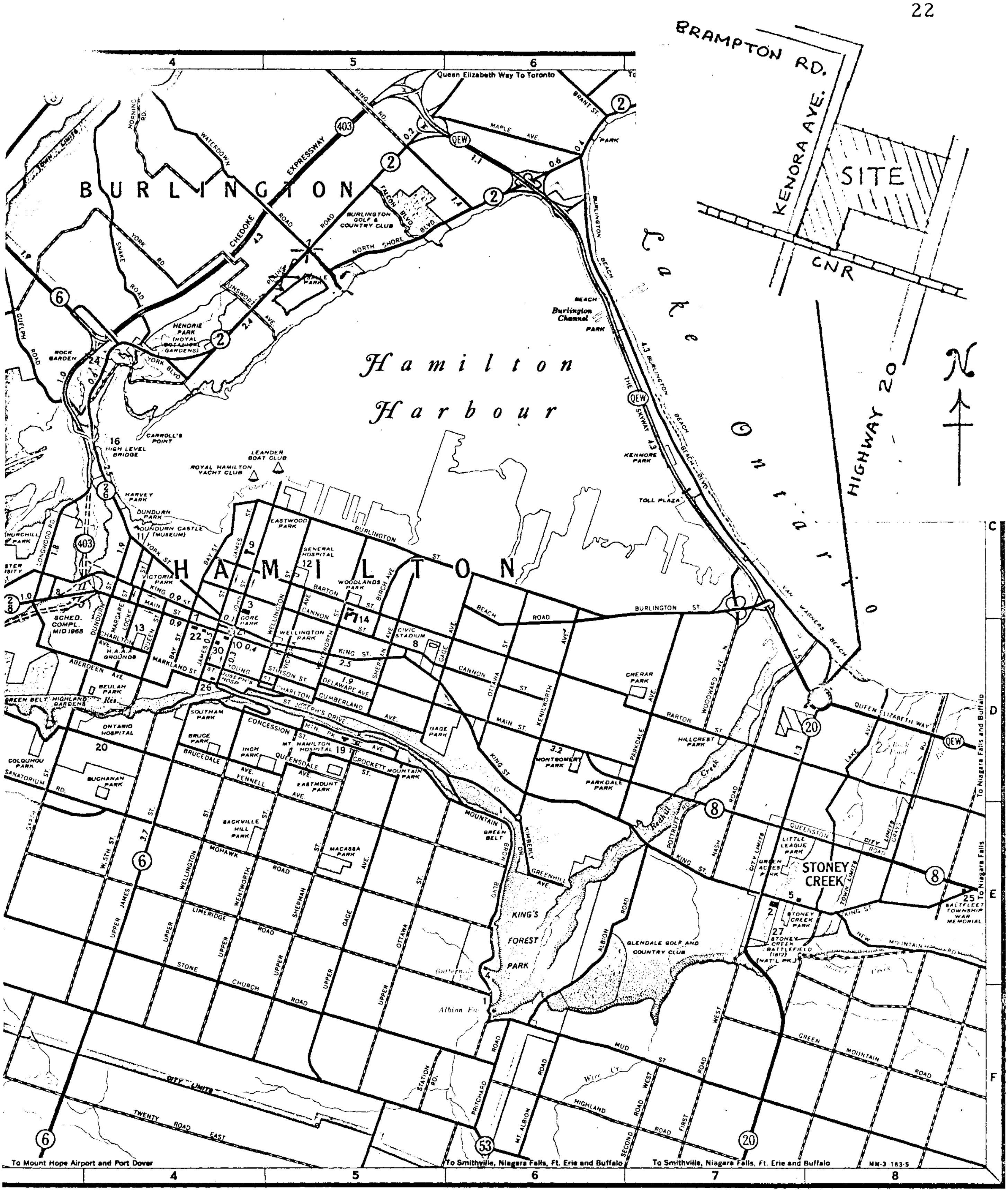


FIG VII-A-1 LOCATION OF EAST HAMILTON S.W.R.U.

This was proposed to the City, but although accepted in principal by the City the plan could not be affected.

The Firm informed the City that the Unit would be able to supply 80,000 lb./hr. of 250 psig steam. This is surplus to the requirements of the Unit, and could be of potential benefit to industries located in the adjacent industrial area.

This site has the potential to process ultimately 1,500 tons of solid waste per day. The 600 ton unit planned could be expanded to a 900 ton unit for an estimated 24% higher capital cost. Maintenance and depreciation costs would not be expected to rise appreciably.

A small scale model of the Unit was evolved with the drawings. This permitted a better appreciation of placement of buildings, finishes and landscaping to be made. Figures VII-A-2 and VII-A-3 show this model, while Figure VII-A-4 shows a simplified plan view. The reader is also referred to Figure VII-M-1 which shows the flow of material.

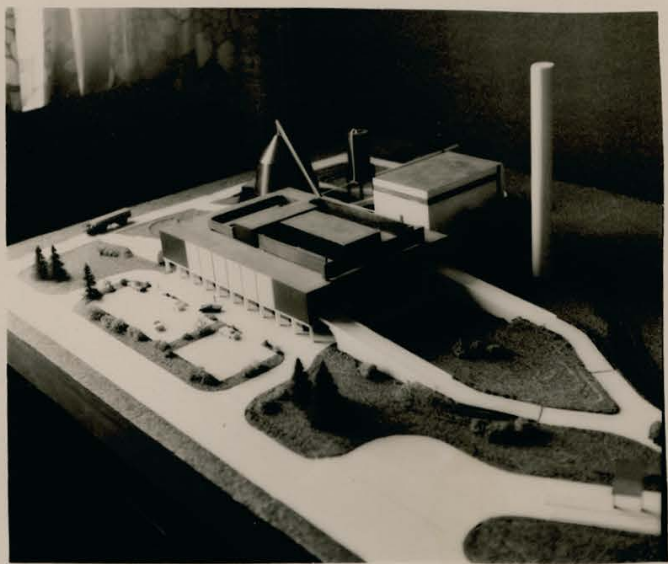


Fig. VII-A-2

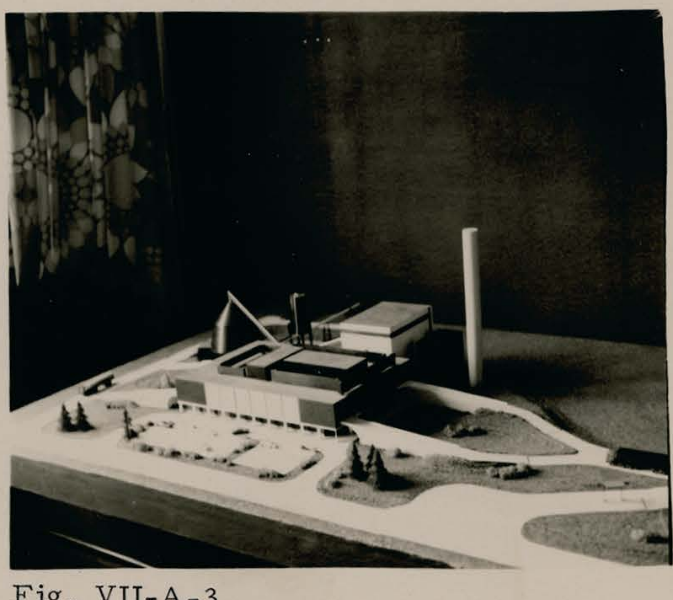
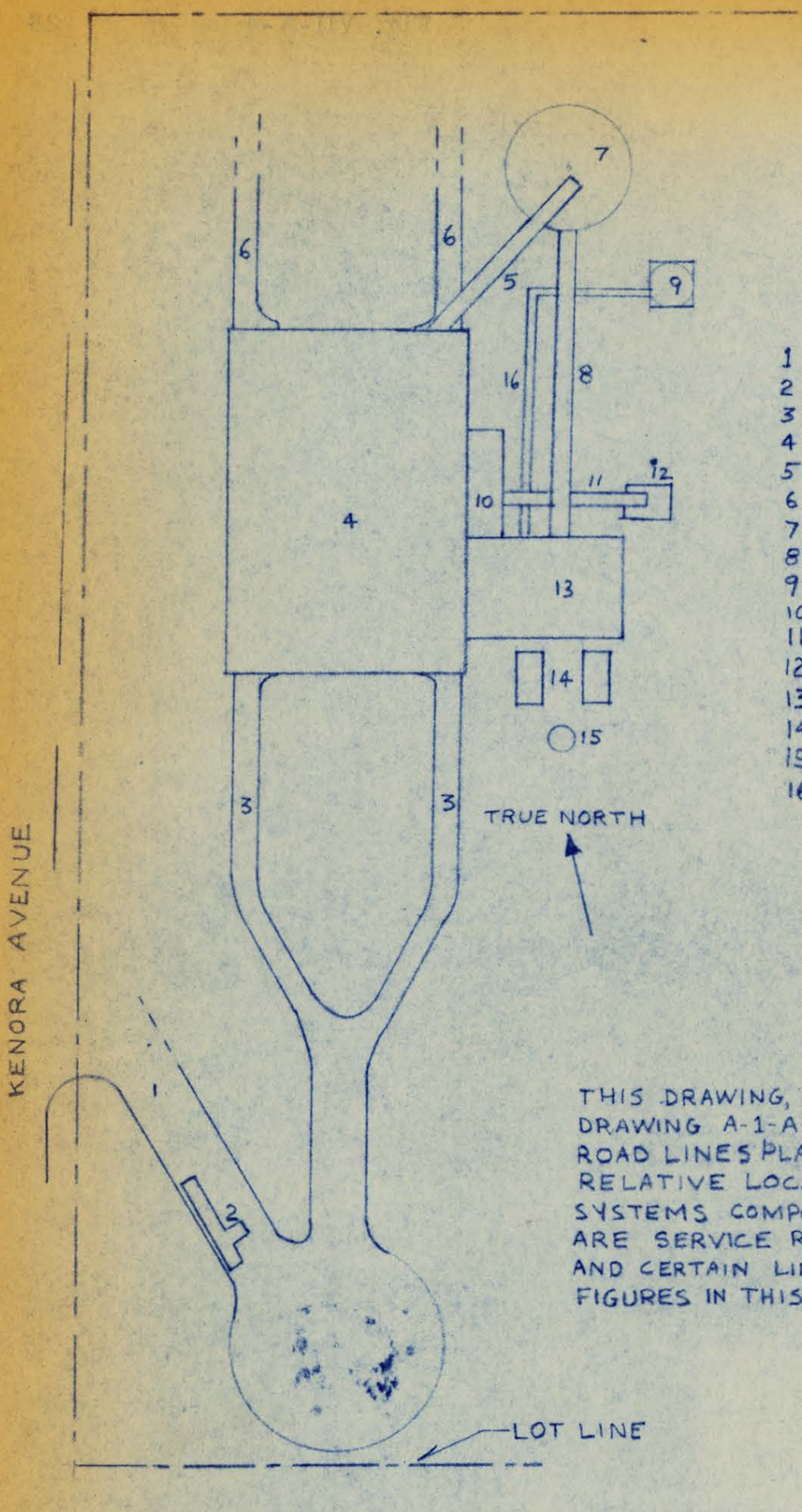


Fig. VII-A-3
Scale Model of the East Hamilton S.W.R.U.
as Used for a Design Aid



KEY

1 ENTRANCE
2 WEIGH STATION
3 ENTRANCE RAMP
4 RECEIVING BLDG.
5 STORAGE TANK CONV.
6 EXIT RAMP
7 STORAGE TANK
8 BOILER FEED CONV.
9 ASH SILO
10 TRANSFER BLDG.
11 METAL REJECTS CONV.
12 METAL HOPPER
13 BOILER HOUSE
14 PRECIPITATORS
15 STACK
16 ASH, ETC., LINES

THIS DRAWING, BASED ON SUTIN DRAWING A-1-A "BUILDING AND ROAD LINES PLAN", SHOWS THE RELATIVE LOCATIONS FOR MAJOR SYSTEMS COMPONENTS. OMITTED ARE SERVICE ROADS, PARKING AREAS, AND CERTAIN LINKS SHOWN ON OTHER FIGURES IN THIS REPORT.

APPROX. SCALE: 1 IN. = 100 FT.

FIG VII-A-4 SIMPLIFIED PLAN - EAST HAMILTON S.W.R.U.

Author's Comments

It is believed that incinerator site selection should be based on the location of collection centres, zoning laws, land costs, topography, haulage distances, local metrology and traffic conditions in the surrounding area.

The Firm was restricted in choice of site. Mr. Sutin mentioned that if only the City were to be serviced perhaps it could have been located in the downtown urban renewal area. The City supplied the site and the Firm had little option.

The site provided, although offered with no alternatives, appears good. It should prove able to serve the Hamilton-Burlington (via Skyway)-Waterdown areas adequately. The land costs at the site are presumably moderate, as the City has designated the surrounding undeveloped area as an industrial park. Traffic conditions at the site should prove no problem. It appears a down-town location would receive poor acceptance as truck traffic there would be objectionable.

As a design restriction, the selection of the site by the City appeared to have presented no real handicap. Mr. Sutin considers the Unit as an industrial plant, and normally these do not have much choice in their location.

B. Continuous Processing

The Firm favoured the concept of continuous processing in place of the more traditional batch processing mode from the earliest design stages.

The advantages of continuous processing recognized by the Firm were that it allowed the Unit to be more easily automated, and that it would allow better air pollution control. Furthermore, operating costs would be reduced.

The Firm felt that the advantages gained from automation were most important. They reasoned fewer and less skilled operators would be needed. In the Preliminary Engineering Report, increased capital costs were felt advantageous as lower operating costs could be maintained in future. This will be discussed later.

Pollution control was felt to be easier with continuous processing for several reasons. The batch process incinerator may be intentionally overloaded. This can create poor refuse burn-out and likely increased air pollution. There is also danger of fires near the loading hoppers with an overloaded batch furnace. With poor refuse burn-out, water pollution is raised. The ashes from the furnace would require a water-quench before disposal. This water would either then have to be treated before re-use or discarded. However, the continuous process ensures complete burn-out. The ashes, at 200°F to 300°F on leaving the furnace, require no quench. The use of water is estimated at less than $5,000 per year for the entire Unit. The problem of corrosion and residues from the quenching operation never arises. The capital cost was realized to be lower by the Firm as no water treatment plant on site to reduce its alkalinity after quenching the ash was needed.

Author's Comments

The broad decision to choose continuous processing instead of batch processing is not as easy as it may appear. There are several influences that make it somewhat difficult.

The modern trend in manufacturing is admittedly to automation, and this generally implies continuous processing. Whether the increase in capital cost was justified may be open to question in future. It appears there is a possibility that recycling of material formerly wasted will occur within the next fifteen years. This is well within the useful operating life for this Unit. Recycling is presently unattractive because the financial cost of separation of the component materials is prohibitive. With the rising fears of "ecological disasters" and raw material shortages, recycling may become prevalent. If this occurs, then presumably a high investment in fixed equipment may not have been justified at this time.

One only can discern most trends dimly, so one can make decisions on the best data available. The Firm had no research funding to enable fundamental studies for making a decision on the advisability of continuous processing. Funds for study of incineration will be available in future, at least to non-commercial organizations. Through the Air Pollution Control Act, the Ontario Department of Energy and Resources Management had a research budget in 1970 of $318, 000.

In summary the fundamental decision to pursue continuous processing seems wise in light of that information available for decision-making.

C. First Handling Operations

Waste delivery to site was considered carefully by the Firm. The access to the site was only by Kenora Avenue, which was divided by a C.N.R. railway track. Kenora then was essentially a dead-end street, as there was no overpass considered at the railway line. The Firm received early assurances from the City that no overpass of the line was ever planned. Site access and traffic flow was planned on this basis. The City reversed this decision, so a re-design estimated at $22, 400 was caused. Traffic control on site is aided by closed-circuit television. The ramps for entrance and exit from the receiving building have been duplicated to reduce the delays which could result from a vehicle breakdown on either. The ramps are steam-heated in winter to remove any snow or ice cover. Refer to Figure VII-A-4 for details of site access, and ramps.

An automated weight scale system has been chosen to record the weight of incoming solid wastes. Each truck entering the site will be weighed. Invoice data is to be provided to the City for billing purposes.

The traditional first handling operation for incinerator refuse is to dump it into a collection pit. Overhead cranes fitted with clam-shell buckets then lift the refuse to load the feed hoppers which supply the furnace. In theory, a crane operator is supposedly able to obtain a consistent mix for each charge of the furnace.

Before the presentation of the Preliminary Engineering Report, the Firm had decided to adopt a unique first handling operation. Mr. Sutin recognized early in the design stage that the purchase and operating costs of the usual overhead crane were high. As the pit size, and thus crane span, rises their initial cost increases rapidly. Existing units were supplied with cranes of high reliability to obtain the most trouble-free service possible. High capital costs were then involved.

The nature of a dump pit which is unloaded from the top has intrinsic odour and vermin problems. The "first in, last out" nature of the usual crane-emptied pit causes these.

The Firm eliminated the crane cost and odour problems inherent in the traditional first handling operation. The dump pit was re-named the truer term receiving pit. Four 15 h.p. electrically driven conveyors operating at its base transport the refuse to the next processing stage. Each is a metal apron type unit with cleats formed from standard angles and plate material. It appears to be easy to maintain.

The receiving pit capacity was selected to maintain the operation of the Unit. It is able to retain 480 tons of refuse which is nearly enough for one days full capacity operation of the Unit. Refuse collection in the City is done five days a week. Enough refuse must be retained in the Unit for weekend operation and for covering weekends with statutory holidays as well as inclement weather. Additional capability for the Unit to continue operation is provided in a storage silo to be discussed later.

Author's Comments

There appeared to be no alternatives regarding waste delivery to the site. Kenora Avenue had to be used. The reversal of the City to make the Avenue continuous caused expensive redesign. A designer can only make the best decisions on information available. The additional cost from the routing changes on site necessitated by the route modification are no indication of poor design practice. The Firm did all possible in obtaining what was expected to be a firm commitment to keep Kenora Avenue a no-through road.

The duplications of entrance and exit ramps from the receiving building are advisable but possibly not essential. Replication of the exit ramps are especially not as essential as disabled vehicles could be rolled down. Admittedly any such traffic congestions are all but eliminated, but the Unit itself has sufficient "fuel" in the pit to permit operation until any conceivable blockage is removed. However, if only single ramps were used the pit length would have to be increased or some means provided to permit dumping from both sides of the pit. The cost saving in using single ramps would likely be eliminated by the rise in receiving building costs. A big advantage of ramp duplication is that queues on Kenora Avenue are eliminated.

The selection of the receiving pit capacity must fall between two extreme sizes. If too large, the pit would be likely empty only rarely. Necessary conveyor repairs would be difficult. If too small, it could not retain sufficient material to allow the Unit to operate over long weekends and during winter blizzards when waste collection is slowed. The Firm has ensured that the minimum size at least has been provided.

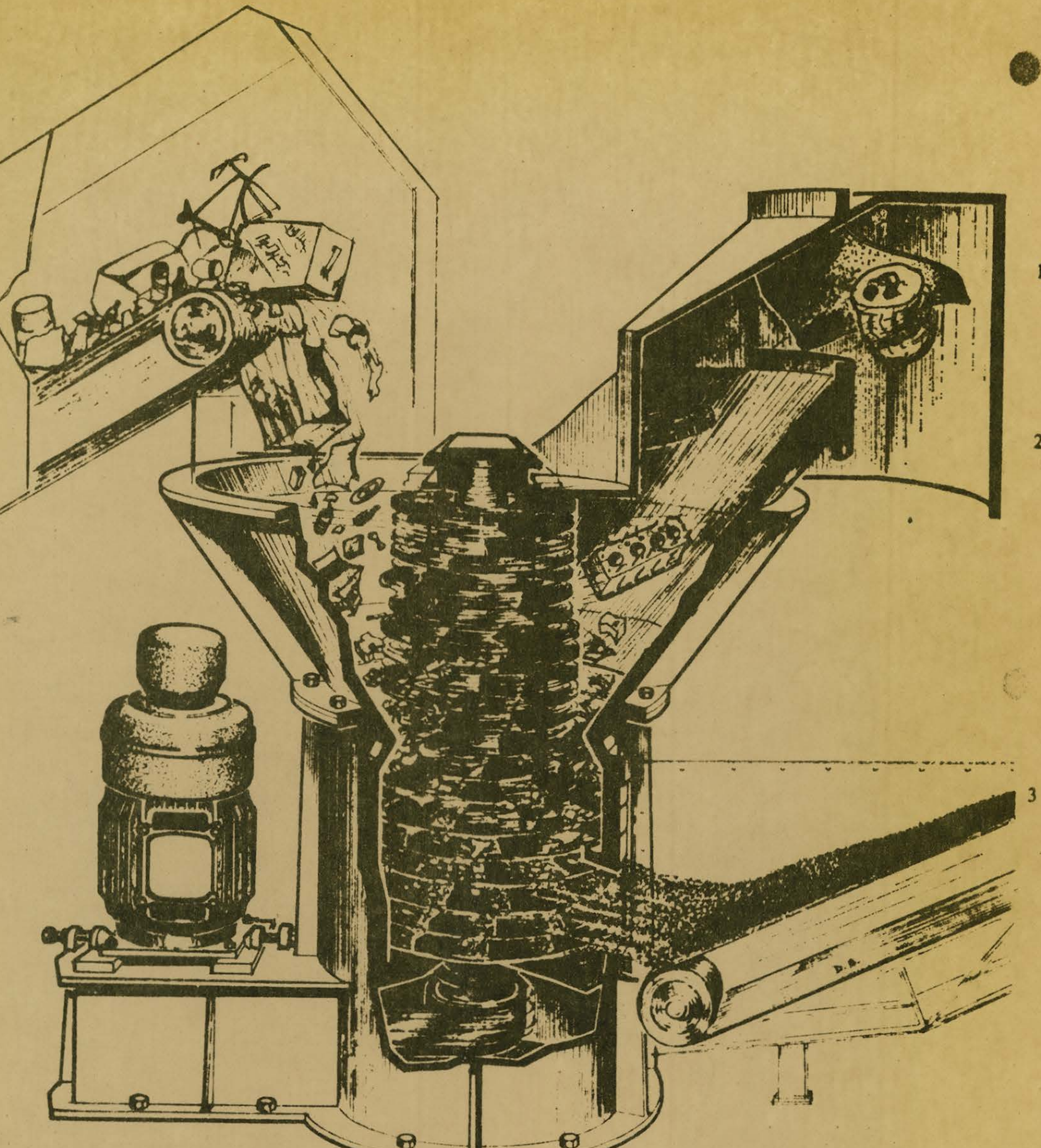
D. Refuse Shredding

The refuse analysis done by the Firm in the spring of 1968 predicted Hamilton was generating 150 tons per day of demolition lumber from its urban renewal program.

Prior to 1968 salesmen for wood-burner manufacturers had been in contact with the Firm. Wood-burning equipment on the market had been developed for the use of the forest products industry. The equipment although able to process wet wood and bark could not handle wood with attached concrete and plaster as anticipated from urban renewal projects. Waste wood in the forest products industry normally is shredded to improve its burning.

Mr. Sutin recognized that shredding or pulverizing the refuse before burning did improve its burnout. However, he told the author that the decision was made to shred all refuse besides wood scrap primarily on the improvements to be expected in materials handling. The decision meant that the aim of maximum refuse volume reduction could be achieved more easily.

The equipment for refuse shredding was chosen early. The Tollemache Composting Systems "Vertical Shaft Pulverizer" was selected, and is illustrated in Figure VII-D-1. The Firm favored this type for several reasons. The Tollemache firm, located in England, builds them primarily for composting and land-fill operations. Their design is simple enough that one of these pulverizers can be run and maintained by one or two men. Refuse is loaded with no prior sorting into the top conical section. Large metal parts and some rubber parts are rejected ballistically by the vertical shaft hammers. Unlike some competing types which have only a linear travel for the refuse through their grinding section, the Tollemache model almost never requires shut-down in service from jamming. It provides a uniform fine grind at less power than other shredders. Mr. Van Hille examined two competing types of shredder. One looked promising but as it showed little operational experience, he conservatively chose the more tested Tollemache model.



1. Rejects chute.
2. Adjustable rejects control plate.
3. Adjustable grinding depth plates and retention lip (inside machine).

FIG. VII-D-1 THE TOLLEMACHE SHREDDER

Both Mr. Sutin and Mr. Van Hille noted the advantages of using the Tollemache shredder to grind refuse for land-fill operations. In their promotional bulletins, Tollemache claims that their shredders produce up to an $87\frac{1}{2}\%$ reduction in volume. They emphasize that odour problems and fire hazards for the refuse in land-fill are reduced by shredding. Vermin are absent, and less top cover is therefore needed. The product is easily contoured into the landscape, and into on-site road fill useable in all weather. Mr. Sutin confirmed these advantages during a visit to the Madison, Wisconsin land-fill where Tollemache-type shredders were used.

The shredding operation was expected to produce dirt and dust problems, as well as a high noise level. To solve these problems, the original plan was to locate the shredders in a separate shredder building. They each produce a 75dB sound intensity at six feet. Instead of installing them in a separate building, it was decided to install them deep inside the S.W.R.U. unit.

The problem of dust and dirt was hopefully solved by using a re-circulation duct to the shredder in-feed. The final exhaust of air to atmosphere from the shredding area is via an air filter system at the end of the conveyor room. The conveyor room referred to is that containing the conveyor collecting the shredded refuse.

The shredders and their related conveyor systems contain redundancy. The four shredders each have a 15 ton per hour capacity. Each then need operate only 10 hours per day to supply the unit to full capacity. This number of shredders allows their maintenance at convenient times. The shredding requirements could be done with two shredders if necessary. Redundancy in the receiving pit conveyors and shredders was planned to improve system reliability. Two entirely separate hydraulic motor systems to power the four conveyors and shredders were planned. Although Mr. Van Hille originally planned steam turbines for this use, space limitations ruled them out and they were to be powered by low-pressure hydraulics. Use of low pressure hydraulics meant special oils would be unnecessary.

The somewhat premature loss of the Depew Street incinerator had unfortunate effects on the S.W.R.U. When Mr. Sutin realized the City was about to lose their old incinerator, he informed the City that the four Tollemache shredders could be temporarily installed, two at each of two land-fill sites. He told the author he hoped the City would recognize their value as shredder stations in a regional system, and that he felt they might be left on their "temporary" locations. These "temporary" shredders were to be electrically-powered. The City agreed to the Firm's recommendations, and tenders were called. Unfortunately, the bids far exceeded the estimates based on data supplied from Britain by Tollemache. As a result, the shredders and pit conveyors both are electrically-powered. It would be too expensive to have retained a hydraulic drive for the latter.

As the City was to lose its existing incinerator, the Firm realized it could obtain additional work in designing the temporary shredder stations. Some financial disagreements between the S.W.R.U. general contractor and the City resulted as follows. The bid tenders for both the General Contract (without the shredders) and the temporary shredder installations both closed the same day. If the City intended to discard the temporary station plan, the Firm advised them to increase the general contract by $209,000 which was the cost of the four shredders. The general contractor, Pigott Construction, asked for a further $28,000 for their overhead and profit if they were asked to buy and install the four shredders at the site as part of their contract. However, on the understanding they would receive the $28,000 addition they agreed to the $209,000 payment. The Firm, on further study, could only justify $19,000 as additional payment to the General Contractor above the $209,000. One city council member wanted to then delete the pulverizers from the general contract, and have the City buy them. This was the plan intended to be followed although against the Firm's advice and under Pigott's objections. During this protracted argument, the four shredders as part of the general contract arrived, were quickly installed with Pigott receiving its $19,000 additional payment.

Author's Comments

The choice of the well-proven Tollemache pulverizer was conservative. Mr. Van Hille admitted he selected them in preference to others he felt equal or superior as the alternatives had not received enough service use to completely convince him. Civic projects can cause politicians embarrassment and consultants bad public exposure if large problems arise. Projects being developed for industrial concerns can justify the use of new types of process and equipment for the sake of increasing profitability. With civic projects, ensured reliability is more important.

It should not be implied that innovations should not be introduced on civic projects. At some future time, it may well prove an advantage to the City to try different shredder types in place of one of the Tollemache units if possible.

The consideration of a separate shredder building for the Tollemache units probably need never have occurred. As previously mentioned, they produce a sound intensity of about 75 db at six feet. British precedents use these units near residential areas with apparently no noise problems. The sound intensity is bearable to men working near the equipment.

The circumstances forcing a change from steam to electrical power on the shredders were unfortunate. They illustrate how sometimes a designer must employ solutions he realizes are no longer the best as circumstances change.

In discussing the argument which developed concerning the shredder purchase, the strong influence of legal aspects in the project specifications was noted. Mr. Sutin mentioned the original specification was drafted showing the percentages allowed for the overhead and profit of the General Contractor. This was deleted under civic pressure. In any subsequent re-design on the project, such a deletion seems a prime area for high mark-ups by a contractor. Possibly this occurred with the shredder purchase.

The design decision to shred all refuse was a major decision. It was a step which preceded the selection of many of the major system components.

E. Shredded Refuse Storage

Following shredding the refuse, it was originally planned to transport it to the post-shredder storage silo using two conveyors. The duplication was for improved Unit reliability. This redundancy was eliminated after the Firm realized the silo contained sufficient boiler fuel for one day operation at full capacity and that the boiler may be operated at only 25% of full capacity. Also, Mr. Van Hille realized from past personal experience with the conveyor type that all conceivable repairs could be made within one day if adequate spare parts were retained. A suitable spare part inventory was set into the specifications.

At one time, Mr. Van Hille considered tube-type conveyors for transport of refuse to the silo. The tube-type forms from a flat belt into a tube during the transport operation. He decided not to specify them, feeling they lacked proven in-service use. Plain belt conveyors as selected are lower in cost and have lower maintenance requirements. Their use meant the silo had to be moved somewhat further from the shredders, as the conveyor manufacturer limits the recommended slope for the flat-belt type to 25°.

The choice of the Atlas Storage-Reclaim Silo, as illustrated in Figure VII-E-1, was based on Mr. Van Hille's favourable experience with wood refuse storage. It has wide acceptance in the wood products industry for which it was originally developed. Material is dumped in at the top of the silo. Four sweep bucket chains each having one end fixed to a peripheral rotating ring while the other ends are free drag the shredded refuse over a trench which is covered by grizzly bars. Like the receiving pit, the silo is a "first in-first out" operation as the sweep bucket chain drags the refuse from the bottom of the shredded refuse pile. The refuse then falls onto an outfeed conveyor feeding the boilers.

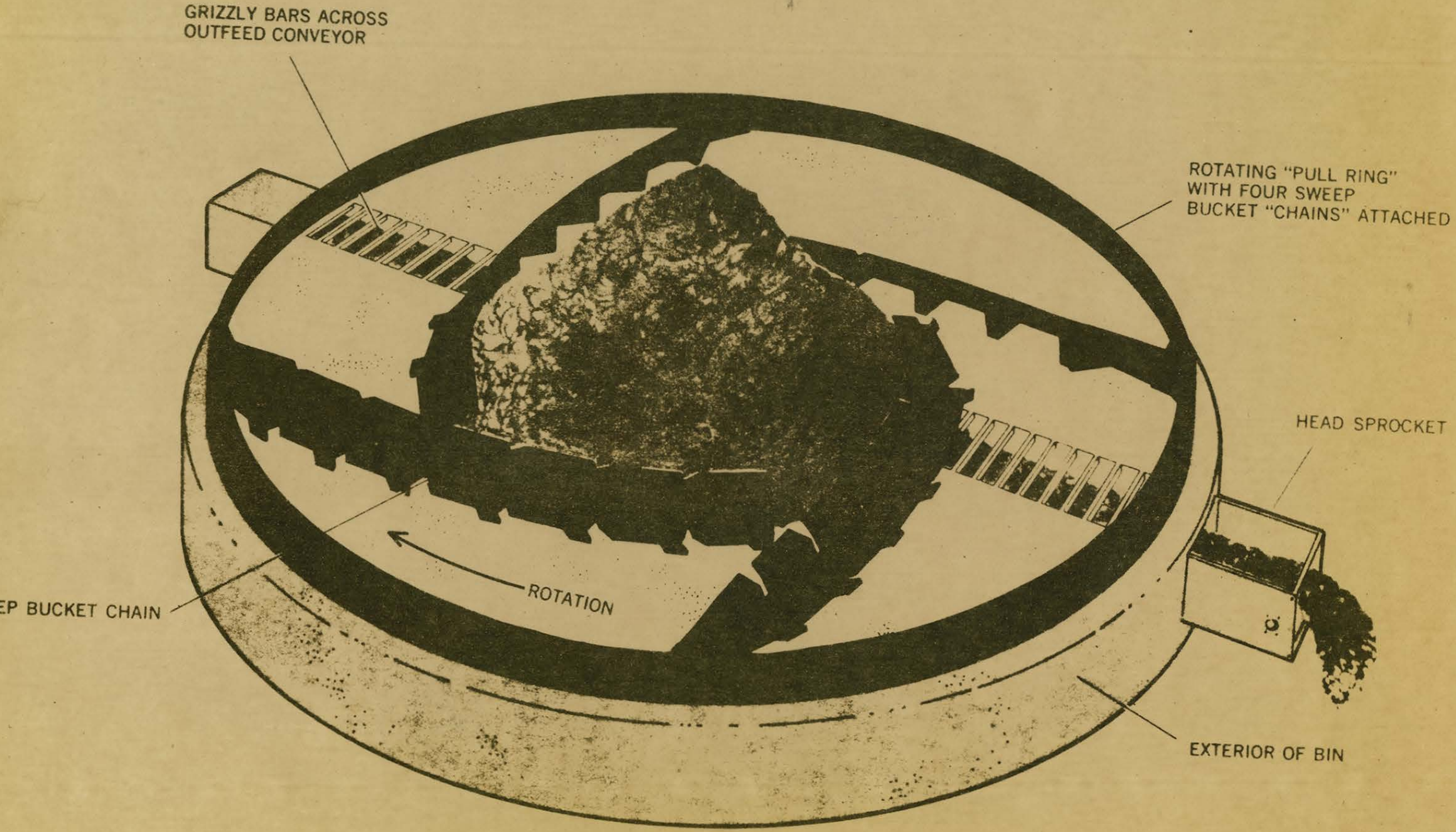


FIG. VII-E-1 THE ATLAS STORAGE-RECLAIM SYSTEM

Author's Comments

The conservative choice of the flat belt conveyor to the silo is in keeping with Mr. Van Hille's philosophy regarding the Unit.

The Unit design was in one sense optimized by the influence of inflation. The Firm realized that the cost of the Unit was rising during the design stage from inflationary pressures. In a study to determine ways that the capital cost could be reduced, they realized that only one post-shredder conveyor was necessary. Only one conveyor now is planned. The Unit has lost no performance or value. This represents a true design optimization, based on the use of techniques of value analysis.

F. Metal Separation

As previously stated, large metal pieces are ejected from the shredder to the top conical section. They are sent to a collection trailer via a conveyor system. The collection trailer is to be supplied by the scrap dealer.

The Firm noted during the initial design stages that the final output volume of ash is expected to be one-tenth that of the original solid waste. Half of this output volume is metal. This metal has salvage value and if it were removed the life of a land-fill site would be doubled. The Firm decided this removal should be made before incineration on the advice of Mr. Van Hille who was concerned with slagging in the boiler. Ferrous materials are removed by a magnetic conveyor on the output conveyor from the shredders. It is transferred by a conveyor to the metal hopper (see Figure VII-A-4).

During the preparation of the Preliminary Engineering Report, the Firm decided to use scrap burn-off furnaces with the Unit. These burn organic materials off the metal scrap before it is taken from the site. An estimate of $46, 500 was allowed for this feature. These furnaces were dropped later for two reasons. The escalating capital costs caused the Firm to review its desirability. The City had shown little interest in the disposal of scrap; the scrap market was glutted and prices were low. As the furnaces are non-essential, they were deleted.

It was realized that the shredded refuse contained much crushed glass, ceramics and non-ferrous metals. The glass material especially can cause slag formation within the furnace. To remove these glass-ceramic-metal fines, a shifting shaker conveyor was planned to be included. It was placed on the boiler feed system conveyor from the storage silo. A smaller shifting shaker conveyor could be installed here, as the boiler feed material flow is smaller at its greatest flow than the material flow on conveyors to the silo.

The shifting shaker conveyor was removed from the plans. Messrs. Sutin and Ragetlie recognized it as an ineffective portion of the system which raised the capital cost. Mr. Van Hille still prefers to have this feature retained. Mr. Ragetlie observed that many fine materials other than those causing slagging came through a shifting shaker conveyor he saw in operation at an American wood products operation. Mr. Sutin then obtained assurances from the stoker manufacturer that slag formation in the furnaces would jeopardize neither the stokers nor the heat transfer characteristics of the boilers. From his European tour, Mr. Sutin learned that certain Parisian incinerators required a regular shut-down to service furnace grates. De-slagging operations if required were then possible.

Author's Comments

Mr. Sutin mentioned the fluctuating value of scrap metal. It appears that the City should be responsible for analyzing the economics of scrap sales. The economic value of by-products, as will be discussed in sub-section I, is a potential bonus to the City which has so far shown little interest in it. The Firm is quite justified in deleting the scrap burn-off furnaces which were only considered to help make the scrap metal more marketable. They could be added later, perhaps by a scrap-dealer who was interested in buying salvage rights to the Unit.

The removal of the shifting shaker conveyor may cause additional furnace maintenance. The S.W.R.U. serviceability should not be reduced as their grates will require periodic servicing with or without the shifting shaker conveyor. The intended Unit function--maximum volume reduction--is achieved with a lower capital cost. This is further discussed in the next section.

G. Burning

Complete refuse burn-out has long been recognized as absolutely essential for pollution-free volume reduction.

The Firm always regarded the shredded refuse as a fuel rather than a garbage to be burned. It decided that supplementary fuel is likely to be required only during start-ups of the unit or when the fuel is extremely wet. Natural gas will be used as the supplementary fuel. At an intermediate stage in the planning, the Firm had to consider using oil. Babcock-Wilcox insisted quite strongly that the use of gas in Hamilton involved compliance with especially strict safety codes. However, when the Firm and Babcock-Wilcox realized the size and cost of the oil storage tanks that would be needed if oil supplementary fuel were used, the plan to use gas was retained. Modern refuse has such a high calorific value that the Firm expects it can burn at even 50% moisture by weight. Refuse rarely will be this wet. The Firm expects supplementary fuel may be necessary to maintain steam pressure during servicing to the silo, shredders or conveyors.

An air preheater has been included in the boiler system. The function of an air preheater normally is to raise the thermal efficiency of a steam generator by using unclaimed exhaust gas heat to heat the incoming combustion air. The efficiency is improved around 5%. Although efficiency as such is of no real importance with the S.W.R.U., the Babcock-Wilcox Company insisted on an air preheater to maintain combustion of wet refuse.

Suspension burning is to be used in the boiler. This decision was again based on Mr. Van Hille's experience with bark-burning boilers. Bark is tossed up into the combustion zone where a high fraction of the burning occurs. He feels that the shredded refuse will burn more readily and thoroughly than the wetter bark. At the earliest stages, Mr. Van Hille hoped to use a tangential feed to supply the boiler fuel. This form of suspension burning introduces the refuse tangentially to the combustion zone. As its capital cost was around $500,000 more than a conventional type of suspension boiler, it was not economically justified. Discussions were conducted with its manufacturer, but the cost could not be brought down to a satisfactory level. The Detroit Stoker Company "Rotograte" system was chosen instead. Refuse is tossed into the combustion zone by a series of revolving rotors and air blast at the bottom of fuel receiving hoppers. After some burning in suspension it falls onto the rotating grate where combustion is completed. The Rotograte is a slow-moving endless belt which eventually dumps the ash which is left upon it.

In order to reduce furnace area maintenance, refractories have been used as little as possible. They are subject to glass slagging and thermal shock failures, both likely in the burning operation to be expected in the S.W.R.U.

Author's Comments

As has previously been discussed, the decision to shred all refuse was a major decision having an effect on the overall design.

Mr. Neil Johnson of Detroit Stoker was contacted to find the benefits of suspension burning after estimates that 50% of the total burning would occur in suspension. His reply was that the fraction of burning which would occur in suspension was influenced by several factors. These include the size, shape, moisture content, and non-combustibles in the fuelling charge, plus the air-to-fuel ratio and heat release per grate area in the burning process. Variation in the input refuse quality and therefore its suspension burnout can be expected.

As will be discussed in sub-section K, the maintenance of continuous high quality refuse burnout is difficult. Mr. Johnson stated that the knowledge of suspension burning is largely based on operating experience. Apparently little investigation has been made of refuse incineration, especially as shredded fuel.

H. Heat Removal

As outlined earlier, Mr. Sutin had concluded that burning was the best method to affect a maximum volume reduction of refuse. This decision to burn created problems in regard to pollution control which had to be solved.

At the earliest stage in design, Mr. Van Hille decided to ensure complete odour removal from the combustion gases a tall furnace was necessary. His experience was that bark burning furnaces generally are tall to have a sufficient "retention time" for this purpose. Babcock-Wilcox design philosophy also favours a tall furnace.[2] Mr. Sutin mentioned to the author that air pollution regulations specified that the combustion gases be exposed to 1600°F as a minimum temperature for at least 0.5 seconds. A tall type of boiler was thus chosen.

---

2 Reeling, N. E., "How Fuels Affect Current Boiler Design", Babcock and Wilcox, Paper BR-850, February 15, 1967.

As detailed in Section V, the delivery of the boilers and certain related items were critical to the completion schedule for the S.W.R.U. The Firm, with considerable assistance from their process consultants, prepared the "Boiler and Auxiliary Equipment" specifications. These are outlined in Appendix 6. The accepted bid, from Babcock and Wilcox Canada Ltd., employed two Stirling boilers of the two drum type. This type has membrane walls for cooler operation.

The Stirling boiler, dating from 1888, is acknowledged to be able to withstand wide variations in load, and to need little maintenance. It is a series of water tubes connecting two drums through which access may be made to service the tubes. The boiler manufacturer has proven its worth in incinerators.

An air-cooled condensor was chosen, roof mounted, thus eliminating the need for a 36 inch diameter pipe to supply cooling water. This decision was in keeping with the philosophy to minimize operating costs, and was made by Mr. Van Hille.

In discussions with potential bidders, the Firm emphasized that efficient steam production was not the aim for the boilers. Steam flow was to be expected to vary with fuel changes. Each boiler was expected to produce 100,000 lb./hr. of steam at 250 psig.

It should be noted that the Firm decided to use two boilers rated at 300 tons/day each to achieve unit reliability. If the unit is later expanded to process 1,200 tons/day, one 600 ton/day boiler would be added. The use of two smaller boilers was specified by the Firm, although the capital cost was raised.

Author's Comments

The selection of a tall furnace seems wise on several accounts. The state-of-the-art as interpreted by Babcock and Wilcox with regard to pollution regulations and by Mr. Van Hille for odour removal both indicate a tall furnace as the best choice.

Section VIII compares the three bids as received by the City for the Boiler Contract. The lowest acceptable bid was that accepted, on the recommendation of the Firm. The contract was admitted to have been awarded on the basis of lowest price.

Mr. Van Hille was asked if additional capital cost resulted from the requirement for a tall furnace to provide sufficient retention time. Were there costs beyond those required to provide a minimum boiler to burn the refuse? Mr. Van Hille said the choice of the three bids received went to the one bidder who guaranteed the boiler operation. It was intermediate as far as height and retention time. The lower furnace was cheaper; the taller, more expensive. As the need for the boiler guarantee was in the specifications, the Babcock and Wilcox boiler could only be chosen. It appears the requirement for sufficient retention time has raised the boiler costs.

I. By-Products

The S.W.R.U. produces steam, scrap metal and ash as by-products. The layman realizes all may have value. The Firm indicated in its Preliminary Engineering Report that the Unit could be operated and amortized at no cost to the tax-payer through the sale of by-products. Their values were prudently not entered into the cost estimates presented, as the uncertainty of the scrap market made them suspect.

During the design evolution the City showed no interest in the potential value of by-products. Mr. Moore, the City Economics Commissioner, and Mr. Sutin both realized the uncertainty of the scrap metal condition at the Unit made the preparation of sale tenders difficult. The scrap market during the design evolution was saturated, realized Mr. Moore. The City has no plans to use the approximately 80, 000 lb. /hr. of steam that will be surplus to the needs of the Unit, nor to use the ash.

The lack of civic interest in the by-products caused the burn-off furnaces to be deleted (see sub-section F) at a substantial saving.

Author's Comments

The Firm was prudent in considering any cash value received from the sale of by-products as a bonus for the City.

Literature supplied by the U.S. Bureau of Mines indicates the potential value of residues as high. The metals alone, in American units, have a scrap value exeeding $1 billion annually. Much is from discarded cans, numbering 46 billion. However, their recovery as a residue is at present not economic. The recovery of crushed glass is also not economic, although this material is being tested as a road surfacing material in Scarborough, Ontario.

Eventually the City must face the problem of metal salvage from the Unit. Admittedly the vagaries of the scrap market make this unappealing. Mr. Sutin mentioned, for instance, that in August 1970 scrap steel was worth $15 to $20 per ton, well over what it was during the design stage. However, half the final volume of residue from the Unit is scrap metal and if the scrap metal were recovered, the volume of ash would be halved. Land-fill life would be doubled.

Regarding the design decisions influenced by the by-products, the Firm has been frank with the City. The City has been made aware that scrap burn-off furnaces if necessary for the pre-sale conditioning of scrap metal may be added. Mr. Sutin mentioned that the City of Toronto had been approached by scrap dealers willing to pay scrap salvage rights to an incinerator.

Mr. Sutin commented that in times of a scrap glut the City would possibly even have to pay for scrap removel from the site.

J. Pollution Control

The Firm realized that the S.W.R.U. must operate with the minimum environmental pollution to satisfy provincial regulations.

The pollution of water from the Unit is minor. Little water is required; unlike most incinerators, no treatment facilities for water are required on site.

The Firm was more concerned with reducing air pollution from exhaust gases. During his European tour, Mr. Sutin realized that European incinerators achieved their high standards of air pollution control using electrostatic precipitators. They are rarely used on North American precipitators. In the U.S., the first appeared on a Stamford, Conn., unit in 1969. Mr. Sutin realized that proper gas cleaning might allow a reduced stack height. He realized only the electrostatic precipitator could achieve the necessary exhaust gas standards.

The internal structure of an electrostatic precipitator is limited to a 600°F operating temperature. The combustion gases, at $1600^{\circ}F$ or more, must be cooled before they enter the precipitator. Mr.Sutin investigated the following means of cooling:

(i) Cooling by water spray is impractical. Corrosive acids are formed which attack the Unit, and an obvious steam plume issues from the stack.

(ii) Air dillution cooling also is not practical. If large amounts of cool air were added, a far larger precipitator would be required to handle the larger air volume.

(iii) Steam generation is recognized as the practical method to cool exhaust or combustion gases. Mr. Sutin emphasized this is the reason the S.W.R.U. is a steam generating plant.

The items of equipment covered by the Boiler Contract were recognized to be the critical items for minimizing air pollution. The designs of boilers, precipitators, stacks, etc., are all inter-related.

The stack design, and particularly its height, requires the approval of the Provincial Air Management

Branch. This portion of the Unit is influenced by the design of the boilers and precipitators. In the early stages of design, the Firm could not be sure of the type of stack that would be required. The boiler specifications (see Appendix 6) were prepared with three alternate stacks. The project schedule for completion of the Unit construction required a decision be made on the type of stack to be used before Provincial approval was likely. The boiler and stack foundations could not be delayed. The Firm decided to build a stack foundation for the heaviest of the three alternates.

The exhaust stack specified was a 165 foot Hermet Corporation model. It is a hermetically-sealed double flue model whose design has many good features. The efflux gas temperature is high, as the hermetic (temperature) seal ensures moisture cannot condense from the gas inside it. The smooth inner walls limit particulate deposition. The manufacturer claims its high heat retention aids boiler start-up by adding to the draft. It can be readily extended at moderate cost. The Hermet Corporation also claims its design provides inherent acoustic insultation.

The Firm decided on the Hermet stack for both financial and aesthetic reasons. It is light weight, as it is made of steel plate, weighing not over one quarter that of the conventional concrete or brick type. This meant a cost saving was made on the foundation for the stack. Both boilers are served by the one stack which will have a fluted Grecian column exterior painted white. The Firm took care to achieve an aesthetic stack as this feature of the Unit will be the most obvious to the public.

The selection of the preferred electrostatic precipitator manufacturer was interesting. Mr. Sutin recognized European incinerator designers favored the Wheelabrator-Lurgi types. This firm installed its first precipitator in 1927. The settling chambers then commonly used removed only 60 to 80% of the fly-ash. When Wheelabrator-Lurgi realized that Mr. Sutin was interested in their product, he was flown to New York to view examples in action. Mr. Sutin was favorably impressed. A competitor, the Joy Manufacturing Company, was later considered, and the Firm realized that its product was a comparable product. Joy emphasized to the Firm the ease with which their installations may be enlarged if needed. This caused some suspicion in Mr. Sutin's mind. When Babcock and Wilcox were obtaining engineering data for their bid, Joy supplied data too late for their contribution to be considered. The Firm, meantime, had promoted the Wheelabrator-Lurgi type to the City authorities, and was reluctant to re-consider the merits of the Joy type. The base tender specification was for Research-Cottrell precipitators, but their lack of incinerator experience meant that neither Babcock and Wilcox nor the Firm nor Consoer, Townsend favoured them.

Efficient electrostatic precipitation requires the gas to be cleaned to spend sufficient time within the equipment. This produces cooling and pressure drop in the gases. Forced draft fans must be used to raise the outlet velocity of the gases from the stack to the recommended minimum of 72 feet per second.

Author's Comments

The selection of the stack involved choices between several alternatives. Government approval for height required the submission of considerable data. In Ontario, approval is based on impingement concentration from the stack at a selected point. This sets the allowable effluent rate (0.25 lb. per 1000 pounds of gas) and sets the permissable effluent concentration. This code is based on the A.S.M.E. and U.S. Department of Health methods. For the Unit, the effluent rate is to be limited to 0.08 lb. per 1000 lb. of gas. European codes are slightly less strict. The Toronto incinerator on Commissioner's Street requires the installation of $8 million in new pollution control equipment to meet these standards. Certification by the Department of Air Management then would cause a long project delay if the Firm had waited for all data before selecting the stack.

The Firm planned on using the foundation design capable of carrying the largest stack which would be required. This possibly non-optimum choice seems justified to maintain a realistic project schedule. The interactions between precipitator, stack, boiler and other suppliers, manufacturers, and contractors would take too long to settle as to their final effects on the stack height and foundation. Mr. Sutin estimated that no more than $3,000 additional cost was incurred in choosing the most conservative foundation, and the extra capacity ensures a very safe design.

The Hermet stack aesthetics seemed subject to alterations until late in 1970. The Federal Department of Transport requires such potential hazards to low-flying aircraft be made conspicuous. Usually an orange and white striped pattern plus nocturnal illumination is specified. The Firm hoped at most only top warning lights would be needed. This was not approved in writing from the Department until late 1970. The Firm did obviously not want the garish orange-white scheme from the aesthetic viewpoint. Top warning lights were planned, with required electrical services and an external service ladder up the stack. The stack manufacturer said the service ladder wasn't necessary to service the stack, and the D.O.T. approved flood-lighting from the ground for the stack. However, Mr. Van Hille insisted on the ladder for stack inspection. The top warning lights were left as planned. The design solution to the stack lighting problem is not optimal. The slowness in reply from the D.O.T. appears to have caused additional cost as additional lighting plus an inspection ladder have been used.

There appears to be no alternative to using electrostatic precipitators to minimize air pollution from the Unit. As mentioned, they have been little used on incinerators in North America. Dr. Kardos correctly remarked their acceptance was ensured in the S.W.R.U. design at this design period.

The reasons for the choice of the Wheelabrator-Lurgi precipitator are interesting. The salesforce for this firm were aggressive and likely impressed the Firm. The Joy Company alternative may be just as suitable. However, a designer must make decisions to achieve deadlines with available data; Joy's data was not ready. With a civic project, the designer must convince the civic authorities his choice is at least as good as those provided by alternative suppliers. Mr. Sutin mentioned that the Joy alternative could have caused a project delay as precipitator foundations had to be specified. They are convinced their choice is as good as the Joy alternative.

K. Control System

The design of the control system for the Unit is quite intricate. The author did not attempt a complete study of it.

Traditionally, boiler manufacturers supply only the boiler. They may, and often do, manufacture the auxiliary equipment such as pumps, condensors, etc. These auxiliaries are not sold directly to the customer like the boilers, but are supplied through subsidiaries. To meet the standards for the process engineering on the

Unit, Mr. Van Hille of Consoer Townsend carefully specified those auxiliaries which he by experience felt best. The control systems related to the boiler operation also are in this category.

Bailey Meter Company was one of the control equipment suppliers approved by the Firm and Mr. Van Hille. This company was selected to supply the majority of controls for the entire Unit. Bailey, as a member of the Babcock and Wilcox corporate family, is in a favorable position. They presented the Firm with a presentation of over 30 pages giving the functions and models of each piece of equipment they would supply to measure and/or control the Unit. They claim to have a 90% market share of the Canadian boiler control and metering field.

Redundancy for boiler protection is supplied. Van Hille insisted on a feedwater supply being held in reserve which can be supplied electrically if steam power fails.

A difficult but interesting control problem arose with the regulation of refuse feed to the boilers. It is necessary to obtain good refuse burn-out as well as maintain a uniform steam pressure. Only in late summer of 1970 was the means to do this decided by Mr. Van Hille and Bailey Meter. If the fuel were wet and fed to the boilers at a faster rate in an attempt to maintain steam pressure, the burn-out quality would drop. A weighing type conveyor, plus closed circuit television monitoring of the burning process by the operator, will be used. Deeper bed burning on the Rotograte is satisfactory to maintain burn out.

Author's Comments

The author when confronted with the design of the control system elected to only survey it. It is somewhat specialized for the more general nature of this study.

The traditional approach used by boiler manufacturers seems rather out-dated. They normally supply neither the auxiliary items nor the manpower to commission the new boiler system. In answer to the author's request, Mr. J. Young of Babcock and Wilcox wrote that "...operation of the unit is the responsibility of the operating (stationary) engineer on duty and since it is impossible to control his actions we can assume no responsibility for his errors". These restrictions seem a stern limitation to the Firm during the run-in trials for the Unit. With customers demanding 'turn-key' operation, this approach likely will change in future.

It is possible that lack of basic knowledge of refuse combustion has required that refined, complex controls are required. Possible fundamental studies could reduce the sophistication of these controls.

L. Drives

Since the steam was available as a by-product from the burning and heat-removal operations, it was logical to consider harnessing it for equipment drives. In Europe such steam is used to develop electrical power for the national power grids.

Mr. Van Hille decided not to generate electrical power using the available steam. The City requested this to avoid any conflict with Ontario Hydro. He felt that its generation would raise the capital cost by approximately one million dollars which was unacceptable.

The Unit is generally powered by electric motors for requirements below 25 h.p. It was uneconomical to consider using steam turbines in this small size. Apparently small power turbines consist of a small rotor inside a casing suited to a larger unit. Even at 25 h.p., electric motors are still comparable to turbines in cost.

The changes in drives for the shredders and refuse pit conveyors were described in detail earlier. They originally were to have been driven by steam turbines.

Interesting developments resulted from the selection of the steam turbine supplier. Part 3, Process Equipment Specifications, for the General Contract calls for Terry steam turbines. Terry turbines are a simple, rugged type which were preferred as they were less likely to cause maintenance problems.

A Hamilton factory manufactures steam turbines. Mr. Van Hille did not favour them for the Unit. The Company apparently showed little interest in bidding on the equipment before the contract was let.

When general contract was awarded, pressure was brought upon the Firm to change from the Terry to the local builder turbine. Submissions to the City from both the local company and the union were made. The Firm told both to write to the City if they wished their turbines to be considered now the contract had been awarded. Traditionally, the local manufacturer had been given the chance to supply equipment on other city projects if they were willing to meet the price of the accepted or preferred source. Mr. Sutin felt this process was dubious, and that the Terry product was superior for this use. Mr. Van Hille supplied him with a letter comparing the two brands in detail to aid a letter that Mr. Sutin sent to the City. Mr. Sutin wrote that he will not accept responsibility for their satisfactory operation if the local alternatives are used. A meeting of City council voted to re-assign the turbine contract to the local builder. The mayor stated that as it was a leader, he favoured their product. Van Hille, the engineer, stated in his comparison of the two types "...I must disapprove of (these) turbines". The capital cost was quoted as rising by $529 in using these turbines in place of the Terry type.

At the time of writing (June 1971), the cost of the Unit has risen by around $50,000 because of the decision to use locally built turbines. It was noted that this type was unable to carry any vertical (beam) load over 25 pounds. Special clutches are being specified. The local manufacturer apparently claims that the Terry type also would have required such clutches. The matter has not yet been resolved, and is still a very sensitive issue.

Author's Comments

Mr. Van Hille feels Ontario Hydro would not object to on-site electrical power generation for on-site use. The City's fear of a conflict with Hydro appears unfounded. The rise of capital cost of approximately one million dollars to allow on-site electrical generation likely makes it unjustified. Mr. Sutin remarked Hydro would not buy excess power generated on site.

The turbine controversy involving the Firm, City, local supplier and union clearly illustrates unique pressures on the design of a civic project. The Firm was forced to accept a decision based on other than technical aspects. The Firm did all that was possible in a difficult situation. The alternatives were compared, presented to the City, and a statement was issued that the Firm could not be held responsible for the local manufacturer's turbine performance. They told the City they would do all possible to ensure their proper operation.

The subsequent problems originating from the limited transverse shaft load capacity should be examined in retrospect later. At present this sensitive issue is best not reported.

M. Design Evolution Diagrams

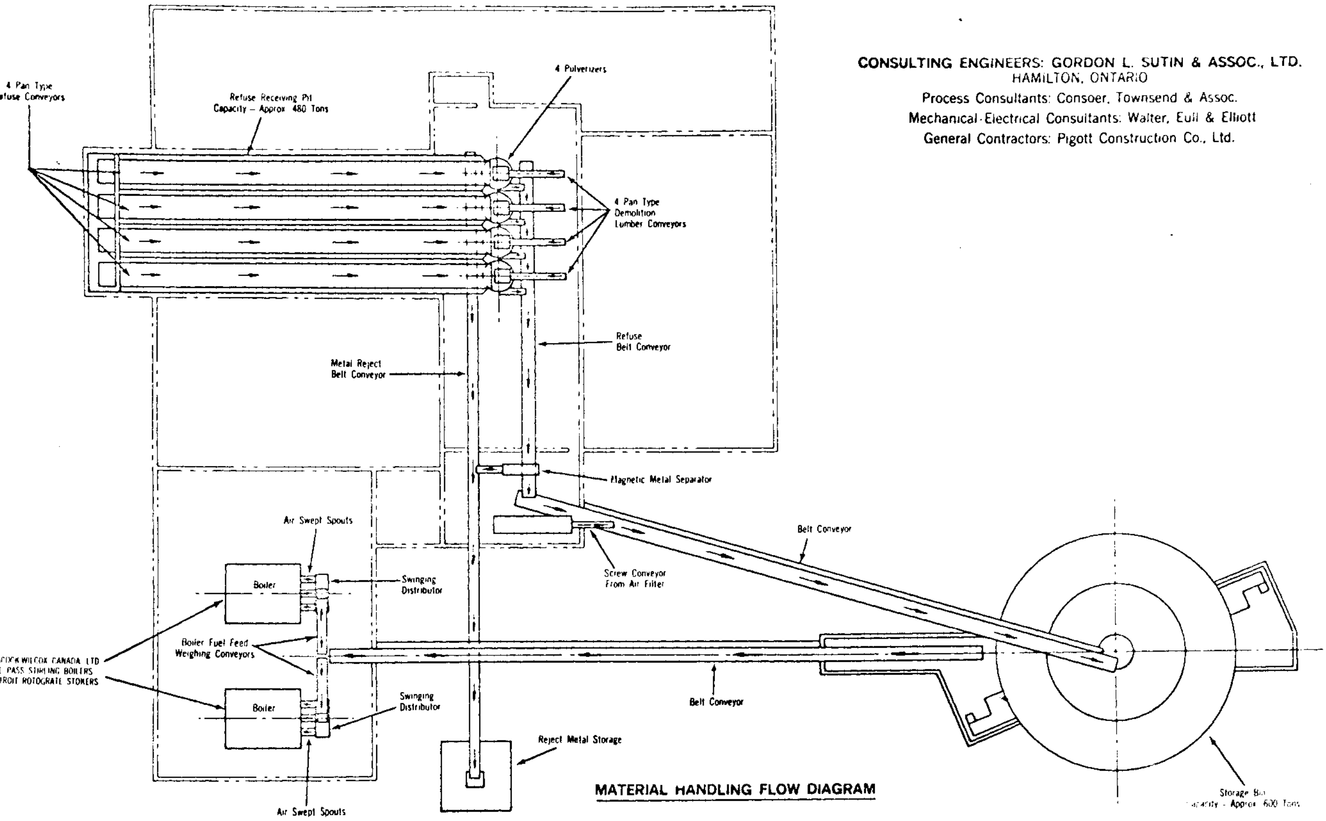
This sub-section consists of a series of block-diagrams intended for reference with the earlier portions describing the evolution of the system.

With the exception of Figure VII-M-1 as supplied by the Detroit Stoker Company, all represent the attempts by the author to show the broad influences, interactions and alternatives which may be less obvious in the discussions. The heavier line shows the path or alternative finally chosen. The broad influences are represented by a broken line.

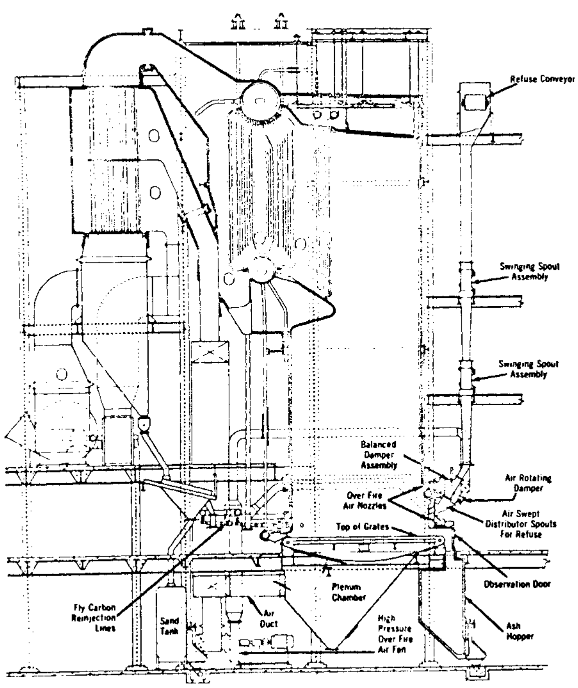
The reader is also referred to Section XII "The Evolution of the Concept as a Design Process".

The East Hamilton Solid Waste Reduction Unit • City of Hamilton, Ontario

CONSULTING ENGINEERS: GORDON L. SUTIN & ASSOC., LTD.
HAMILTON, ONTARIO
Process Consultants: Consoer, Townsend & Assoc.
Mechanical-Electrical Consultants: Walter, Eull & Elliott
General Contractors: Pigott Construction Co., Ltd.

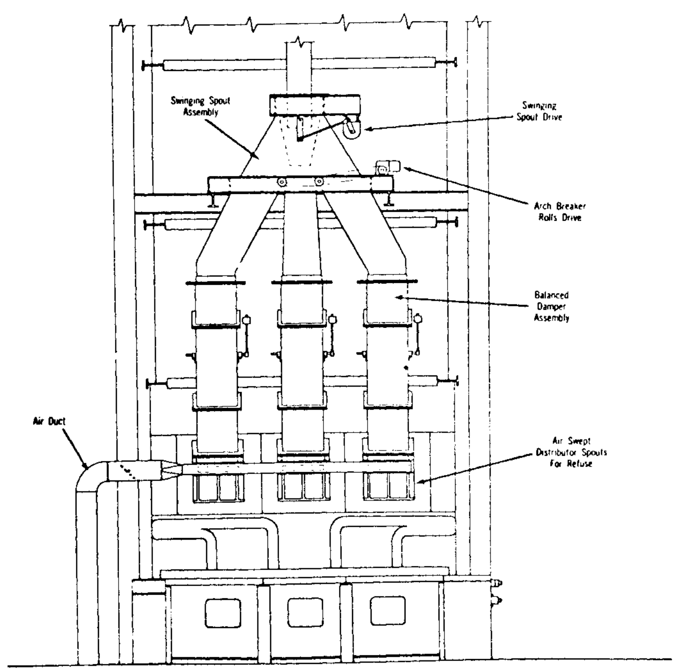


MATERIAL HANDLING FLOW DIAGRAM



TYPICAL SIDE SECTION

Arrangement of water tube boiler fired by a Detroit RotoGrate Stoker for burning hogged municipal or industrial refuse.



FRONT VIEW

Shows Detroit Swinging Distributor Spout Assembly equally distributing hogged municipal refuse to 3 Detroit Air Swept Distributor Spouts located in the boiler front wall.

The 2 Babcock & Wilcox Canada Ltd. boilers and the Detroit RotoGrate Stokers (stokers built under license arrangement by Babcock & Wilcox Canada Ltd.) are each designed to burn 25,000 lb./hr. of mixed municipal refuse.

Fig. VII-M-1 S.W.R.U. MATERIAL HANDLING FLOW DIAGRAM

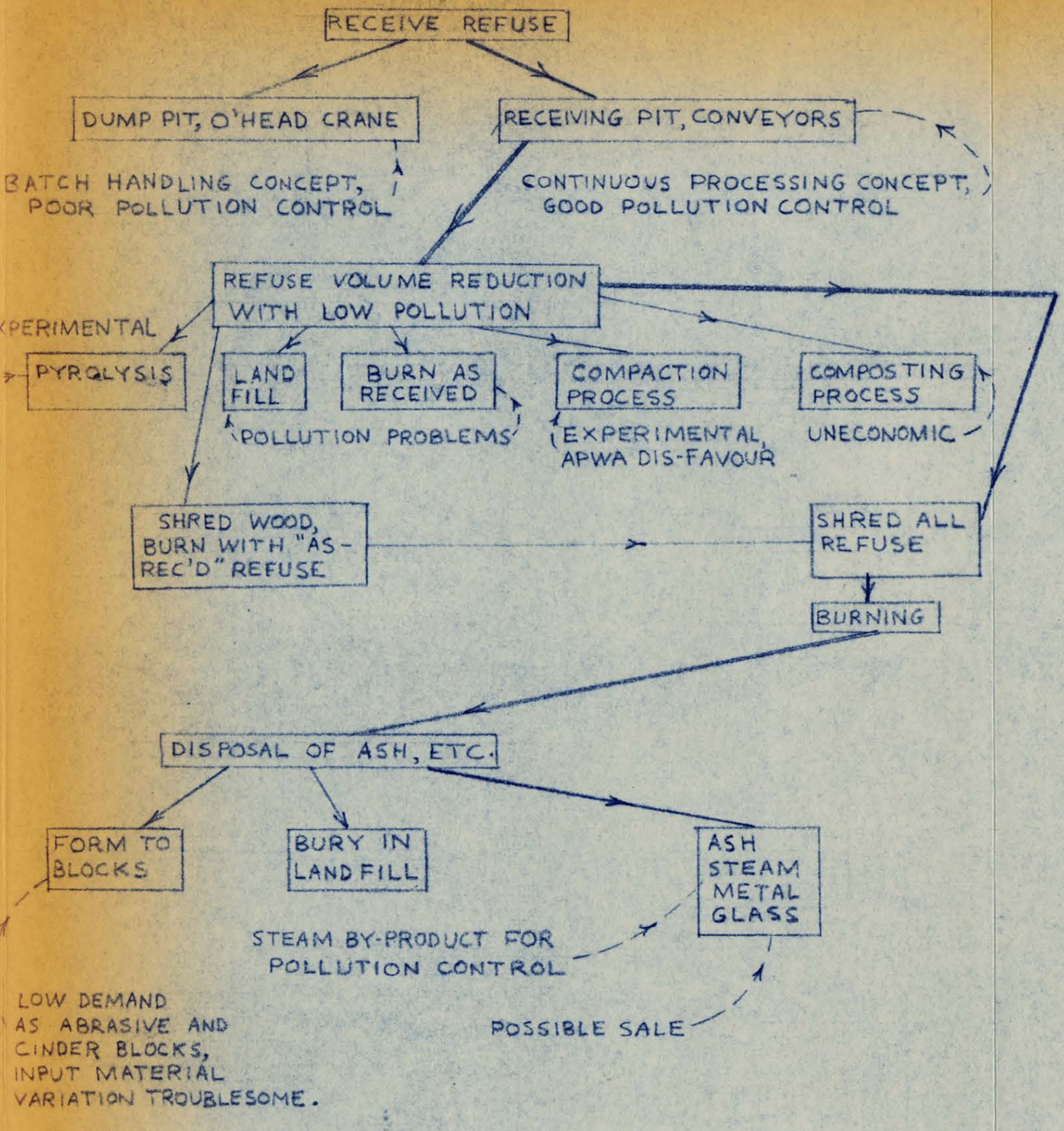


FIG. VII-M-2 GENERAL PROCESS EVOLUTION

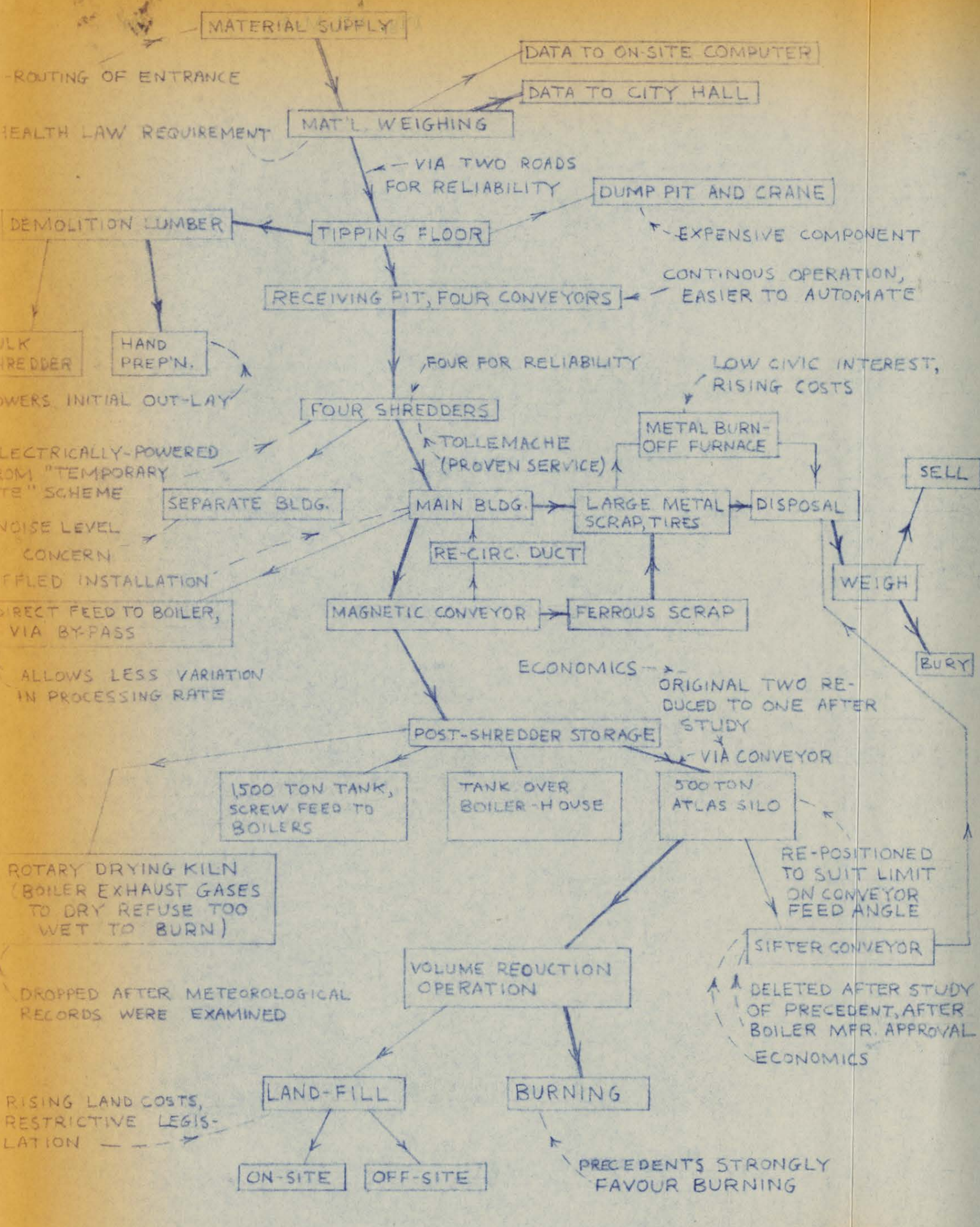


FIG. VII-M-3 FIRST HANDLING TO BURNING OPERATION

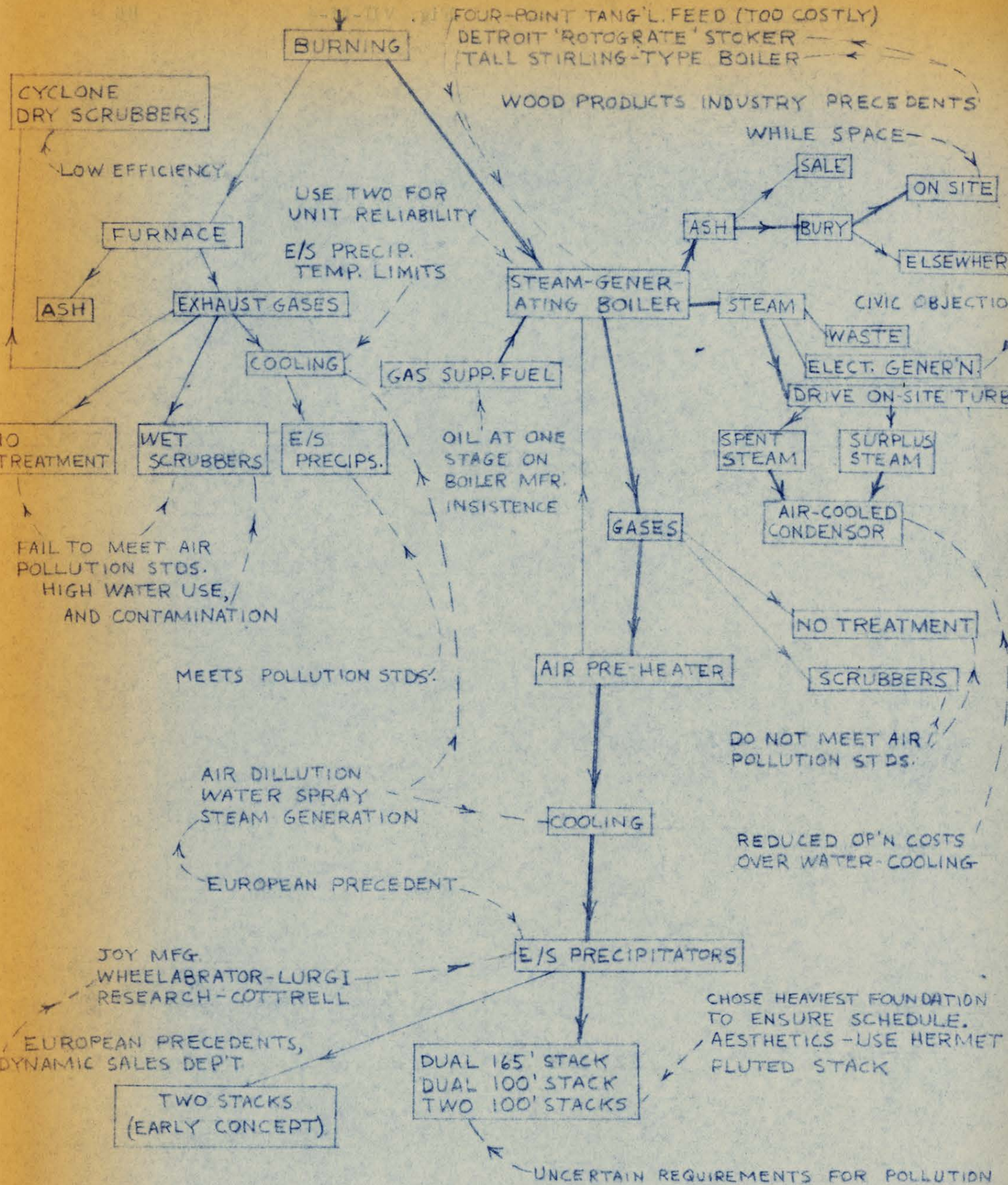


FIG. VII-M-4 BURNING TO POLLUTION CONTROL EVOLUTION

VIII COMPARISON OF CONTRACT BIDS

The project specifications were issued for tenders in two portions (see "Evolution of the Contract".)

The "Boiler and Auxiliary Equipment" specifications received three bids. These were:

Babcock and Wilcox Canada Ltd.	$2,258,749 base bid
Combustion Engineering--Superheater Ltd.	$2,657,429 base bid
Foster Wheeler Ltd.	$2,478,453 base bid.

The "General Contract" specifications received seven bids. The base prices for each bidder are:

Pigott Construction	$5,075,000
Eaglewood Construction	5,089,000
Kemp Construction	5,109,000
Newman Bros. Construction	5,189,166
Foundation Co. of Canada	5,315,000
Frid Construction	5,321,000
Perini Pacific	5,333,000

Incorporating the changes recommended by the Firm, the final Pigott bid was $5, 074, 146 and this was still lowest.

The cost estimate, in the Firm's February 4, 1970 "Analysis of Tenders Received, etc.", is for $7, 745, 968. This is 24% above that predicted in the Preliminary Engineering Report. Much of this is from the price inflation. The original estimate was $10, 700 per ton of capacity. The "modern traditional" unit runs from $4, 000 to $7, 000 per ton. The capital cost now is estimated at $12, 300 per ton.

The closeness of the bids received for the general contract show the quality of the specifications and estimates. Mr. Van Hille told the author these specifications had little vagueness. Poorer specifications for a similar project can show a 25% difference. The base bids received show the highest bid received is only 5% above the lowest.

IX TABULATION OF SIGNIFICANT DATES

Nov. 1960 -	"Report on Refuse Collection and Disposal", by Canadian-British Engineering Consultants, presented to the City.
July 3, 1962 -	"Contract for the Installation of Furnaces, Flues and Appurtenances for a Mechanically Stoked Incinerator", by above firm, issued.
Nov. 16, 1967 -	"Refuse Collection and Disposal", by the Firm, presented to the City.
July 31, 1968 -	"Preliminary Engineering Report", by the Firm, presented to the City.
March 13, 1969 -	"Boiler Tenders" called by the City.
May 16, 1969 -	Boiler Contract awarded to Babcock and Wilcox Canada Ltd., Galt.
Nov. 11, 1969 -	Draft "Test Proposal", by O. R. Love, presented to Dr. G. Kardos.
Nov. 27, 1969 -	General Contract Tenders called by the City.
Feb. 11, 1970 -	General Contract awarded to Pigott Construction Co. Ltd.
March 1970 -	Construction started.
April 10, 1970 -	Official sod-turning by the City.
November 1971 -	Start-up.

X. GENERAL OBSERVATIONS AND ANALYSES

The state of our ecology has attracted strong public interest. Pollution control is recognized as being necessary to maintain and hopefully improve our environment. Some public reaction is emotional; one letter on air pollution to the Hamilton "Spectator" quoted French historian Ernest Renan in "...the closest concept we have of infinity is the extent of human stupidity". There follows in this section a discussion on how public pressures, political influences and the consultants' attributes react on the final design.

The Firm maintains a considerable public relations effort. Publication material has been submitted to a number of technical and trade magazines. Both Messrs. Sutin and Ferguson have presented lectures on topics such as "A Systems Approach to Garbage Disposal on a Regional Scale". The Firm has sent literature on solid waste disposal to many individuals and action groups, as "Pollution Probe", who have requested this. Such public exposure should be helpful to the future of the Firm. Mr. Sutin has asked that the S.W.R.U. not be referred to as an "incinerator". He felt that the name "...conjures up...general undesirability". The selection of the name S.W.R.U. occurred before the Preliminary Engineering Report was issued. The author noted that Canadian enquiries about the Unit had been received by the Firm from Moncton to Calgary. The Firm is considering arranging a promotional colour film as well.

The Firm self-admittedly has prepared project drawings and specifications in a careful form. This is to heighten the good impression they should create. The Process drawings were re-traced. Both drawings and specifications as mentioned elsewhere are more detailed than is customary.

The author found the insights into the technical life of a consultant of interest. The consultant seems primarily a co-ordinator of the efforts of a large number of specialists. Usually the specialists are employed by the equipment manufacturers and it is they who do considerable detail design and almost all development work. The consultant normally has neither the funding nor the time for many detailed activities.

Mr. Sutin remarked that a consultant must"...have faith in himself". He must make rapid technical-economic decisions in areas with which he has little detailed experience. The decisions he makes are ones he must be prepared to defend strongly. Customers demand perfection. Consultants do a minimum of documentation; Mr. Van Hille's organization contains little record of the S.W.R.U. process design efforts. One employee of that Firm remarked that only Mr. Van Hille could handle the process engineering. The author feels that Consoer Townsend should maintain records of his design work. Possibly, however, management in a larger consulting firm feels it must allow a freehand to its engineers lest they become restricted and slow to react to project variables. The project engineer could spend much of his time documenting a one-off design.

A consulting engineer must have certain personal qualities. He expects considerable travelling, often on short notice, and at someone else's convenience. Frequent long work days and frustrating delays are to be expected. The inherent communications problems with this project are particularly irritating. It takes at least ten days for a set of drawings to be sent, studied and returned to their source when using the mails between Canada and the U.S. The postal strikes and lock-outs in Canada during 1969 compounded the problem. The consultant should develop and value the technical experience of others. He should be a diplomatic individual, and not display any hint of arrogance. He should be a person able to make friendships as well as acquaintances. He must give an impression of technical competence. The consultant would be expected to have a greater degree of management skills than the engineer working in a more narrow technical specialist capacity.

The consultant is rarely able to do development testing of equipment or processes. He must choose proven equipment and processes where often he is confident newer designs or unproven equipment may be better. The importance to him of industrial contacts should be obvious, as well as a developed sense of observation.

The admit to a better way is essential to a good designer. In his discussions with Mr. Van Hille, the author was told that proven equipment was chosen. Van Hille strongly feels that any project change can be made while the project is on paper. When it is committed (tendered), and later, changes become progressively more difficult and expensive.

The effects of political influence have been discussed in the turbine aspects. Other political influences are evident.

The City Engineering Department was reluctant to become involved with approving the design of the Unit. Before the Boiler Contract was tendered, the City Engineer sent a letter, dated March 12, 1969, to the Board of Control. It stated fourteen items of personal concern regarding the specifications.

The City Engineer declined to speak to the author on the Unit. The Board of Control never formed a "Technical Committee" as suggested by the Firm to independently study the design specifications before tenders were issued. This lack of technical involvement by the City is regretable.

The Department of Streets and Sanitation was more involved. Its former director, Mr. W. Muirhead, has long recognized new disposal facilities were required. He had seen several proposals come to nothing, so was understandably pessimistic the Unit would ever be built. The author still sensed he felt that a Case Study of the Unit intended to cast a shadow on the operations of his Department. As mentioned earlier, this Department is acknowledged to be well-run.

An event with political overtones occurred the day tenders were closed for the Boiler Contract. The awarding of this contract by the City was almost certain to ensure the whole Unit would be built. A complete alternative to the S.W.R.U. concept was presented by the Canadian Valve Company. This firm presented, as Canadian representative, the Tezuka Refuse Compaction System. A presentation was arranged whereby all council members were invited to a cocktail hour. The Firm, however, received no invitation. Mr. Sutin countered this by presenting to Council copies of a "Preliminary Report on the Tezuka Refuse Compression System" by the American Public Works Association dated April 15, 1968. Possibly this was a ploy to delay the Unit.

Government sponsored projects, particularly on a local government level, often require the co-operation and approval of non-technical people. Van Hille said that if several suppliers met government specifications the cheapest would almost inevitably be accepted. If the engineer recommended a more expensive contender as more worthwhile, it would rarely be accepted. The influence of non-technical decision makers is evident from the remark made by one controller who felt that because this local manufacturing company gives good home service from their home dryers, their turbines should also be good, and, therefore be chosen for the Unit.

The influences of inflation may have been profound on this unit. The best bid received was 24% over the original estimate. Suppliers and bidders were very cautious in committing themselves. No bidder was prepared to guarantee costs beyond one year; the specifications required a two year guarantee for the receival of bids. It is possible certain pieces of better equipment were not chosen which may have been selected had their suppliers provided data.

Design expertise in the incinerator field has reversed since Mr. Sutin toured European units in 1968. Now the Firm is receiving interest in its concept from Europe. Mr. Sutin feels Europe offers a more promising market than either the small Canadian or the competitive American ones.

As a final comment, the author would like to mention an observation of Mr. Van Hille regarding Canadian "technical nationalism". He has found Canadian subsidiaries of American companies often unwilling to contact their experienced American opposite numbers. The American home office is aware of this but is hesitant to interfere. Possibly such obstinancy may become increasing prevalent.

XI. AUTHOR'S VIEWS OF THE CASE STUDY METHOD

Following are the author's views on the Case Study method in an Engineering Design Master's programme. As a teacher himself, he would like to express his views as to the merits of a design case study as compared to the more traditional research programme associated with the Master's degree too.

A good case allows the student to see first-hand how engineering design proceeds. By its nature, it must contain enough description to set the stage for any extrapolation or opinions presented by its writer.

A study of the design process while still in progress is most ideal. It shows how the designer must make sound decisions despite imperfect data. The relative unimportance of mathematics for its own sake during the synthesis stage is very obvious. The student can begin to grasp the importance of the engineering ethics and absolute personal integrity of the designer in providing sound leadership. The problem-solving approach which in school is often seen as direct often becomes an iterative process in real design practice.

The McMaster University School of Graduate Studies calendar states the Master of Engineering design program "is designed to provide well-educated generalists". For this degree, it implies that the field of design is on the same level and is closely related to scholarship. The design-oriented person must by education, training and inclination be more able to synthesize than a research-oriented person. He must however recognize those areas requiring high-level analysis and decide whether to attempt these himself or seek aid from others. The designer's goal is synthesis, not analysis. He should be imaginative, and have the interest and ability to work in a design team. He also should have organizational skills, both for technical work and for the management of the efforts of others. The researcher is often more individualistic, and less a team-worker. His personal satisfaction may come more from the "means" than the "ends" themselves.

These attributes required for good design engineering are displayed to the graduate student in preparing a Design Case Study. Besides seeing technical decision-making in an engineering design project, one sees the less-tangible but equally important "skills" of imagination, tact and organization. These skills are not and cannot be encouraged in traditional research-oriented graduate programmes.

Certain management consultants are concerned that typical School of Business graduates feel their goal is to learn, and that of management is to teach them. Surely their respective goals are to produce and to manage. David Riesman, in his book "The Lonely Crowd", attempts to prove that modern industrialized society is entering an "other-directed" phase, where one's personality is of more importance than one's character. He also implies the resulting tendency of people to become passive and refuse responsibility.

The author has noted the over-emphasis placed on learning for its own sake amongst certain of his students. He also believes what author Riesman claims if true would harm engineering as a profession. The generally accepted aim of the engineer is to produce solutions to problems. If engineering students do not learn this during their years of formal education, and if they were to develop the passivity Riesman studies, then possibly the observance--admittedly passive-- of the engineer in practice which the case study permits can reduce these influences.

Finally, the author would like to point out the legalistic-psychological nature of many of the S.W.R.U. design problems. The engineering student is generally fitted to tackle technical problems. He is not as well-trained nor often as interested in facing the legal ramifications and closely related human factors embodied in such a project as the S.W.R.U. Engineering projects involve communication between people about design. If such a case study does not train the student in these non-technical areas, it at least makes him aware of what important areas they are.

Following are a number of suggestions to aid in the mechanics of doing a case study. It is most important to develop the co-operation of the Engineer. Lacking empathy, one may find his case study lacks the human touch. One should maintain a list of questions for the engineer. The student must realize that the engineer is donating his time to him, and should learn to minimize interruptions. Brief visits the same time each week may be best if data are to be collected over a period. A tape recorder may be useful, but some are reluctant or naturally hesitant to allow its use. One can note key points during the interview for summarizing immediately afterwards. One should avoid total immersion in the Firm's files, as one can stumble through them happily for a considerable time without learning a great deal.

The particular study undertaken in this report contains a feature not usually associated with cases. Normally they are studied after the fact. Thus a student may never be aware of all design influences, as the engineer has forgotton why he did certain things, or is unsure of the relative importance of design influences. Certainly a student is able to see operational problems with usual cases. When he back-tracks these problems to investigate their root causes, he may be blinded to other important influences. This study was prepared over a long period from the late conceptual design stage. A full-time student normally would spend time over a far shorter period. He could, however, more readily investigate the influence of fast-changing parameters as they occur.

XII. THE EVOLUTION OF THE CONCEPT AS A DESIGN PROCESS

Following is a critical review of the design process for the Unit through its various stages. Comments on the stated design approaches are included. Figure XII-1 provides a similar presentation.

The stated design approach of the firm is:

a) Determine the exact nature of the problem to be solved,

b) Carefully examine all the possibilities and means of solving the problem,

c) Determine the optimum method of solution from all points of view (economics, feasibility, practicability),

d) Design in accordance with these determined solutions.

This approach was stated to the City in early 1968.

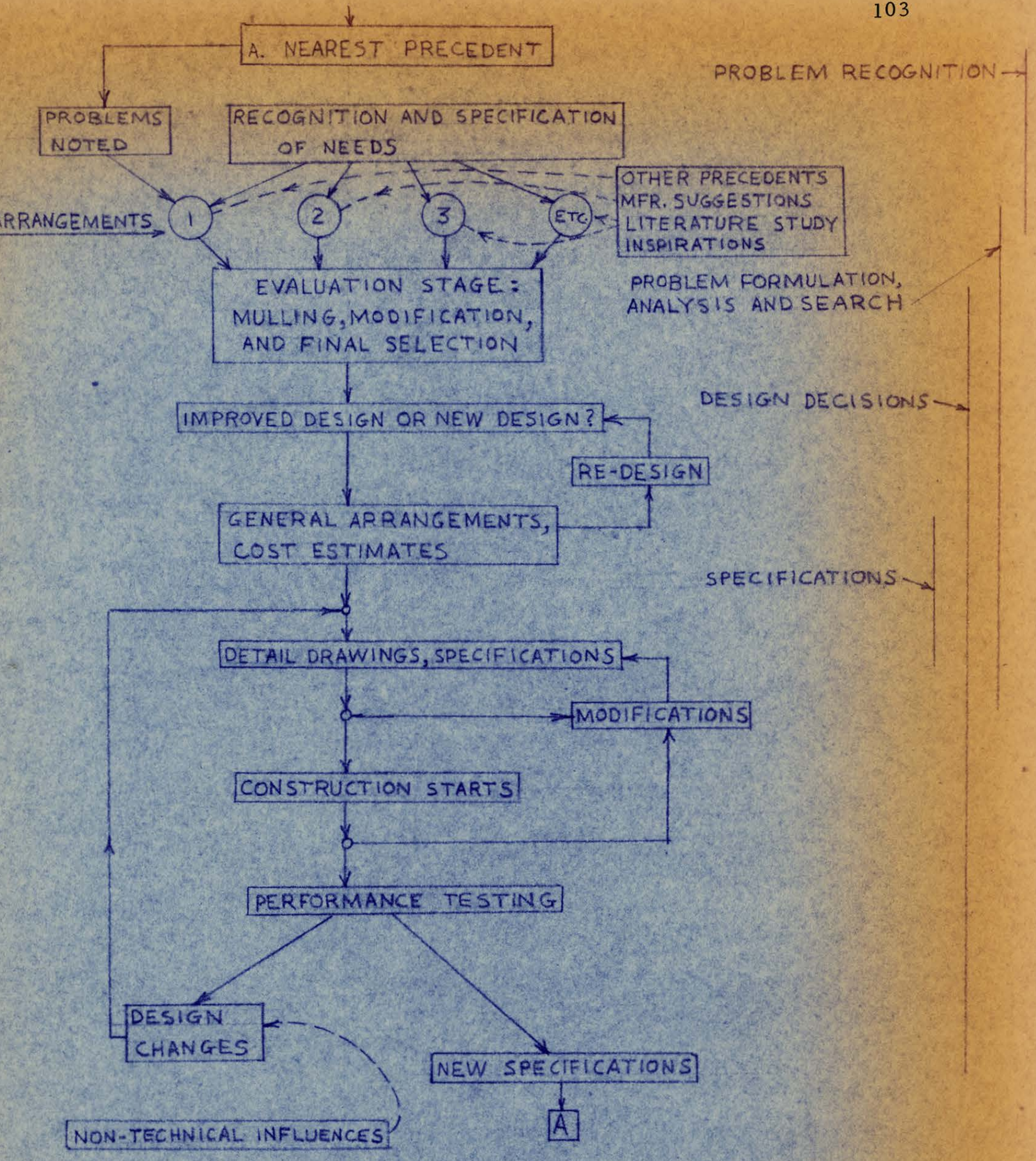


FIG. XII-1 A GENERALIZED MODEL OF ENGINEERING DESIGN

(ADAPTED FROM P. J. BROOKER "PRINCIPLES AND PRECEDENTS IN ENGINEERING DESIGN")

1. Problem Recognition

The Firm became aware of the City's need for solid waste disposal facilities indirectly through a sales representative for a refuse wood-burner. Pressure on the City by citizen objection to the Upper Ottawa land-fill plus their realization of the imminent problems from the 1960 Canadian-British Engineering Consultants report made the City council aware of the problem.

2. Problem Formulation

The City commissioned the Firm to update the 1960 report as it recognized the problem. The resulting 1967 Report on Refuse Collection and Disposal recommended a program of incinerator construction as the preferred way to extend the use of land-fills.

3. Problem Analysis

This stage the author believes was critical in gaining the willingness of the City to invest in the S. W. R. U. The 1967 Report was accepted. On January 9, 1968, the City authorized the Firm "...to design a Municipal Refuse Incinerator"... In this, they had accepted the Firm's analysis of the imminent disposal problem.

4. Search and Formulation of Alternatives

This fourth step is of very great importance, and also one of considerable difficulty. The Firm had first to objectively study the "state-of-the art". Mr. Sutin's investment in his tour of existing North American and European designs was felt to be very wise at this stage. His well-planned itinerary allowed him to rapidly educate himself in solid waste disposal.

During the search stage, Mr. Sutin became more aware of the difficulty with which pollution control regulations could be met. He provided Carl Bowen (Partner-Consoer, Townsend) with copies of Ontario pollution control legislation at an early date.

Mr. Van Hille provided the Firm with his years of consulting experience in solid waste disposal. This was invaluable to the less-experienced firm. He was able to provide the names of recommended equipment manufacturers and distributers with whom he had personal experience. Both he and Mr. Sutin were able to evaluate potential suppliers of equipment.

Much objective analysis of equipment alternatives was done during the search phase. It is inevitable that decisions were made at this time. The relative unimportance of mathematics in this crucial design search is possibly surprising to the student. Theoretical aspects of design, such as value engineering and decision theory, were used only implicitly if at all. The choice of the best piece of equipment from several alternates can probably be done by an experienced engineer for such a project based on this experience. It is an interesting conjecture how close to an optimum can be obtained by such a method of decision making.

The Preliminary Engineering Report for the S.W.R.U. was the culmination of the 'Search and Decision' design stage. It is discussed further in the next sub-section.

5. Decision

During and following his tour, Mr. Sutin was able to make decisions as to processes and equipment. He was aided and influenced in this by Mr. Van Hille, and the constraints provided by the City (fixed site, no electrical generation), and the Provincial pollution control bodies. The Preliminary Engineering Report contains eighteen conclusions and recommendations of major importance. It also provides cost analyses, a section on the design concept plus a series of general arrangement drawings. It purposely was not made too detailed so as to restrict detailed design. The Report provided the Firm with guidelines for further detailed design following its acceptance by the City.

As emphasized earlier, the Firm made little explicit use of design theory in trying to optimize the design. Its recommendations and conclusions were based on technical and specifically economic considerations. Aesthetics and reliability were considered. The City government was faced with the "utility" of political attractiveness. The aspects of political utility became high in civic estimation during the turbine selection controversy.

6. Specifications

The specifications were issued in two sections:

a) The "Boiler and Auxiliary Equipment", plus drawings,

b) the "General Contract", in three parts, each with related drawings.

The author was surprised at the degree of legal detail in the specifications. This is apparently usual. Civic criticism came from the City Solicitor K. A. Rouffe. He voiced concern with legal protection in the tender specifications for the city.

The lack of technical feed-back from the City to the Firm has been mentioned. Mr. Sutin does not believe a poorer design has resulted; no one at City Hall is conversant with Incinerator design anyway.

7. Completely-Specified Solution

The Firm realizes the transitory nature of all "best solutions". They have planned for convenient and economical future expansion of the Unit, and have kept contact with influences which may affect the latter. Surrounding municipalities now wishing to use the Unit may force its expansion in the very near future.

In fairness, it is evident the Firm follows its stated design approach. Good project management is evident throughout; Mr. Sutin does delegate authority. With the assistance of Mr. F. Ferguson, he planned and organized the Firm's design manpower to maintain the schedules. He has avoided personal immersion in technical details by relying on his sub-ordinates and sub-consultants. Finally, Mr. Sutin has displayed integrity and determination in resisting political pressures.

The preparation and maintenance of the construction critical path network is interesting. The power of these techniques in viewing the inter-dependency of activities which influence the completion data is evident. The difficulties to effectively schedule the activities may be tackled logically by this method. Mr. Sutin pointed out that such a project could extend for five years if C.P.M. were not used. Further notes on the C.P.M. follow in Appendix 9.

XIII. CONCLUSIONS

The objectives, stated in Section I, were:

1. To summarize the chronological evolution of a municipal solid waste disposal system on a process basis,
2. To record key influences (economic, technical, aesthetic and political) on the design,
3. To present analyses of their effects on the design evolution,
4. To interpret the effects of design decisions upon the processes,
5. To present personal observations and analyses on the project and the case study method.

The author feels his objectives were in general realized. The analyses of design influences have been presented as completely and as accurately as has been possible. Some material was edited as a compromise to avoid embarrassment to those who gave him their candid views.

The Case Study Method has considerable potential for a Master's Degree programme. It allows the student to observe the iterative design process, and the importance of engineering ethics. The student is made aware of the influence of legalistic-psychological problems in design too.

XIV. RECOMMENDATIONS

This Case Study was prepared during the design of the S.W.R.U.. As has been reported, this has the advantage that the student sees the true evolution without the mellowing influences of hindsight. However such a report is less readily terminated as some design usually continues until the project is built and operating satisfactorily.

Realizing the long term evolutionary nature of this Unit, a test proposal was prepared by the author for Dr. G. Kardos in November 1969. A typed copy of this hand-written draft is included as Appendix 11. No overall test programme for an incinerator is known to exist. In the interests of continuity, the proposal has in no way been changed from its original form.

It is recommended this draft test proposal be considered as a means to gain further knowledge on incineration units, with a goal of design extrapolation. The S.W.R.U. offers scope for useful effort by future graduate students; such involvement should be continuous. It is recommended this case study be continued so that a complete history of the design, construction and testing of the S.W.R.U. will be available.

XV BIBLIOGRAPHY

American Society of Mechanical Engineers publications, New York--

"Power Test Codes"PTC 4.1-1964

"Proceedings of the National Incinerator Conferences"--1966, 1968, 1970.

Walters, S. "The Garbage Block: A New Building Material". Mechanical Engineering, December 1969.

Penney, G. W., etc. "Electrostatic Precipitation". Mechanical Engineering, March 1965 and October 1968.

Sebastian, F. P., A. F. Ariey, and B. B. Garretson. "Modern Refuse Disposal in Dusseldorf" A.S.M.E. Paper 68-PWR-3.

Stephenson, J. W. "Incineration--Past, Present and Future" A.S.M.E. Paper 69-WA/Inc-1.

"The Heating Value of Refuse" Mechanical Engineering, September 1968.

Anon. "Cash in Trash? Maybe." Forbes magazine, January 15, 1970.

Booker, P. J. "Principles and Precidents in Engineering Design" Journal, the Institution of Engineering Designers, London, England, September, 1962.

Faires, V. M. "Thermodynamics, 3rd Edition" Macmillan, 1957.

"Engineering Digest", Toronto--

"Environmental Engineering" issue, August 1969.

Penney, G. W. "Electrostatic Precipitation" February, 1970.

Fayed, M. E. S. "Selecting Air Pollution Control Equipment". August 1970.

"Engineering Journal", Pollution Control Issue. Engineering Institute of Canada, Montreal, June, 1969.

Moder, J. J., and C. R. Phillips, "Project Management with CPM and PERT". Reinhold, 1964.

Newspaper articles--

"The Spectator", Hamilton, Ontario - various 1968-1971.

"Pollution Control Report" Financial Post, Toronto, June 28, 1969.

Ontario Civic and Provincial Governments--

Personal communication from R. Clarke, Commissioner of Works, Toronto, August 6, 1969.

Personal Communication from Department of Energy and Resources Management, August 31, 1970.

Other personal communications from--

J. Young, Babcock and Wilcox Canada Ltd., various.

N. Johnson, Detroit Stoker Company, various.

T. Melnechenko, Babcock and Wilcox Canada Ltd., various.

H. Ragetlie, G. L. Sutin and Associates Ltd.., various.

G. L. Sutin, G. L. Sutin and Associates Ltd.., various.

Promotional Literature from--

Atlas Systems Corporation, Spokane, Washington, U.S.A.

Babcock and Wilcox Canada Ltd., Galt, Ontario.

Detroit Stoker Company, Monroe, Michigan, U.S.A.

The Foxboro Company Limited, Cooksville, Ontario.

The Heil Company, Milwaukee, Wisconsin, U.S.A.

Hermet Manufacturing Corp., Corona, New York, U.S.A.

Joy Manufacturing Company (Canada) Ltd., Montreal, Quebec.

Simon-Carves of Canada Ltd., Toronto, Ontario.

Tollemachine Composting Systems Ltd., Surbiton, Surrey, U.K.

A. L. Verdonck, P. Eng., Sarnia, Ontario.

Reinhardt, J. J. "A Report on Milled Refuse and the Use of Milled Refuse in Landfill". Engineering Department of Madison, Wisconsin, U. S. A.

Sproull, Dr. W. T. "Air Pollution and Its Control, 1st Edition". Exposition Press, New York, 1970.

Sutin, G. L. and Associates Limited--

Various files as listed in Appendix 1.

"Preliminary Engineering Report", July 31, 1968.

"A Simplified Approach to Construction Management Using CPM", 1968.

United States Government Agencies--

Department of the Interior, Bureau of Mines Publications:

Rampacek, C. "Reclaiming and Recycling Metals and Minerals Found in Municipal Incinerator Residues".

Kenahan, C. B., etc. "Composition and Characteristics of Municipal Incinerator Residues", R.I. 7204.

Department of Health, Education and Welfare:

"Workbook for Atmospheric Dispersion Estimates"

Vesper, Karl H. "Morphology Anthology of Engineering Operations", April 1965.

APPENDIX 1

S.W.R.U. File Systems - Gordon L. Sutin and Associates Ltd.

Pre Working Drawings: "Incinerator Files - 380 Series"

Literature - Crushers	A	Literature-Conveyors	J
Laws and Regulations	B	Calculations-Soils Tests	K
Month-end Reports	C	Garbage Sampling Plan	L
Consoer, Townsend Correspondence	D	Tenders and Prices	M
Literature-Incinerators and Pollution Equipment	E	Incinerator Conference	N
Re-prints of Articles, etc.	F	European Trip	P
Correspondence out re: Design	G	Miscellaneous Correspondence	Q
Miscellaneous Literature	H	Drawings	R
		Reports	S
		Correspondence with Contractor's Machinery	T

Design Files: "S.W.R.U. Files - 421 Series"

Public Relations	A	Site Supervision	H
Correspondence with City	B	Promotion	J
Ontario Dept. of Health	C	Boilers	K
Correspondence with Consoer, Townsend	D	Process Control	L
Correspondence with Walter, Eull and Elliot	E	Control Systems	M
General Equipment	F	H. Van Hille	N
Addendas - General Contract	G	Office-Working Drawings -General Correspondence	O
		Unassigned	P
		Precipitators and Stacks	Q

Specifications	R
O. R. Love	S
Schedule	T
Tollemache	U
Structural	V
Pulverizers	W
Reports to Board of Control	X
Boiler Tenders	Y
Cost Estimates	Z
Correspondence - BW Canada Ltd.	AA
General Contract Specifications	BB
Boiler Contract	CC
M. S. Paikin,	DD

Approved Invoices - BW Canada	EE
General Contract Tenders	FF
Change Order Inquiries	GG
Approved Extras and Credits	HH
Meetings with Pigott Construction	JJ
Correspondence with Pigott	KK
S421 Shop Drawings and Process Equipment	
S421A B & W - Hold	
B Process Equipment	
C Architectural & Structural	
D B & W - Approved	

<u>Construction Files: S.W.R.U. Construction - 548 Series"</u>
(Incomplete listing)

Photographs	--
Correspondence with Pigott	A
Correspondence with B & W	B
Correspondence with City	C
Correspondence with C, T	D
Correspondence with Walter, Eull and Elliot	E
Request for Quotation Work Authorization-Pigott	F
Approved Monthly Draws - Pigott	G
Approved Invoices - B & W	H

Reports - Field Supervisor	J
Inspection Reports - W, E & E	J2
Inspection and Test Reports	K
Request for Quotation Work Authorization - B & W	M
Meetings with Pigott Construction	N
Miscellaneous Corresp.	O
Shop Dwg. Transmittals	P
Transmittal - Pigott	P1
- Crump	P2
-Can Comstock	P3
Field Instruction Record	Q
Photographs	R

APPENDIX 2

Composition of Hamilton, Ontario, Refuse:

Paper	35.27%
Plastics	1.02
Leather, Rubber	.85
Garbage, Food	27.03
Grass, Dirt, Leaves	14.73
Textiles, Rags	2.62
Metal	5.11
Wood	6.95
Glass, Ceramics	6.45
	100.00%

The City of Hamilton refuse, as received, weighs approximately 200 lb. per cubic yard.

--fron G. L. Sutin File 380-L.

APPENDIX 3

Conclusions and Recommendations of the Preliminary Engineering Report

CONCLUSIONS

The following conclusions constitute our qualified opinions arrived at through a detailed analysis of our research data:

1. Any incinerator should be referred to as a

   "SOLID WASTE REDUCTION UNIT" (SWRU)

2. An SWRU constructed in Ontario must be equipped with Electrostatic Precipitators in order to meet the flue gas cleaning requirements of the Air Pollution Control Division, Ontario Department of Public Health.

3. The most economically desirable method of reducing flue gas temperatures for treatment in Electrostatic Precipitators is by the production of High Pressure Steam.

4. An SWRU should be operated on the basis of 24 hours per day, 365 days per year.

5. In the design of an SWRU, full advantage should be taken of modern engineering techniques and technology relating to material handling and combustion.

6. If possible, the use of moving cranes should be avoided for they generate very high capital, operating and maintenance costs.

7. Generally speaking, it is advantageous to increase capital investment now, in order to maintain low operating costs in the future.

8. SWRU design should ensure that plant capacity is not reduced due to breakdown in sensitive areas.

9. Careful attention must be paid to traffic control in order to avoid congestion and ensure prompt delivery of refuse.

10. The architectural concept should take into account the need for an attractive and desirable appearance. Both aesthetics and function form important segments of good design.

11. Where possible, provision should be made for convenient and economic future expansion.

12. No consideration should be given to the construction of an SWRU having a capacity of less than 600 Tons per 24 hour day, as capital and operating costs for smaller units cannot be justified.

13. Having investigated solid waste disposal by means of high temperature incineration or high pressure compaction processes, we believe that neither of these methods has been yet proven to be satisfactory and should not be considered at this time by the Corporation.

RECOMMENDATIONS

1. THE CITY SHOULD PROCEED IMMEDIATELY WITH THE DETAILED DESIGN AND CONSTRUCTION OF THE EAST HAMILTON SOLID WASTE REDUCTION UNIT, HAVING A CAPACITY OF 600 TONS PER 24 HOUR DAY, IN ACCORDANCE WITH THE PRELIMINARY DRAWINGS ATTACHED HERETO, AT A TOTAL ESTIMATED CAPITAL COST OF.................................. $6,250,000.

This plant, if design is started immediately, will not be in full operation until late 1971.

Per capita waste generation is increasing as is the population itself. Therefore:

SERIOUS CONSIDERATION SHOULD BE GIVEN TO THE INSTALLATION OF A THIRD BOILER WITH ACCESSORIES AT THIS TIME. WE ESTIMATE AN INCREASED CAPITAL COST OF APPROXIMATELY .... $1,500,000.

No other additional investment would be required to obtain in 1971, a plant capable of consuming 900 Tons per 24 hour day. Any surplus capacity at that time could be sold to nearby municipalities and/or private contractors until such capacity is required by the Corporation.

Thus an increase of only 24% in capital cost would enlarge plant capacity by 50%. Except for amortization costs, total operating costs would remain virtually unchanged so that operating cost per ton would reduce by 22%, a saving of about $1.20 per Ton.

2. THE SWRU SHOULD BE OPERATED ON THE BASIS OF 24 HOURS PER DAY, 7 DAYS PER WEEK, AND ALL COMBUSTIBLE REFUSE NOW ENTERING THE EXISTING CITY OF HAMILTON DISPOSAL FACILITIES SHOULD BE PROCESSED AT THIS UNIT. THIS WILL ENABLE THE CLOSING OF ALL EXISTING LAND FILL SITES AND THE EXISTING INCINERATOR.

3. BY 1985, SUBJECT TO FUTURE EXAMINATION OF SOLID WASTE GENERATION, THE PLANT SHOULD BE EXPANDED TO ITS ULTIMATE CAPACITY OF 1,500 TONS PER 24 HOUR DAY.

4. THE CITY SHOULD PROCEED IMMEDIATELY WITH REZONING OF THE EAST END SITE TO PERMIT CONSTRUCTION OF THE NEW EAST HAMILTON SOLID WASTE REDUCTION UNIT.

5. IN THE DEVELOPMENT OF ADJACENT LAND TO THE NORTH OF THE SITE, THE CITY SHOULD RETAIN THE SOUTH-WEST CORNER FOR POSSIBLE FUTURE EXPANSION (1995) OF RECEIVING BUILDING FACILITIES, EXIT RAMPS, AND DRIVES. THE LAND RETAINED SHOULD HAVE A FRONTAGE ON KENORA AVENUE OF 75 FEET AND A DEPTH OF 300 FEET.

APPENDIX 4

Ontario Pollution Control Legislation

Until recently, the Provincial Department of Health administered the legislation controlling air pollution and solid waste disposal. By Bill 71 section 95A, the Provincial Minister of Health had the right to regulate existing land-fill sites and even to prohibit the raising of money by-laws for funds for new sites until they had received approval certificates.

Land-fills were not to be used for building zones for 25 years. Besides being likely to settle, the production of methane gas from the decomposing refuse creates a real explosion danger. This danger may be partly circumvented by novel building designs. A school built near a former land-fill will be erected on pillars. The air space below it should not permit an explosive concentration of methane to form.

Ontario legislation regarding pollution control is advanced. The provincial roles are defined by:

1. The Air Pollution Control Act

2. The Waste Management Act (land waste disposal)

3. The Ontario Water Resources Commission Act (sewage treatment, etc.)

All this legislation is enforced by agencies within the Department of Energy and Resources Management. Their organization within the Department is recent. The control of air pollution and solid waste management were formerly under the Department of Health.

The Air Pollution Control Act of 1967 removed its control from the Department of Health which relied on the control of air pollution by municipalities. The Air Pollution Index, motor vehicle emission standards, etc., are all results. Enforced by the Air Management Branch, the Act possesses broad centralized powers to control air pollution.

The Waste Management Act of 1970 deals primarily with domestic and commercial refuse disposal, industrial waste disposal and incinerator residue disposal. It specifies the licensing and inspection of dumps, land-fills and incinerators. After March 1, 1971 no existing systems will be allowed to continue unless they have applied for a permit. Alterations or new systems will require a permit.

The O.W.R.C. Act of 1957 concerns water pollution control. Its basic objectives are to control and regulate public water supplies, to finance, build and operate water works, sewage works, to conduct water surveys to determine the presence of pollution and to prevent wastage of water.

All agencies work together closely as necessary. Incineration, for example, involves all three agencies.

The Pollution Abatement Incentive Act of 1970 allows the Department to make grants to various organizations for the purchase of pollution abatement equipment.

APPENDIX 5

List of Persons

This list is not exhaustive. It states the contributions of certain individuals towards the Unit, in a random order.

Civic: W. A. Wheten, P. Eng.--City Engineer.

Provided criticism of the design.

W. Muirhead--Director (Ret'd), Streets and Sanitation Department. Aided in refuse analysis.

K. A. Rouffe--City Solicitor. Responsible for civil legal protection in the specifications.

J. R. Jones--Secretary, Board of Control.

Received bids from tenderers.

J. Moore -- City Economics Commissioner.

Influences disposal of by-products.

Provincial:

Hon. G. Kerr -- Minister of Energy and Resources Management (Ontario). Responsible for air pollution regulations and their enforcements.

Engineering:

G. L. Sutin, P. Eng.--developed the conceptual design, promoted it, developed final design specifications, co-ordinator.

F. Ferguson, P. Eng. --provided critical path methods to schedule the design and erection.

H. Ragetlie, P. Eng. --responsible for architectural and structural work during design and construction.

A. Brown --resident inspector, S.W.R.U. construction.

(The four fore-mentioned are associated with the Firm)

C. Bowen, P. E. --advisor on process engineering

H. A. Van Hille, P. E. --responsible for process engineering design specifications

(The two fore-mentioned are associated with Consoer, Townsend and Associates, Chicago, U.S.A.)

J. Young, P. Eng. -- Babcock and Wilcox Canada Ltd., Galt.--project engineer on boiler and auxiliary equipment.

B. Seed, P. Eng.--Bailey Meter of Canada Ltd. Prepared proposal data for Instrumentation.

G. Elliot, P. Eng.--Walter, Eull and Elliot, Ltd., Hamilton. Responsible for design of electrical services.

APPENDIX 6

Survey of Specifications

The following is intended to indicate their scopes. It is not a summary of these lengthy documents. They contain Table of Contents for reference purposes. The parentheses indicate the page or addenda from where the material has been quoted.

6.1 Boilers and Auxiliary Equipment Specifications (dated March 12, 1969)

Scope -- "...construction of equipment from discharge of the outlet conveyor to the top of the stacks." (10-1) "This Contract shall include, but not be limited to, the following major items:

1. The boilers and air preheaters.
2. The fuel burning equipment (burners and/or stokers, and auxiliary oil burners).
3. The fuel...conveying equipment from the... storage(silo)...conveyor to the...stokers.
4. The electrostatic precipitators.
5. The fans and ductwork.
6. The stack or stacks". (100-1)

Responsibility -- the contractor "...will be required to co-operate with the 'General Contractor' and take direction from (him) respecting co-ordination and scheduling" to meet scheduled unit completion (A 3-1)

Tender Forms -- "All tenders shall be made upon the form provided..." (10-2) See Appendix 7.

Bid Deposit-- "..., payable to the Corporation of the City of Hamilton, in the amount of at least 5% of the bid." (10-2)

Performance Bond-- "...in the amount of 100% of the contract price,..." (10-3)

Approved Equals -- listed in alphabetical order.

a) Boiler manufacturers

Babcock Wilcox

Combustion Engineering

Erie City Boiler Company

Foster Wheeler (10-9)

b) Controls

Bailey Meter Company

Bristol Controls of Canada Ltd.

Fischer Porter

Minneapolis Honeywell (10-10)

c) Electric Motors

Canadian General Electric

Canadian Westinghouse (10-10)

Wage Schedules for Various Building Trades--see (10-11) for the agreements between unions and the Hamilton Building Contractors Association, etc.

Contract for Works -- see (10-26) for the three page Form of the Contract.

Correlation and Intent of Documents-- "...what is called for by any one shall be binding as if called for by all." (20-2)

Ownership of Drawings and Models-- "All Drawings, Specifications and copies thereof and all models furnished by the Engineer are his property". (20-4)

Liquidated Damages -- "In case of failure to complete... within time stated...the City will make a deduction from the Contract price at ...$100 per working day ..." (20-22)

Guarantees -- The Contractor "...shall...agree to repair and replace all defective materials and workmanship ...for...two...years...from date of final acceptance by the Owner..." (20-27)

Work Performed Under Other Contracts -- see (100-2)

Basic Design Data -- "...each boiler...to burn continuously ...a total of 25,000 lb. per hour" (100-3). "Auxiliary oil burners...having a total input capacity of 50% of the burning rate......will be utilized only on start-up...and when the...moisture content" will not allow ignition or sustained burning. (100-3)

-The refuse has"...a heating value of not more than 6,000 B.T.U. per pound." (100-3).

-"...assume that...approximately 95% of the glass, ceramics, and metal"...is removed from the shredded refuse. (100-4)

-"...gas temperature at entrance to the... precipitator does not exceed 600°F". (100-4).

-"...boiler shall operate at...250 pounds saturated." (100-4)

<u>Code Compliance</u>--"All work...in strict compliance with laws of the City...and the Province...governing the installation...(100-4)

<u>Boiler, etc., Technical Specifications</u>--see (200-1) to (200-5)

<u>Fuel Conveying and Burning Specifications</u>-- see (300-1) to(300-4)

<u>Electrostatic Precipitator</u>--see (400-1) to (400-6)

<u>Fans and Drives</u> -- see (500-1) to (500-6)

<u>Ducts and Insulation</u> -- see (600-1) and (600-2)

<u>Stack Specification</u> -- see (700-1) and (700-2)

<u>Instrumentation and Controls</u>-- These are very completely detailed on (800-1) to (800-11)

Boiler Piping Specifications -- see (900-1) to (900-5)

Soot Blowing Equipment -- see (1000-1) and (100-2)

Miscellaneous Equipment -- see (1100-1) to (1100-3)

Tests and Guarantees -- The drying and boiling out procedures are stated. The initial operation is stated as the Contractor's responsibility. The acceptance and performance test procedures are to be done by the efforts of the Boiler Contractor, Owner and Engineer. A certificate of acceptance will be issued by the owner to the Contractor. The guarantee is for a two year period from this date. (see (1200-1) to (1200-4).

Stack Height -- "This contractor shall submit to the Ontario Department of Public Health, Air Pollution Division, calculations and data necessary for determination of acceptable stack height". (1200-5). This is required before the certificate of acceptance will be issued.

6.2 General Contract Specifications

This consists of three lengthy parts, each with related drawings. Only a brief survey is attempted.

Part 1 " Architectural and Structural Specifications" prepared by the Firm.

Notice to Contractors - the same general conditions apply to this as to the Boiler Contract (section 1300).

Inspection -- "The materials and process... shall be... (inspected periodically)... by the Owner or Engineer...". (If)... "unacceptable to the Engineer", he "is hereby empowered to condemn same..." (1400-10)

Time For Completion--"Completion of all work, 430 working days after receipt of Engineers' written order to commence". (1400-14)

Maintenance - "For ... (two years)... the Contractor's liability shall be limited to the replacement of any defective workmanship as part..." (1400-16)

Critical Path Method--"The Contractor will (allow) a cash allowance of $25, 000 for "the development and control of a C.P.M. network. The Contractor will co-operate with the Engineer. (1400-18)

Subcontracting -- The Contractor may utilize specialty subcontractors where normally they are hired. (1400-24) The Owner and Engineer must approve them.

Air Pollution Testing Allowance--"The Contractor shall (allow) $7, 500 to cover the cost of air pollution tests..." (1400-31)

Excavation, Piling, Poured Concrete, Precast Concrete, Flooring and Masonry--see Sections 1500 to 2000 respectively.

Structural Steel - The Delivery and Erection is a critical factor in Unit completion (2100-1). Its work is governed by various codes and regulations (2100-2).

Part 2 "Mechanical and Electrical Specifications"

prepared by Walter, Eull and Elliot Ltd., Hamilton.

Specifications for Heating, Ventilating, Plumbing, Electrical, etc., work are included.

Part 3 "Process Equipment Specifications"

prepared by Consoer, Townsend and Associates, Chicago, U.S.A.

This part contains the largest amount of technical specification of the three. Great care hasbeen taken to specify spare parts to be furnished to the Owner.

Conveying Equipment -- The "...contract shall include the design, fabrication, installation, testing and "commissioning of eighteen conveyors (5000-2). "For structural design of all Refuse Pit Conveyors" ...assume a 350 lb. per cubic yard density". For volume design use a density of 250 lb. per cubic yard. (5000-2)

"The(Refuse Pit) conveyors shall be the product of Pemco, Inc...or approved equal...(and)... installed and placed in operation under... a representative of the manufacturer". (500-3)

The pulverizer outfeed conveyor, storage tank conveyor and boiler feed conveyor are almost identical. (5000-7)

The Boiler Fuel Feed conveyors are weigh-type. A Feed Splitter "..to provide a uniform...feed to each boiler" is included (5000-8).

Spare parts which "the Contractor shall furnish to the Owner..." are detailed (5000-14).

Refuse Pulverizers--"The Contractor shall employ...the manufacturer's personnel" (Tollemache) to install these units (5100-1).

Storage Tank -- "The shredded refuse storage tank shall be an all welded steel tank...(of) ...the Atlas System Corporation...(having a) 600 ton capacity". (5200-2). The shell is to be of an air corrosion resistant steel.

The sweep conveyor drive speed shall "be varied from11.2 RPM to 56 RPM". (5200-3)

Ash Handling Equipment -- "The ash conveying system shall be of the pneumatic suction type, steam operated..." (5300-2)

Hydraulic Equipment and Drives-- "Each of the hydraulic pumps shall be...(a) De Laval Turbine, Incorporated" type. (5400-1) driven by a steam turbine.

Air-Cooled Steam Condensor-- "The equipment shall be of the forced draft design equal to McKenzie-Ris Mfg. Corp....size 11W-36L-2F10 unit" (5500-1). It must be able to condense all steam generated.

Air Filtering Equipment -- "The equipment shall be a continuous cleaning high pressure reverse jet type...as designed by W. C. Wiedenmann and Son Inc....Model No. 2X7LF225-3150 Filtramatic, or approved equal", "capable of handling 15,000 CFM of dust laden air at 10 grains per cubic foot" (5600-1).

Pumps--"All pumps furnished...meet...requirements shown" ...(5700-2).

Steam Turbines--"All of the turbine drives...shall be Terry (type)" or approved equal. (5800-2)

Technical requirements are stated. The local manufacturer's type substituted does not have many of these.

De Aerator and Condensate Surge Tank -

Boiler Water Softening Equipment and Chemical Feed Systems--

Necessary auxiliaries for the Boiler. See Sections 5900 and 6000.

Air Compressors and Drives--"The compressed air system shall be operated at a primary design of 150 psig." (6100-1). It is for plant air (150 psig) and instrument air (25 psig). Ingersoll-Rand Type 40 Packaged Air Compressors or approved equal are to be used. They are each to be driven by a natural gas engine (6100-2).

Power Piping-- This large section includes steam piping, all boiler piping (condensate returns,feedwater, drain, etc.), compressed air piping, etc. (6200-2). The appropriate A.S.M.E.-ASA codes (6200-2) for the pipe plus fittings (ASTM codes - 6200-3) are given. A table for pipe for each particular service is specified (6200-5). Valves are similarly specified (6200-6) and 6200-7).

Insulation--Piping "shall be insulated with 85% magnesia moulded pipe covering" at specified thickness. (6300-1). A canvas jacket is required for some equipment as well (6300-3). Color coding for steam, cold water, etc., is specified (6300-5)

Instrumentation and Controls -- All work must receive the Engineer's approval before installation (6400-2). Panel construction, and wiring specifications are given (6400-4). The control panels requirements are very explicit (6400-4 to 6400-8).

APPENDIX 7

Form of Tenders

7.1 Boiler Contract

7.2 General Contract

His Worship Mayor Victor K. Copps,
Chairman,
Board of Control,
c/o E. A. Simpson, Esq.,
City Clerk,
Hamilton, Ontario.

Dear Sir,

We enclose herewith 3 copies of our tender, pages __________ to __________ for supply and installation of specified equipment required in the construction of the East Hamilton Solid Waste Reduction Unit.

1. PROPOSAL (BASE BID) for furnishing all labour, material, and equipment for the two (2) Refuse Burning Boilers including a dual stack having a total height of 165 feet, all as indicated on the Drawings __________ through __________ inclusive and as defined in the Specifications for the sum of:

____

____ ($ ____________)

TIME OF COMPLETION. If awarded the Contract for the work under the foregoing Proposal, we agree to proceed with the various phases of the work included under this Contract within __________ calendar days after issuance date of written notice to proceed, and agree to complete within __________ calendar days after issuance date of written notice to proceed.

2. ALTERNATE PROPOSAL NO. 1. For furnishing all labour, material and equipment for the two (2) Refuse Burning Boilers including a dual stack having a total height of 100 feet, all as indicated on the Drawings __________ through __________ inclusive and as defined in the Specifications for the sum of:

____

____ ($ ____________)

TIME OF COMPLETION. If awarded the Contract for the work under the foregoing Proposal, we agree to proceed with the various phases of the work included under this Contract within __________ calendar days after issuance date of written notice to proceed, and agree to complete within __________ calendar days after issuance date of written notice to proceed.

3. ALTERNATE PROPOSAL NO. 2. For furnishing all labour, material and equipment for the two (2) Refuse Burning Boilers including (2) individual stacks each having a total height of 100 feet, all as indicated on the Drawings __________ through __________ inclusive and as defined in the Specifications for the sum of:

____

____ ($ __________)

TIME OF COMPLETION. If awarded the Contract for the work under the foregoing Proposal, we agree to proceed with the various phases of the work included under this Contract within __________ calendar days after issuance date of written notice to proceed, and to agree to complete within __________ calendar days after issuance date of written notice to proceed.

4. <u>ELECTROSTATIC PRECIPITATOR ALTERNATIVES</u>

(a) If Joy (Western) Precipitator is used
Add ______________________________ ($ __________)
or
Deduct ______________________________ ($ __________)

(b) If Wheelabrator-Lurgi Precipitator is used
Add ______________________________ ($ __________)
or
Deduct ______________________________ ($ __________)

We have included in our tender a contingency allowance as specified of $20,000.00.

ADDENDA. We have included the following addenda (if none, so state)

____

____

We enclose herewith our Bid Bond No. ____________

from __________________________________
(Name of Bonding Company)

in the amount of $ ____________________________

(minimum 5% of Base Bid).

Submitted this ________ day of __________, 1969.

Bidder's Name ____________________

Bidder's Address ____________________

____

Telephone ____________________

Company Seal
if Applicable

Authorized
Signature ____________________

NOTE: Sign also on Page 12of Tender Forms "Data to Accompany Proposals"

DATA TO ACCOMPANY PROPOSALS

Note Failure to completely fill out the following requested data may warrant rejection of the bidder's proposal.

Each bidder shall submit with his proposal three (3) sets of prints showing the general type, characteristi .s, materials, equipment and over-all dimensions of the installation he proposes to supply. All material accompanying the proposal shall be contained in binders (not loose).

Performance Data. Each proposal shall be accompanied by the following expected performance data for each boiler unit based on firing 75% shredded mixed municipal refuse and 25% shredded demolition lumber in the quantities given below:

Firing Rate Total Fuel, Lbs./Hr.	7,500	12,500	25,000
Steam Outlet Pressure, psig sat.	250	250	250
Feedwater Temperature, F	227	227	227
Air Temperature Entering Unit, F	80	80	80
Evaporation Rate, Lbs./Hr.	_____	_____	_____
Excess Air Leaving Boiler, %	_____	_____	_____
Air Flow from F.D. Fan, Lbs./Hr.	_____	_____	_____
Flue Gas Flow from Boiler, Lbs./Hr.	_____	_____	_____
Flue Gas Temperature			
Leaving Boiler Furnace, F	_____	_____	_____
Entering Air Preheater, F	_____	_____	_____
Leaving Air Preheater, F	_____	_____	_____
Draft Losses: Furnace, in.w.g.	_____	_____	_____
Boiler, in.w.g.	_____	_____	_____
Air Preheater, in.w.g.	_____	_____	_____
Flues, in.w.g.	_____	_____	_____
Precipitator, in.w.g.	_____	_____	_____
Total, in.w.g.	_____	_____	_____
Air Resistance:			
Duct to Preheater, in.w.g.	_____	_____	_____
Air Preheater, in.w.g.	_____	_____	_____
Overfire Duct, in.w.g.	_____	_____	_____
Underfire Duct, in.w.g.	_____	_____	_____
Grate, in.w.g.	_____	_____	_____
Total, in.w.g.	_____	_____	_____

Firing Rate Total Fuel, Lbs. /Hr.	7,500	12,500	25,000
Heat Release:			
Per Cubic Foot of Furnace, Btuh	______	______	______
Per Square Foot of Grate, Btuh	______	______	______
Per Square Foot of Flat Projected Water Cooled Furnace Envelope, Btuh	______	______	______
Blowdown, Lbs. /Hr.	______	______	______

EQUIPMENT

Boilers (See Note 1)		
Manufacturer	______________	
Effective Boiler Heating Surface, Ea.	______________	sq. ft.
Steam Drum O. D.	______________	in.
Lower Drum O. D.	______________	in.
Drum Design	______________	psig
Water Volume When Full	______________	Imp. Gal.
Furnaces (See Notes 2 and 3)		
Width, Ea.	______________	
Depth, Ea.	______________	
Height, Ea.	______________	
Volume, Ea.	______________	cu. ft.
Water Cooled Wall Area, Ea.	______________	sq. ft.
Boiler Insulation (See Note 4)		
Material	______________	
Thickness	______________	in.
Refuse Fuel Burning Equipment		
Manufacturer	______________	
No. of Burners, Ea. Boiler	______________	
Type of Grate	______________	
Width of Grate, Ea.	______________	
Length of Grate, Ea.	______________	
Effective Grate Area, Ea.	______________	sq. ft.
Type of Drives	______________	
Power Required, Ea.	______________	BHP
No. 2 Oil Burning Equipment		
Manufacturer	______________	
No. of Burners, Ea. Boiler	______________	
Oil Flow per Burner	______________	gpm
Inlet Oil Pressure Required	______________	psig
Inlet Air Pressure Required	______________	in. w. g.
Air Required, Ea. Burner	______________	cfm
Type Ignition	______________	

Refuse Conveying System		
Manufacturer	____________	
No. and Type of Compressors	____________	
Steam Turbine Drive Manufacturer	____________	
No. of Feeder Conveyors Required	____________	
Motor Drives on Feeder Conveyors	____________	H.P.
Air Preheater		
Manufacturer	____________	
Size of Air Tubes, Ea.	____________	in.
No. of Air Tubes, Ea.	____________	
Effective Area Air Tubes, Ea.	____________	sq.ft.
Temperature Rise through Unit at Maximum Firing Rate and 80 F amb.	____________	F
Electrostatic Precipitator		
Manufacturer	____________	
Cross-Sectional Area, Ea.	____________	sq.ft.
Gas Passages, Ea.	____________	
Field Height, Ea.	____________	
No. of Fields, Ea.	____________	
Collecting Area: Projected	____________	sq.ft.
Collecting Area: Actual	____________	sq.ft.
Collecting Surface: Type	____________	
Collecting Surface: Material	____________	
Plate Spacing Discharge Electrodes: Type	____________	
Plate Spacing Discharge Electrodes: Material	____________	
Total Length of Electrodes, Ea.	____________	ft.
Electrode Supports: Number, Ea.	____________	
Electrode Supports: Type	____________	
Casing Materials & Thickness: Sides	____________	
Casing Materials & Thickness: Hoppers	____________	
Casing Materials & Thickness: Roof	____________	
No. of Access Doors, Ea.	____________	
No. of Manholes, Ea.	____________	
Rappers (Collecting Surface)		
No. of Hammers, Ea.	____________	
No. of Drives, Ea.	____________	
Rappers (Discharge Electrode)		
No. of Hammers, Ea.	____________	
No. of Drives, Ea.	____________	
Rapper Control	____________	
Electrical Power Consumption - Precipitator, Insulator Heaters and Rappers, Ea. Unit	____________	KW
Rectifier Rating	____________	KVA

Precipitator Design Data -		
Wind Load	______	psf
Snow or Live Load	______	psf
Hopper Dust Load-Full	______	pcf
Forced Draft Fans and Drives		
Manufacturer	______	
Size, Ea.	______	
Capacity, Ea.	______	cfm
Static Pressure	______	in. w. g.
Fan Speed	______	rpm
Power Required, Ea. (Full Load)	______	BHP
(1/4 Load)	______	BHP
Manufacturer of Turbine	______	
Turbine Speed	______	rpm
Turbine Steam Rate, Ea.	______	lbs. /BHP Hr.
Manufacturer of Motor	______	
Motor Horsepower, Ea.	______	
Manufacturer of Clutch Couplings	______	
Induced Draft Fans and Drives		
Manufacturer	______	
Size	______	
Capacity, Ea.	______	cfm
Static Pressure	______	in. w. g.
Fan Speed	______	rpm
Power Required, Ea. (Full Load)	______	BHP
(1/4 Load)	______	BHP
Manufacturer of Turbine	______	
Turbine Speed	______	rpm
Turbine Steam Rate, Ea.	______	lbs. /BHP Hr.
Manufacturer of Speed Reducing Gear	______	
Type	______	
Manufacturer of Motor	______	
Motor Horsepower, Ea.	______	
Manufacturer of Clutch Couplings	______	
Stack Manufacturer	______	
Diameter Dual Stack - 165' ht. @ Base	______	
@ Top	______	
Diameter Dual Stack - 100' ht. @ Base	______	
@ Top	______	
Diameter Individual Stack - 100' ht.		
@ Base	______	
@ Top	______	
Design Wind Loading	______	psf

INSTRUMENTS AND CONTROLS

Draft Gauges
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Pressure Gauges
- Manufacturer ______
- Size, Scale and Range ______
- Model Number ______

Drum Water Level Indicating Controller
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Feedwater Flow Controller
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Temperature Recorder
- Manufacturer ______
- Type of Operation ______
- Number of Points ______
- Range and Scale ______
- Model Number ______

Oxygen Indicator and Recording Controller
- Manufacturer ______
- Type of Operation ______
- Analyzer Output, PSIG ______
- Size, Scale and Range ______
- Model Number ______

Steam Flow Recorders
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Deaerator Water Level Indicator
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Refuse Fuel Pressure Gauges
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Auto-Manual Fuel Feed Control
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Auto-Manual Air Supply Control
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Boiler Feedwater Flow, Temperature and Pressure Recorder
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Oil Flow and Air (for oil) Flow Controller
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Total Air Flow Controller
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Furnace Pressure Draft Controller
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Oil-Secondary Air Damper Control
- Manufacturer ____________
- Type of Operation ____________
- Size, Scale and Range ____________
- Model Number ____________

Refuse Overgrate/Undergrate Air Control
- Manufacturer ____________
- Type of Operation ____________
- Size, Scale and Range ____________
- Model Number ____________

Control Drives
- Manufacturer ____________
- Type of Operation ____________
- Size, Scale and Range ____________
- Model Number ____________

Pressure Transmitters
- Manufacturer ____________
- Type of Operation ____________
- Size, Scale and Range ____________
- Model Number ____________

Signal Selector Relays
- Manufacturer ____________
- Type of Operation ____________
- Size, Scale and Range ____________
- Model Number ____________

Pushbuttons Lighted
- Manufacturer ____________
- Type of Operation ____________
- Size, Scale and Range ____________
- Model Number ____________

Pushbuttons Non-Illuminated
- Manufacturer ____________
- Type of Operation ____________
- Size, Scale and Range ____________
- Model Number ____________

Minimum Air Flow Controller
- Manufacturer ____________
- Type of Operation ____________
- Size, Scale and Range ____________
- Model Number ____________

Induced Draft Fan Suction Pressure Controller
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Adding Relays
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Ratio Relays
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Totalizers
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Square Root Extractors
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Flow and Level Transmitters
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Bias Relays
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Furnace to Windbox Differential Transmitters Convertors
- Manufacturer ______
- Type of Operation ______
- Size, Scale and Range ______
- Model Number ______

Notes

1. Boiler heating surface shall be given in square feet, including convection area of drums and boiler bank tubes which have hot gases on the outside and boiler water on the inside at normal water level in the unit.

2. Furnace volume shall be given in cubic feet above the top of the grate line to the bottom furnace face of the roof tubes, between the side walls, and to the first row of tubes at the furnace exit. The volume of an open pass between the furnace outlet and boiler inlet shall not be considered furnace volume.

3. Water cooled furnace wall area shall be given in square feet based on the flat projected area of the furnace enclosure tubes.

4. Method of applying boiler insulation shall be outlined.

Submitted this __________ day of ________________, 1969.

Bidder's Name ____________________________

Bidder's Address ____________________________

____

Telephone ____________________________

Authorized Signature ____________________________

TENDER FORM

(Submit in Triplicate)

His Worship Mayor Victor K. Copps,
Chairman,
Board of Control,
c/o J. R. Jones, Esq.,
Secretary to the Board of Control,
Hamilton, Ontario.

We are pleased to submit herewith 3 copies of our tender for supply of all labour and material required for the erection of

The East Hamilton Solid Waste Reduction Unit
General Contract

Our tender is in accordance with the requirements of drawings and specifications prepared by Gordon L. Sutin & Associates Ltd., Consulting Engineers, dated November 24, 1969.

Our price, including Federal and Provincial Sales Tax is:

____

____

____

________________________ ($ ________________)

Tenderer's Name (Typewritten) ________________________

We have included in our tender the provisions of the following Addenda:

____

____

____

____

____

We are enclosing herewith our Bid Bond No. ____________________ from

____

____

(Name and address in Hamilton of the Bonding Company or Agents)

in the amount of: ____

____

(Minimum 5% of tender price)

If Westinghouse Turbines are used in place of Terry Turbines as specified,

Add: $ ____________________
or
Deduct: $ ____________________

We have included all the cash allowances as specified.

We propose to use the sub-contractors as listed on Page 4 and 5 of this tender form.

If this tender is accepted and contract awarded to (me) (us), (I), (we) hereby agree to execute the contract, in triplicate, within reasonable time of notification of acceptance of tender, and upon such execution to provide a Performance of Contract Bond in an amount equal to One Hundred Per Centum (100%) of the amount of the tender, which Bond shall be purchased in the City of Hamilton. In the event of default or failure on (my) (our) part to execute the contract as above prescribed and to provide therewith the necessary Performance of Contract Bond, the Corporation of the City of Hamilton shall declare the Bid Bond forfeited, and the Bonding Company shall forthwith pay to the Corporation of the City of Hamilton an amount equal to five percentum (5%) of the total amount of the tender.

This offer is to continue open to acceptance until the formal contract is executed by the successful tenderer for said works, or 90 days, whichever occurs first, and the City may at any time without notice accept this tender whether any other tender has previously been accepted or not within the above noted limits of time.

And also agree if this tender is accepted, to execute whatever additional or extra work that may be required at the rates set forth in the price schedule for additional work or deductions, in strict conformity in all respects with the requirements of the specifications, general conditions and form of agreement.

1. Extra Pile Tests as specified will cost $ ________________ per test.

2. Number of Face Brick required ________________ thousand.

3. Allowing 10 working days for approval by the Engineer of Shop Drawings, we are prepared to begin erection of Boiler Room Structural Steel ___________ working days after award of contract and will complete sufficiently for erection of the boilers within ____________ working days thereafter.

4. Allowing 10 working days for approval of Shop Drawings by the Engineer, we will begin erection of Steel Joists __________ working days after award of contract and complete erection of Steel Joists __________ working days thereafter.

5. If any extras or credits are applicable to the contract, they shall be calculated at the following unit prices, unless other arrangements are made with the Engineer:

<u>Concrete and Reinforcing Steel supplied and placed including formwork:</u>

Footings	$ __________/cu. yd.	Steel $ __________/ton
Pile Caps	$ __________/cu. yd.	Steel $ __________/ton
Walls	$ __________/cu. yd.	Steel $ __________/ton
Beams	$ __________/cu. yd.	Steel $ __________/ton
Slabs on grade	$ __________/cu. yd.	Steel $ __________/ton
Structural Slabs	$ __________/cu. yd.	Steel $ __________/ton

Excavation, removed from site $ __________/cu. yd.

Granular Fill, as specified, installed $ __________/cu. yd.

Structural Steel, erected $ __________/ton

Face Brick, installed, complete with mortar allowing $90.00/M for purchase of brick $ __________/M

Concrete Blocks, supplied and installed
4" $ __________ each
6" $ __________ each
8" $ __________ each
10" $ __________ each
12" $ __________ each

Piles, supplied and installed
100 ton ____________ each
50 ton ____________ each

Asphalt Paving with gravel __________/sq. yd.

We propose to use the following Sub-contractors (if own forces, please mark as such):

Excavation ______________________________

Paving ______________________________

Piling ______________________________

Formwork ______________________________

Concrete Supply ______________________________

Precast and Prestressed Concrete ______________________________

Mastic Flooring and Treds ______________________________

Masonry ______________________________

Structural Steel ______________________________

Steel Joists ______________________________

Steel Siding ______________________________

Roofing and Sheet Metal ______________________________

Metal Suspension, Acoustical Tile ______________________________

Millwork ______________________________

Kalamein Doors and Frames ______________________________

Resilient Flooring ______________________________

Glazed Tile ______________________________

Quarry Tile ______________________________

Louvers ______________________________

Aluminum Entrances and Curtain Wall ______________________________

Weigh Scale ______________________________

Toilet Paritions ______________________________

Steel Lockers ______________________________

Glass and Glazing ____________________

Caulking ____________________

Crane ____________________

Overhead Doors - Manual ____________________

Overhead Doors - Electric ____________________

Rolling Metal Doors ____________________

Miscellaneous Metal ____________________

Conveyors ____________________

Control Room Panel ____________________

Ash Handling Equipment ____________________

Hydraulic Equipment ____________________

Condensers ____________________

Steam Piping ____________________

Refuse Storage Tank ____________________

Plumbing and Drainage ____________________ $ __________

Heating and Ventilating ____________________ $ __________

Air Conditioning ____________________ $ __________

Electrical ____________________ $ __________

The previous 5 pages attached to this page form an integral part of this tender.

All of which is respectfully submitted this ________ day of ________________, 1970.

____
Name of Tenderer.

Corporation Seal
if Applicable.

____
Address of Tenderer

____
Authorized Signature

____
Authorized Signature

APPENDIX 8

List of Sub-Consultants, Contractors and Principal Sub Contractors

Sub-Consultants:

Mechanical and Electrical Consulting Engineering Services:

Walter, Eull and Elliot, Ltd., Hamilton, Ontario.

Process Consultants:

Consoer, Townsend and Associates, Chicago, U.S.A.

Soil Testing:

William Trow Associates, Hamilton, Ontario

Contractors:

Boiler Contractor (boilers, stacks, precipitators, various auxiliaries, controls):

Babcock and Wilcox Canada Ltd., Galt, Ontario.

General Contractor (form work, concrete supply)

Pigott Construction Company Ltd.,

Hamilton, Ontario

Sub-Contractors: (Partial listing only)

Electrical:

Canadian International Comstock Company Ltd.,

Burlington, Ontario.

Mechanical (plumbing, drainage, heating,

ventilation, air conditioning and steam piping):

Crump Mechanical Contracting, Scarborough,

Ontario.

APPENDIX 9

Critical Path Methods Used for Scheduling

During the late 1950's, the escalating complexity of engineering projects lead to the development of various Critical Path Methods. They allow a more detailed analysis of activities, schedules and resource allocations than the Gantt bar chart technique still used in production management. Using computers it now has been refined to provide "time-cost trade-offs" on projects.

Moder and Phillips list six steps to implement the method:

1. Project planning--the activities to achieve the project are related chronologically in a flow chart, usually with the "activities on the arrows".
2. Time estimation--these are added to the flow chart.
3. Scheduling--the Completion dates for activities are added. The "critical path" is noted.
4. Time-Cost Trade-offs--The finish date versus total cost are compared to determine the optimum.

5. Resource Allocations--One ensures that the men and equipment available are realistically scheduled.

6. Project Control -- One compares that achieved with that planned, making adjustments as necessary.

The General Contract (140028) requires the General Contractor maintain updates to the C.P.M. network for the Firm and for the City. Actually, the Firm is doing this function, at a fee to the General Contractor.

Mr. F. Ferguson gave the author some of his views on the C.P.M., which he has implemented for this project. He realized that the complex inter-relations in the construction industry are amenable to the Method. He said that a completion date is set, which sub-trades are to meet. The somewhat esoteric time-cost trade-off was not used. He normally uses a 5 day time block, beginning his project planning at the project design stage. Although some builders still do not employ the Method, some consultants send a network to the bidders to they can fill in their time estimates for their bids. His brochure prepared on the Method emphasises its basic simplicity..."when used intelligently, C.P.M. can cut total project costs up to 25%,...time by 10 to 30%,...free Management from 90% of routine decision making."

APPENDIX 10

Photographic Record of Construction

Please note that the following is arranged chronologically. A date of March 21, 1970 appears for example as 21-3-70.

The direction of view is coded; a view looking north-west appears as LNW.

Fig. 10-1 Site LE
from Kenora 21-3-70

Fig. 10-2 Pile Driving
at Receiving Pit 27-4-70

Fig. 10-3 Pit Excavation
27-4-70

Fig. 10-4 Boiler House
Concrete Forms 27-4-70

Fig. 10-5 Pile Relaxation
Testing (200 tons) 27-4-70

Fig. 10-6 Receiving Pit
Concrete Forms 27-5-70

Fig. 10-7 Receiving Pit Walls 27-5-70

Fig. 10-8 Boiler House Steel Erection 27-5-70

Fig. 10-9 Boiler House LN 7-7-70

Fig. 10-10 Boiler House 7-7-70

Fig. 10-11 Backfilling Receiving Pit 7-7-70

Fig. 10-12 Air Preheater Installation 7-7-70

Fig. 10-13 View LNW
7-7-70

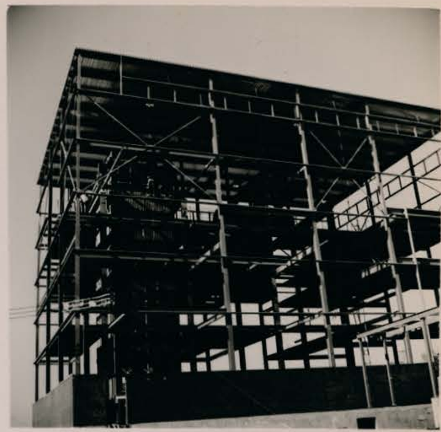


Fig. 10-14 Boiler Erection
Note furnace membrane walls
21-7-70

Fig. 10-15 Boiler House
21-7-70

Fig. 10-16 Receiving Pit LN
21-7-70

Fig. 10-17 View LS
Note exit ramp 23-7-70

Fig. 10-18 View LN
11-8-70

Fig. 10-19 View LS
Note exit ramp and ash-handling steel 11-8-70

Fig. 10-20 View LN
27-8-70

Fig. 10-21 Steel racks for ash handling system. Silo foundation in back 12-9-70

Fig. 10-22 View LS
Compare to Fig. 10-19
12-9-70

Fig. 10-23 View LN
Boiler Erection nearing finish
12-9-70

Fig. 10-24
On-site Sign

Fig. 10-25 Base for Atlas Silo, looking NE
Note trench 1-11-70

Fig. 10-26 Shells of Precipitators LW
1-11-70

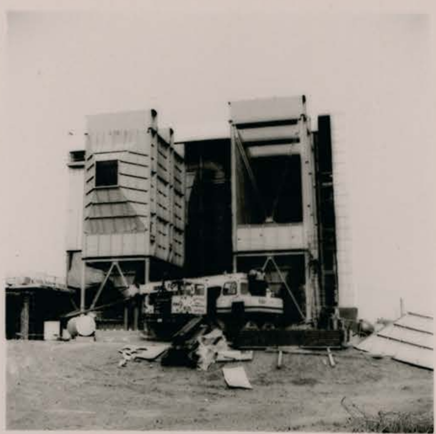


Fig. 10-27 LN

Fig. 10-28 LNE

Two Views of Precipitator Shells.
Note stack foundation in foreground.
1-11-70

Fig. 10-29 Three Stack Sections 29-11-70

Fig. 10-30 Stack and Precipitators, LW 29-11-70

Fig. 10-31 Atlas Silo, LNE
29-11-70

Fig. 10-32 Tollemache Shredders, LW 29-11-70

Fig. 10-33 The S.W.R.U. LN
1-1-71

Fig. 10-34 Atlas Silo LN
1-1-71

Fig. 10-35 Pit and Shredders
LN 1-1-71

Fig. 10-36 Atlas Silo
LNE 21-2-71

Fig. 10-37 Typical Receiving Bldg. Roof Beam 21-2-71

Fig. 10-38 Boiler House LS 21-2-71

Fig. 10-39 The S.W.R.U. LN 21-2-71

Fig. 10-40 Office Area, Rec. Bldg. LE 17-4-71

Fig. 10-41 Entrance Ramp, Precipitator, LE 17-4-71

Fig. 10-42 Silo, Exit Ramp LS 17-4-71

APPENDIX 11

D R A F T

TEST PROPOSAL --

EAST HAMILTON SOLID WASTE REDUCTION UNIT

Prepared by:

O. R. Love

for

Dr. G. Kardos,
Dept. of Mechanical Engineering,
McMaster University,
Hamilton, Ontario.

November 9, 1969

GUIDELINE FOR PROPOSAL

1. SUMMARY

1.1 Technical Requirement Proposal Fulfills

It is hoped this test proposal will lead to improvements in the design and operation of existing and future Solid Waste Reduction Units (S.W.R.U.).

Three specific test programme goals are:

a) To understand the plant functions and efficiencies,

b) To determine the nature of waste products of a city,

c) To formulate a design extrapolation of system elements.

1.2 Brief Analysis of Problem

Existing North American incinerators generally are inefficient volume reducers, many creating environmental pollution. Stricter legislation regulating S.W. disposal must open the development of better methods. Presently neither books nor design codes exist for incinerator design. The A.S.M.E. Incinerator Division is primarily interested in incineration, not the larger one of system design of incinerator stations.

1.3 Proposed Method of Solution

The S.W.R.U. incorporates considerable instrumentation for measurement and control of process variables. The use of this instrumentation, plus the addition of certain other devices for measurement will provide data to give a more complete understanding of the process.

Hopefully, design extrapolations will be possible based on results from this study, and the operational experience with the unit.

References 7 and 8 indicate the U.S. Bureau of Mines work may prove a useful starting point. They have some work on refuse characteristics.

1.4 Relevance to Larger Problem

Environmental pollution is of increasing concern to all industrialized nations. The increasing consumption of goods and energy threatens to choke us with its by-products. The cost of municipal solid waste disposal is, next to school construction and highways, North America's greatest municipal expense. Long realized as unsightly, the full impact of man's pollution of his world is being realized. The ecology of this planet is being disrupted by man.

The well-being of all earth's life forms depends on the ability and willingness of men to preserve them against pollution.

1.5 Brief Description of Hardware

Measurement using supplied equipment involves:

a) Material Supply Weight - by incoming weight scale

b) Scrap Metal Weight - by scrap metal weight scale

c) Ash Weight - by ash silo weight scale

d) Refuse Density - hopefully using weight scales provided

e) Boiler and Furnace Data - see Section 2.3.6

f) Flue Gas Data - see Section 2.3.7

Other data to be collected are:

g) Material calorific value - by bomb calorimetry

h) Ambient Conditions during test - see Section 2.3.8

i) Other - see Section 2.3.9.

1.6 Estimate of Performance

- Not relevant to this proposal.

1.7 Length of Programme

Full S.W.R.U. operation is expected by mid 1971. An ideal test programme should be instituted before this. It may be broken into three phases:

Phase I - Detailed test development and process instrumentation
- Fall 1969 to unit start-up.

Phase II - Process instrumentation de-bugging and data collection

- Unit start-up, to late 1971.

Phase III - Data Analysis and design extropolation

- Mid 1971 to early 1971.

See Section 2.7 for further details.

1.8 Cost Estimate

Costs should be fairly low. Relying on the measurement instrumentation of the Unit will mean those doing the testing will buy, install and de-bug a minimum of additional equipment. The author would guess additional hardware costs at under $2000. No allowance will be made for labour costs.

2. PRESENTATION AND DISCUSSION

2.1 Complete Statement of the Problem

As population and its density both rise, the disposal of wastes becomes a more difficult problem. There will be less and less room available for dumping of solid refuse. The rising per capita generation of solid wastes in industrialized nations must be reduced in volume as much and as pollution-free as possible. Most present methods (dumping, pit-burning, etc.) are not solutions, and are becoming illegal. The East Hamilton S.W.R.U. is a new concept expected to provide some real answers to the problem. The proposed tests for this limit are hoped to allow even greater efficiencies for this and future units.

2.2 State of the Art Assessment

The prime function of a solid waste reduction unit is to reduce waste volume. Incineration is presently believed the best method. Composting is used but it is uneconomic as the final product is in little demand. European incinerators are usually clean in operation but require considerable operating man-power. They are generally equipped with electrostatic precipitators to minimize air pollution. They are used to generate electrical energy. Existing North American incinerators cause more pollution and are not used to generate electrical energy for sale. To remove heat from the combustion gases is best done by steamgeneration if electrostatic precipitation is to be done of these gases.

Public pressure is causing wide-spread pollution control legislation to be enacted on this continent. Strict controls on environmental pollution are being implemented. Ontario is a Canadian leader, both the Ontario Water Resources Commission and the Air Pollution Act influence incinerator operation.

Little formal design data are available for solid waste reduction. The Incinerator Division of the A.S.M.E. provides some design data and operations data on incineration. It is hoped that incineration problems may be located precisely enough to allow for operational improvements and some design extrapolation.

Detailed testing will be developed from an energy-mass balance on the Unit, using A.S.M.E. Power Test Code for Steam Generating Units as a basis to develop the test procedure. See Reference 1.

2.3 Clear, Accurate Description of Hardware and System Visualized

The test effort may be divided in three overlapping phases as discussed in Section 2.7

The process instrumentation will be used whenever possible to reduce costs. It is described in detail in Reference 9.

Data to be collected are:

2.3.1 Material Supply Weight - using incoming weight scale records over the test periods

2.3.2 Scrap Metal Weight - using scrap metal weight scale records over the test period

2.3.3 Ash Weight - using ash silo weight scale provided, over the test period

2.3.4 Material Calorific Value - by bomb calorimetry on randomly selected samples over the test period

2.3.5 Refuse Density - to be done at different stages of processing and at different times. Details are not yet decided

2.3.6 Boiler and Furnace Data - all the following, with the exception of those marked by an asterisk, are being recorded as well as measured:

- steam flow and temperature
- boiler drum pressure*
- combustion air flow
- air flow under grate *
- feedwater flow and temperature
- gas flow and integrator (supplementary burning).

The calorific value as supplied by United Gas may have to be checked.

- boiler steam flow*

2.3.7 Flue Gas Data - as a measure of combustion completeness, records must be taken for Air Pollution Division records. These data should be taken during the test period:

- flue gas temperature
- flue gas oxygen
- stack gas smoke density
- precipitator ash production

2.3.8 Ambient Conditions during Test

Local meteorology stations will provide these data:

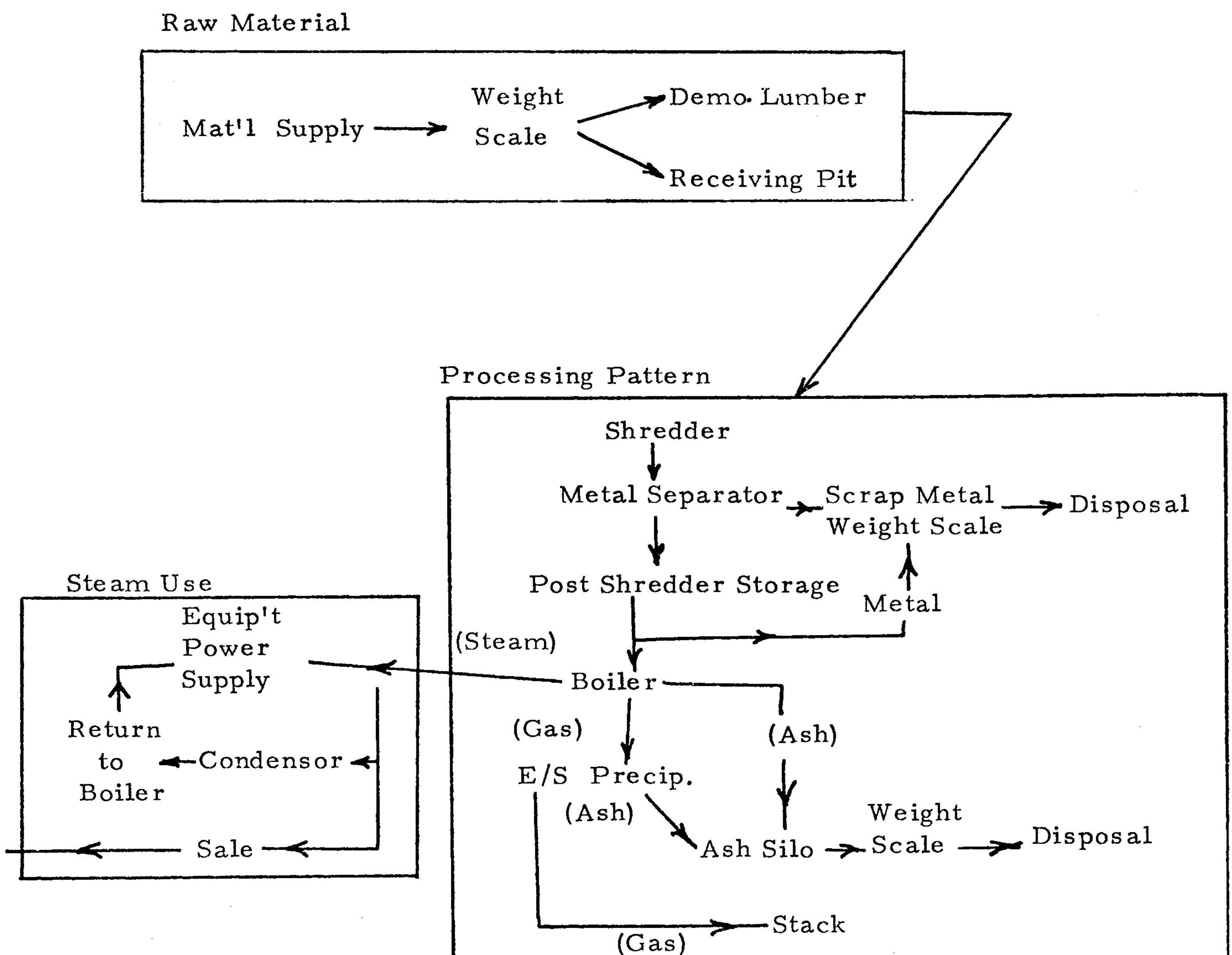
- temperature
- wind velocity
- relative humidity
- cloud cover

2.3.9 Other

- electrical energy supplied
- chemical analysis of furnace ash
- chemical analysis of precipitator ash
- sizing of furnace ash

Shown following is a flow chart indicating points of measurement for most variables. This test proposal, it should be realized, was prepared before the drawings were completed. Further details will be evaluated later.

PROCESS FLOW-CHART (Simplified)



This is based on a process flow chart contained in the "Preliminary Engineering Report".

2.4 Description of Novelty or Uniqueness

No procedures exist to test the performance of a whole incinerator unit. This includes the A.S.M.E. Power Test Codes and work to date of its Incinerator Division.

It is hoped this proposal may start to fill this need.

2.5 Statement of Major Technical Problems to be Solved

Major problems may be expected in data interpretation. The energy-mass balance may be difficult to attain. The validity of proposed design extrapolations may have a high degree of uncertainty.

2.6 Alternate Solutions Considered, and Why Rejected

No alternates were considered.

2.7 Programme Planning Chart and Funding

Three phases of test programme are envisioned.

Phase I - Detailed Test Development and Process Instrumentation

This could begin immediately. The instrumentation design, ideally, should progress with Unit design. The person responsible should thoroughly study the Power Test Codes to determine how to measure variables. He should, further choose, install and get the additional instrumentation into reasonable order.

Phase II - Process Instrumentation De-bugging and Data Collection

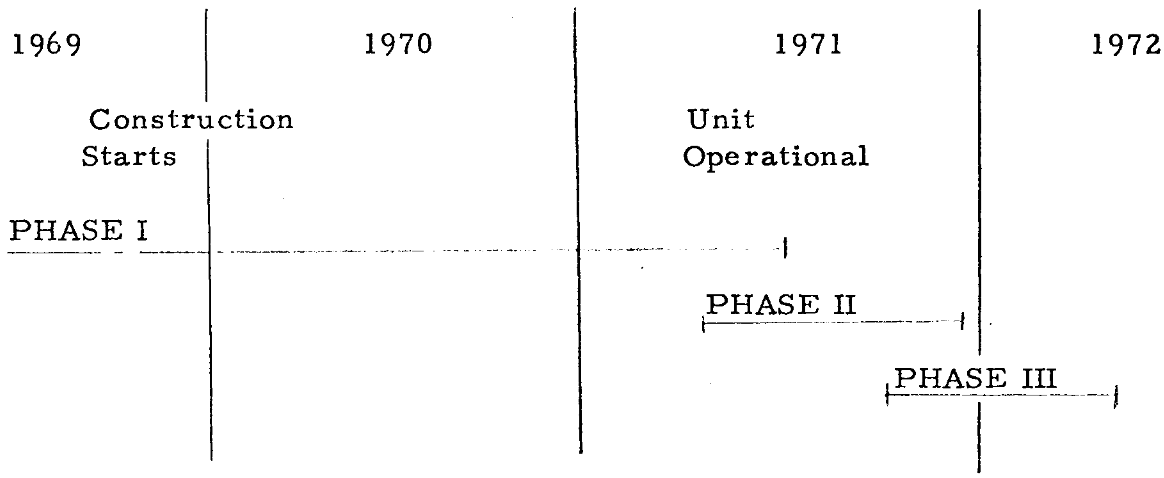
The person responsible should become thoroughly familiar with the supplied instrumentation. His knowledge, abilities and perserverance will be challenged when he is de-bugging his own instrumentation. By completion of this Phase, he should demonstrate consistent data.

Phase III - Data Analysis and Design Extropolation

The responsible individual must here co-ordinate and analyze previous work. Computer programmes will have to be prepared to analyze the vast amounts of data available. He should prepare programmes to allow routine data to be processed, stored and presented to operating personnel.

His final report will be extensive. It should cover, in summary, the work of Phases I and II, present data gathered and his conclusions. It should indicate the recovery value of waste products in the ash and scrap. The most difficult task will be in providing recommendations for design extrapolations.

Funds required for the test programme should be moderate. Instrumentation costs should not exceed $2, 000, plus some amount of technician assistance. It is expected most work will be done by graduate students in Mechanical Engineering, McMaster University.



2.8 Conclusion and Recommendations

2.8.1 How proposal will achieve results

The persons undertaking such a test programme will become familiar with incinerators in general, and the East Hamilton S.W.R.U. in particular.

The background study should indicate expected ranges for test dates. By close liaison with operating personnel, he should gain operational experience. With these aids, the responsible persons should be able to thoroughly gather and thoughtfully analyze test data. It is hoped that some design extrapolation could be then possible.

2.8.2 Exception to Requirements

The goal of a design extrapolation for system elements may not be achieved. There will be considerable uncertainty expected in the validity of recommendations. The programme will be analyzed and reported by one not directly involved with the initial design; his ability to extrapolate may be reduced by this.

2.8.3 Clear Statement of Limitations of Work Covered in Proposal

The proposal covers analysis of an existing unit. Certain measurements are taken for purposes of this proposal, but only its operation is examined in detail. Obvious faults, and shortcomings, in the design can only be tolerated for this proposal. It will be likely not possible to test out any design changes felt desirable arising from this proposal.

2.8.4 Advantages of proposed system

The advantage of this proposal is its uniqueness. No real test procedure for incinerator units is believed to exist.

2.8.5. Statement of Application

It is hoped any results accruing from this proposal may prove useful to its owners, operators and designers.

2.8.6 Envisaged Development to Follow Completion of Proposed Programme

At least one major project report, several technical papers, possible financial assistance to C.A.R.E.D. for in-depth studies in certain areas, etc., are all possible.

3. QUALIFICATION DATA

3.1 Organization Responsible

The proposal will be developed and executed by graduate students in Engineering Design under C.A.R.E.D., McMaster University. It is expected additional technical back-up from without the University will be needed.

The proposal is planned for three stages presumably done by different students. Sufficient continuity and completeness will be ensured by C.A.R.E.D.

3.2 Personnel

3.2.1 Who - one C.A.R.E.D. supervisor, plus graduate students

3.2.2 Qualifications - B.A.Sc. is minimum academic qualification for students involved

3.2.3 Time devoted to project - graduate students will be involved for three years

3.3 Project Organization

It is described above. C.A.R.E.D. must make arrangements with the owner to allow in-depth study of the operations to be done.

3.4 Facilities

3.4.1 Available to do work - the Faculty of Engineering laboratories, etc., at McMaster University may be required by the student for experimental work

3.4.2 Procured for proposed project - the Unit will be its own test equipment. Testing must be planned carefully to minimize disruption of its operation.

4. COST DATA

4.1 Estimate Cost in Detail

This has not been attempted.

5. REFERENCES

1. A.S.M.E. Power Test Codes for Steam Generating Units (PTC4.1, etc.)

2. Mark's "Mechanical Engineers' Handbook"

3. Babcock and Wilcox Canada Ltd. Engineering Department

4. A.S.M.E. Incinerator Division proceedings

5. "Boiler and Auxiliary Equipment Specifications" Gordon L. Sutin and Associates Ltd.

6. Messersmith, etc., "Mechanical Engineering Laboratory" Wiley

7. U.S. Department of the Interior, Bureau of Mines, College Park, Maryland 20740, U.S.A. "Reclaiming and Recycling Metals and Minerals Found in Municipal Incinerator Residues", C. Rampacek.

8. Ibid. - "Composition and Characteristics of Municipal Incinerator Residues", R.I. 7204

9. S.W.R.U. File 421-L "Process Instrumentation" Gordon L. Sutin and Associated Ltd.

6. SUGGESTED CIRCULATION

McMaster University	- Dr. G. Kardos (2 copies) - Dr. J. Norman
Designers, etc.	- Gordon L. Sutin - Consoer, Townsend (H. Van Hille) - Babcock Wilcox Canada Ltd. (J. Young)
Owners	- City of Hamilton (for Messrs. W. Muirhead and W. Wheten)
Government of Ontario	- O.W.R.C. - Air Pollution Division, Department of Health
A.S.M.E.	- Incinerator Division