The New Quebec Metro Incinerator

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ABSTRACT

After an exhaustive feasibility study of the various methods of refuse disposal, the Quebec Urban Community, our metro government, is proceeding with the construction of a 1000 ton-a-day incineration plant in which the heat released will be converted to superheated steam (700 psig and 600° F) (48 bars and 315° C).

All the available steam will be sold to a nearby pulp and paper mill following a long term agreement with the Community.

The main feature of this plant is a heat accumulator whose purpose is to regulate the flow of steam sent out to the client. As far as we know, it is a “première”.

INTRODUCTION

Since 1970, the city and 22 of the surrounding municipalities have been integrated into a regional entity called “the Quebec Urban Community”. It is a regional administrative organization which assumes certain regional responsibilities amongst which are the treatment and disposal of all the refuse collected by the constituent municipalities. Its territory covering 218 square miles has over 425,000 inhabitants.

Like every other metropolitan area, our region is faced with the increasingly serious problem of refuse disposal. The main reasons are:

1) the rapid growth of its population and, consequently, of the quantity of refuse to be disposed of (Fig. 1);

2) the growing scarcity of land suitable for sanitary landfill within economic distance from the core of the district;

3) the more and more stringent requirements for sanitary disposal of refuse without creation of environment pollution problems.

In 1968, some of the suburbs, concerned with the incoming necessity for landfill sites away from their boundaries, initiated a thorough study of their refuse disposal problem.

The study was carried out by a consulting firm whose report was made available in March 1969. Meanwhile, most of the small municipalities of the region had also decided to participate in this study.

As for the city of Quebec, its officials were looking at this initiative with great interest. Even if almost all the garbage of the city was incinerated, they were well aware of the following facts:

1) the operating cost of their twenty-year-old incinerator was increasing rapidly;

2) in a very short length of time, they would have to get rid of an important part of the city’s refuse by transporting it over great distances;

3) above all, they were about to start an important renovation program along the banks of the St. Charles river, located in the heart of the city, and involving the re-location of the incineration plant.

The engineers’ report exposed in detail the results of the feasibility study they had made about the various methods of refuse treatment and disposal, the most universally used being sanitary landfill, composting and incineration.
The recommendation was that, in our region, the most suitable method was incineration and, if possible, incineration with heat recovery.

They did not retain sanitary landfill mostly because nowhere in or around the metropolitan area were they able to find suitable land of sufficient size.

The composting was rejected because our refuse contains a too small percentage of organic matter and also because there is no market in our country for compost nor for the majority of the by-products of the process.

In 1970, the newly formed metro government carried on with the study of this problem on behalf of all its constituent municipalities and was able to find a client ready to buy all the steam production of the future incineration plant.

After intensive negotiations, a long-term contract was signed between the QUC and the Anglo Canadian Pulp and Paper Company. Meanwhile, the QUC had decided to build an incineration plant with a capacity of 1000 tons per day. This capacity was determined so as to cover the area's requirements up to at least 1981 (Fig. 1).

It was also decided to build a plant designed to meet the increasingly stringent air pollution requirements which involve the use of efficient electrostatic precipitators.

At the time this paper was prepared, construction of the plant was in progress and it is intended here to describe the main features of the system together with the contractual arrangements for construction.

The design called for a refuse-fired furnace composed of motorized grates and of a combustion chamber lined with water tubes clad with appropriate refractory. The system should also include a steam generating boiler with an auxiliary oil burner.

Our choice went to the Von Roll system constructed under license by an important Montreal firm. It is similar to the one installed at the new Montreal incinerator which has been in operation for almost two years.

Figure 2 shows a cross section of the furnace and boiler. Each unit was designed for the following operating conditions:

- Refuse burning rate: 10.4 t/h (9.5 t.m./h)
  (nominal):
- H.H.V.: 6000 Btu/lb (3300 Kcal/Kg).
- Steam production: 81,000 lb/h (36,800 Kg/h).
- Feed water temperature: 287° F (142° C).
- Steam pressure design: 775 psig (54 bars)
- Steam pressure at boiler discharge: 680 plus or minus 20 psig (48 bars)
- Steam temperature: 600 plus or minus 25° F (315° C)
- Combustion air temperature:
- Gas temperature at boiler outlet: 480° F (250° C).

From the storage pit, the refuse is uniformly fed to the stoker through a feeding vibrator and a water cooled chute. At the Montreal incinerator, this feeding system has given excellent results.

The stoker is composed of three separated grates independently driven. The speed of each grate, as well as the combustion air distribution can be controlled to insure a satisfactory combustion.

The three grates are sloped at 15°. The middle section on which most of the burning takes place is equipped with mobile knives which stir the burning bed to achieve a complete combustion.

The first section is the drying grate. It has a total area of 91 square feet (8.45 m²). The second and the third, which are respectively the burning grate and the finishing grate, have the same total area of 181 square feet each (16.8 m²). The total area being 453 square feet (42 m²), the average burning capacity is a safe 46 #/sq. foot/h (224 Kgs/m²/h).

It may be of some interest to emphasize that we use the shortest grate as the drying grate, following the experience gained with the operation of the Montreal stokers. There, the drying grate is a large one and, due to the nature of our refuse, (Table 1) the burning takes place so rapidly on it that, to protect the grate and the adjoining walls, the burning refuse must be cooled with the aid of water sprays.
The combustion chamber above the fire-bed is formed with conventional panel-type water walls.

Since standing oil burners are provided and that they may have to operate simultaneously with the burning of refuse, there is a special water-wall lined combustion chamber in the upper part of the radiation section of the furnace.

The boiler has been designed with the intent to reduce as much as possible the corrosion and fouling problem concerned with the refuse burning furnaces.

1) It is a boiler with only one drum (the steam drum) and with all the tube-panels hung up vertically and perpendicular to the gas flow. From the radiation section, the combustion gases in one pass go straight through two evaporators, the superheater, a third evaporator and, finally, the economizer.

2) For tubes cleaning, we will use a mechanical rapping system instead of soot blowers. The rapping system is essentially composed of revolving hammers attached to an horizontal driving shaft. When the hammers strike the spring loaded rods in contact with the lower part of the tube panels, vibration is induced in every heating tube. The result is a tube cleaning without wear.

3) During the shut down period, the boiler will not be completely cooled unless it appears necessary to empty it. Low pressure steam (125 psig) (8.8 bars) will continually be injected at the bottom of tube-panels so that the entire heating surface will remain at a mean temperature of 350° F (177° C).

The results will be:
\begin{itemize}
  \item a) During shut down period, a better protection from the so-called dew point corrosion;
  \item b) during start-up period, a better protection from the thermal shock;
  \item c) start-up period almost reduced by half.
\end{itemize}

As the steam is sold, it is very important for us that its production may be resumed as soon as possible after an interruption.

RESIDUE AND FLY ASH HANDLING SYSTEMS

As you can see on Fig. 3, residue and fly ash are separately handled.

Moved from the quenching trough by a drag conveyor, the residue is carried over an incline to a storage pit. From there, it is transferred to vehicles by means of an overhead crane. We are not contemplating the installment of sorting drum or of magnetic separator until we find a market for the metallic residue.

Fly ash coming from the economizer section of the boiler and from the precipitator are moved by a chain conveyor to a silo, from which they will be trucked to a potential client or to landfill areas.

STEAM DELIVERY AND ITS REGULATION

According to the terms of the contract signed with the client, we must keep the steam supply to his plant within the limits of plus or minus 7 percent of the daily average flow.

We know that because of the inconsistent calorific value of the refuse and its irregular rate of burning through the grates, the steam production rate cannot be prevented from fluctuations exceeding plus or minus 7 percent.

To provide compensation between the fluctuating steam production of the boilers and the steady steam sent out, the designers have strongly recommended the use of a feedwater accumulator coupled with the deaerator.

Here is a brief description of the vessel and of how it will operate (Fig. 4):

Within one vessel there are three sections, the deaerator section, the feedwater section and the accumulator.
FIG. 2 CROSS SECTIONAL VIEW OF THE QUEBEC PLANT
FIG. 3 FLOW DIAGRAM – QUEBEC INCINERATOR PLANT
section. In our case, the vessel has a volume of over 3000 cubic feet (85 m³).

In the accumulator section, we have two layers of water, one at 287°F (142°C) and the other at approximately 110°F (43°C). These two layers are kept separated around an interface zone by virtue of the difference in density.

When the steam production is in balance with the steam sent out, the vessel operates as a conventional deaerator, that is the relative amount of feedwater and cold water remains the same.

When the steam production exceeds the demand due to an increase in the calorific value of the refuse being burned, the following sequence of events will take place:

The increase in the steam production causes a pressure increase in the system. Detected, this increase induces a greater admission of cold water in the deaerator section.

So, more steam will be needed in order to maintain deaerator balance and then the excess steam produced by the boiler has now been diverted to the deaerator.

As the excess water requirement is taken from the bottom, the accumulator is now being charged because the proportion of hot and cold water stored in the vessel is gradually changing in favor of more and more feedwater.

This will continue as long as there is excess steam produced or until the feedwater has reached a predetermined low level detector of the interface. At this moment, the accumulator is said to be fully charged.

During periods when the low calorific value of the refuse being burned causes a drop in steam production, the system will react as following:

Less water is admitted in the deaerator. So, the quantity of steam normally going to the deaerator is automatically decreased and diverted toward the consumer.

FIG. 4 STEAM DIAGRAM – QUEBEC INCINERATOR PLANT

LEGEND
1 CITY WATER
2 FEED WATER TREATMENT
3 WATER STORAGE
4 CONDENSATE
5 CONDENSATE TREATMENT
6 RECIRCULATING PUMP
7 ACCUMULATOR PUMP
8 DEAERATOR
9 ACCUMULATOR
10 FEED WATER PUMP
11 ECONOMIZER
12 EVAPORATOR
13 SUPERHEATER
14 H.P. HEADER 680 PSIG
15 STEAM TRANSMISSION LINE TO THE CUSTOMER
16 L.P. HEADER 125 PSIG
17 IN PLANT USES
As the level of water in the accumulator must be maintained, make-up water is admitted at the bottom of the vessel and so displaces the deaerator feedwater toward the upper section and out to the boiler feed-pumps according to the needs of the boiler. When a predetermined high level of the interface is detected, the accumulator is said to be completely discharged.

In fact, the accumulator, which will operate automatically, will have two functions:

1) it will balance the fluctuations in the steam supply which are mainly caused by the variation in the calorific value of the refuse;

2) it will also provide a bridging period in which to adjust the firing level by giving sufficient warning to the operators that the heat reserve in the accumulator is either approaching the upper or the lower limit.

**PROCESS WATERS**

The plant water effluents will mainly come from the residue quench and handling system (Fig. 3). Between our consultants and the engineers of the governmental environment protection agency, discussions took place about the anticipated characteristics of the process waters, their pos-
### Table 2. Contracts Awarded

<table>
<thead>
<tr>
<th>Contract No.</th>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>Furnaces, boilers, precipitators, I.D. fans, ash conveyors, ash crane —</td>
<td>$11,900,000</td>
</tr>
<tr>
<td>401</td>
<td>Building, foundations and concrete works —</td>
<td>1,247,000</td>
</tr>
<tr>
<td>402</td>
<td>Refuse cranes —</td>
<td>426,000</td>
</tr>
<tr>
<td>403</td>
<td>Pumps and steam turbine —</td>
<td>103,000</td>
</tr>
<tr>
<td>404</td>
<td>Building, steel structure —</td>
<td>379,000</td>
</tr>
<tr>
<td>405</td>
<td>Tanks and heat exchanger —</td>
<td>15,000</td>
</tr>
<tr>
<td>406</td>
<td>Water treatment plant —</td>
<td>176,000</td>
</tr>
<tr>
<td>407</td>
<td>Bunker oil tank —</td>
<td>13,000</td>
</tr>
<tr>
<td>408 (see 415)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>409</td>
<td>Bunker oil heating and pumping unit —</td>
<td>16,000</td>
</tr>
<tr>
<td>410</td>
<td>Control central panel and instrumentation —</td>
<td>76,000</td>
</tr>
<tr>
<td>411</td>
<td>Building, general construction —</td>
<td>784,000</td>
</tr>
<tr>
<td>412</td>
<td>Chimney and fly ash silo —</td>
<td>235,000</td>
</tr>
<tr>
<td>413</td>
<td>Deaerator-accumulator —</td>
<td>67,000</td>
</tr>
<tr>
<td>414</td>
<td>Conveyors system for fly ash —</td>
<td>193,000</td>
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<tr>
<td>415</td>
<td>Air compressors —</td>
<td>56,000</td>
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<tr>
<td>416</td>
<td>Power transformers (2) —</td>
<td>24,000</td>
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<tr>
<td>417</td>
<td>Electronic weighing scale (2) —</td>
<td>82,000</td>
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<td>418</td>
<td>Diesel generator set —</td>
<td>33,000</td>
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<td>419</td>
<td>Emergency steam condenser —</td>
<td>253,000</td>
</tr>
<tr>
<td>420</td>
<td>Temporary services during construction —</td>
<td>127,000</td>
</tr>
<tr>
<td>421</td>
<td>Switch gear panel and bus bars —</td>
<td>20,000</td>
</tr>
<tr>
<td>422</td>
<td>Mechanical works - Steam transmission line —</td>
<td>2,175,000</td>
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<tr>
<td>423</td>
<td>Access ramps, water and sewer —</td>
<td>400,000</td>
</tr>
<tr>
<td>424-425</td>
<td>Landscaping and site works —</td>
<td>200,000</td>
</tr>
<tr>
<td></td>
<td>TOTAL construction cost $19,000,000.</td>
<td></td>
</tr>
</tbody>
</table>

### Table 3. Estimated Total Owning and Operating Costs

<table>
<thead>
<tr>
<th></th>
<th>1975</th>
<th>1976</th>
<th>1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tons of refuse</td>
<td>$ 225,000</td>
<td>$ 250,000</td>
<td>$ 325,000</td>
</tr>
<tr>
<td>burned annually</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amortization</td>
<td>$1,768,000</td>
<td>$1,768,000</td>
<td>$1,768,000</td>
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<tr>
<td>Operating cost</td>
<td>$ 800,000</td>
<td>$ 900,000</td>
<td>$1,000,000</td>
</tr>
<tr>
<td>Total cost/ton</td>
<td>$ 11.41</td>
<td>$ 10.67</td>
<td>$  8.51</td>
</tr>
<tr>
<td>burned</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenues from</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>steam sale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(based on</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>actual price)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenues/ton</td>
<td>$ 6.15</td>
<td>$ 5.84</td>
<td>$  5.70</td>
</tr>
<tr>
<td>burned</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net cost/ton</td>
<td>$ 5.26</td>
<td>$ 4.83</td>
<td>$  2.81</td>
</tr>
<tr>
<td>burned</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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sible recirculation rates and the treatment that should be required before discharge to the municipal sewer system. The exact characteristics of the waste waters being actually unpredictable, both parties have agreed to delay the decision about recirculation rates and treatment after some months of plant operation. During this period, an intensive program of sampling and analysis will be conducted.

**CONTRACTS ARRANGEMENTS**

Now, it may be of interest to talk about the arrangements of construction contracts.

The construction time of such a plant takes almost two years. On the other hand, the need of this plant was immediate and the delivery of steam to the paper mill was scheduled to begin at the latest in the middle of 1974.

At the end of 1971, when the green light was given to the QUC by the provincial government, construction scheduling has been a major concern. It was felt that we would save time if the works were to be undertaken as a series of interrelated contracts rather than a single package contract which could not be bid prior to completion of the total design.

So, the QUC decided to act as general contractor, signed immediately the refuse-burning and boiler system contract and gave the responsibility for managing the entire project to a Quebec engineering firm.

In conjunction with the designers, the architect and the contractor for the system, and using the critical path method, the managers established the bidding sequence and the awarding of contract for every predetermined phase of the project in order that the plant may be started in time.

As we can see in Table 2, they also used the pre-purchase procedure for some pieces of equipment such as pumps and accumulator which require long construction time.

All contracts have been awarded at this time and we are very confident that, as foreseen, two units will be ready for operation at the beginning of 1974.

The main advantages obtained from the use of this construction procedure are the following:

1) the construction time is significantly shortened;
2) the owner can have closer control on every phase of the project;
3) for some parts of the project, better prices can be obtained.

**ANTICIPATED COSTS**

The likely total construction cost of the plant is equal to the sum of the costs of all individual contracts listed in Table 2. This figure, $19,000,000, represents the construction costs only and does not include land cost as well as engineering and contingencies. These figures, added to the construction cost, bring the total capital outlay to $20,500,000.

Thus, the unit cost of this plant will be $20,500. per ton of daily rate capacity and $60.00 per ton of refuse burned annually. On the other hand, the anticipated revenues for the selling of steam will eventually bring down the net cost of the incineration to $2.81 by ton of refuse (Table 3).

The selling price of steam is based on the price of bunker C: If it increases, the steam price will also increase; so it is foreseeable that the real net cost to the taxpayer will be lower.

**CONCLUSION**

At the outset of this project, the objectives were:

1) to build an incinerator plant that could burn refuse and produce steam efficiently and continuously at design capacity;
2) to make a significant contribution to the pollution abatement in the Quebec area.

In order to reach the first objective, new design concepts have been developed and the foregoing discussion has covered them.

As for the second goal, no doubt that it will be attained and the main reasons are:

1) The particulate content of the flue gases will be at a level acceptable to the government agencies due to the performance of very efficient electrostatic precipitators;
2) refuse contains 5 to 8 times less sulphur than bunker C oil and also produces less nitrogen oxides and less hydrocarbons. The start up of the incineration plant will be followed by the shut down of two of the paper mill’s bunker C boilers;
3) the old Quebec incinerator will be shut down and demolished, eliminating an additional pollution factor;
4) the start up of the plant will be followed by the closing of all dump sites in the metropolitan area.

Finally, it is hoped that operational experience, when it becomes available, will be beneficial to the progress of refuse incineration technology.

**ACKNOWLEDGMENTS**

The help of Mr. Roland Rinfret, Eng., director of the plant, has been most important in the preparation of this paper. Credits are also extended to Mr. Jean Côté, Eng., manager of the project, Messrs. G. S. Farkas and D. Martinoli of Surveyer, Nenniger and Chenevert, designers of the plant, and Y. Poulin, Eng. of Dominion Bridge Company, builder of the furnaces and boilers system.