PRE-FEASIBILITY STUDY
FOR
THE GOVERNMENT OF CANADA
DEPARTMENT OF REGIONAL ECONOMIC EXPANSION

2,000,000 TONS PER YEAR
COKE PLANT

Submitted by

ARTHUR G. McKEE & COMPANY OF CANADA LTD.

ENGINEERS AND CONSTRUCTORS

21 VOYAGER COURT SOUTH
REXDALE, ONTARIO
CANADA

SEPTEMBER 1978

CCL-348

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ENGINEERS AND CONSTRUCTORS

September 29/1978

Government of Canada
Department of Regional Economic Expansion
6th Floor
200 rue Principale
Hull, Quebec.
K1A 0M4

Attention: Mr. Suresh Khandelwal
Senior Analyst
Department of Project Assessment

Re: Coke Plant Study
McKee Ref. CCL 348

Dear Mr. Khandelwal:

As mentioned in our letter of September 25, 1978, we are pleased to enclose five copies of our "Pre-Feasibility Study for a 2,000,000 Tons Per Year Coke Plant". The parameters for this study are identical to the ones for the 1,000,000 TPY study.

We understand that the funds for a 5,000,000 TPY plant study have been authorized and that you will be issuing an addendum to Contract Number 2757 shortly. We intend to proceed with this study as a continuation of the one and two million TPY work. The first step will be to decide on the split between Phase I and Phase II, e.g. Phase I: 3×10^6 TPY, Phase II 2×10^6 TPY or Phase I and Phase II at 2.5×10^6 TPY each.

As previously agreed, all three reports will be issued combined in its final form toward the end of October 1978.

Yours very truly,

ARTHUR G. McKEE & COMPANY
OF CANADA LTD.

A. Berndl, Ph.D., P. Eng.
Project Manager

AB/sk

encl.

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PRE FEASIBILITY STUDY OF A 2,000,000 TON PER YEAR COKE PLANT

Prepared for

THE GOVERNMENT OF CANADA
DEPARTMENT OF REGIONAL ECONOMIC EXPANSION

SEPTEMBER 1978

CONTRACT CCL-348

By

ARTHUR G. McKEE & COMPANY OF CANADA, LTD.
ENGINEERS & CONSTRUCTORS
TORONTO, ONTARIO

McKee

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I. INTRODUCTION

This report has been prepared by Arthur G. McKee & Company of Canada, Ltd., for the Minister of Regional Economic Expansion acting for the Government of Canada, in accordance with the understandings in the Terms of Reference attached to the contract dated September 14, 1978. The Terms of Reference are included at the end of this section.

The basic purpose of this study is the definition of two sets of coke plant facilities to produce 1,000,000 tons and 2,000,000 tons of merchant coke per year respectively from indigenous high volatile and imported low volatile coking coals. In addition to metallurgical quality coke, coke oven gas, tar, anhydrous ammonia, elemental sulfur and light oils are to be produced as saleable products. The results of the study, contained herein, will be used by Department of Regional Economic Expansion personnel to determine the opportunities for manufacturing metallurgical coke in Nova Scotia for the world export market.

The study has been prepared in a very limited time period and, accordingly, it has been necessary to maximize the utilization of in-house work developed for prior feasibility and engineering studies. In this regard, Dr. C. Otto & Comp. GmbH of Bochum, West Germany, has provided information based on their proprietary coke ovens and auxiliary equipment. The facility complement described herein reflects the Dr. C. Otto design.

All references to tons in this report mean metric tons of 2205 pounds. All references to dollars in this report mean Canadian dollars.

Terms of Reference

"The work to be performed by the Contractor is as follows:

1. The study to assume that coke facilities will be a free standing plant, i.e. greenfield site.

2. Soil conditions to be based on those known for Sydney, Nova Scotia.

3. Construction and operating cost estimates will be provided for a conventional type plant, e.g. incorporating wet quenching (for both 1M and 2M metric ton sizes). Based on the above, a differential analysis will be provided assuming dry quenching techniques.

   The differential analysis will, as a minimum, provide the cost differences in percentage terms between the plant incorporating wet quenching (for both 1 and 2M metric ton sizes), however, the contractor will make a best effort to provide the differential analysis in dollar terms as well. The contractor's report will also contain a description of preheating and pipeline charging processes and how they might be applied in the subject plant.

4. Study will be based on approximately 75% DEVCO high volatile coal and approximately 25% low volatile coal from either Virginia, U.S.A. or British Columbia. The coke of specifications of 55 to 60 stability, 0.7% sulfur and 8 to 9% ash, will, in essence, determine the coal blend(s). As far as possible use of DEVCO coal will be maximized.

5. Accuracy of the estimates will be at least ± 35%.

6. For this study, starting point will be a car dumper to receive DEVCO coal in rail cars, and dock side equipment to receive low and medium volatile coal.

7. Coke plant will include coal preparation coke (about 6 meter) ovens, minimal by-product plant, shipping facilities (rail, barge and ships), maintenance shops, offices, storage facilities.

8. Storage facilities will be sufficient to hold 30-day inventory of DEVCO (high volatile) coal, 90-day inventory of low and medium volatile coal as well as of manufactured products, e.g. coke, tar, light oils, ammonia and sulfur.

9. Engineering estimates would include an estimate of equipment which will be required to transfer surplus coke oven gases to a purchaser at battery limits.

10. Capital cost breakdown, among other things, should clearly list equipment and its cost related to pollution abatement requirement. The study should also discuss cost and effectiveness of the various pollution abatement alternatives.

11. Study will incorporate the current U.S. pollution control requirements (OSHA and EPA). A summary of these requirements will be provided.

12. Imported items will be identified, and Canadian/Non-Canadian costs will be shown. (Where possible indicating Customs and Excise duty, federal and Nova Scotia sales tax.)

13. The Study will explicitly state the kind of dollars (nominal, current or otherwise) in its reports.

14. The Study, wherever possible, would indicate prices in both Canadian and U.S. dollars.

15. Real estate cost - land and improvements - should be separately identified for each plant size.

16. The study data will be arrayed in a manner that can be readily utilized for Departmental economic and financial analysis.

17. Construction labor requirements to be identified by craft and by year, based on Hamilton, Ontario rates and productivity.

18. A factor of 1.35 will be applied to Hamilton manhours to reflect construction efficiency at the proposed site.

19. Contractor will provide a complete description of the nature and size of all infrastructure requirements relating to the two plants. The infrastructure would include, among other things, dock and wharf, water and power to plant site and other facilities viewed as a part of requisite infrastructure for such a facility.

20. Material flow sheets will be prepared but no engineering drawings will be provided."

II. SUMMARY

GENERAL

The basic purpose for this study is to define a coke plant facilities to produce 2,000,000 tons of merchant coke per year from indigenous high volatile and imported low volatile coking coals. The results of the study will be used by Department of Regional Economic Expansion personnel to determine the opportunities for manufacturing metallurgical coke in Nova Scotia for the world export market.

FACILITIES

The facilities required in order to produce 2,000,000 tons of coke will consist of 2 units of 90 ovens of 6.5 meter size with the necessary complement of oven machinery.

Minimal by-product facilities are provided to recover tar, light oil, anhydrous ammonia, sulfur and the coke oven gas. In this case the excess coke oven gas is available for sale to a user such as a power plant.

The description of the facilities is based on a conventional coke plant, if preheating and hot charging are desired the investment costs are of the same order of magnitude.

The coal storage facilities are based on the sizes requested by DREE.

Coal can be received by rail or by sea and handled at the rate of 2,000 tons per hour. The coal will be crushed into separate stock-bins, mixed and conveyed to the coke batteries.

The coke, after quenching is screened to remove the breeze; thereafter the facilities consist of stockpiles to hold three months quantities of coke and of coke breeze. Recovery systems will deliver 2,000 tons per hour to dockside loading of ships or railway cars for export or Canadian use.

CAPITAL COSTS

The following table indicates the dispersal of the Capital Cost of approximately $330.8 million.

	Million $	
Materials & machinery of Canadian manufacture	143.8	
Construction labour wages	90.0	
Other field expenses, professional expenses & fee	42.5	
Land purchase	2.0	
Total Canadian $		278.3
Purchases of foreign refractory bricks and machinery	37.9	
Other field costs professional services & fee	14.6	
Total Canadian $ required to be spent on foreign resources		52.5
		330.8

Some reduction in the estimated capital cost may be obtained by decreasing the size of the by-product or coke products storage facilities below 90 days. This could only be ascertained by further studies relating such costs against various sized facilities to obtain an optimum.

Approximately $4 million has been calculated for purchases of railway locomotives and rolling stock and for heavy front-end loader equipment.

No allowance has been made for docking and quay-side dredging or similar works.

It is estimated that from the date of a contract being awarded approximately three years would be required to complete the assignment. Approximately, 80% of the construction labour hours and 85% of the material costs would be spent in the second and third years.

OPERATING COSTS

Operating costs have been provided for the cost of coke in the form of unit quantities and/or dollar values and credits have been alloted for by-products.

The estimated manpower requirements for the plant is 395 people.

SECTION III

III. DESCRIPTION OF FACILITIES

a. INTRODUCTION

The facilities described herein will produce 2,000,000 tons of metallurgical quality coke per year. The facility complement includes coal unloading and handling equipment, stocking and reclaiming facilities, coke oven battery, by-products plant, product storage and shipping facilities. The installation, as conceived, will produce merchant products at a "greenfield" location.

For the purposes of this study, a mix of 75% high volatile and 25% low volatile coals has been assumed. The high volatile requirement will be met by indigenous DEVCO coals from Cape Breton Island. Pocahantas #3, from the state of West Virginia, U.S.A., has been assumed to meet the low volatile requirement. Pocahantas #3 is the world standard for low volatile, by-product, metallurgical coal. Representative analyses for these coals are as follows:

	Devco	Pocahantas #3
Ash	4.1%	4.0%
Volatile Matter	33.9%	17.0%
Fixed Carbon	62.0%	76.0%
Sulfur	1.25%	0.5%
Gross Calorific Value	8190 KCal/kg	8120 KCal/kg

While the 75-25 mix would be adjusted in actual practice to maximize the utilization of the indigenous DEVCO coal so as to minimize the amount of the higher cost low volatile coal to be imported, the assumed mix meets the requirements for reasonability for study purposes.

The coal mix and the selected carbonization facilities will produce a metallurgical grade coke of the following approximate analysis:

Volatile Matter	0.7	-	1.2%
Fixed Carbon	90.0	-	92.0%
Ash	5.0	-	7.0%
Sulfur	0.8	-	0.9%
Moisture	3.0	-	5.0%
Stability	55.0	-	60.0%
Hardness	64.0	-	68.0%

Provisions are made for receiving in-bound coal and shipping coke by rail or by water. Secondary products, i.e. tar, anhydrous ammonia, light oils and elemental sulfur, will be shipped by rail, road or sea. Coke oven gas with a heating value of approximately 4450 kcal/cubic meter is piped to the boundary limits for off-site consumption by others.

The coke oven gas is expected to have the following analysis:

		%, by volume
Hydrogen,	- H_2	55
Methane	- CH_4	28
Carbon Monoxide	- CO	6
Nitrogen	- N_2	4

The facility complement is described on the following pages.

The coal mix and the selected carbonization facilities will produce a metallurgical grade coke of the following approximate analysis:

Volatile Matter	0.7 - 1.2%
Fixed Carbon	90.0 - 92.0%
Ash	8.0 - 9.0%
Sulfur	0.7%
Moisture	3.0 - 5.0%
Stability	55.0 - 60.0%
Hardness	64.0 - 68.0%

Provisions are made for receiving in-bound coal and shipping coke by rail or by water. Secondary products, i.e. tar, anhydrous ammonia, light oils and elemental sulfur, will be shipped by rail or truck. Coke oven gas with a heating value of approximately 4450 kcal/cubic meter is piped to the boundary limits for off-site consumption by others.

The facility complement is described on the following pages.

b. MATERIAL HANDLING

COAL STOCKPILES

Coal will be imported by ships which have their own unloading equipment. Receiving bins at dockside and transfer conveyors will transport this coal at the rate of 2,000 tons per hour to a 192,000 ton stockpile. This is the amount required for 90 days' operations of the coke plant.

Coal can also be received by rail and unloaded with a car dumper capable of handling 100 ton coal cars, as unit trains. This stockpile also for 192,000 tons of local coal is required for 30 days' operations. The radial stacker is shared by the two operations.

COAL RECOVERY, CRUSHING & MIXING

The coals are recovered by an underground conveyor system to feed a coal impactor at the rate of 800 tons per hour. This impactor will reduce the coal size to all minus 18 mm and 80% minus 3 mm. Stockbins will separately hold the crushed coals which will be mixed and conveyed to the coal header bins; storage for 2,000 tons.

COKE STOCKPILES

The quenched coke is screened to remove minus 20 mm coke breeze. These fines and the coke product are conveyed to 90 day stockpiles.

The coke stockpile will hold 500,000 tons and recovery will be made by two conveyor systems in tunnels which supply an inclined conveyor for shipment at 2,000 tons per hour.

At the dockside a shiploader will feed coke at the rate of 2,000 tons per hour. It will be partially mobile and the coke will be protected from breakage by adequate retractable feeding downcomers.

BREEZE STOCKPILE

The breeze stockpile will hold 35,000 tons.

The breeze will normally be shipped by rail although recovery conveyors will be linked to the coke shiploader for 2,000 tons per hour loading of breeze to barges or ships.

BY-PRODUCTS

The ammonia, sulfur, light oils and tar products will be sold and transported by road or rail, or as was recently requested by DREE, by sea.

COKE OVEN GAS

Coke oven gas will be transferred by a pipeline for consumption by a local power plant.

c. BATTERIES

GENERAL

The plant will consist of two batteries of 90 nominal 6.5 meter ovens with three sets of oven machinery and one by-product plant.

The ovens will be designed to produce approximately 2,000,000 metric tons of sized blast furnace coke (+20 mm) per year at 25 mm coking rate. Provisions for future installation of coal preheating will be included.

The batteries will consist of 180 underjet ovens for underfiring with coke oven gas.

The general cold dimensions of the ovens are approximately as follows:

Width

Oven Chamber, average	470 mm
Oven Chamber, pusher side	430 mm
Oven Chamber, coke side	500 mm
Center to Center of Ovens	1,350 mm
Oven Taper	75 mm

Length

Inside of Oven Door Lining	14,720 mm
Face to Face of Brickwork	15,480 mm
Inside of Regenerators	14,730 mm

Height

Oven Sole to Oven Roof	6,750	mm
Oven Roof to Top of Battery (Average)	1,390	mm
Oven Pad to Oven Sole	5,280	mm
Oven Pad to Top of Battery	13,450	mm

Capacity Figures

Hot Volume	43.2	m^3
Bulk Density of Coal (Wet)	800	kg/m^3
Metric Tons per Charge	34.6	t

BATTERY FOUNDATIONS AND SUBSTRUCTURE

The battery substructure consisting of the bottom slab, the nozzle decking supports and girders, the nozzle decking and the angular retaining wall. The foundations for pusher machine track and the quench car track.

WASTE GAS FLUE, STACK FLUE, BATTERY STACK

The waste gas flue running along the coke side of the battery and the two stack flues will be from heavy-duty reinforced concrete with a 50 mm thick lining inside.

The battery stack will consist of the outer reinforced concrete column and the full height self-supporting independent brick lining.

REFRACTORY OVEN BLOCK

The refractory oven block rests on the reinforced concrete nozzle decking between the reinforced concrete pinion walls. It consists of the sole flues, the regenerators with the checkers, the heating walls forming the oven chambers, and the oven roof.

The refractory materials used are fireclay for the sole flues, the lower regenerator courses, and the checkers, silica for the upper regenerator courses, high density silica for the heating walls, silica for the lower oven roof courses, and fireclay for the upper oven roof courses.

The oven top is covered with special concrete slabs.

The oven top slopes from the battery axis to both sides.

OVEN BRACINGS

The longitudinal bracing with all necessary connections.

The upper cross bracing consisting of tie rods for each oven wall.

The oven top bracing.

The lower cross bracing consisting of tie rods for each oven wall.

The buckstay girders for fastening the buckstays at the concrete columns on coke and pusher side.

The buckstays for coke and pusher sides of wide flanged beams.

The wall protection plates behind the buckstays.

The regenerator bracing.

The additional bracing under the benches.

The bracing below the oven sole.

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BENCHES AND PLATFORMS

The coke and pusher side benches will be structural steel construction. They will be filled with rammed concrete between the top girders and also have a course of hard burned red brick paving.

The end and intermediate platforms will be structural steel construction with reinforced concrete slabs.

OVEN DOORS AND FRAMES

The door frames will be from ductile iron and have a square cross section. The doors will be self-sealing type coke oven doors consisting of the heat-resistant ductile iron box-type door body, the special fused silica door plugs, the two spring-loaded latch gears, the NICUTE sealing strips.

The pusher side doors will be equipped with leveler doors.

HEATING SYSTEM

The coke oven gas supply main from the by-product plant to and within the battery area with the steam heated gas preheaters.

The coke oven gas distribution main along the battery.

The pipe connections between the distribution main and the coke oven gas headers with shut-off cocks and reversing cocks.

The coke oven gas headers, including the riser pipes and the coke oven gas nozzles.

The decarbonizing air system with two heavy-duty fans, the air headers and the connection pipes to the reversing cocks.

REVERSING SYSTEM

The hydraulic reversing winch with rods, chains, sprockets, brackets, etc. for operating the waste gas valves, air flaps at the air inlet boxes and the coke oven gas reversing cocks.

GAS COLLECTION SYSTEM

Each battery will be equipped with refractory-lined standpipes on coke and pusher side with elbows and collecting main valves with flushing liquor spray nozzles and steam jet. Each battery of 90 ovens will have two collecting mains with two off-take mains on the pusher side and two collecting mains and two crossover mains on the coke side. The collecting mains will be equipped with liquor sprays and remote controlled liquor sealed bleeders.

The two crossover mains convey the gas from the coke side collecting mains to the pusher side off-take mains, at each battery.

The off-take mains run across the pusher machine tracks to the suction main.

The suction main runs along the battery and to the primary coolers.

OVEN TRACKS

The tracks for pusher machine, the coal charging car and the coke guide/ door machine extended over the battery ends to allow parking of a second machine. The quench car track between quench station and coke wharf, including turnout for parking of a second quench car.

DOOR RACKS

Two electrically operated slewable and winch-tiltable door racks on coke and pusher sides of one end platform will be provided, including hoist for each battery. The door service area will be weather-enclosed, heated and lighted.

Four spare door racks for the recesses at the pinion walls and four steel frames at each end and intermediate platforms will be provided.

RAM AND LEVELER BAR CHANGING STATION

A changing station for ram and leveler bar in each end platform.

QUENCH STATION

The quench towers will be of concrete with brick lining inside. They will include a wooden mist suppressor with flushing system. The quench water tanks will be supported on a steel structure of the settling pond.

The settling plants will be from reinforced concrete.

COKE WHARF

The wharves will be approximately 70 meters long each, inside to inside and approximately 11 meters from center line quench car track to center line of the wharf conveyor.

The wharves will be of reinforced concrete and the sloping surfaces lined with hard burned brick pavers.

The trenches will extend the length of the wharfs and beyond to accommodate the plow maintenance platforms and stairways.

Two plows, each capable of reclaiming 200 tons per hour, will be provided for each. One is a standby.

PIPING IN THE BATTERY AREA

The necessary supply piping and connecting piping for flushing liquor, steam, service water and compressed air.

PUSHER MACHINES

Three complete pusher machines. Door removal, door replacing, pushing, automatic door and jamb cleaning, etc., will be performed without respotting. An interlocking system between pusher machine and coke side to ensure proper positioning before pushing.

COKE GUIDE/DOOR MACHINES

Three complete one-spot coke guide/door machines. Door removal and replacing, automatic door and jamb cleaning, coke guide positioning, etc., will be performed without respotting.

COAL CHARGING CARS

Three complete coal charging cars. Charging hole lid removing and replacing, cleaning goosenecks and standpipes, charging, etc., will be performed without respotting.

COKE SIDE EMISSION CONTROL SYSTEM

Two land-based systems for coke side emission control, complete with hood cars, duct along the battery, up to the quench station and on-ground scrubber station.

QUENCH CARS

Two complete one-spot quench cars of the fixed bottom type.

QUENCH LOCOMOTIVES

Two complete quench locomotives about 25 t, standard railroad gauge.

COAL BIN

One coal bin with 2,000 t storage capacity of concrete with 2 bays and 4 outlet hoppers per bay.

At lower levels, offices and facilities for personnel and maintenance services will be provided.

A service elevator will be provided with exit landings at various levels and a charging car track scale.

d. BY-PRODUCTS

PRIMARY COOLERS

Two direct spray-type primary coolers operate in parallel to process the coke oven gas derived from each battery.

Each primary cooler is designed for a volumetrical coke oven gas throughput of 75%.

FLUSHING LIQUOR SYSTEM

Two flushing liquor decanters operate in parallel and handle the returned flushing liquor from each battery.

Each decanter is designed for a 75% flushing liquor throughput, with a retention time of 25 minutes.

AMMONIA LIQUOR TREATMENT PLANT

Gas condensates and process water, which are collected in several intercepting sumps adjacent to the respective process units, are processed through the ammonia stills. Caustic soda is injected into the stills for proper control of the pH value of the treated effluent and to release the fixed ammonia compounds.

The vapors derived from the ammonia stills, which include besides ammonia also other strippable organic and inorganic compounds, are recycled for further processing into the coke oven gas.

EXHAUSTER

The exhausters are designed to draw off the gas from the Coke Oven Batteries. They provide sufficient positive pressure to deliver the gas through the by-product plant and to transfer the appropriate quantity of cleaned gas for underfiring back to the Coke Oven Batteries.

Exhauster drivers are back pressure steam turbines. The exhaust steam will be utilized in several sections of the by-product plant either for heating and/or stripping purposes.

ELECTROSTATIC TAR PRECIPITATOR

The two electrostatic tar precipitators operate in parallel and are designed for a tar removal efficiency of 98% under normal operating conditions.

PHOSAM PLANT

The ammonia absorbed from the coke oven gas by an ammonium phosphate solution, with subsequent steam stripping and condensation of the ammonia vapors. The aqua ammonia condensate is then fractionated to yield a high purity anhydrous ammonia.

FINAL GAS COOLER

Process heat generated by the Phosam Plant is removed in the final gas cooler. The gas is cooled to the lowest possible temperature in order to improve the light oil absorption efficiency in the subsequent Light Oil Plant.

LIGHT OIL PLANT

Light oil is removed in an absorption/stripping operation by means of mineral wash oil.

The product of the plant is a light oil mixture comprising mainly of benzene, toluene, xylene and some solvent naphtha fractions.

STRETFORD PLANT

Hydrogen sulfide is selectively absorbed from the coke oven gas by an aqueous sodium carbonate solution with subsequent oxidation to elemental sulfur.

Formation of fixed cyan-sulfur compounds within the Stretford Plant is reduced by processing the coke oven gas through an HCN-Removal Section prior to the Stretford Plant.

The blowdown quantities from the HCN-Removal Section and the Stretford Plant are treated in a Waste Liquor Incineration System. The vapors and the condensates derived from the incineration are recycled to the Stretford Plant.

GAS HOLDER AND FLARE STACK

After being processed through the by-product plant, the gas enters the gas distribution system where it is divided into a stream to the **Batteries.** for coke oven underfiring and a stream to the consumers.

To avoid surges in the coke gas distribution system, a gas holder is installed serving as a buffer tank.

A gas flare stack is provided to release into the atmosphere and ignite any excess gas from the gas system.

WASTE WATER TREATMENT

Waste water treatment facilities have been provided for a by-product coke plant producing approximately 6000 tons per day.

e. INFRASTRUCTURE

The following facilities or items represent some of the known infrastructure requirements. When a specific location is selected others may exist.

a. a dock approximately 400 meters long
b. water - potable 92 m^3/day
  - industrial 85,000 m^3/day
c. electric power - 140,000 kwh/day
d. access roads for cars and trucks to the battery limits of the plant
e. railroad tracks to battery limits

Some of the infrastructure items such as water, power, railroads, etc. may become a part of the rate structure.

f. BUILDINGS - MISCELLANEOUS

Buildings and equipment have been provided for an administrative office, maintenance shops, a laboratory and a warehouse.

SECTION IV

IV CAPITAL COSTS

This section of the report presents the capital cost requirements for the construction of a coke and by-product plant for the production of 2,000,000 tons of coke per year and other associated costs. The estimates are shown as current costs (3rd quarter 1978). The accuracy of the estimate is at least ± 35 percent.

INCLUSIONS

The estimates include the cost of equipment and material, engineering, purchasing, field supervision, and construction labor, tools and equipment required for construction, and overhead charges incurred during construction.

Moneys have been included for nominal site preparation, land costs and taxes.

EXCLUSIONS

No provisions have been made for infrastructure items, such as dock, harbor dredging and breakwall, if required, water or power supply to the battery limits, roads or railroads to the battery limits.

Escalation has not been included.

TOTAL CONSTRUCTION COST

The total constructed cost for the plant is $330,800.
This includes mechanical and electrical spares, amounting to $3,500,000.

The shipping expenses are estimated at 1-1/2% of the equipment and material costs.

A breakdown of this estimate follows:

TABLE IV-1

CAPITAL COSTS

(Thousands of Canadian Dollars)

	Domestic Supply	Foreign Supply	Total
Batteries			
Equipment			
Refractory	-	36,600	36,600
Oven Machinery	13,400	1,200	14,600
Castings	13,200	-	13,200
Other Equipment	4,300	-	4,300
Materials	26,600	-	26,600
Sub-contract Materials	13,500	-	13,500
Field Costs	62,700	2,300	65,000
Professional Services & Fees	7,200	7,600	14,800
Total Batteries	140,900	47,700	188,600
By-Products			
Equipment	13,600	-	13,600
Materials	13,600	-	13,600
Sub-contract Materials	18,800	-	18,800
Field Costs	36,300	600	36,900
Professional Services & Fees	4,100	4,100	8,200
Total By-Products	86,400	4,700	91,100

Materials Handling

	Domestic Supply	Foreign Supply	Total
Equipment & Materials	23,400	-	23,400
Field Costs	17,500	-	17,500
Professional Services & Fee	4,300	-	4,300
Total Materials Handling	45,200	-	45,200
Land 200 Acres	2,000	-	2,000
Heating up of Batteries	400	-	400
Mechanical & Electrical Spare Parts	3,425	0,075	3,500
Total Plant	278,325	52,475	330,800

Field costs include all field labor and field indirects including construction supervision, temporary construction, construction equipment, small tools, consumables and payroll burdens.

Heating-up of Batteries

The drying out and heating-up to temperature of a new coke battery requires approximately 10 weeks (70 days).

The labor required for this procedure is included in the total manhours requirements but at a greenfield site location oil for the drying and heating functions will have to be purchased.

The cost for the fuel oil and possibly a storage tank, lines, etc., is estimated to be $400,000.

Spending Schedule

The spending schedule as shown below represents the 3 - year project schedule with a carry over into the 4th year for performance guarantees, field charges, deferred charges, etc. This schedule includes the constructed plant, battery heat-up expense, and spare parts.

Year	Million Dollars
1	33.1
2	132.4
3	148.8
4	16.5
	330.8

Project Schedule

It is estimated that the construction schedule for this project would cover a period of about 36 months. This begins with the award of the contract through to start of operations. It is anticipated that the major engineering work, site preparation and some civil work would occur in the first year, with the major construction and erection and the heating-up of the batteries taking place in the next 24 months.

Escalation

The Consultant's reply to DREE's request for a forecast of the escalation rate in the construction industry for the next three years follows:

U.S.A. - 9 percent per year

Canada - 8 percent per year

U. S. Pollution Control Requirements

Regulations (EPA and OSHA)

It should be pointed out that the pollution control requirements vAry from state to state in the U.S.A., as well as from municipality to municipality. In addition, some of the previously approved processes or equipment are not now acceptable. Nevertheless, the facilities provided for this project meet the generally accepted current U.S. pollution control requirements.

A summary of these regulations follow:

a. Environmental Protection Agency (Federal) Iron and Steel Manufacturing Point Source Category - Effluent Guidelines and Standards, Volume 39, Number 126, dated 6-28-74. Subpart A - By-product Coke Subcategory 420.10 describe, define and establish guidelines.

b. State E.P.A. Regulations: (Typical Example) State of Illinois Pollution Control Board AR Pollution Regulations, Rules 202 and 203(d)(6), Part II.

c. Municipal E.P.A. Regulations: (Typical Example) Environmental Control Ordinance, Chapter 17 of the Municipal Code of the City of Chicago, Section 17-2.3 and 17-2.4.

d. OSHA Regulation (Federal Register): Department of Labor, Occupational Safety and Health Administration, Exposure to Coke Oven Emissions, Part III, Dated 10-22-76 covers:

   Charging Emission
   Pushing Emission
   Employee Exposure

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Quenching Emission

Raw Material Handling Emission

Product Handling Emission

Water and Air Pollution

Equipment and Environmental Noise Control

Estimated Costs Related to Pollution Abatement Requirements

Description	Dollars
Second Gas Collecting Main	300,000
Larry Car Equipment	200,000
Steam Aspiration	500,000
Door Machine Enclosure	100,000
Coke Side Emission System	9,000,000
Quench Tower Baffles	200,000
H_2S Removal	17,000,000
Final Effluent Treatment Plant	16,000,000
Conveyors-Dust Collection	500,000
Total	43,800,000

TRAINING

The consultant recommends that an allowance be provided for the recruiting and training of personnel as this is a greenfield site concept. Furthermore, experienced personnel would require some retraining to effectively operate the proposed modern coke and by-product facilities.

A few selected supervisory personnel as well as key operating and maintenance people should be sent to a coke plant with comparable equipment for training.

A training period of approximately three months is envisioned and is estimated to cost $350,000 to $400,000 for salaries, travel, living expenses and training fees.

TECHNICAL AND OPERATING ASSISTANCE

It is recommended that provisions be made for technical and operating assistance during the first year or so of operations. A selected engineering or operating company can provide this type of service.

Specialists would assist in the initial phase of operations in the analysis and solution of technical and operating problems and in attaining satisfactory levels of quality and efficiency.

An estimated cost for these services including salaries, fee, travel and living expenses in Nova Scotia is $150,000 to $200,000.

CONSTRUCTION LABOR, BY CRAFT, BY YEAR

The total estimated construction manhours by craft and by year are shown in Table IV-2. This includes journeymen helpers, apprentices, laborers, etc.

The manhours of labor required to construct the project reflect an adjustment of 1.35 to reflect labor efficiency in the Nova Scotia labor area.

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TABLE IV-2

ESTIMATED MANHOURS, BY CRAFT, BY YEAR

(Thousands of Construction Manhours)

	Year 1	Year 2	Year 3	Total
Boilermakers	10	173	77	260
Bricklayers	8	303	34	345
Carpenters	235	205	150	590
Electricians	24	250	166	440
Ironworkers	150	240	220	610
Millwrights	90	160	120	370
Operating Engineer	70	70	60	200
Teamsters	12	15	8	35
Pipefitters	175	360	335	870
Laborers	220	300	220	740
Misc. Crafts	12	14	14	40
Total	1,006	2,090	1,404	4,500

V. OPERATING COSTS

General

This section concerns the development of operating costs for coke. Pertinent data relative to production volumes, yields, unit costs, labor requirements, etc. are presented herein.

Production Volume and Operating Schedule

The proposed facilities are sized to provide capacity for producing approximately 2,000,000 tons of sized coke annually.

The coke plant operations are scheduled to work 365 days per year.

The production rates and yields used in the configuration represent reasonable and attainable operations.

a) Yield:

Coal to sized coke	65 percent

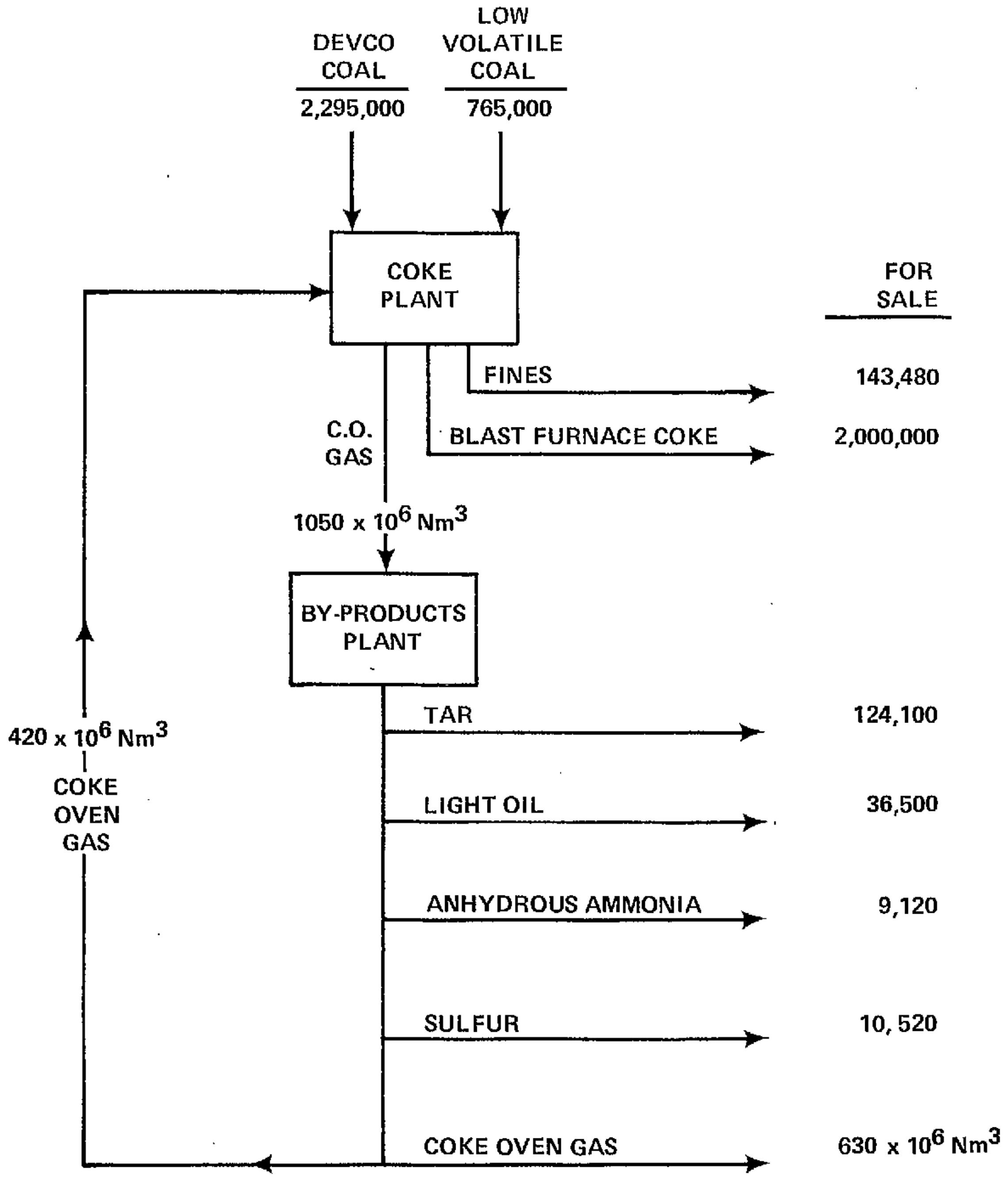
b) Approximate quantity of by-products recovered per ton of coal charged:

Coke oven gas	340 Nm^3
Tar	35 liters
Light oil	13 liters
Anhydrous ammonia	3 kg
Sulfur	3.5 kg

A material flow chart is shown on the following page.

MATERIAL FLOW CHART

(METRIC TONS PER YEAR–
EXCEPT AS INDICATED)



It is forecast that in the start-up year of operations approximately 80 percent of capacity will be attained. In the second year, production should be at the projected level of 2,000,000 tons.

Basic Unit Costs

The unit costs shown below represent data provided by DREE and by data developed by McKee. Other unit costs, as required for the economic analysis, will be developed by DREE.

Description	Unit	Dollars Per Unit	Source
Coal - DEVCO (H.V.)	Ton		DREE
- Low Volatile	Ton		DREE
Coke Fines	Ton		DREE
Coke Oven Gas	10^6 kcal	8.00[2]	McKee
Tar	Ton	130.00	McKee
Light Oil	Ton	145.00	McKee
Sulfur	Ton	25.00	McKee
Anhydrous Ammonia	Ton	125.00	McKee
Electric Power	kwh	.04	McKee
Water	m^3	.065	McKee
Labor, average including fringe benefits, etc.[1]	Manhour	9.05	DREE
Salaried, average including fringe benefits, etc.	Manhour	12.50	McKee

[1] Basic Wage Rate (average) $6.85

Fringe Benefits

- Unemployment insurance, Canadian pension, Company pension, group insurance, medical	22.0%
- Workmen's Compensation	2.1%
- Vacation and holiday pay	8.0%
Total Fringe	32.1%

[2] Based on cost of fuel oil at $13.00 per barrel.

Estimated Operating Costs

The estimated operating costs are based on costs reflective of coke plants similar in size to this module.

The operating costs include the cost of raw materials (in this case the unit quantities to be provided by McKee) and the other items of expense such as labor, fuel, utilities, maintenance materials, supplies (consumables such as lubricants, by-product chemicals, etc.), and miscellaneous office and sales expense.

Credits are given for the various by-products derived from the coking process.

Start-Up Operating Costs

McKee recommends that the standard operating costs as shown on Table V-1 be adjusted by 25 percent in the first year to recognize the impact of the "learning curve" with its lower operating performances, lower yields and higher spending rates during the first year of operations. This is the natural and unavoidable consequence of breaking in new equipment, processing problems, and the learning period for operating personnel in addition to lower productivity.

Manpower Requirements

A summary of the manpower requirements for the 2,000,000 tpy coke plant is shown in Table V-2 .

The personnel have been classified into the following categories:

	CWS Job Classification
Unskilled	1 - 3
Semi-skilled	4 - 9
Skilled	10 and up
Office & Clerical	
Technical	
Management	

Examples of occupations included in the various classification categories follow:

J.C. 1 - 3	Laborer, Janitor
J.C. 4 - 9	Helpers, Lidman, Coke Loader, Light Oil Operator, Sampler
J.C. 10 and up	Heater, Pusher Operator, Exhauster Engineer, Maintenance Tradesmen
Office & Clerical	Secretaries, Accounting Clerks, Clerk Typists
Technical	Engineer, Draftsman, Computer Operator
Management	Manager, Foreman

Table V-3 presents the labor force by classification by department.

TABLE V-1

OPERATING COSTS

Operation: Coke Plant

Product: Screened Coke

Description	Quantity	Unit	Dollars Per Unit	Dollars Per Ton
Materials				
Low Volatile Coal	0.382	Ton		
High Volatile Coal	1.148	Ton		
Total Material Costs				
Credits				
Coke Fines	0.072	Ton		
Coke Oven Gas	2.340	10^6 kcal	8.00	(18.72)
Tar	0.062	Ton	130.00	(8.06)
Light Oil	0.018	Ton	145.00	(2.61)
Sulfur	0.005	Ton	25.00	(.13)
Anhydrous Ammonia	0.004	Ton	125.00	(.50)
Total Credits				
Net Material Costs				
Other				
Labor, Supervision, Clerical				3.85
Fuel (coke oven gas)	.94	10^6 kcal	8.00	7.52
Utilities				
- Electricity	25.00	kwh	.04	1.00
- Steam	.23	Ton	8.25	1.90
- Water	15.50	m^3	.065	1.00
Maintenance Materials				2.00
Supplies (Consumables)				1.00
Miscellaneous Office & Sales Expense				.60
Total Other				18.87
Total Cost - Screened Coke				

TABLE V-2

SUMMARY OF MANPOWER REQUIREMENTS

		2.0 MMTPY
1.0	Executive	6
2.0	Accounting, Storeroom	31
3.0	Engineering	7
4.0	Industrial Relations, Plant Protection	24
5.0	Quality Control	8
6.0	Purchasing, Traffic, Raw Material	4
7.0	Marketing (Sales)	10
8.0	Coke Plant Management	39
9.0	Docks, Storage Yard, Coal and Coke Handling	45
10.0	Batteries	88
11.0	By-Products	20
12.0	Assigned Maintenance	57
13.0	Shop Maintenance	36
14.0	Services	15
15.0	Utilities	5
	TOTAL	395

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TABLE V-3

MANPOWER REQUIREMENTS BY CLASSIFICATION

Department	Unskilled	Semi-Skilled	Skilled	Clerical	Technical	Management	Total
Executive & Administrative, etc.	5	18	6	25	20	16	90
Plant Management, Production and Maintenance	-	-	-	4	-	35	39
Docks, Storage Yard, Coal and Coke Handling	12	27	6	-	-	-	45
Batteries	21	29	38	-	-	-	88
By-Products	3	8	9	-	-	-	20
Maintenance and Shops	13	31	49	-	-	-	93
Service and Utilities	10	5	5	-	-	-	20
TOTALS	64	118	113	29	20	51	395

VI. PREHEATING AND CHARGING OF PREHEATED COALS

General

The preheating and hot charging of coking coals into coking ovens is a recent addition to coke plant technology. The basic underlying premise is that when coals are externally heated to a temperature of 260°C, all of the moisture is driven off prior to charging and the time required in the capital intensive coke ovens is significantly reduced. Depending upon the coal used, reductions in coking time and, hence, increases in production rates are reported to be on the order of 35 to 50%.

The removal of the moisture results in a significantly higher bulk density than can be achieved with the conventional untamped method of wet coal charging. The effective result of this factor is that medium volatile coals can be substituted for the low volatile portion or, if the same coals are utilized, a larger percentage of high volatile coals can be charged. The results of existing commercial installations are difficult to assess due to the wide variety of coal mixes charged in different coke plants.

All operators agree, however, that there are advantages to preheating. In addition to those previously mentioned, the higher and more evenly distributed bulk density of the preheated coal produces a more consistent and, in general, a better quality metallurgical coke. Appreciable increases in coke stability have been noted when a given coal mix is subjected to preheating prior to carbonization compared to conventional wet charging. The improvement in coke quality varies according to the rank of coal being carbonized to the extent that the magnitude of improvement is greater for the lower grade coking coals. In general, the abrasion resistance of coke will show improvement. In many cases it is this factor of coke quality improvement which might make the preheating system attractive, especially when lower cost coals could not otherwise be used.

The thermal shock to the oven chamber brickwork is considerably reduced and should, therefore, give a longer battery life expectancy.

The self-leveling nature of preheated coal eliminates the possible pollution source of an open leveler door and reduces the duty cycle of the ram machines.

In general, preheating has little effect on yield or composition of gas and by-products, except predictably, the quantity of ammoniacal liquor is appreciably reduced.

Dry, preheated, pulverized coal tends to flow like water. This characteristic greatly facilitates the charging and, as previously pointed out, the leveling functions. There are two principal methods being used today to transfer the preheated coal mix into the ovens, pipeline and gravity charging. In the former method the coal is conveyed under pressure from a storage bin and through a refractory lined circular conduit which runs the length on the charging side of the oven battery. At the appropriate times, valves are manipulated to permit the coal to flow directly into the oven being charged. There are two principal gravity methods being used: one utilizing a "hot car" which transfers one oven charge of preheated mix from metering bins directly to the coke oven, and one utilizing a "hot car" fed by redler conveyors transferring the mix from a storage bin.

The pipeline system claims certain advantages because the coal mix remains totally enclosed during charging, but because of the nature of its admission through the side of the ovens under pressure, the coal must settle of its own weight and some is carried over into the exhaust gases and tar stream. The "hot car" system must include dust collecting systems at transfer points, but because the charge is released downward into the oven by gravity, the charge is more dense and larger charges are possible. The "hot car" also has the flexibility of being able to charge wet coals should the preheater be out of service for any reason. All of the hot charging methods are "clean" by existing pollution guidelines.

Description of Process

There are many proven commercial processes used for dry coals as well as several methods for charging the preheated coal. The following is a brief description of the Coaltek System.

Wet coal is withdrawn from a storage bin by screw conveyors and screened, crushed and discharged to the preheater feed hopper.

Coal from the hopper is fed to the preheater by variable speed screw. The wet coal is fed into a flash-drying entrainment section where it comes into contact with a stream of hot oxygen-free gas. The gas carries the partly dried coal up to a dilute phase fluidized bed. A rotating swing hammer crusher in the lower part of the fluid bed chamber provides rapid dispersion and agitation of the coal particles in the gas stream and breaks the larger pieces into smaller pieces. All preheated coal goes overhead and is recovered in conventional cyclone separators.

Hot coal from the cyclones is conveyed to a hot coal receiving bin. From the receiving bin, the hot coal is conveyed as needed to an elevated measuring bin for transport to the ovens. The coal is conveyed through a pipeline to the ovens whenever an oven is ready. Coal transport in the pipeline is induced by means of steam jets strategically spaced along the pipeline.

Cost Comparison

At the present time, the capital and operating cost differences between preheating and pipeline charging and conventional wet coals with larry car charging are not discernible within the estimating limits of this study.

Of the capital cost items, the higher cost due to the inclusion of the preheating facilities are offset by the reduced number of coking ovens required to produce the same tonnage as conventional wet charge ovens.

The operating costs are similarly related.

The cost of preheating the coal mix is offset by the reduced heating requirements in the subsequent carbonization stage. Manpower requirements and by-product recovery are reasonably the same for either the preheated or the conventional coking systems.

Dry Coke Quenching vs. Wet Quenching

The major advantages of dry cooled coke expressed by proponents of the process are:

1. Utilization of the sensible heat in coke to produce 0.35 Tons of steam at gauge pressure per ton of coke.
2. Improvement in the quality of the coke.
3. Provides coke devoid of moisture, therefore a savings in transportation costs.

Capital Costs

The published quotes for dry coke quenching facilities escalated to current prices, when compared to wet quenching costs appear to require an additional 14 million dollars for a 6,000 ton per day unit.

Operating Costs

It would appear that the dry quenching process would require one additional man per shift to operate the cooling station vs. no operators in a wet quench tower.

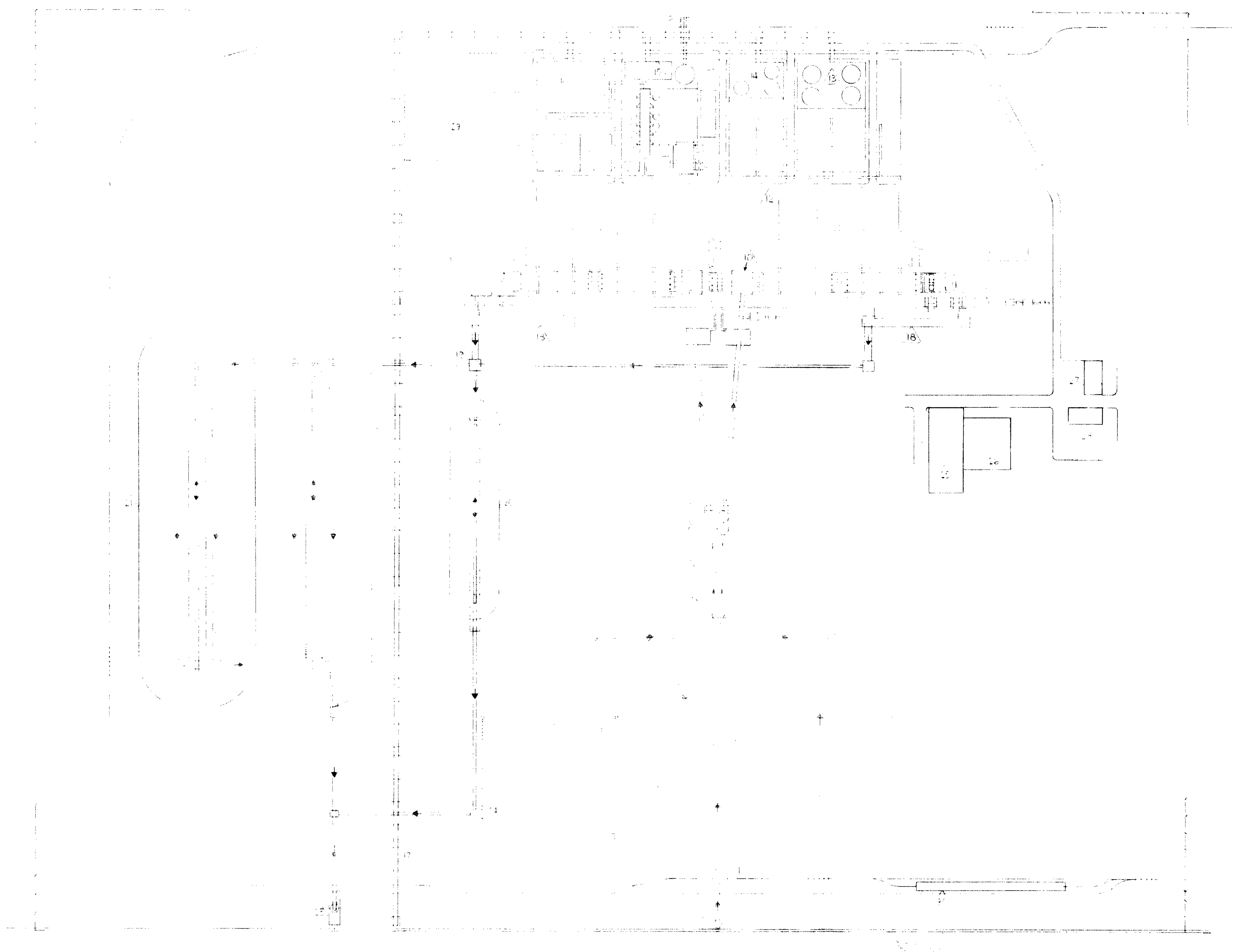
The maintenance costs required in the dry process would be somewhat offset by a reduction in quench car maintenance which is quite high in the wet process.

Both of the above items are relatively small and would increase the operating costs less than 0.4 percent.

The economic justification for the dry quenching process is based on credits derived from savings of fuel, i.e. utilization of the sensible heat of the coke. Dry coke cooling uses practically inert gas, which is recycled through a vertical shaft cooler where the gas is heated and the heat is then transferred via heat exchangers to produce steam or hot pressurized air for hot turbines; or 60 to 70% of the heat can be utilized most economically for coal drying and preheating.

The above credits are only applicable if the steam can be sold or the heat utilized in some manner.

As an example, a current cost for steam is about $8.25 per ton and at 0.35 tons of steam produced per ton of coke a savings in operating costs of about $3.00 could be realized.



ITEM Nº	DESCRIPTION	CAPACITY
1	COAL DUMPER	100 TONNES
2	RADIAL STACKER 100 M RADIUS	
3	STOCKPILE (HIGH VOLATILE)	90 DAYS 100,000 TONNES
4	STOCKPILE (LOW VOLATILE)	90 DAYS 102,000 TONNES
5	RECLAIM CONVEYORS	800 TONNES/HR EACH
6	CRUSHER	300 TONNES/HR
7	CRUSHED COAL STOCK BINS	1,600 TONNES
8	MIXING STATION	
9	[illegible]	
10	COAL HEADER BINS (2 REQUIRED)	[illegible] TONNES EA.
11	COKE OVENS [illegible]	
12	BYPRODUCT PIPING	
13	LIGHT OIL STORAGE	90 DAYS
14	TAR STORAGE	90 DAYS
15	ANHYDROUS AMMONIA STORAGE	90 DAYS
16	SULPHUR STORAGE	90 DAYS
17	PIPE RACK FOR DOCKSIDE (IF REQUIRED)	
18	COKE WHARF	
19	SCREEN HOUSE	
20	COKE BREEZE STOCKPILE	90 DAYS 35,000 TONNES
21	COKE PRODUCT STOCKPILE	90 DAYS 500,000 TONNES
22	DOCKSIDE COAL UNLOADING	
23	DOCKSIDE COKE LOADING	2000 TONNES/HR
24	COKE BREEZE SHIPPING	
25	WORKSHOPS	
26	WAREHOUSE	
27	ADMINISTRATION OFFICES	
28	SECURITY, FIRST AID & CHANGE ROOMS	
29	WASTE WATER TREATMENT PLANT	
30	THAWING SHED	
31	COAL GAS MAIN & LOADING AREA	

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GOVERNMENT OF CANADA
DEPARTMENT OF REGIONAL ECONOMIC EXPANSION

McKee
ENGINEERS AND CONSTRUCTORS
TORONTO, ONTARIO

TITLE
2,000,000 TONNE PER YEAR
COKE PLANT
PLOT PLAN

SCALE 1:2000 B.M. NO.

CCL348A-10-2

NO.	DESCRIPTION	BY	CH.	APPROVED	DATE

DESIGNED / DRAWN / CHECKED / APPROVED 1 / APPROVED 2 / APPROVED 3 — BY / DATE

DATE TO: CLIENT / FIELD

McKee
ENGINEERS AND CONSTRUCTORS