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Air Pollution Emissions and Control Technology. Metallurgical Coke Manufacturing Industry

Economic and Technical Review
Report EPS 3-AP-74-6

ir Pollution
l Directorate
nber 1974

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AIR POLLUTION EMISSIONS AND CONTROL TECHNOLOGY
METALLURGICAL COKE MANUFACTURING INDUSTRY

by

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Air Pollution Control Directorate

Report EPS 3-AP-74-6

November 1974

ABSTRACT

This study was initiated to evaluate the current and future contributions to air pollution by the Canadian metallurgical coke manufacturing industry and to assess the technology available to control these air pollution emissions. Actual atmospheric emissions of particulate matter from the production of metallurgical coke in Canada during 1972 were 8863 tons and estimated emissions for 1975 are 8816 tons. Emissions of sulphur dioxide to the atmosphere from the consumption of coke oven gas produced in metallurgical coke manufacturing during 1972 were 19 556 tons and estimated emissions for 1975 are 26 093 tons.

Virtually all coking coal consumption in Canada is directly related to the primary production of iron and steel. Indeed, the four largest coke manufacturing plants, producing over 90% of the total Canadian coke, are owned and operated by integrated steel companies which not only utilize the coke in blast furnaces but also use the associated coke oven gas in several operations throughout the steel complex. Metallurgical coke manufacturing is, therefore, directly geared to the industrial growth of the Canadian economy. Most of the coke-making plants in Canada are located in industrial or residential communities. This situation has persuaded these plants to endeavor to reduce particulate and sulphur dioxide emissions to acceptable levels. Their effort has demonstrated that application of best practicable technology will result in control of emissions sufficient to satisfy regulatory limits being considered by government agencies. This report serves to provide background information for use in establishing National Emission Guidelines, as set forth in Section 8 of the Clean Air Act, for the Canadian metallurgical coke manufacturing industry.

Increases in production planned for 1975 amount to 24% of the total coke produced by the industry in 1972. To achieve this aim, some integrated steel companies will upgrade their coke-making plants to peak capacities and others will add new facilities. Installation of pollution control equipment and changes in operating practice or technology scheduled by the Canadian coke-making industry for 1975 and beyond should reduce particulate and sulphur dioxide emissions from this industry to a small fraction of the total now emitted by industrial sources.

RÉSUMÉ

La présenté étude a été entreprise afin d'évaluer la part actuelle et future de la pollution atmosphérique au Canada, attribuable à l'industrie manufacturière de coke métallurgique, ainsi que les techniques anti-pollution disponibles. En 1972, l'industrie canadienne du coke métallurgique a émis 8,863 tonnes de particules à l'atmosphère, et les estimations pour 1975 sont de 8,816 tonnes. Pour ce qui est des émissions de dioxyde de soufre attribuables à la consommation des gaz des fours à coke métallurgique, elles ont été de 19,556 tonnes en 1972, et seront vraisemblablement de 26,093 tonnes en 1975.

Presque toute la consommation du charbon à coke, au Canada, est directement reliée à la production primaire du fer et de l'acier. En effet, les quatre plus grosses installations productrices de coke (plus de 90% de tout le coke au Canada) appartiennent à des aciéries intégrées qui n'utilisent pas seulement le coke dans leurs hauts fourneaux mais, de plus, utilisent les gaz produits par les fours à coke pour plusieurs opérations, dans l'ensemble du complexe. La production du coke métallurgique est par conséquent directement liée à la croissance industrielle du Canada. Dans ce pays, la plupart des fours à coke sont situés dans des centres industriels ou résidentiels. Cet état de chose fait que les responsables de ces installations s'efforcent de réduire les émissions de particules et de dioxyde de soufre à des niveaux acceptables. Leur effort a montré que l'utilisation des meilleures techniques praticables permet de réduire les émissions de façon à respecter les limites proposées par les organismes de réglementation du gouvernement. Le présent rapport renferme des renseignements de base qui serviront à l'élaboration de normes nationales pour les émissions à l'intention des fours à coke métallurgique, tel que spécifié à l'article 8 de la Loi sur la lutte contre la pollution atmosphérique.

L'accroissement de la production prévu pour 1975 est de 24% par rapport à 1972. Pour atteindre cet objectif, certaines aciéries intégrées vont augmenter leur production à des niveaux jamais atteints tandis que d'autres vont ajouter d'autres installations à celles qui existent déjà. L'aménagement de matériel anti-pollution et des changements dans le mode opératiore ou dans la technologie, à compter de 1975, devraient réduire les émissions de particules et de dioxyde de soufre de cette industrie à une petite fraction de la quantité actuelle émise par les sources industrielles.

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1 INTRODUCTION

1.1 Scope

This study pertains to air pollution control in the metallurgical coke manufacturing industry during the base year 1972 with changes projected to 1975. Size and location of plants, relative importance of the industry to the Canadian economy, and process and emission control technology are discussed. Results from a national emission inventory and relevant air quality objectives are included.

1.2 Purpose

The primary purpose of this report is to provide the necessary technical information for the preparation of emission guidelines for the Canadian metallurgical coke manufacturing industry. The information has been assembled to enable assessment of the impact of emission control on the ambient air in the vicinity of coke-making plants. These data can then be used to develop an overall plan to protect the Canadian public at large as required by the Clean Air Act of 1971. For this purpose, a metallurgical coke manufacturing plant is defined as a stationary source, subject to both national emission standards and guidelines that may be published by the Governor in Council. Guidelines regarding emissions from coke-making plants have evolved from information given in this report and from reports and studies oriented towards the socio-economic aspects of the industry. Provinces are encouraged to adopt the federal guidelines as their minimum standards, but in some cases they may enact stricter regulations because of situations that have significantly higher pollution potential due to predominantly different atmospheric conditions, geographic differences or areas of high industrial activity.

1.3 Information Sources

A computer search of the literature was conducted by the National Science Library and the Environmental Protection Agency (EPA) of the United States. Copies of original papers were acquired through the reference section of the library of the Department of the Environment. Articles issued in the most recent trade literature were also reviewed. Various books on coke-making technology were used as a general source of information (1,2,3). Personal contacts were established with the following Departments of the Federal Government: Energy, Mines, and Resources; Industry, Trade, and Commerce; Statistics Canada; and with members of the National Research Council of Canada.

A draft questionnaire, prepared by the Abatement and Compliance Branch, was given to Statistics Canada, provincial regulatory agencies and Environmental Protection Service Regional Offices across Canada for review and comments. Discussions also took place with representatives of Canadian coke-making plants before final revisions were made. Approval was then given by the Air Pollution Control Directorate to distribute the questionnaire to the metallurgical coke manufacturing industry. Copies available in English and French were mailed to the headquarters of the coke-making plants in June 1973. The English version of the questionnaire is reproduced in Appendix I.

2   INDUSTRY DESCRIPTION

2.1   Introduction

Coke is the residue from the destructive distillation of bituminous coal. Air is excluded from the coking process per se and the necessary heat for distillation is supplied from external combustion. During the heating process the volatiles are driven off, and the hydrogen contained in the coal reacts with carbon and nitrogen to form other compounds which are volatilized. The various volatile products are collected and processed to reclaim chemicals, coke oven gas and coal tars. The hot residue, which is carbon with some inorganic compounds present as ash, is water quenched and is known as coke.

In 1972, about 95% of the coke produced in Canada was by the by-product coke oven process. This process involves heating coal in rectangular chambers known as slot-type ovens which are grouped together in a series and alternately interspersed with heating flues. The overall assembly is known as a coke battery. Coal having a sulphur content ranging from 0.3 to 1.2% is charged through 3 or 4 holes or ports located on the top of an oven and then heated for about 17 h (for metallurgical coke). At the end of the coking period, the coke is pushed out of the oven into an open railway car by means of a ram. It is then transported to a specially designed tower for water quenching and, finally, transferred to a sizing plant.

2.2   Size

Coke production in Canada was 5.2 million tons in 1972, 5.1 million tons in 1971 and 5.7 million tons in 1970 (4). Total consumption was 5.4 million tons in 1972, 5.4 million tons in 1971 and 5.8 million tons in 1970. Coke production, consumption, and imports and exports is further broken down in Table 1. In 1972, 85% of the coke production was charged to blast furnaces for pig iron production. Projected coke consumption in 1975 is 7.9 million tons for Canada and 366.3 million tons world-wide. Estimated world-wide and Canadian coke requirements for 1975 are given in Tables 2 and 3 respectively.

Coke pricing, for captive production of coke, is not published but is based on export-import prices. The value of coke consumption in Canada was $126.7 million in 1970, $128.4 million in 1971 and $114.9 million in 1972. Average price of metallurgical coke based on export prices has been estimated at $19/ton in 1970, $21/ton in 1971 and $19/ton in 1972. Quoted price of foundry coke (in the U.S.) was about $55/ton f.o.b. in January 1973, and about $75/ton in January 1974 in Canada.

2.3   Geographic Distribution

The geographic distribution of coking plants in Canada is shown in Figure 1. The plants are numbered in the figure to correspond with the numbering in Table 4 which lists the plants by location and production capacity. Technical characteristics of the ovens used at these plants are contained in Appendix II. More than 85% of the total Canadian coke production in 1972 came from plants located in the Province of Ontario.

TABLE 1   CANADIAN COKE PRODUCTION, CONSUMPTION AND TRADE (4)

	1970		1971		1972	
	,000 tons	,000$	,000 tons	,000$	,000 tons	,000$
Production						
Ontario	4 590	*	4 288	*	4 458	*
Other provinces	1 078	*	818	*	696	*
TOTAL	5 668	*	5 106	*	5 154	*
Consumption	5 789	*	5 434	*	5 400	*
Imports						
United States	332	10 666	459	14 928	380	13 196
West Germany	63	2 462	187	7 219	128	4 499
Japan	–	–	–	–	1	41
United Kingdom	–	–	–	–	–	4
TOTAL	395	13 128	646	22 147	509	17 740
Exports						
United States	129	2 562	184	4 862	171	4 022
Netherlands	–	–	79	981	75	809
West Germany	36	393	23	224	15	106
Spain	18	242	8	340	2	22
St–Pierre and Miquelon	–	–	–	–	–	4
Panama	–	–	–	–	–	1
Others	91	2 017	24	257	–	–
TOTAL	274	5 214	318	6 664	263	4 964

* Not given for coke which is made and used internally in the iron and steel industry.
– Nil

TABLE 2   ESTIMATES OF WORLD COKE REQUIREMENTS FOR BLAST
             FURNACE AND TOTAL USES, 1975(5)

| | Rate (lb/nthm*) | | | Millions of tons | |
	Fuel	Coke	Pig iron production	Blast furnace coke consumption	Total coke consumption
World	1104	1010	555.6	280.5	366.3
North America	1126	1050	109.5	57.5	64.8
United States	1120	1040	98.2	51.0	56.9
Latin America	1230	1200	20.4	12.2	13.3
Brazil	1200	1170	8.3	4.9	5.2
Mexico	1230	1200	4.5	2.8	3.1
Europe-West	1160	1060	130.4	69.4	100.6
EEC & UK	1150	1040	109.6	59.5	90.1
Belgium and Luxembourg	1220	1140	17.3	9.8	12.1
France	1240	1130	20.1	11.4	15.5
West Germany	1126	1040	37.8	19.6	29.8
Italy	1200	1110	10.9	6.1	12.5
Netherlands	1180	1100	4.5	2.5	4.5
United Kingdom	1160	1060	19.0	10.1	14.6
Spain	1200	1100	6.9	3.9	5.0
Europe-East	1070	1010	144.3	73.0	102.5
USSR	1050	970	107.1	51.9	62.4
Czechoslovakia	1220	1180	10.6	6.3	9.5
East Germany	1250	1220	5.3	3.2	6.3
Poland	1230	1200	11.2	6.7	12.8
Romania	1250	1160	7.4	4.3	8.4
Asia	1050	880	128.5	56.5	71.1
Japan	940	770	101.2	38.8	47.4
China	1400	1360	19.8	13.4	15.4
India	1280	1220	7.3	4.4	6.3
African and Mid-East	1230	1170	7.2	4.2	5.0
Republic of South Africa	1230	1170	6.4	3.7	4.5
Oceania	1060	1000	15.3	7.7	9.0
Australia	1060	1000	15.3	7.7	9.0

*   Net Tons of Hot Metal

TABLE 3   ESTIMATES OF CANADIAN COKE REQUIREMENTS FOR BLAST
                 FURNACE AND TOTAL USES, 1970-75* (4)

	Rate (lb/nthm)		Millions of tons	
	Coke	Pig iron production	Blast furnace coke consumption	Total coke consumption
1970	1113	8.28	4.61	5.76
1971	1116	7.84	4.37	5.46
1972	1060	8.83	4.68	5.85
1973	1030	9.91	5.10	6.38
1975*	1050	12.00	6.30	7.88

* 1975 figures are Environment Canada estimates

2.4   By-products

In addition to coke, a number of by-products are obtained from the process of carbonizing coal. It should be noted, however, that no in-plant refining of by-products is done in Canada because of the relatively small scale of chemical recovery.

2.4.1   Coke breeze. Undersize coke from screening and crushing operations which cannot be used in the blast furnaces is known as coke breeze. Approximately 100 lb of undersized coke is produced per ton of coke. Production of coke breeze was about 250 000 tons for the base year 1972. Traditionally, coke breeze has been used either as a low grade in-plant fuel, because of its high moisture and ash content, or sold. In recent years, it has been the practice in several plants to recharge small amounts of coke breeze to the coke ovens.

2.4.2   Coke Oven gas (COG). About 17 500 ft^3 of COG is produced per ton of coke. Heating value of COG is about 510 Btu/ft^3 from metallurgical coke manufacture and 400 Btu/ft^3 from foundry coke manufacture. The total heating value of COG produced in 1972 was about 45×10^{12} Btu. Over 90% of the production of coke oven gas is used as in-plant fuel either within the coke ovens or in other areas of the steel plant where the two industries are collocated.

2.4.3   Coal Chemicals

2.4.3.1   Tar. From 9 to 15 gal of tar is produced per ton of metallurgical coke and from 4 to 6 gal per ton of foundry coke. The tar may be used as a plant fuel but more often it is sold to petrochemical companies for further processing. One plant uses limited quantities of tar in a captive refractory brick-making operation (Dofasco).
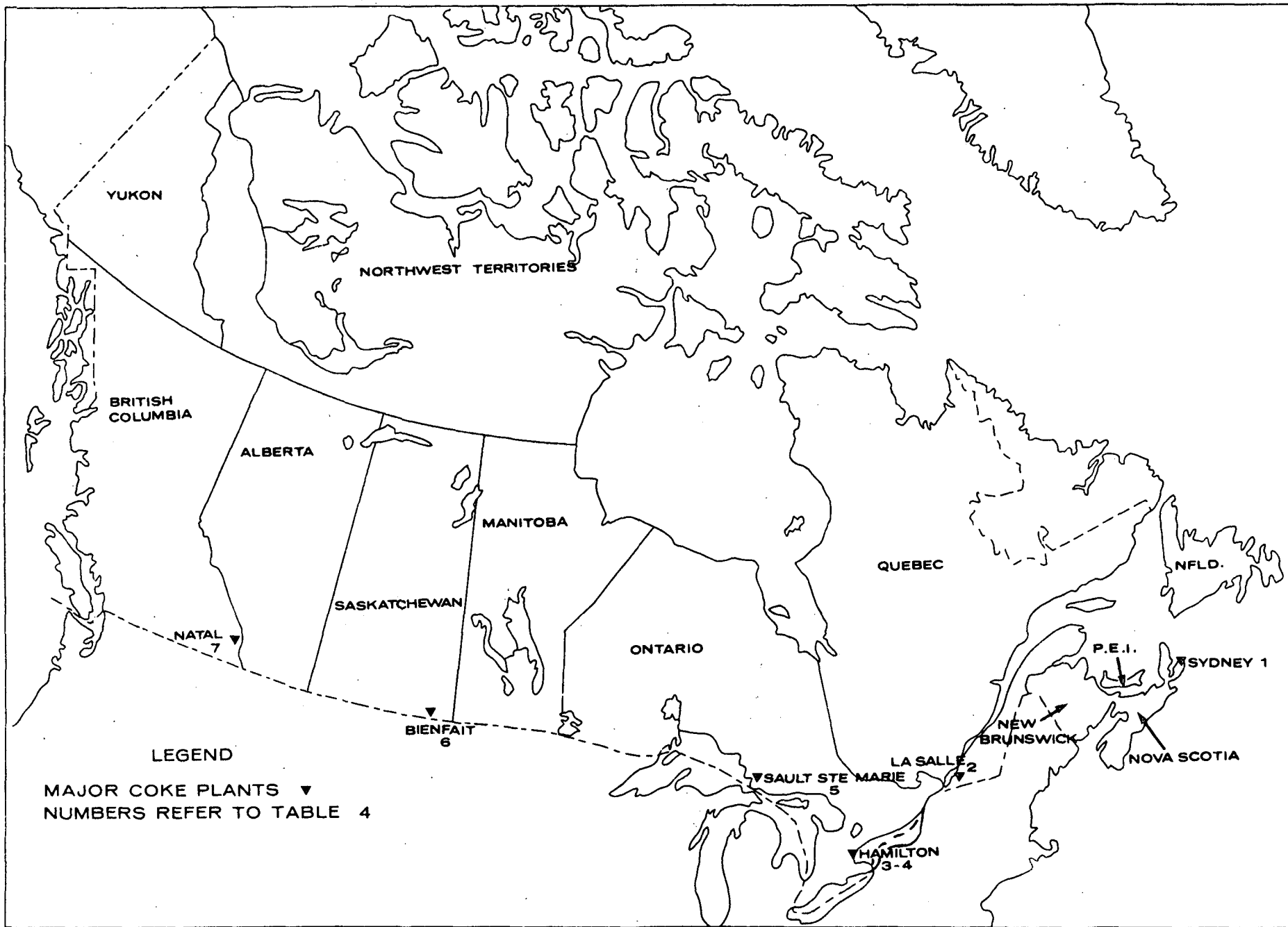
Figure 1 Geographic Distribution of Coke Oven Plants in Canada in 1972

TABLE 4   CAPACITIES AND PRODUCTION OF CANADIAN COKE PLANTS

| Company[1] | Location | Plant capacity (tons of coal) 1972 | Net production (tons of coke) | |
			1971	1972
1 Sydney Steel	Sydney, Nova Scotia	1 000 000	385 000	300 000
2 Gaz Metropolitain	Ville La Salle, Quebec	626 000	264 000	230 000
3 The Steel Company of Canada	Hamilton, Ontario	3 400 000	1 824 000	1 787 000
4 Dominion Foundries & Steel	Hamilton, Ontario	1 800 000	1 013 000	1 080 000
5 The Algoma Steel Co	Sault Ste Marie, Ontario	2 100 000	1 481 000	1 503 000
6 Manitoba & Saskatchewan Coal	Bienfait, Saskatchewan	110 000[2]	40 000[3]	52 000[3]
7 Kaiser Resources	Natal, British Columbia	245 000	162 000	133 000

[1] Numbers refer to Figure 1

[2] Lignite

[3] Char

2.4.3.2   Ammonia. This chemical is present in both the flushing liquor (condensate from the volatile products driven off in the coking process) and in the coke oven gas. From 1 to 2 lb of ammonia per ton of coke is contained in the flushing liquor and from 5 to 6 lb in the COG. Crude ammonia is removed from the flushing liquor at one plant and incinerated (Dofasco). Ammonia is removed from the coke oven gas in two plants; in one, anhydrous ammonia is produced (Stelco), and in the other the product is ammonium sulphate (Dofasco).

2.4.3.3   Light oils. From 3 to 6 gal of light oil is produced per ton of coke. Light oil is a mixture of toluene, benzene, xylene and other hydrocarbons. Most Canadian coke-making plants recover light oil which is sold to petrochemical companies for further processing.

2.4.3.4   Phenol. From 0.25 to 0.50 lb of phenol per ton of coke is present in the flushing liquor. One plant recovers phenol for sale with a dephenolizing plant (Algoma). Another plant removes phenol from the liquor by biological oxidation (Dofasco).

2.4.3.5   Pyridine bases (tar acids). From 0.1 to 0.2 lb of pyridine bases are produced per ton of coke.

2.4.3.6   Sulphur. From 20 to 30% of the sulphur in the coal goes into the coke oven gas as H_2S. One plant removes H_2S from the coke oven gas by the Stretford process (Dofasco). Elemental sulphur is produced directly in this process.

2.5   Relative Importance

Coke is one of the essential raw materials for the basic steel industry. It is also used as a raw material for iron foundries, and in lesser amounts as a heating fuel, and in various chemical and metallurgical processes. The coke-making industry, therefore, is important to the economy of the country.

3   INDUSTRIAL PROCESSES

3.1   Conventional Coking Process

A diagram of the metallurgical by-product coke oven process, from receipt of coal as a raw material to the final product of coke for the blast furnace, is shown in Figure 2. Included in Figure 2 are the potential emission sources as well as a material balance showing the proportionate amounts of products and by-products.
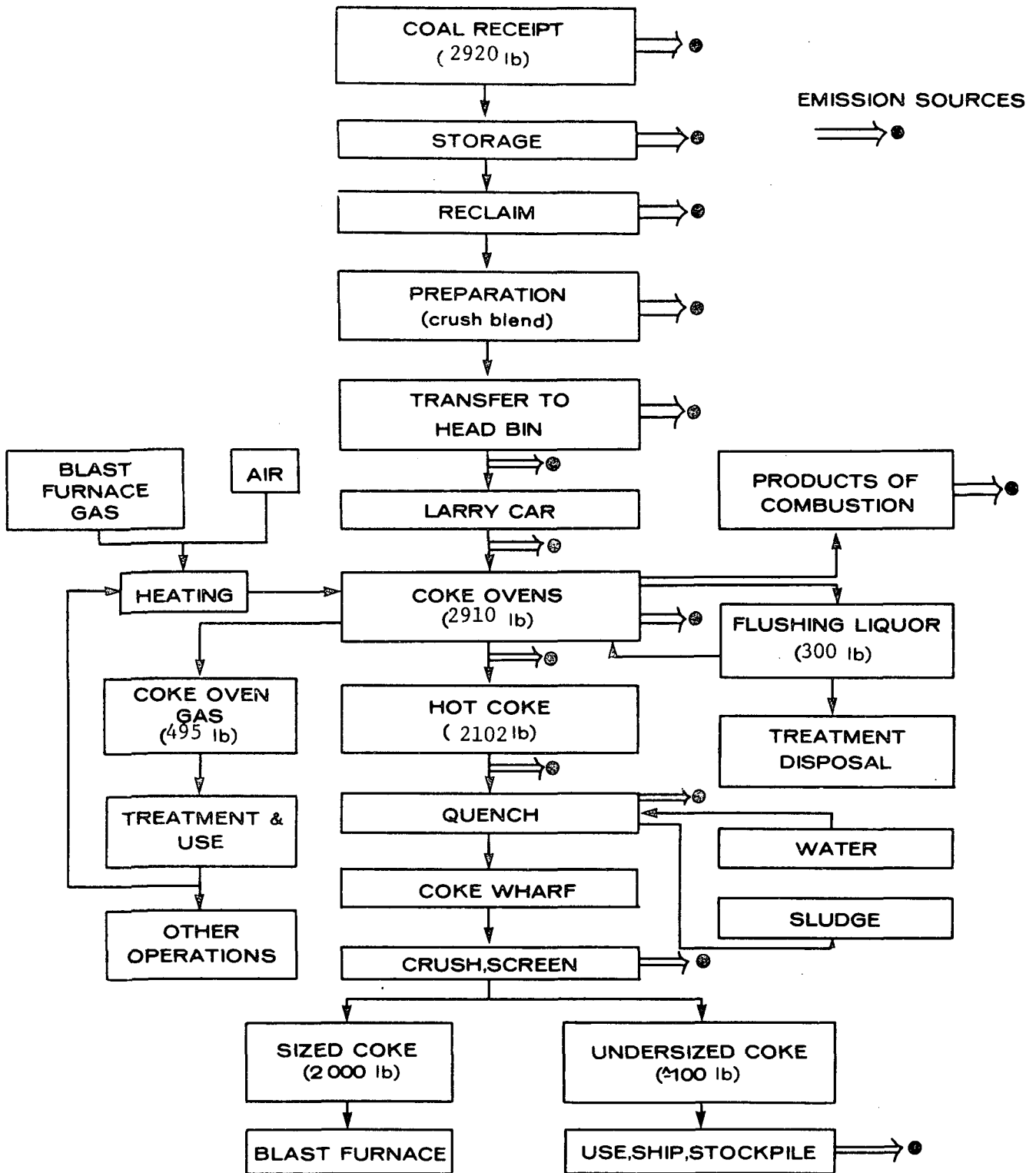
Figure 2 Typical Metallurgical By-Product Coke Oven Flow Sheet

3.1.1   Description

3.1.1.1   Coal receipt, storage and preparation. Approximately 2920 lb of coal is required to produce 2000 lb of dry coke suitable for blast furnace use. Coal for coke production is generally imported from the coal fields of West Virginia in the United States. This coal is transported to the coke plants by ship and unloaded either by ore bridges or self-unloader ships. Locally mined coal or lignite is used in part or wholly in the Nova Scotia, Saskatchewan and British Columbia coke plants. Coal is stock-piled for use at the coke ovens and recovered from the stockpile by reclaimers or mobile materials handling equipment. Reclaimed coal is crushed and the various coals used are blended to maintain a uniform coal mix for the coking process. Small amounts of fuel oil and coke breeze may be added to the coal mix before it is transported by enclosed conveyor to the oven head bins.

3.1.1.2   Oven charging. Charging of the coal into the coke ovens is accomplished by a mobile machine called a larry car, which travels on rails located on the top of the coke ovens. The larry car usually has three or four hoppers (one for each oven charging hole) which are first filled with coal from the head bins, and the larry car then travels to the oven to be charged. Lids which seal the charging holes in the oven roof are removed, either manually or by a mechanism mounted on the larry car, and coal chutes are lowered into the charging holes. Coal can be discharged into the oven from the larry car hopper either by gravity or mechanically using a screw feeder or a rotating table feeder. The more recent larry cars use mechanical feeders so the coal feed rate can be controlled and the charging carried out in a shorter period of time. During the latter part of the charging cycle a leveler bar is inserted into the oven to level the coal. When the coal is completely discharged from the hoppers the larry car coal chutes are retracted and the lids replaced, either manually or mechanically. The larry car then returns to the head bins for a new charge and the above cycle is repeated for another oven. From 15 to 30 tons of coal may be charged into a by-product coke oven in 3 to 5 min. Figure 3 shows the sequence of operations involved in the charging, leveling and pushing of a by-product coke oven.

3.1.1.3   Coking cycle. Each coke oven is a refractory-walled slot with a door in each vertical end wall. Heating is carried out by the combustion of fuel, usually blast furnace gas and/or coke oven gas, in flues built into the walls between the ovens. A battery usually consists of fifty to over one hundred ovens. Typical oven dimensions are shown in Table 5.

TABLE 5   TYPICAL COKE OVEN DIMENSIONS

Size	Height (ft)	Width (in)	Length (ft)	Coal capacity (tons)
4 metre	12 – 13	17 – 18	40.5 – 43	16 – 18
5 metre	16.5	18	46 – 50	26 – 28
6 metre*	18.5 – 20	18	50 plus	32 – 37

* There are no 6 metre ovens in Canada. Some are operating in the United States, in Japan and elsewhere.
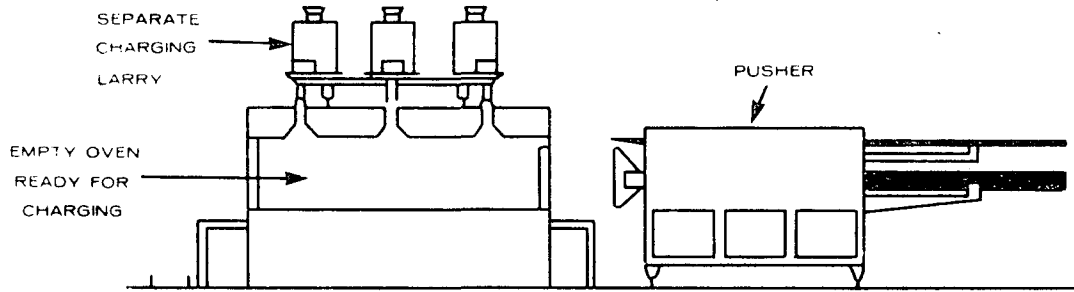
A. THE CHARGING LARRY, WITH HOPPERS CONTAINING MEASURED AMOUNTS OF COAL, IS IN POSITION OVER CHARGING HOLES FROM WHICH COVERS HAVE BEEN REMOVED. THE PUSHER HAS BEEN MOVED INTO POSITION.
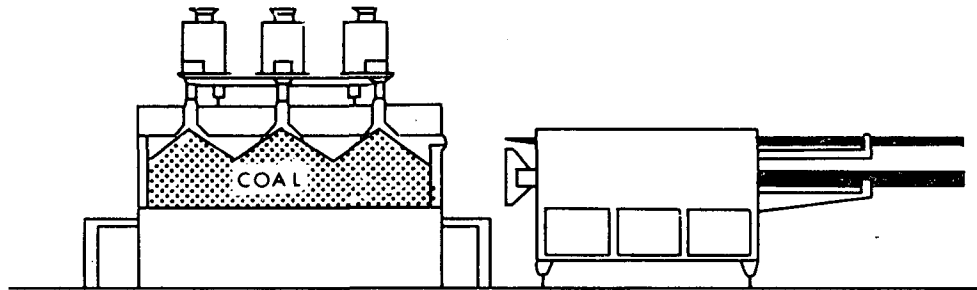
B. THE COAL FROM THE LARRY HOPPERS HAS DROPPED INTO THE OVEN CHAMBER, FORMING PEAKED PILES.
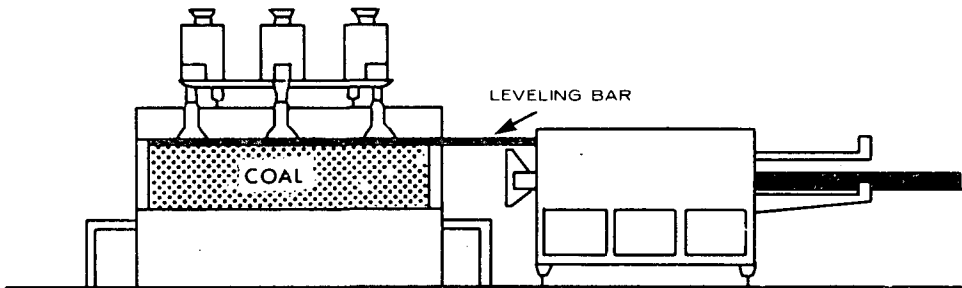
C. THE LEVELING DOOR AT THE TOP OF THE OVEN DOOR ON THE PUSHER SIDE HAS BEEN OPENED, AND THE LEVELING BAR ON THE PUSHER HAS BEEN MOVED BACK AND FORTH ACROSS THE PEAKED COAL PILES TO LEVEL THEM. THE BAR NEXT IS WITHDRAWN FROM THE OVEN. THE LEVELING DOOR AND CHARGING HOLES ARE CLOSED, AND THE COKING OPERATION BEGINS.
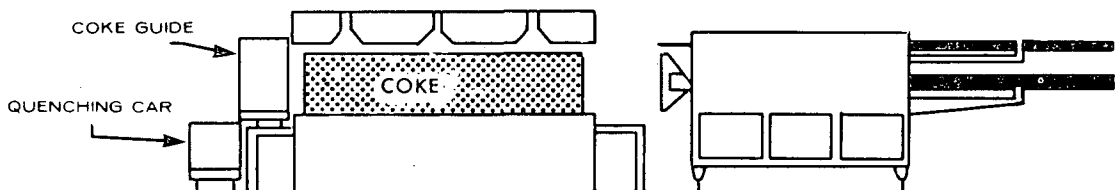
D. COKING OF THE COAL ORIGINALLY CHARGED INTO THE OVEN HAS BEEN COMPLETED (IN ABOUT 17 HOURS) AND THE OVEN IS READY TO BE "PUSHED". THE OVEN DOORS ARE REMOVED FROM EACH END. AND THE PUSHER, COKE GUIDE AND QUENCHING CAR ARE MOVED INTO POSITION.
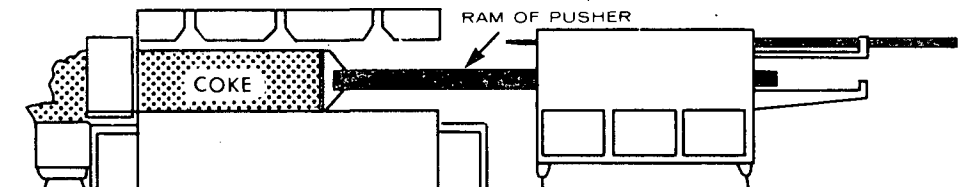
E. THE RAM OF THE PUSHER ADVANCES TO PUSH THE INCANDESCENT COKE OUT OF THE OVEN THROUGH THE COKE GUIDE AND INTO THE QUENCHING CAR.

Figure 3 Sequence of Operations Involved in Charging, Leveling and Pushing in One Coking Cycle of a By-Product Coke Oven

Coal is heated indirectly to about 2000°F over a period of time and at a rate that depends on the end product required. Metallurgical coke is generally heated at a rate of 1 to 1.25 in/h for a total period of about 17 h, whereas foundry coke is heated at a slower rate, about 0.75 in/h for a total of 24h. During the heating cycle the oven is sealed and usually maintained at a slight positive pressure to prevent air infiltration. The gases which evolve from the coking process are drawn off through a duct system and cooled for further use. When the charge is fully coked, it is pushed out of the oven.

3.1.1.4   Pushing operation. A pushing machine removes the oven door on the pushing end of an oven and aligns a ram inside the door jambs. On the coke side, a door machine removes the door and positions a coke guide against the door jambs. The pushing machine then pushes the slab of hot coke out of the oven and into a quench car positioned below the coke guide. The total pushing operation takes about 3 min. After the pushing ram has been retracted, spillage is cleaned up and the sealing edges of the doors and door jambs are cleaned and the doors replaced.

3.1.1.5   Quenching. The quench car, filled with freshly pushed coke, is moved into a semi-enclosed tower where water is sprayed on the hot coke. Of the 600 to 800 gal of water necessary for quenching one ton of coke, approximately 150 gal is vaporized. After the coke has been quenched and cooled to a temperature less than 400°F, the quench car moves to a coke wharf where the coke is dumped onto a conveyor belt that moves it to the coke handling area.

3.1.1.6   Coke handling. Metallurgical coke is screened and then transferred by enclosed conveyors to the blast furnaces. Foundry coke is crushed to the size required and shipped to customers. For a more detailed description and explanation of the coking process, References 1, 2 and 3 are recommended.

3.1.2   Relative Importance of the By-product Oven. In 1972, about 95% of the coke produced in Canada was carbonized in conventional by-product slot ovens. The balance was produced in unconventional type ovens, such as the Curran-Knowles oven in which the coal is heated in a horizontal coke oven unidirectionally from the floor or 'sole' of the furnace (Kaiser Resources). Another is the Lurgi carbonizing retort in which lignite is converted into a char composed of fixed carbon, ash and volatile matter (Manitoba and Saskatchewan Coal Co). In Canada, from 80 to 85% of the coke produced by the by-product process is used for pig iron production in blast furnaces. The balance of the coke is used for foundry, heating, and other miscellaneous metallurgical processes.

3.1.3   Pollution aspects. Air pollution emissions occur at various points throughout the coke oven complex (Figure 2). Emission factors for uncontrolled coke-making operations, as published by the United States Environmental Protection Agency (6), are given in Table 6.

3.1.3.1   Raw material receipt, handling and storage. Particulate emissions occur whenever the coal is handled, such as during ship unloading, reclaiming operations, crushing and conveying. Particulate emissions also occur as fugitive dust from the wind action on the storage piles.

TABLE 6   UNITED STATES ENVIRONMENTAL PROTECTION AGENCY EMISSION FACTORS FOR UNCONTROLLED METALLURGICAL COKE MANUFACTURING OPERATIONS (6)

Operation	lb/ton of coal charged					
	Particulate	Sulphur dioxide	Carbon monoxide	Hydro carbons[1]	Nitrogen oxides[2]	Ammonia
Unloading	0.4	–	–	–	–	–
Charging	1.5	0.02	0.6	2.5	0.03	0.02
Coking cycle	0.1	–	0.6	1.5	0.01	0.06
Discharging	0.6	–	0.07	0.2	–	0.1
Quenching	0.9	–	–	–	–	–
Underfiring	–	4	–	–	–	–
Total	3.5	4.02	1.27	4.2	0.04	0.18

[1] Expressed as methane

[2] NO_2

3.1.3.2   Emissions from the coke ovens. Particulates, hydrocarbons and carbon monoxide constitute the major emissions that occur during the charging of the coal into the hot ovens. For Canadian plants it is estimated that about 25% of the total uncontrolled particulate emissions from the coke-making complex occur during the charging operation. Hydrocarbon, particulate, carbon monoxide, ammonia and minor sulphur compound emissions occur during the coking process from leaks in the ovens. Major sources of leaks are around oven doors and charging hole lids that are not adequately sealed and, in older ovens, through cracks in the brick work. Particulate emissions can also occur as fugitive dust from wind action on coal or coke spillage on top of or around the ovens.

Hydrocarbon, nitrous oxide, sulphur compound and particulate emissions can occur from the coke oven heating system. Sulphur in the flue gas is emitted eventually as sulphur dioxide. Nitrous oxides are formed in the combustion process. Hydrocarbon and particulate emissions can be present and are caused by combustion deficiencies or oven flue leakage.

Particulate, hydrocarbon and carbon monoxide emissions occur during the pushing operation. It is estimated that emissions from this source account for almost 25% of total uncontrolled particulate emissions from Canadian coke plants. These emissions are minimized when all coal is fully coked, and increase as the amount of inadequately coked coal ('green coke') increases. Additional particulate emissions occur during the quenching operation as small coke particules are carried along with the ascending hot air and steam quench plume. These emissions are estimated to be about 15% of the total uncontrolled particulate emissions from Canadian coke plants.

3.1.4   New Process Technology

3.1.4.1   General considerations. Although the overall coke consumption in Canada is expected to rise because of increased steel production, blast furnace techniques have lowered the quantity of coke necessary to produce a ton of pig iron. For example, in the past ten years the rate of coke consumption has decreased from 1400 to 890 lb/nthm in some modern Japanese blast furnaces. Other changes which could reduce coke consumption would be the increased use of electric arc furnaces and the use of pre-reduced iron ore. The increased use of electric arc furnaces is not expected to significantly affect coke production in Canada. There is currently one pre-reduced iron plant in Canada with an annual capacity of 400 000 tons (Sidbec-Dosco).

3.1.4.2   New coke-making technology. Form coke is the major new coking process now in the development stage. In North America, the processes developed by FMC and the Consolidation Coal Company produce a form coke that has been proven successful for partial use in the blast furnace, and could supplant conventional coke. In the FMC process, (Figure 4), pulverized noncaking coal is first charred and then devolatilized at 1500°F or higher in a fluidized bed reactor. The calcine is blended with pitch, obtained from the coal-charging step, before being briquetted. The briquettes are cured, to harden the briquettes, and then finish coked in a gas fired vertical shaft furnace operating at 1650°F. The Consolidation Coal process, (Figure 5), produces a low temperature char which is mixed with caking coal and pitch and formed into balls in a rotating hot pelletizer operating at about 850°F. The balls are then coked in a vertical shaft furnace at about 1650°F. The entire operation for both processes can be enclosed, thereby eliminating emissions from oven doors, and during charging and pushing.

Preheating of coal prior to charging into the coke ovens is of current interest to the coke-making industry. The advantages of this technique include a substantial increase in oven throughput, the use of lower cost, poorer quality coals and improved overall coke quality. One of these processes, licensed by Coaltek Associates, employs pipeline charging to the coke ovens which virtually eliminates the charging emissions because coal transport is accomplished via completely enclosed pipeline. Another benefit claimed from pipeline charging of preheated coal is a reduction in emissions associated with the pushing operation.

An alternative system to standard quenching towers is the Koppers enclosed quenching system. The benefits derived from such a system are the elimination of pushing emissions, a substantial reduction in the amount of particulate matter emitted during quenching, a reduction in the amount of water required and the production of a uniform, low moisture coke. Recent information has revealed that this system may be discarded because of maintenance problems.

The dry coke quenching method, licensed by American Waagner-Biro Co. and used extensively in Europe, is said to eliminate air and water pollution in the quenching operation. In this method, coke is cooled by recycling inert gas through the incandescent coke. Simultaneously, it recovers sensible heat which can be used for steam generation. Figure 6 gives a typical dry coke quenching process flow sheet. Dry quenched coke is moisture-free and generation of coke breeze is greatly reduced as compared with the wet quenching method. Although other benefits are claimed for this system, major steel producers in the USA and Japan have not yet adopted this technology.

PULVERIZED NONCAKING COAL → FLUIDIZED-BED DRIERS OXIDIZERS, AND COMPLETE DEVOLATILIZATION OF CHAR, 1500°F OR HIGHER → PITCH → BRIQUETTING → CURING → VERTICAL-SHAFT FURNACE, GAS-FIRED, 1650°F → FORMCOKE
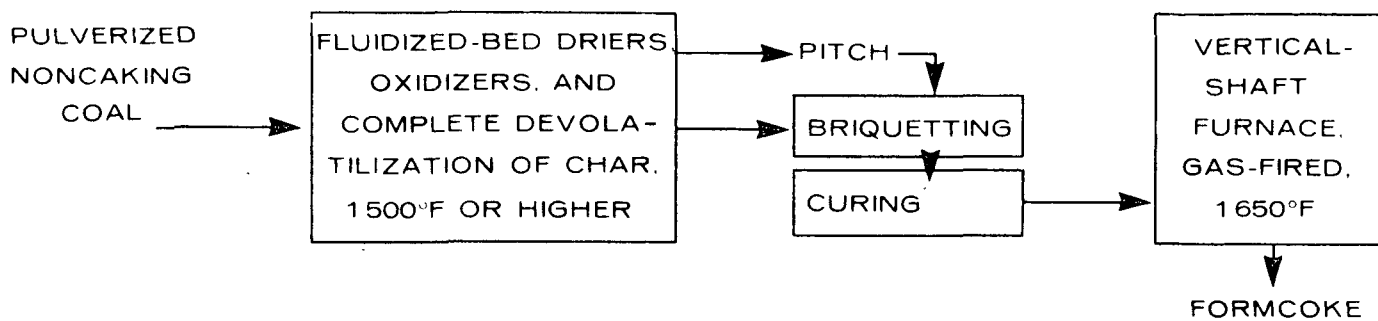
Figure 4 FMC Corporation Formcoke Process

PULVERIZED COAL → FLUIDIZED BED DRYER AND LOW-TEMPERATURE CHAR PRODUCTION → [CAKING COAL] [PITCH] ROTATING RETORT HOT PELLETIZER, 850°F → VERTICAL-SHAFT COKING, 1650°F → FORMCOKE
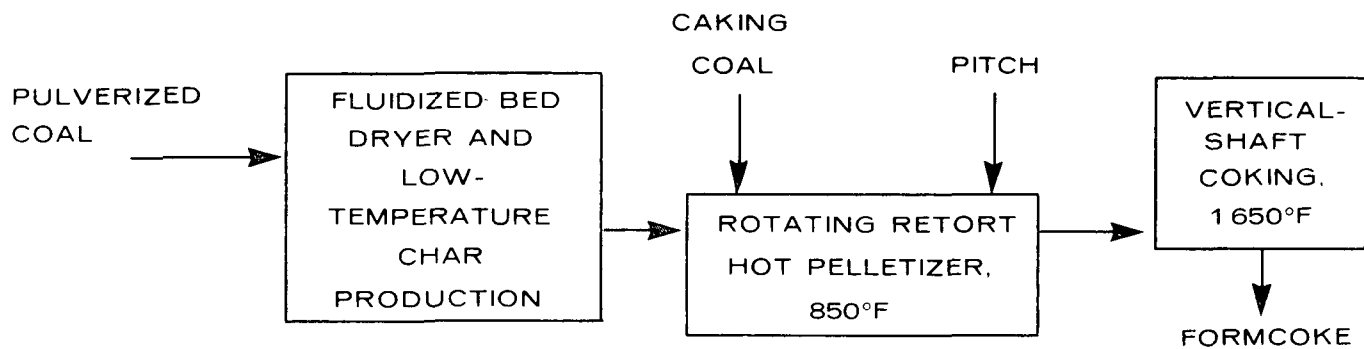
Figure 5 Consolidated Coal Company Formcoke Process

Figure 6 Dry Coke Quenching Flow Sheet
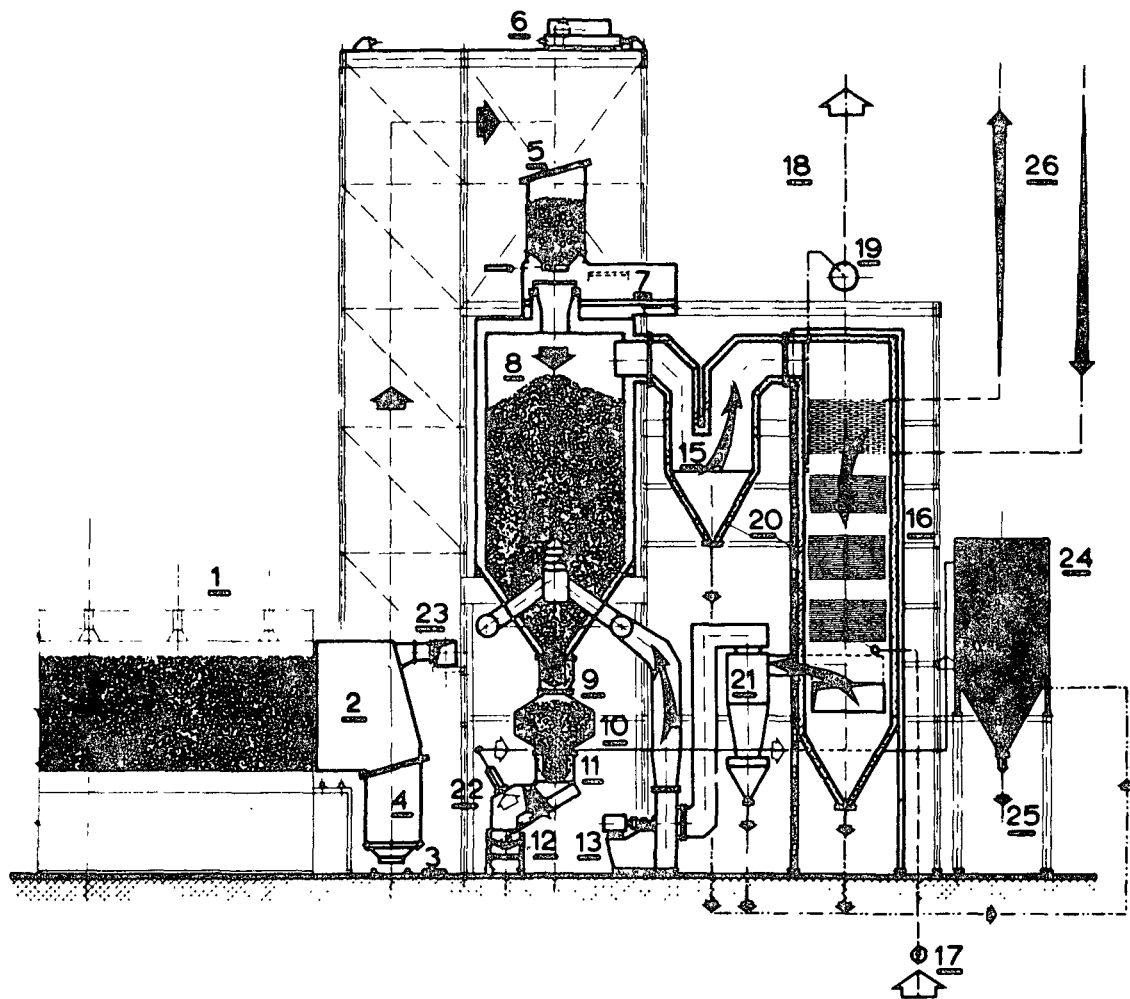
1 COKE OVENS
2 HOODED COKE GUIDE
3 TRANSFER CAR
4 HOT COKE BUCKET
5 BUCKET LID
6 CRANE TROLLEY
7 BUNKER TOP SEAL
8 COOLING BUNKER
9 BUNKER BOTTOM SEAL
10 MEASURING HOPPER
11 DISCHARGE EQUIPMENT
12 CONVEYOR
13 INERT GAS FAN
14 GAS DISTRIBUTOR
15 DUST DROP OUT CHAMBER
16 WASTE HEAT BOILER
17 FEED WATER SUPPLY
18 STEAM MAIN
19 STEAM DRUM
20 REFRACTORY LINING
21 CYCLONE
22 COKE TRANSFER POINTS EXHAUST
23 PUSHING EMISSION EXHAUST DUCT
24 BAG HOUSE
25 DUST DISCHARGE
26 HEAT EXCHANGER -
COAL PREHEATING

3.2   By-product Plant for Conventional Coking Process

Figure 7 is a schematic diagram of the major operations found in a typical by-product plant. It also indicates where major air pollutant emissions may occur.

3.2.1   Description. Approximate quantities of major by-products generated in the production of one ton of metallurgical coke are

Coke oven gas	–	16 500 to	18 500	ft³
Ammonia	–	6 to	8	lb
Tar	–	9 to	15	gal
Light oil	–	3 to	6	gal
Hydrogen sulphide	–	5 to	8	lb

A complete breakdown of the coal chemicals produced in the coking process is given in Appendix III

3.2.1.1   Flushing liquor. Flushing liquor is sprayed into the offtake mains on the coke ovens to flush out condensed tars and other residues and to provide some direct gas cooling. The flushing liquor is collected in a drain tank and, for batteries with a single collecting main, is recycled at a rate of about 1000 gal/ton of coke produced The drain tank residues pass through a decanter where the tar is reclaimed and the weak ammonia liquor recovered for disposal. The weak ammonia liquor contains phenols; some ether solubles, dissolved H_2S, CO_2, and NH_3; ammonia compounds, cyanides and thiocyanates; and trace quantities of mercury and fluorides that were present in the coal and have been absorbed in the flushing liquor Disposal of the liquor directly to a waterway would create a water pollution problem and use of this liquor for coke quenching would create an air pollution problem. These practices are not used in Canada.

One method of disposal used by Stelco includes the settling of solids and skimming of ether solubles. The liquid remaining is discharged to a sanitary sewer for ultimate biological treatment. Another method is the removal of ammonia, usually in an ammonia still, followed by further treatment of the liquor to remove phenols. Ammonia removal in an ammonia still (Figure 8) is a two-stage process. In the first stage, the weak ammonia liquor is directly heated with steam to release most of the dissolved hydrogen sulphide, carbon dioxide and ammonia and some of the hydrogen cyanide. In the second stage, the hot weak ammonia liquor is treated with a lime slurry which reacts with the fixed ammonia compounds and releases the ammonia as a vapour. The ammonia vapours are then collected and incinerated Incinerator emissions include some NO_x and SO_2. The weak ammonia liquor is further treated either in a biological treatment facility, which reduces phenols, cyanides and thiocyanates, or in a phenol recovery plant. One plant uses the ammonia still, incinerator and biological treatment process for disposal of its weak ammonia liquor (Dofasco).

3.2.1.2   Primary cooler. Coke oven gas is further cooled in a direct primary cooler, using water which has been cooled in indirect heat exchangers. Condensate is bled off from this system into the flushing liquor draintank for treatment. A turbo exhauster provides the negative pressure required to exhaust the gases from the ovens, and provides pressure for further processing and distribution of the coke oven gas

Figure 7 Typical Coke Oven By-Product Plant Flow Sheet
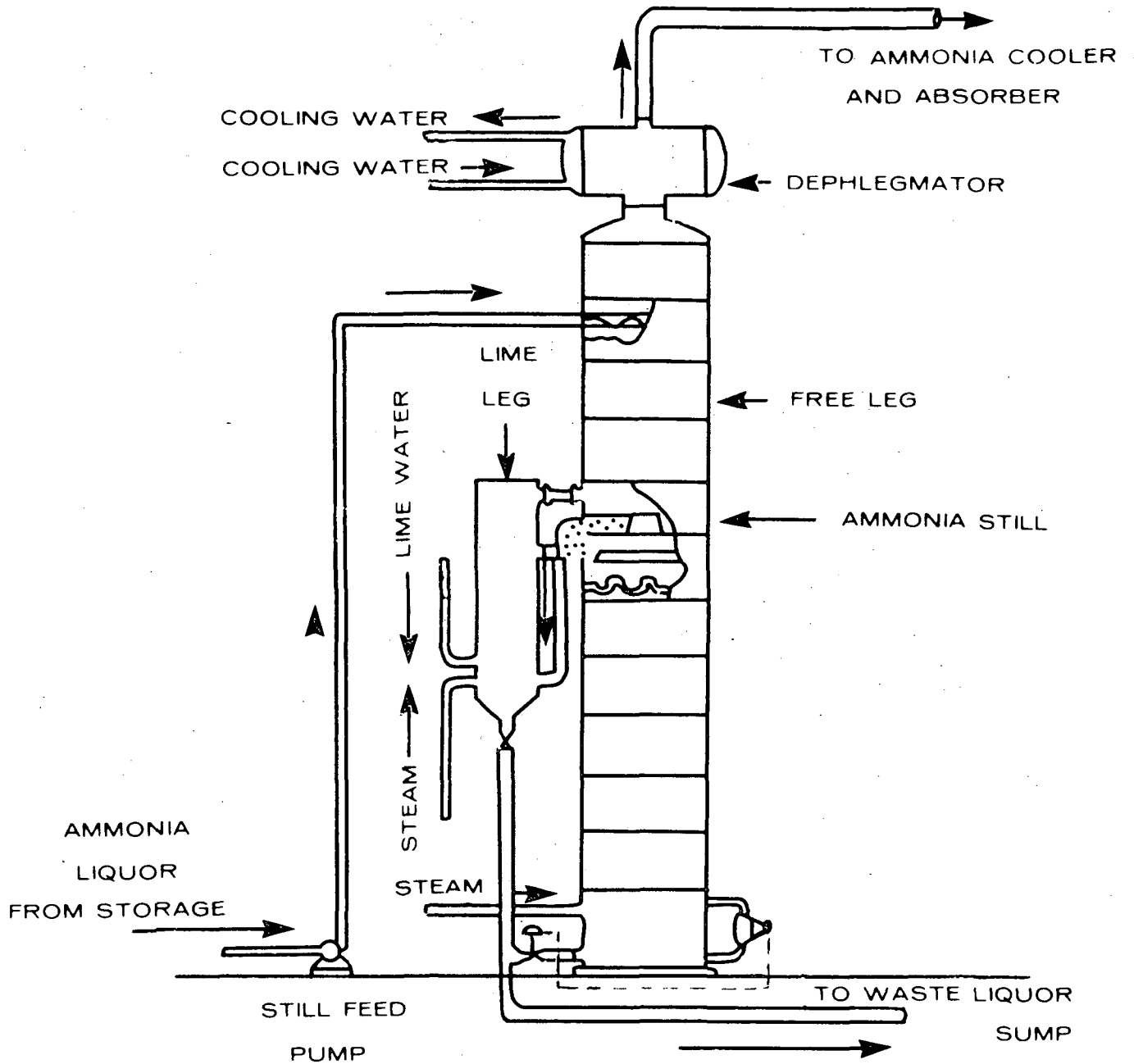
Figure 8. Essential Parts and Operation of an Ammonia Still

3.2.1.3 *Tar precipitators.* Any tar mist remaining in the coke oven gas after the primary coolers is usually removed in an electrostatic precipitator as shown in Figure 9. Coke oven gas at this stage could be called 'raw coke oven gas' and is sometimes used as fuel for boilers and/or underfiring the coke ovens. A coke oven gas flare is sometimes used to prevent excess pressure build up in the system because of a lack of balance between coke oven gas production (which fluctuates in the short term as each oven is charged, and in the long term depending on the coking cycle) and consumption. Additional coke oven gas processing varies from plant to plant and, accordingly, the description given in the following paragraphs is generalized for this reason.

3.2.1.4 *Ammonia removal from coke oven gas.* Ammonia is usually removed from the coke oven gas to reduce later processing problems, to reduce pipeline corrosion and to eliminate possible secondary sources of air or water pollution. One of the processes used is direct water scrubbing with subsequent heating to remove the ammonia vapour. This process, supplied by Koppers and others, is used in several plants in the United States. Another process involves direct scrubbing with sulphuric acid to remove the ammonia and fix it as ammonium sulphate, a by-product. A typical flow sheet of this operation is shown in Figure 10. Allied Chemical and others supply this process, which is used in one Canadian plant (Dofasco). A variation of the process is the use of phosphoric acid to produce ammonium phosphate as a by-product. A third process that is used to recover ammonia vapour involves the direct scrubbing of the coke oven gas with a regenerated phosphate liquor as outlined in Figure 11. This is the Phosam process (U.S. Steel) which is used in another Canadian plant (Stelco). The vapour may be incinerated or recovered as anhydrous ammonia by fractionation (Stelco). When the ammonia vapour is recovered, but is not upgraded to anhydrous ammonia, it is incinerated.

3.2.1.5 *Final cooler.* Additional cooling of the coke oven gas occurs in the final cooler. Two basic methods are used. In the first conventional method, the gas is direct water-cooled which removes some impurities, especially naphthalene. The naphthalene is skimmed-off for disposal and the water may be diverted to a treatment plant, recycled using a cooling tower, or discharged to a sewer. Ammonia, H_2S and HCN vapours will be released if a cooling tower is used in association with the final cooler. The second method is a closed cycle in which wash oil is used as the cooling and scrubbing medium. The wash oil is indirectly water cooled and naphthalene is stripped in a wash oil still. This method avoids the cooling tower stage and, therefore, produces none of the emissions mentioned above.

3.2.1.6 *Benzol washer.* A wash oil direct scrubber is used to remove the light oils from the coke oven gas stream (primarily toluene, benzene and xylene). Light oils are steam stripped in a wash oil still and recovered. All of the Canadian plants sell the recovered light oils to petrochemical companies for further processing.

3.2.1.7 *Sulphur removal.* A number of sulphur removal processes are presently available. Some of these processes are discussed in Section 5. Coke oven gas at this stage may be termed 'clean' and is used as a plant fuel. A turbo booster may be used to increase the gas pressure for distribution. Usually a gas holder is floating on the line to provide a buffer to even out fluctuations in the supply-demand situation. A flare is also used with the gas holder to act as a pressure relief system.
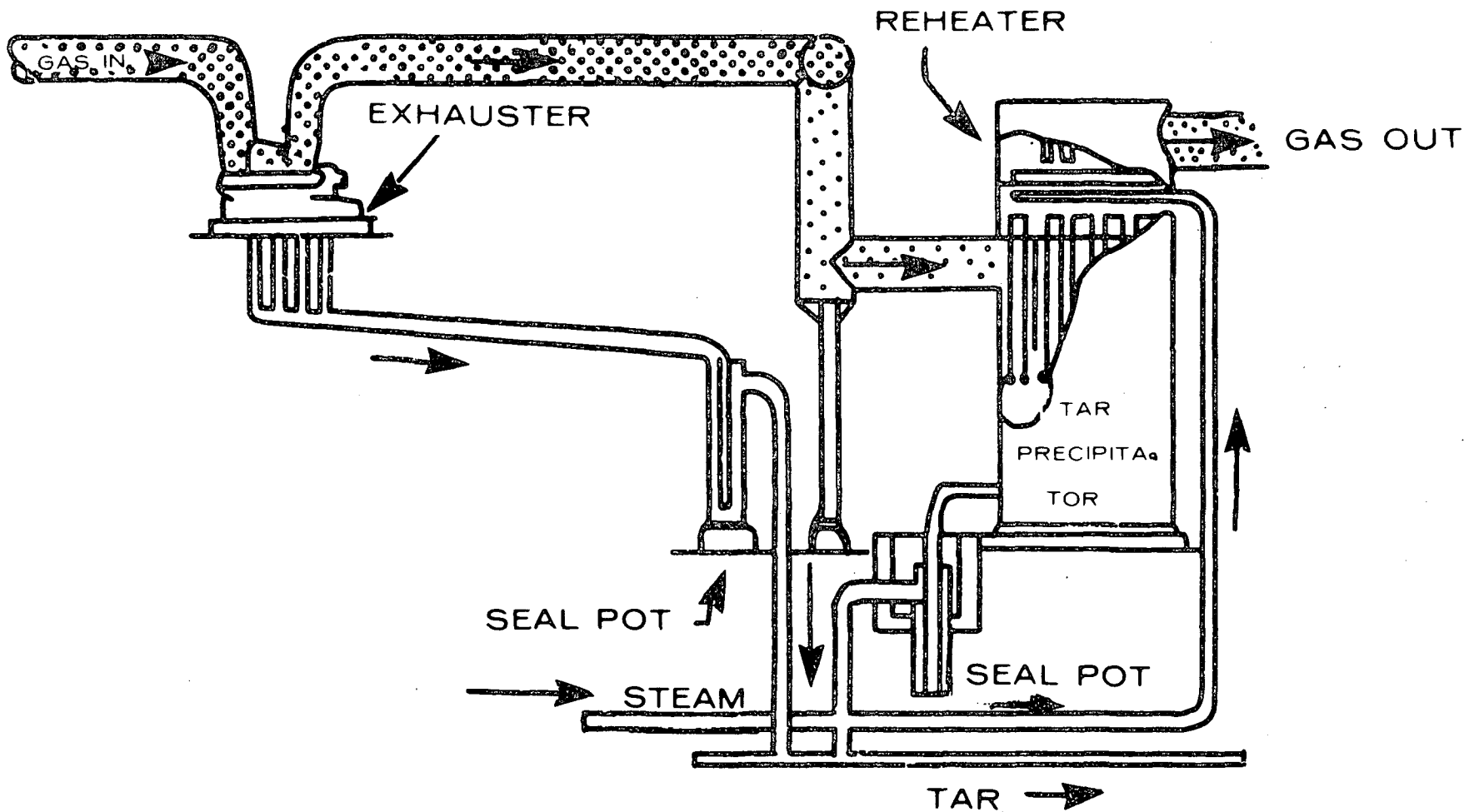
Figure 9 Electrostatic Precipitator for Precipitation of Tar From Coke-Oven Gases
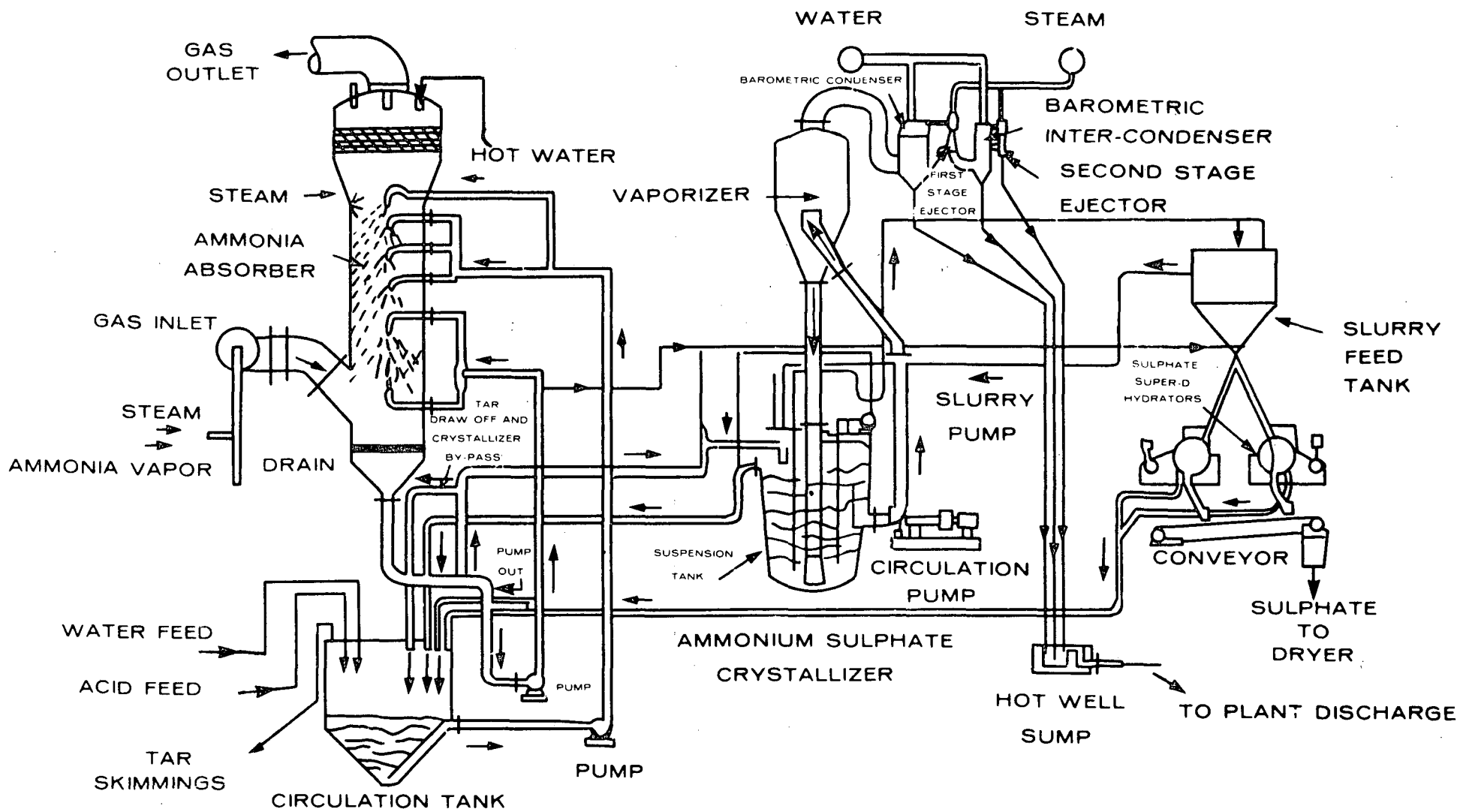
Figure 10 A Low-Differential Controlled - Crystallization Process for Producing Ammonium Sulphate

S=Steam
W=Water

Clean
Coke-Oven Gas
(Ammonia-Free)

W

Clean
Coke-Oven
Gas

Rich
Phosphate
Solution

W

S

Lean
Phosphate
Solution

Aqua Ammonia

W

Anhydrous
Ammonia

W   S

Absorber

Stripper

Fractionator
Ammonia

-23-
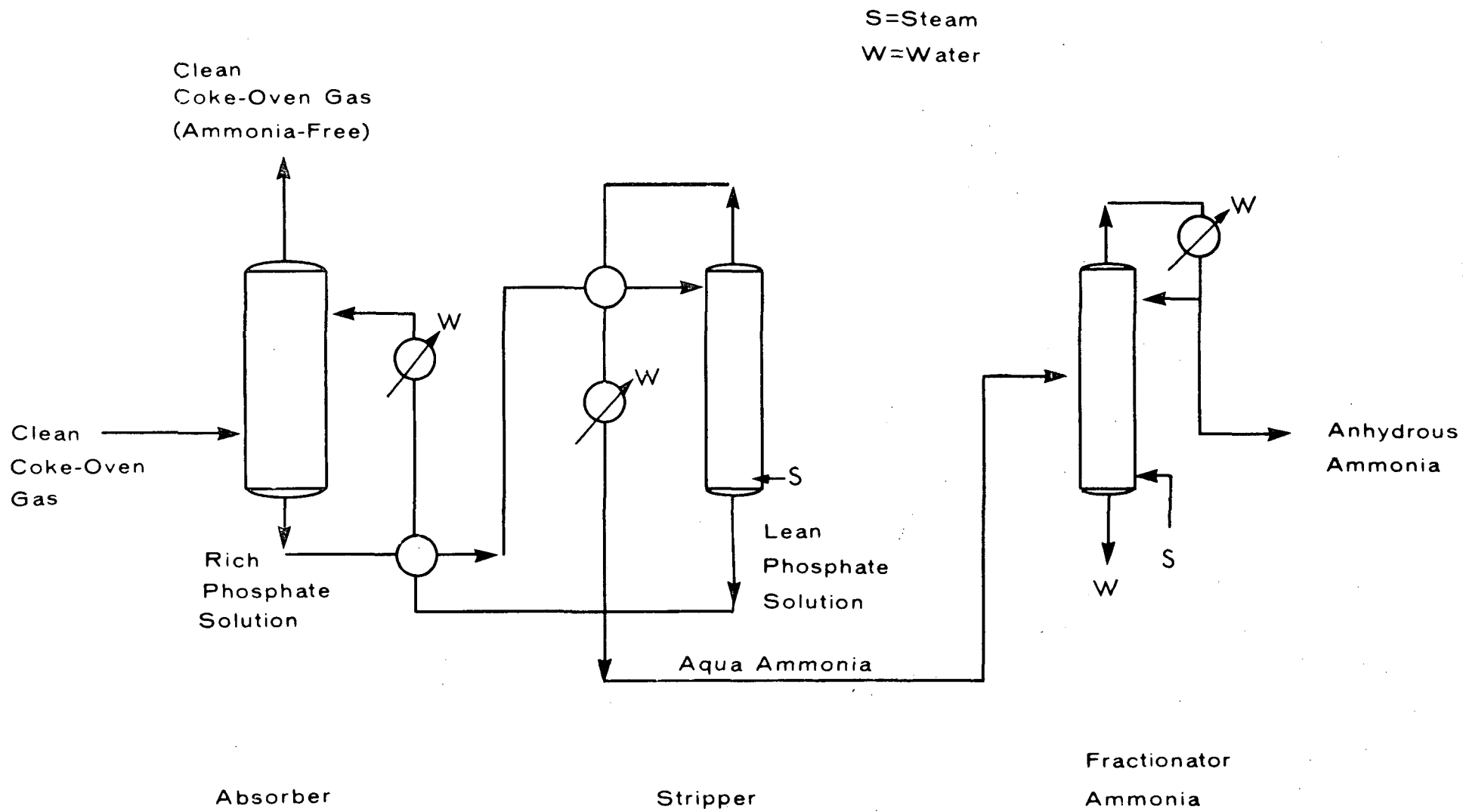
Figure 11   USS Phosam Process

3.2.2 Pollution aspects. Locations of the major emission sources in a by-product plant were indicated in Figure 7. Emissions are mainly hydrocarbons from leakage and spills. There can also be hydrocarbon fumes from tank vents. Ammonia and H_2S vapours can be present from coke oven gas drips. When ammonia is incinerated, some NO_x and SO_2 emissions occur. The SO_2 emissions develop when the H_2S in the ammonia solution is oxidized. The use of a cooling tower in association with the final cooler will result in the emission of ammonia, H_2S and HCN vapours. Sulphur dioxide emissions occur at flare stacks and wherever coke oven gas is used as a fuel, if H_2S has not previously been removed from the coke oven gas. There can also be minor H_2S emissions from a biological treatment plant. Particulate emissions occur from flare stacks when the flared gas is not completely combusted.

4 EMISSIONS

4.1 Sources of Air Pollution in Metallurgical Coke Manufacturing

The major sources of dust, smoke and gas emissions when carbonizing coal in by-product coke ovens, identified in Section 3.1.3, are:
- handling, crushing, and blending of coals
- charging of coal into slot ovens
- underfiring slot ovens with fuels containing sulphur
- discharging (pushing) of freshly produced coke
- quenching of hot coke
- handling and screening of coke.

Control of these emissions requires a major investment in capital as well as expertise in control technology.

4.2 Data Previously Published

A nationwide inventory of air pollutant emissions for 1970 reported that the coke manufacturing industry was responsible for approximately 11 000 tons of particulate matter and 40 000 tons of sulphur dioxide (7). A regional breakdown of emissions by type of pollutant is given in Table 7. It shows that the metallurgical coke manufacturing industry contributed about 0.8% of the total particulate and sulphur dioxide emissions from Canadian industrial sources.

4.3 Data Obtained from Metallurgical Coke Manufacturing Industry Questionnaires, 1973

Emission factors for uncontrolled metallurgical coke manufacturing operations in Canadian plants given in Table 8 have been developed from information provided in response to Air Pollution Control Directorate Questionnaire, 1973, and from literature surveys.

TABLE 7   EMISSIONS IN 1970 FROM THE METALLURGICAL COKE MANUFACTURING INDUSTRY (7)*

	(tons)				
	Particulate matter	Sulphur oxides	Nitrogen oxides	Hydro–carbons	Carbon monoxide
Ontario	7 885	32 658	131	13 678	4 131
Other Provinces	2 679	7 672	31	3 213	970
TOTAL	10 564	40 330	162	16 891	5 101
% of total Industrial Sources	0.75%	0.74%	1.06%	15.15%	0.67%

* These figures are based on the United States Environmental Protection Agency emission factors for uncontrolled operations (6).

TABLE 8   EMISSION FACTORS FOR UNCONTROLLED CANADIAN METALLURGICAL COKE MANUFACTURING OPERATIONS[1]

	lb/ton of coal charged	
Operation	Particulate	Sulphur dioxide
Crushing & screening of coal & coke	1.12	–
Charging	1.12	0.01 – 0.03[2]
Pushing	1.03	–
Quenching	0.69	–
Coking cycle	0.10	–
Underfiring	0.08 – 1.50[3]	–[4]
Flaring	<0.01[3]	–[4]
Coke oven gas consumption	–[5]	3.90 – 12.20[6]

[1] These emission factors have been developed from data reported in Air Pollution Control Directorate Questionnaire, 1973, and information obtained from a literature survey. They are based on normal operations.

[2] Varies from plant to plant with sulphur content and type of coal.

[3] Partially controlled, varies from plant to plant with type and quantity of fuel used.

[4] Included in coke oven gas consumption.

[5] Included in underfiring, see [3].

[6] Total emission rate due to coke oven gas consumption throughout steel and coke complex; rate varies from plant to plant with sulphur content of coal.

Data reported in Air Pollution Control Directorate Questionnaire, 1973, was also used in compiling the total particulate and sulphur dioxide emissions from the Canadian metallurgical coke manufacturing industry in 1972, as given in Table 9. These emissions were calculated using the emission factors in Table 8 and taking into account air pollution control equipment and operating practices utilized in 1972. Table 9 also gives estimates for emissions in 1975 that are based on control equipment or operating practices expected to be utilized at that time. A breakdown of emissions according to type of operation for 1972 and 1975 is given in Table 10.

TABLE 9 REPORTED AND ESTIMATED PARTICULATE AND SULPHUR DIOXIDE EMISSIONS FOR 1972 AND 1975 FROM THE CANADIAN METALLURGICAL COKE MANUFACTURING INDUSTRY[1]

| Year | Region | No. of plants | (tons) | | (lb/ton of coke) |
			Coke production	Emission	Emission rate
PARTICULATE					
1972	Ontario	3	4 370 056	7 022	3.2
	Others	4	715 263	1 841	5.1
1975[2]	Ontario	3	5 195 000	5 914	2.3
	Others	4	1 090 000	2 902	5.3
SULPHUR DIOXIDE[3]					
1972	Ontario	3	4 370 056	15 897	7.3
	Others	4	715 263	3 659	10.2
1975[2]	Ontario	3	5 195 000	19 102	7.4
	Others	4	1 090 000	6 991	12.8

[1] Based on normal operations, from data reported in Air Pollution Control Directorate Questionnaire, 1973, from 7 plants.

[2] Estimated from expected air pollution control equipment expenditures and changes in operating practice or technology at Canadian coke plants for the period 1973-75.

[3] Total sulphur dioxide released as a consequence of coke oven gas use throughout the steel and coke complex.

Based on expected expenditures for air pollution control equipment by the Canadian coking industry and on changes in operating practice or technology, it is estimated that by 1975 plants located in the Province of Ontario will have reduced their particulate emission rate to 2.3 from 3.2 lb/ton of coke produced, or a reduction of 28% over 1972 figures. Other plants will show a slight increase in particulate emission rates during the same period. The sulphur dioxide emission rate for the period 1972-1975 should not change significantly for Ontario plants. However, it is estimated that other Canadian plants will show an increase of 25% during the same period (Table 9).

Of the total particulate emissions released by the Canadian coke-making industry in 1972, approximately 70% came from the pushing and charging operations. The pushing operation alone accounted for 43% of the total emissions. A similar situation should prevail in 1975 when particulate emissions from the pushing operation will account for about 46% of total emissions. Emissions from the charging operation however, will have been reduced by 1975 to about 14% of total emissions from 26% in 1972, reflecting the addition of air pollution controls and changes in charging procedures (Table 10).

TABLE 10   BREAKDOWN OF EMISSIONS ACCORDING TO TYPE OF OPERATION[1] AT CANADIAN COKE PLANTS IN 1972 AND ESTIMATED FOR 1975

Operation	Particulate		Sulphur dioxide	
	tons	% of total	tons	% of total
1972				
Crushing & screening of coal and coke	1320	14.9	–	–
Charging	2335	26.3	33	0.2
Coking cycle	53	0.6	–	–
Pushing	3809	43.0	–	–
Quenching	470	5.3	–	–
Underfiring	869	9.8	19 523[3]	99.8
Flaring	7	0.1	–[4]	–
TOTAL	8863	100.0	19 556	100.0
1975[2]				
Crushing & screening of coal & coke	1625	18.4	–	–
Charging	1272	14.4	20	0.1
Coking cycle	36	0.4	–	–
Pushing	4040	45.9	–	–
Quenching	687	7.8	–	–
Underfiring	1147	13.0	26 073[3]	99.9
Flaring	9	0.1	–[4]	–
TOTAL	8816	100.0	26 093	100.0

[1] Based on normal operations, from data reported in Air Pollution Control Directorate Questionnaire, 1973, from 7 plants.

[2] Estimated from expected air pollution control equipment expenditures and changes in operating practice or technology at Canadian coke plants for the period 1973-75.

[3] Total sulphur dioxide released as a consequence of coke oven gas use throughout the steel and coke complex.

[4] Included in underfiring.

4.4 Other Pollutants

An inventory of hydrocarbon, nitrogen oxide and carbon monoxide emissions has also been completed using the most recent published information. Estimated emissions of other pollutants for 1972 and 1975, based on the uncontrolled emission factors given in Table 11, are shown in Table 12. Air pollution control equipment and operating practices utilized in 1972 and expected for 1975 have been taken into account in preparing Table 12. A breakdown of estimated other pollutant emissions for 1972 and 1975, according to type of operation, is given in Table 13.

Development of new control technology for particulate emissions from the charging and pushing operations should also reduce emissions of other pollutants such as hydrocarbons, carbon monoxide and nitrogen oxides. For this reason Tables 12 and 13 show a decrease in total emissions of other pollutants from 1972 to 1975. Similarly, emissions of ammonia, hydrogen sulphide and hydrogen cyanide from a by-product plant will also be reduced when air pollution control equipment is used in the various stages of a by-product plant.

TABLE 11   EMISSION FACTORS FOR OTHER POLLUTANTS FOR UNCONTROLLED CANADIAN METALLURGICAL COKE MANUFACTURING OPERATIONS[1]

Operation	lb/ton of coal charged		
	Nitrogen oxides[2]	Hydrocarbons	Carbon monoxide
Charging	0.01	0.2	0.5
Coking cycle	0.01	1.0	0.6
Pushing	–	0.2	0.1

[1] These emission factors have been developed from a literature survey conducted by the Air Pollution Control Directorate.

[2] Expressed as NO_2

TABLE 12   ESTIMATED EMISSIONS OF OTHER POLLUTANTS FOR 1972 AND 1975 FROM THE CANADIAN METALLURGICAL COKE MANUFACTURING INDUSTRY[1]

	tons		
Region	Nitrogen oxides[2]	Hydrocarbons	Carbon monoxide
1972			
Ontario	21	1441	1430
Balance of Canada	6	280	330
TOTAL	27	1721	1760
1975			
Ontario	8	1015	719
Balance of Canada	8	396	496
TOTAL	16	1411	1215

[1] Based on Table 11 and taking into account air pollution control equipment or operating practices utilized in 1972 and expected for 1975.

[2] Expressed as NO_2

TABLE 13   ESTIMATED EMISSIONS OF OTHER POLLUTANTS FOR 1972 AND 1975, ACCORDING TO TYPE OF OPERATION, FROM THE CANADIAN COKE-MAKING INDUSTRY

	tons		
Operation	Nitrogen oxides[1]	Hydrocarbons	Carbon monoxide
1972			
Charging	21	422	1054
Coking cycle	6	560	336
Pushing	–	739	370
1975			
Charging	12	235	588
Coking cycle	4	394	236
Pushing	–	782	391

[1] Expressed as NO_2

5 CONTROL METHODS

5.1 Present Controls and New Technology in the By-product Coke-Making Process

5.1.1 *Coal and Coke Handling.* Dust suppression methods include shrouding (partial or complete enclosure of dust source) of handling sites and transfer points. At exceptionally dusty sources, enclosed shrouds and induced draft hoods are used to draw the dust off into cyclones and other dust collectors. However, only partial shrouding and enclosure has been used for most entry and exit points such as coal car dumps, coal receiving hoppers, coke wharves, discharge chutes between coal bunkers and larry cars, and discharge chutes between screening stations and the rail cars receiving coke breeze. The overall emission of dust from most existing coal and coke handling plants depends on housekeeping and weather, because internal suppression of dust is incomplete and sources are not fully enclosed.

Three concepts are now being regarded as major improvements in reducing emissions from coal and coke handling operations. One is the full enclosure of coal-handling and coke-handling plants, and improved enclosure of entry and exit points. Another is improvements and additions to existing systems of shrouds, hoods, seals, and dust collectors. The third concept is increased use of dust-retarding methods such as wetting.

Conventional controls such as shrouding, hooding and dust collection devices (cyclones and baghouses) are well developed. Where ventilated enclosure systems fail to contain or control dust adequately, the next best approach is to wet the dusty materials. Coke seems most amenable to controlled wetting although it may change either the productivity or the fuel economy of the blast furnace operation. The wetting of coals is also a feasible method for decreasing fugitive dust emissions.

The Japanese have developed the practice of spraying coal to maintain a minimum 6% free moisture on exposed surfaces; the practice appears both adequate and effective. Points of exposure such as piles and conveyors are sprayed as required. Wetting agents are occasionally used and, for long-term storage, pile surfaces are wetted with water containing vinyl acetate or other sealants. The wetting approach seems practical, need not lead to surface runoff, and can probably be adjusted to winter conditions as experience is gained.

In the future, coal handling plants are likely to have few open conveyors other than those necessary to carry unprocessed coal into the surge bunkers.

5.1.2 **Oven Charging.** Because of the quantity of emissions released during the charging operation, most plants have directed their efforts to the reduction or elimination of 'charging smoke'. There are three methods for controlling emissions from charging:

- the collection of gases in the collecting main systems,
- the external collection and cleaning of gases from the larry car or standpipes; and
- sealed charging of preheated coal (not an air pollution control method per se; primary reason for installing a coal preheating system is increased productivity of ovens).

These concepts will be described briefly.

5.1.2.1 *Sequential and staged charging practices.* Sequential and staged charging practices are based upon the principle that aspiration in a standpipe controls the pressure balance at only one opening in the oven. In response to this principle, only one opening is permitted at any one time adjacent to any one source of draft. Therefore, the basic concept is to confine the gases to the oven and collecting main(s). The essential elements of staged or sequential charging include two-way drafting of the free space above the coal; restriction of portal (charging hole and chuck door) openings to one or at most two at any one time; and sequencing of coal flow. Neither a second collector main nor a set of auxiliary roof holes is essential to clean staged charging.

Staged charging in North America, and sequential charging in the United Kingdom are equivalent terms denoting a practice in which one or at most two hoppers are opened, emptied, and closed before charging begins from other hoppers of coal. Several variants exist and one is shown in Figure 12. Sequential charging, in North America only, is a special practice in which coal may flow from all of the hoppers simultaneously, but for which the flow of coal is commenced in some strict, timed sequence. Sequential charging is, therefore, a variety of staged charging practices, valid under some conditions and in some plants.

Staged charging is a practice and an operator's solution which possesses the features of completeness and reliability. Even though it was developed and originally practiced with twin collector mains, for which both standpipes were aspirated to provide two-way drafting of the free space, it is also applicable to single-main batteries. When staged charging is applied to a single-main battery there are several methods that can be used to provide two-way drafting of the free space. One method, for example, is to use a portable jumper duct between ovens on batteries equipped with smoke holes or extra ports. Use of this method means that two ovens, one being charged and one serving as a drafting duct, are on full aspiration during each charge. Another method to provide two-way drafting is to use a fixed u-bend containing a damper valve, and connecting each smoke hole to a neighboring one. A third method is to use a single header or manifold connected to all of the smoke holes with valves between each.

Staged charging techniques can still be used in coke plants without a twin collector main, smoke holes, or clearance to bore smoke holes in the available roof space. However, it is necessary that the jumper connection to an adjacent oven be provided via one of the charging ports. Several techniques, depending on oven configuration, can be adopted.
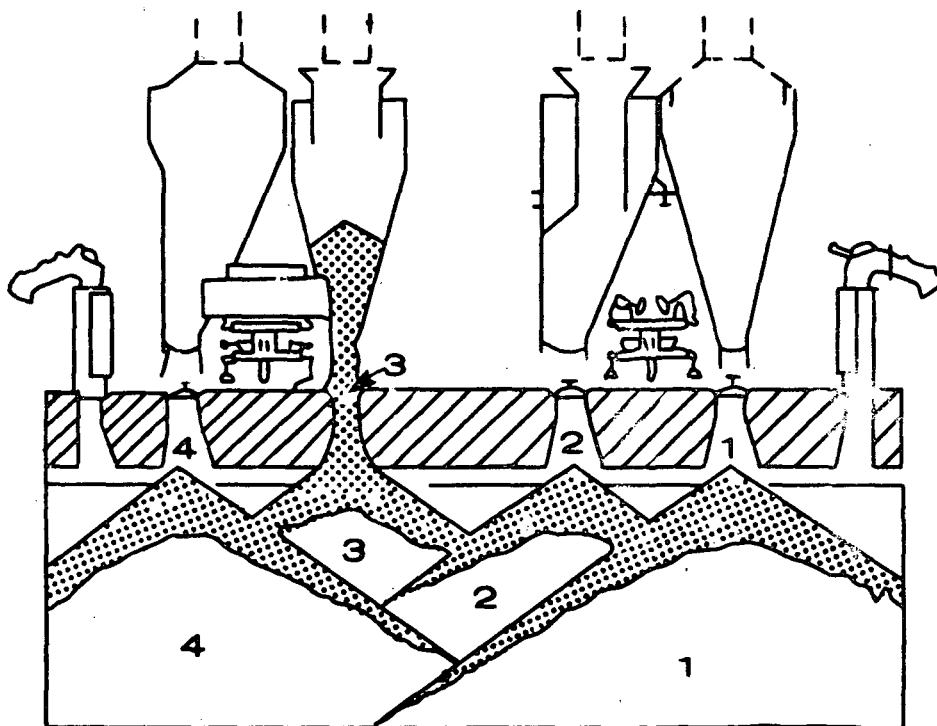
Figure 12 A Staged Charging Practice With Twin Collector Mains and Four
Hoppers Charged in Sequence 1-4-2-3

The aspiration requirements for smokeless staged charging need not exceed the actual rate of evolution of gas and smoke. Too much aspiration will permit air to be drawn in through the open hole which could start a fire in the free space and result in excessive gas losses and dust carryover into the main. Figure 13 shows a typical aspiration system.

Proper use of a staged charging technique is claimed to provide a reduction in excess of 90% of particulate and gaseous emissions. Several coke plants in Canada have adopted a staged charging practice on some of their batteries.

5.1.2.2   *Direct smoke collection.* This method of controlling emissions is based on a larry car equipped with shrouds or hoods surrounding the charging ports and drop sleeves. Gases drawn through these shrouds, together with inspirated air, are combusted and drawn through various types of wet scrubbers. The combusted and scrubbed gases are exhausted through one or more fans and stacks on the larry car. Venturi-type scrubbing systems have recently replaced rotary scrubbers because they provide more efficient removal of particulates from incompletely burned charging smoke, and require less maintenance. A representative larry-car-mounted, wet-scrubbing system is shown in Figure 14. The state of the art with respect to larry-mounted wet scrubbers is represented by cars similar to the latest Heinrich Koppers design which differ from older designs by the use of independent fans, ductwork, and scrubbers for each of the charging ports served. In addition, the latest Koppers design is fitted with two tangential propane igniters in each shroud and another in the duct-work of each separate system. It appears that overall performance of the system is dependent upon the degree of ignition attained and maintained.

Variations of direct collectors include larry cars equipped with single wet collectors, incinerators without scrubbers, and scrubbers without incinerators. Prospects for the selection of the most successful of these appears limited to a combined incinerator-scrubber unit.

Wet scrubbers for control of oven charging emissions are widely used in Japan in connection with MCI (Mitsubishi Chm. Ind.) liquor sprays (which appear to enhance the strength of aspiration), but are being abandoned progressively in Germany and the United Kingdom. Presently, three plants in Canada use a scrubber system on at least one of their batteries.

A state-of-the-art wet scrubber in good condition and properly adjusted, operating with a strong aspiration system, appears to eliminate all but a little of the charging smoke for about 90% of the time.

5.1.2.3   *Preheated coal charging.* Preheated coal charging is claimed to increase coke production throughput by 20 to 55% and to permit use of coals of lower overall quality. One method of charging preheated coal is by pipeline (Coaltek System). In this system the preheated coal is crushed and pneumatically conveyed to individual ovens in pipes by means of steam jets spaced along the bottom of the pipes. Another sealed system is the Precarbon process employing a Redler conveyor with fixed charging chutes. Both the Coaltek and Precarbon systems are truly sealed and, consequently, free of charging emissions. Flow sheets for these systems are given in Figure 15. The selection of Coaltek or Precarbon technology is not a matter of emission control. It is a question of increased productivity of the ovens and should not be contemplated as a basis for smoke prevention alone.
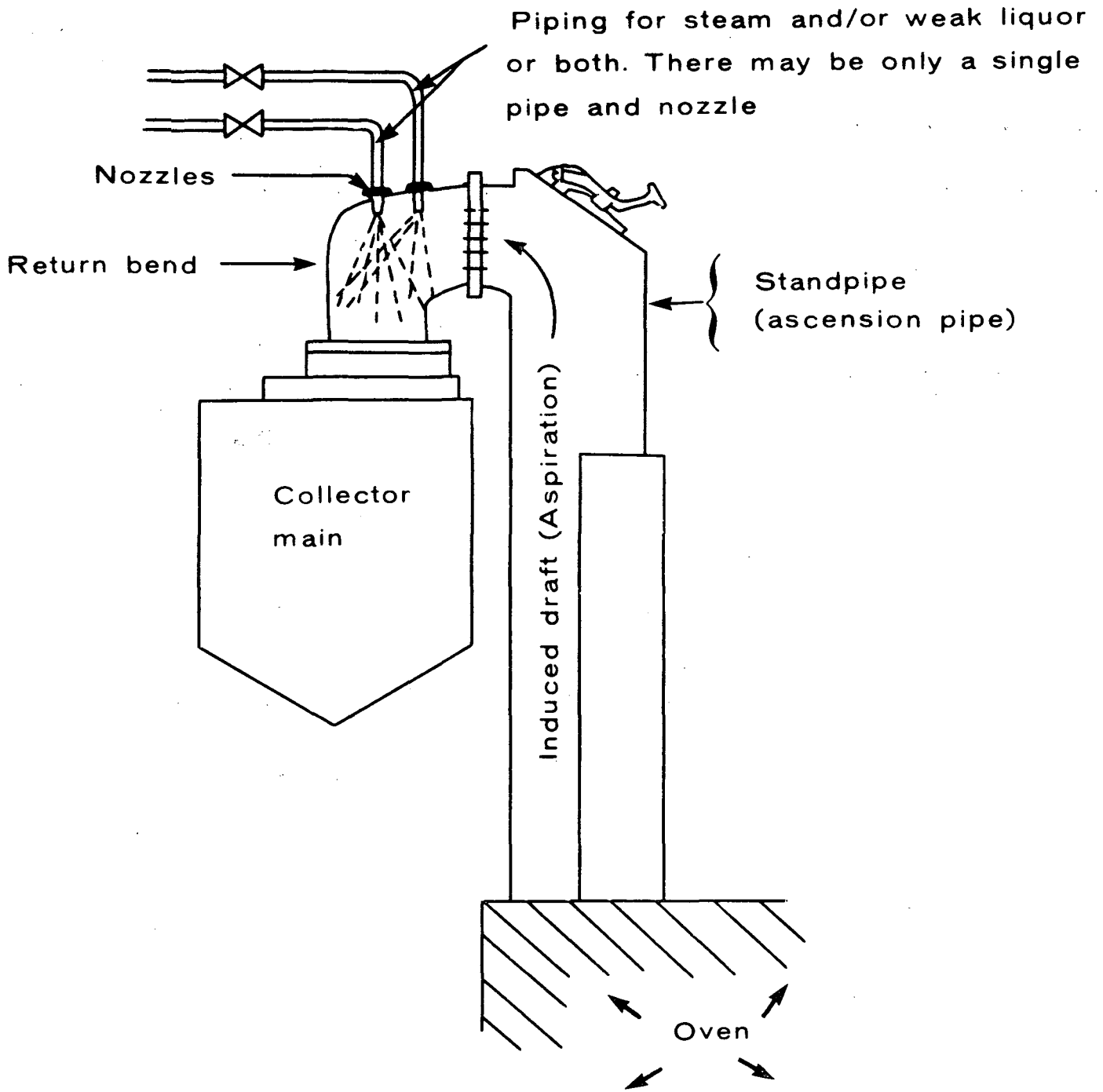
Figure 13 Typical Aspiration System Operating in the Return Bend of the
Gas-Collection Duct

Exhaust

Coal hoppers

Wet scrubber

F A N

Ductwork

STANDPIPE

Shrouds (hoods)

Charging ports

Oven (in section)
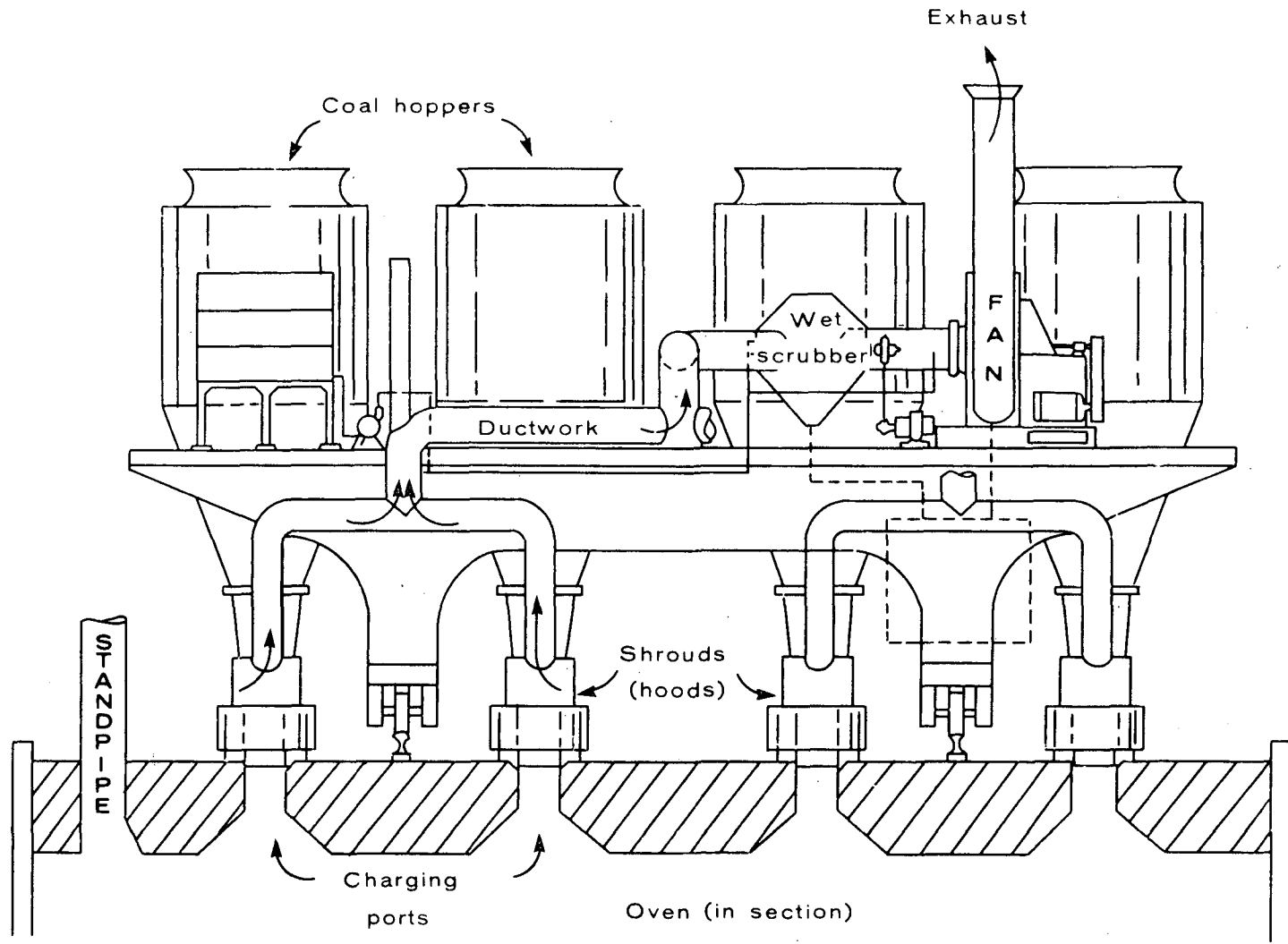
Figure 14 Representative Larry-Car-Mounted Wet-Scrubbing System
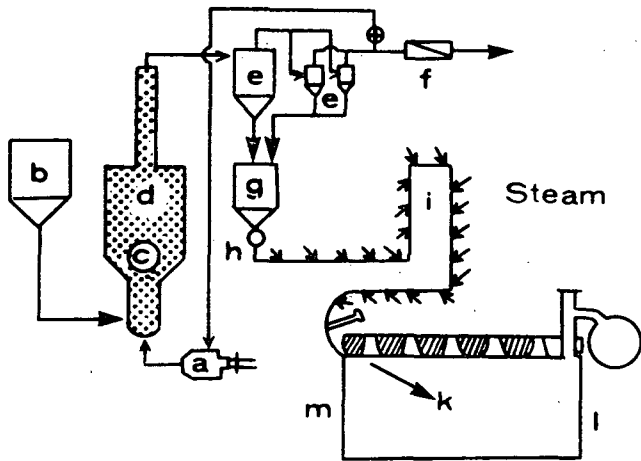
Coaltek process:

c-Hammermill

d-CERCHAR dryer

h-Coal valve

i-Pneumatic ducting

Steam

Common symbols:

a-Combustion chamber

b-Input bunker

e-Cyclone

f-Wet scrubber

g-Measuring bunker

i,k-Coke oven

j,l-Coke side

l,m-Machine side
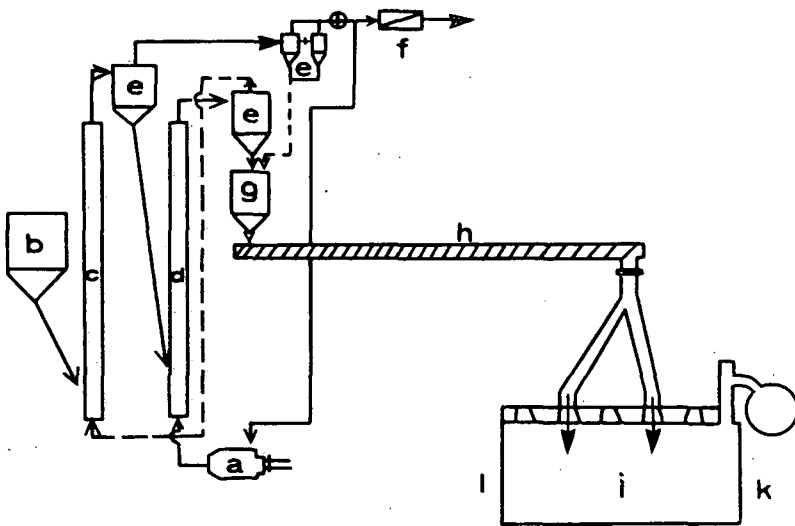
Precarbon process:

c-Drying column

d-Heating column

h-Redler conveyor

Figure 15 Coaltek Pipeline Charging and Precarbon Redler Charging of
Preheated Coals Through Sealed Systems

5.1.3 **Coking.** Continuous emissions occur during the coking process from various sources such as oven charging hole lids, gooseneck lids, oven doors, door jambs, door sills, standpipe base seals, collecting mains and gooseneck extension elbows. Proper maintenance and operation techniques should minimize emissions from these sources. New techniques for door cleaning, also applicable to the cleaning of oven ascension pipes, goosenecks, and return bends, are based on the use of high-energy water jets to blast away carbon deposits without scraping the steel parts, as a mechanical device might.

5.1.4 **Oven Pushing.** Oven pushing is a source of emissions to the atmosphere that varies widely from plant to plant, depending upon many factors. Ovens in which coals have been completely coked do not normally produce excessive smoke emissions, although there are certain amounts of particulate matter discharged as the coke falls into the quenching car. The voluminous black clouds caused by pushing 'green' coke has drawn attention to all pushing operations.

5.1.4.1 **Mitsubishi - Amagasaki - Shinwa Smokeless Pushing System.** The technology involved in this system is shown in Figure 16. A hood is mounted on the coke guide that travels on a platform or bench immediately adjacent to the coke oven doors. The hood connects to an overhead plenum duct at each oven during the pushing operation. As the quench car moves under the hood, the emissions are collected and discharged from the plenum duct into a high-efficiency wet scrubber, through a suction duct and out the stack. The development of the connecting system between hood, coke guide and suction duct permits the application of this technology to existing coke ovens.

5.1.4.2 **Modified Mitsubishi Design.** A system that is anticipated to operate even more efficiently than the control unit described in Section 5.1.4.1 is a modified version of the Mitsubishi design. It has been installed in one United States plant (Great Lakes Steel). The main difference between the two systems is the installation of two Venturi scrubbers (instead of one), and a cyclone separator before the discharge to the stack. Expected efficiency of the collector equipment is estimated to be 99.8% by weight.

5.1.4.3 **Koppers Hooding Concept.** Another concept for control of emissions during pushing operations is the hood and fume main system designed by Koppers and installed at Ford Motor Company's Dearborn plant in the United States. A high energy scrubber is used in this system. Close clearances between hood and quenching car reduce the effects of lateral winds. The discharge from the scrubber is reported to be less than 0.02 grain of dry particulate matter per standard cubic foot.

5.1.4.4 **Halcon/Allen System.** This system has been designed to control the emissions that occur during the travel period to the quenching station. It was developed by Halcon/Allen and installed at an Interlake Steel plant. The main components of equipment, as shown in Figure 17, include a hood over the discharge end of the existing coke guide, a hood over the existing quench car containing slotted openings through which the exhaust gases are drawn, and a control car containing gas cleaning and induced draft equipment with quench water and pumps. Quenching is started as the coke enters the quenching car and finished at a pad at the end of the battery. This system has not yet been proven and its value is questionable.
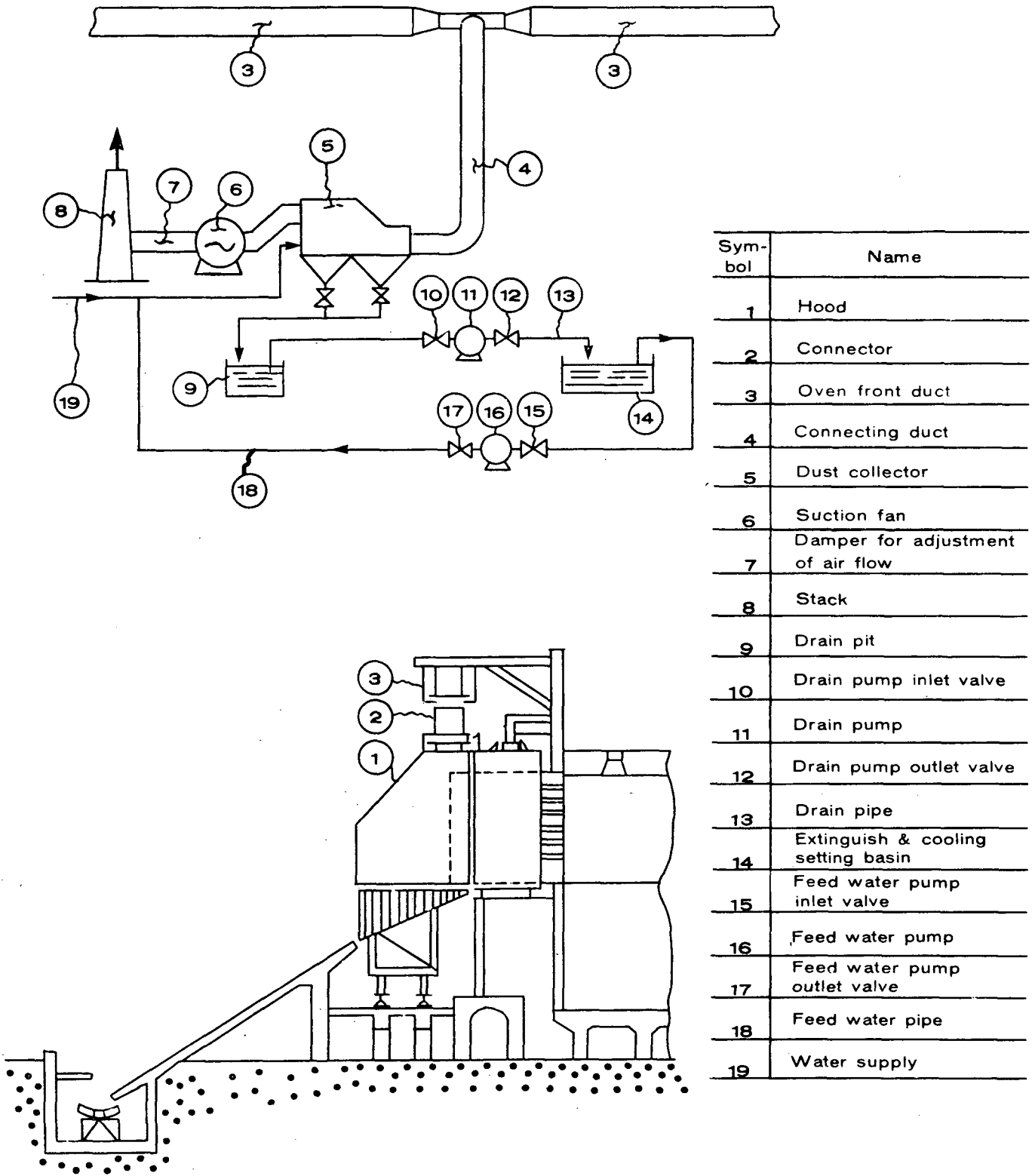
Sym-bol	Name
1	Hood
2	Connector
3	Oven front duct
4	Connecting duct
5	Dust collector
6	Suction fan
7	Damper for adjustment of air flow
8	Stack
9	Drain pit
10	Drain pump inlet valve
11	Drain pump
12	Drain pump outlet valve
13	Drain pipe
14	Extinguish & cooling setting basin
15	Feed water pump inlet valve
16	Feed water pump
17	Feed water pump outlet valve
18	Feed water pipe
19	Water supply

Figure 16 Mitsubishi-Amagasaki-Shinwa Smokeless Pushing Technology

Clean air exhaust
Mixing stack
Cyclonic demister
Metal ducts
Control car
Adjustable openings
Quench car hood
Hooded quench car
Heater recirculating pump
Two phase jets
Diesel generator
Hot water
Hot water heater
Cyclonic demister
Hot water accumulator
Quench pumps
Motor control center
High pressure pumps
Sump
Refill
Fuel tank
Fog sprays
Quench sprays
Service water tank
Fog spray pump and standby

Figure 17   Halcon/Allen Hooded Quench Car System

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5.1.4.5   Koppers Mobile Quencher. A concept similar to the one described in Section 5.1.4.4 is a mobile quencher designed by Koppers. This system is shown typically in Figure 18 and includes a complete enclosure of the coke guide and a single position container to catch the entire push from an oven. The container is then tilted to feed the coke into a rotary kiln where it is quenched and discharged onto a conveyor belt. The quenching vapours are collected and passed through a mist suppressor before being discharged from a stack. A similar system is the Salem Mobile Continuous Quencher designed by Wilputte. An experimental fixed model has been installed at the Clairton works of U.S. Steel (USA). Both systems have not yet been proven successful and are questionable.

5.1.4.6   Coke-Side Shed Enclosures. Another method of containing pushing emissions is the shed concept. In Germany and the United States, entire batteries have had their coke sides fully enclosed as an alternative to mobile hoods of any kind. A hood, sometimes equipped with baffles, encloses the entire coke side of a battery and traps smoke generated during coke pushes as well as any that has escaped from leaky doors. In North America, the Great Lakes Carbon Corp. has recently installed such a system on its St. Louis battery, as illustrated in Figure 19. Inland Steel is also building a similar hood. Other sheds have either been started or committed for construction, or are under consideration. It appears that some type of low-pressure-drop, high-throughput exhaust cleaner would best serve the shed design; an electrostatic precipitator could be ideal. Exhausting by dual systems through effective air cleaners should lead to an overall high efficiency in air pollution control. Although collection efficiency data for the shed concept are scarce, sheds now under construction or in the planning stages are expected to show improvements in performance over the original sheds. Overall coke-side effectiveness in excess of 80% of potentially visible emissions captured and eliminated should be possible.

5.1.5   Coke Quenching. Another source of intermittent emissions is the quenching operation. Particulate matter is carried along with the steam generated when water is dumped onto the hot coke. A mist suppressor is sometimes added to the quenching station stack to reduce the emission of particulate matter. Several different suppressor designs are available such as wooden baffles, coke beds, and back sprays, as shown in Figure 20. Most installations use wooden baffles (adopted by four Canadian plants). These are claimed to reduce particulate matter by approximately 90%. When contaminated water from other coking operations is used for quenching, emissions such as ammonia, cyanide and phenol vapours are released (abandoned practice in Canada).

Apart from the usual method of reducing emissions by installing suppressors on quenching towers, there are also the concepts discussed earlier such as the Koppers and Wilputte systems. These could decrease to a large extent the pushing emissions and minimize emissions from the quenching operation. In addition, use of these sytems would eliminate the drizzle of water from the quenching plume and provide better coke moisture control.

Dry coke cooling is another method for handling coke from a fully enclosed container, and there is interest in North America in the process because of pollution and energy considerations. This method was discussed briefly in subsection 3.1.4.2 under new coke-making technology.
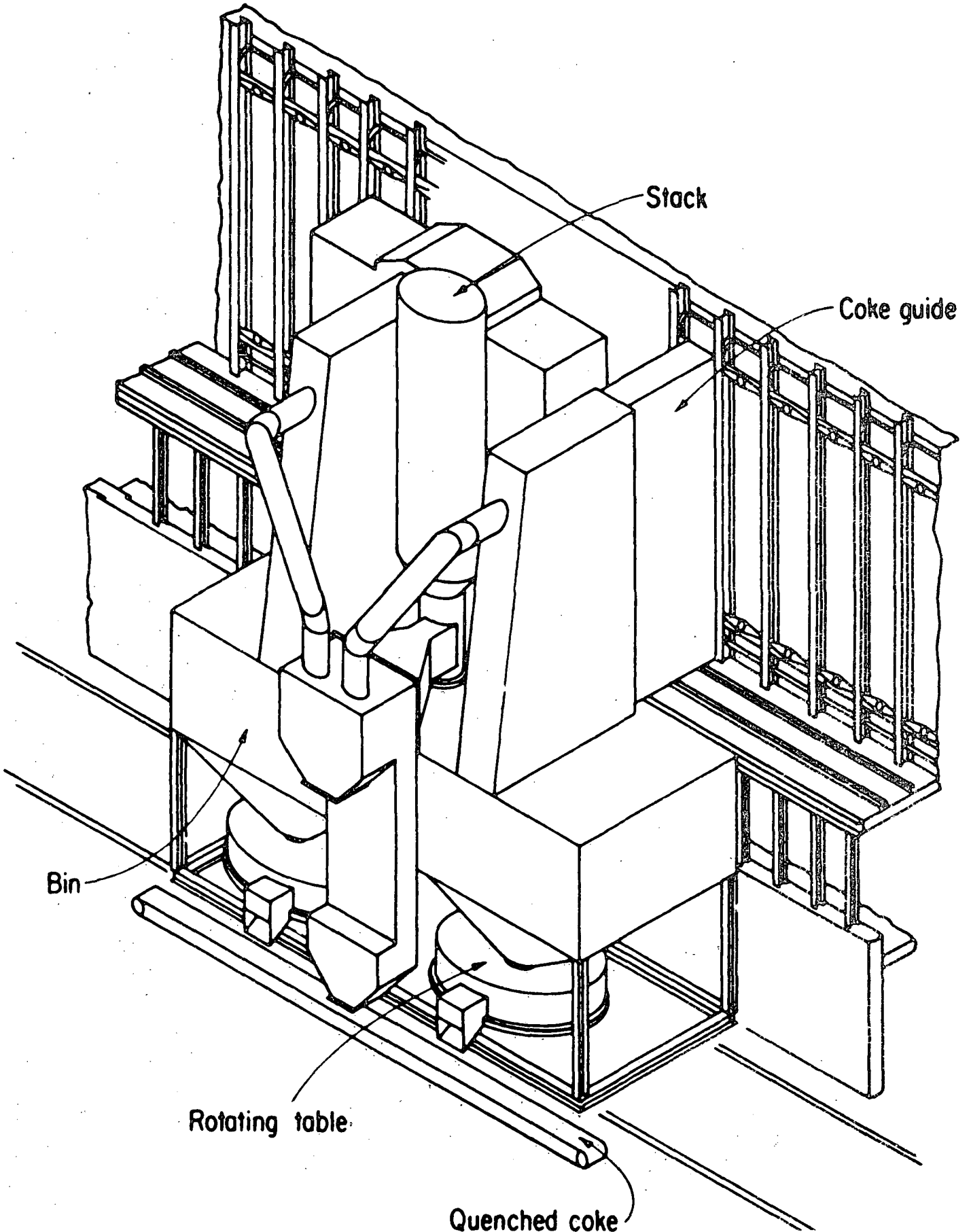
Figure 18 Mobile—Type Rotary Quencher
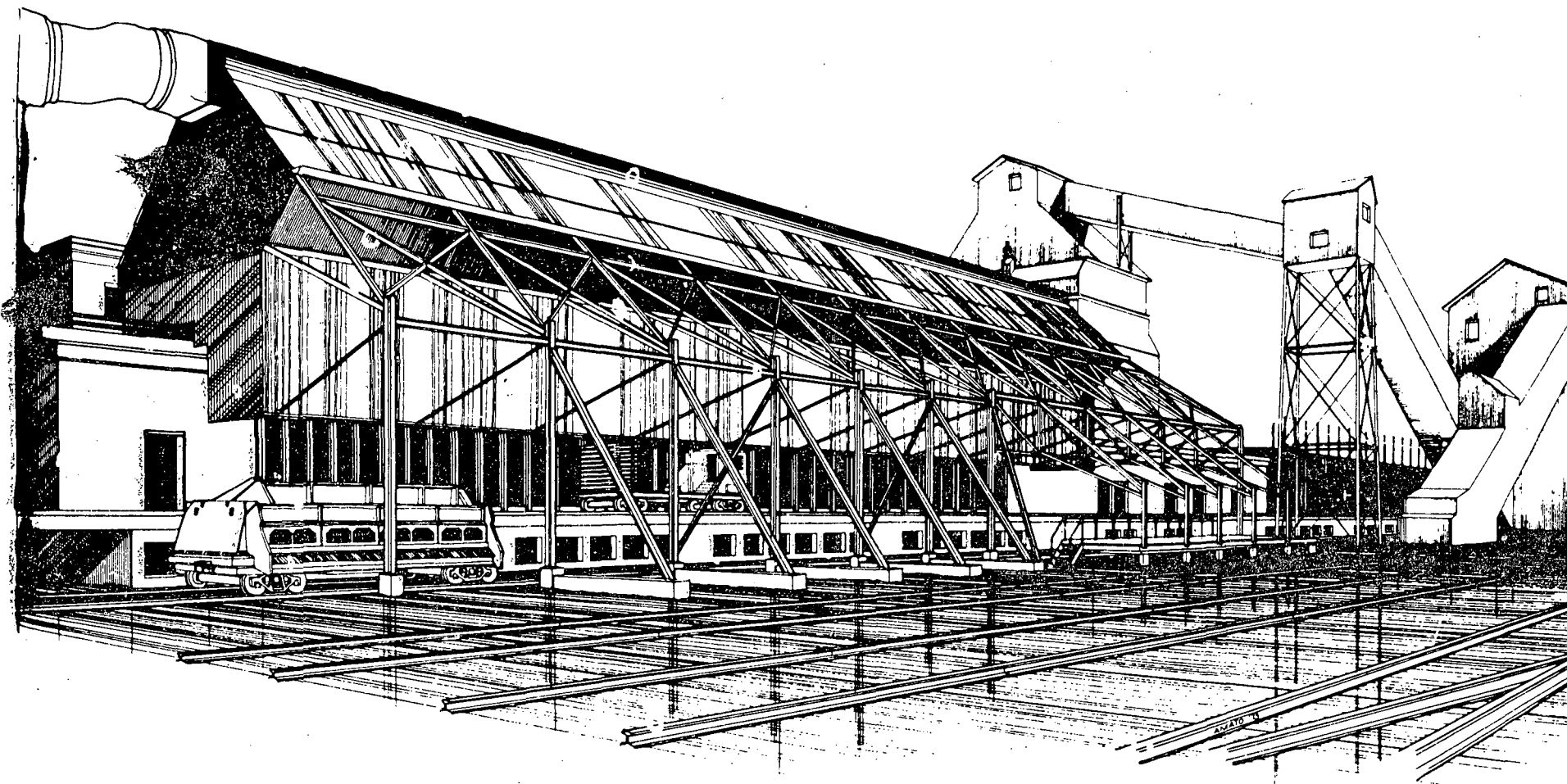
Figure 19   Coke-Side Hood at the St. Louis Plant of Great Lakes Carbon Corporation
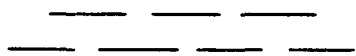
Horizontal, lapped
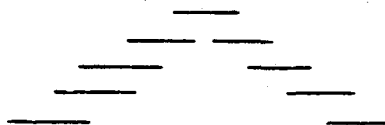
Horizontal, staggered

Single louver

Opposed louvers
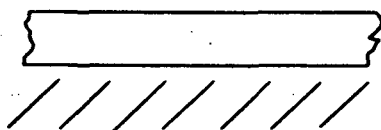
Crossed louvers

Chevron louvers

Large pieces of coke
supported on wire mesh
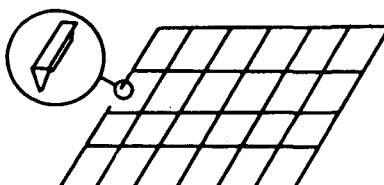
Wedge-wire screen used as a
baffle slat (arranged as
opposed louvers)

Figure 20   Types of Baffles Used in Quench Towers

5.2 Controls in By-Product Plant

5.2.1 *Summary of Existing Controls.* After passing through primary coolers, exhausters, and conventional gas-cleaning equipment to remove entrained solids, water and tar, the coke oven gas is generally stripped of ammonia (a detailed description of the by-product plant process with mention of controls was given under Section 3.2). Of the Canadian plants which remove ammonia from the coke oven gas some use a counter-flow water wash, others use sulfuric acid and produce ammonium sulphate, and one uses an ammonium phosphate solution to produce anhydrous ammonia (Stelco). The efficiency of these processes for removing ammonia from the coke oven gas is approximately 99%. The coke oven gas is further processed to recover light oils (all Canadian plants), remove hydrogen sulfide (two plants to various degrees) and cyanide (two plants to different degrees). The clean coke oven gas is used as an in-plant fuel.

Treatment of flushing liquor, the other major coke-making by-product, to remove constituents is practiced less than is treatment of coke oven gas. Phenol is sometimes removed and the two processes used for this purpose in Canada are biological oxidation and light oil extraction a dephenolizing plant. Only one plant removes ammonia from the flushing liquor and this is done with the use of a free and fixed leg ammonia still (Dofasco). Another plant discharges its flushing liquor to a municipal sewage plant for treatment (Stelco). Emissions of HCN, H_2S and ammonia, which will be released when utilizing a cooling tower in association with the final cooler, can be avoided by the use of an indirect cooling method.

5.2.2 *Description of Major Sulphur Removal Processes.* There have been many processes either proposed or developed to remove hydrogen sulfide from coke oven gas. One of the earliest methods was an iron oxide or dry box purification process. This method has been used successfully and was utilized, up to 1972, by one Canadian plant but has since been discarded (Lasalle Coke). The efficiency of hydrogen sulphide removal was claimed to be about 80%. This method seems applicable mainly to small plants because of the large area required by the oxide boxes and the serious problem of disposal of the spent oxide. For large coking plants, several technologies are commercially available for the desulfurization of coke oven gas, each with different desulfurization capabilities, and each with attendant difficulties. Two of these technologies are the Vacuum Carbonate System and the Stretford Process, for which simplified flow sheets are given in Figures 21 and 22. Other available gas purification systems have not yet been proven successful in commerical operations for coke oven gas desulfurization because of system fouling by small amounts of organic compounds and HCN in the gas.

5.2.2.1 *Vacuum Carbonate System.* This system encompasses the vacuum carbonate process for stripping H_2S from coke oven gas and the Claus process for converting H_2S to elemental sulphur. The vacuum carbonate plants are designed by either Koppers or Bethlehem Steel. The H_2S removal efficiency of the carbonate plant varies from 80 to 93% depending on the H_2S content of the original gas. The carbonate process removes most of the HCN present in coke oven gas (up to 60 g/100 scf). This leads to problems such as the production of thiocyanate in the absorbing solution, HCN contamination of steam jet condensed water and HCN contamination of Claus plant feed gases.
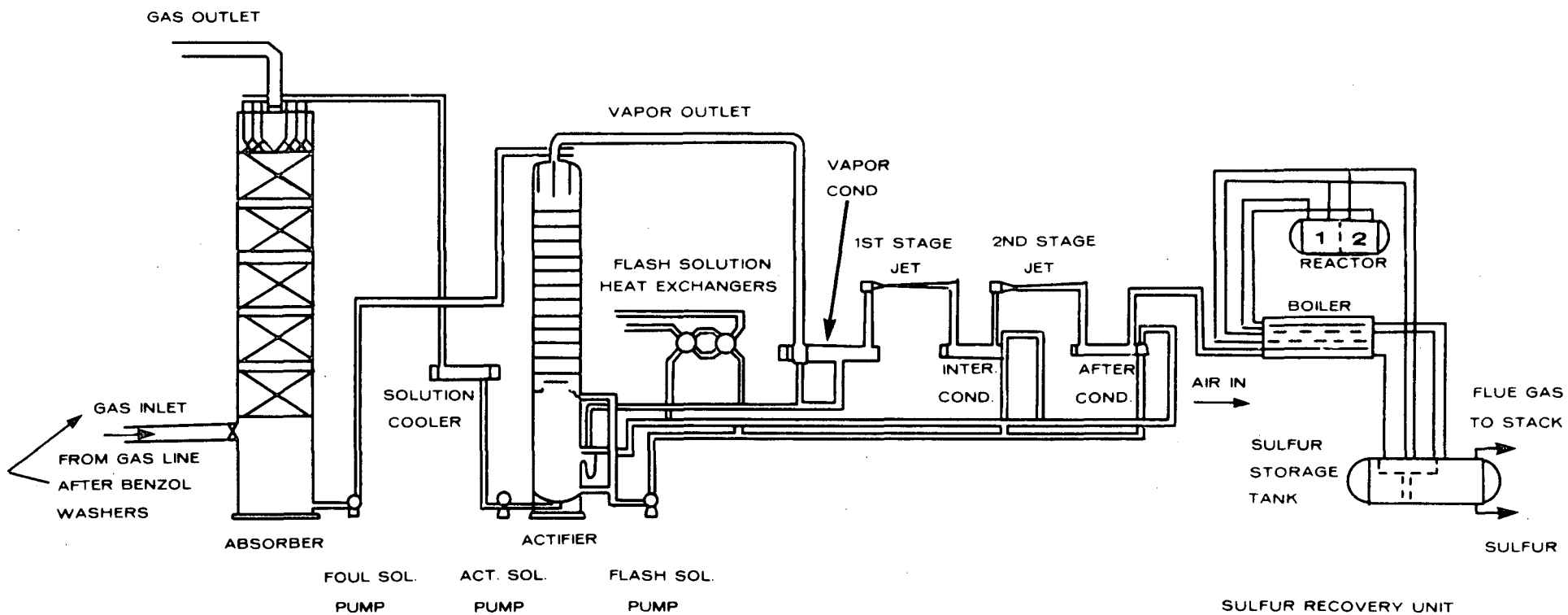
Figure 21 Vacuum Carbonate Process
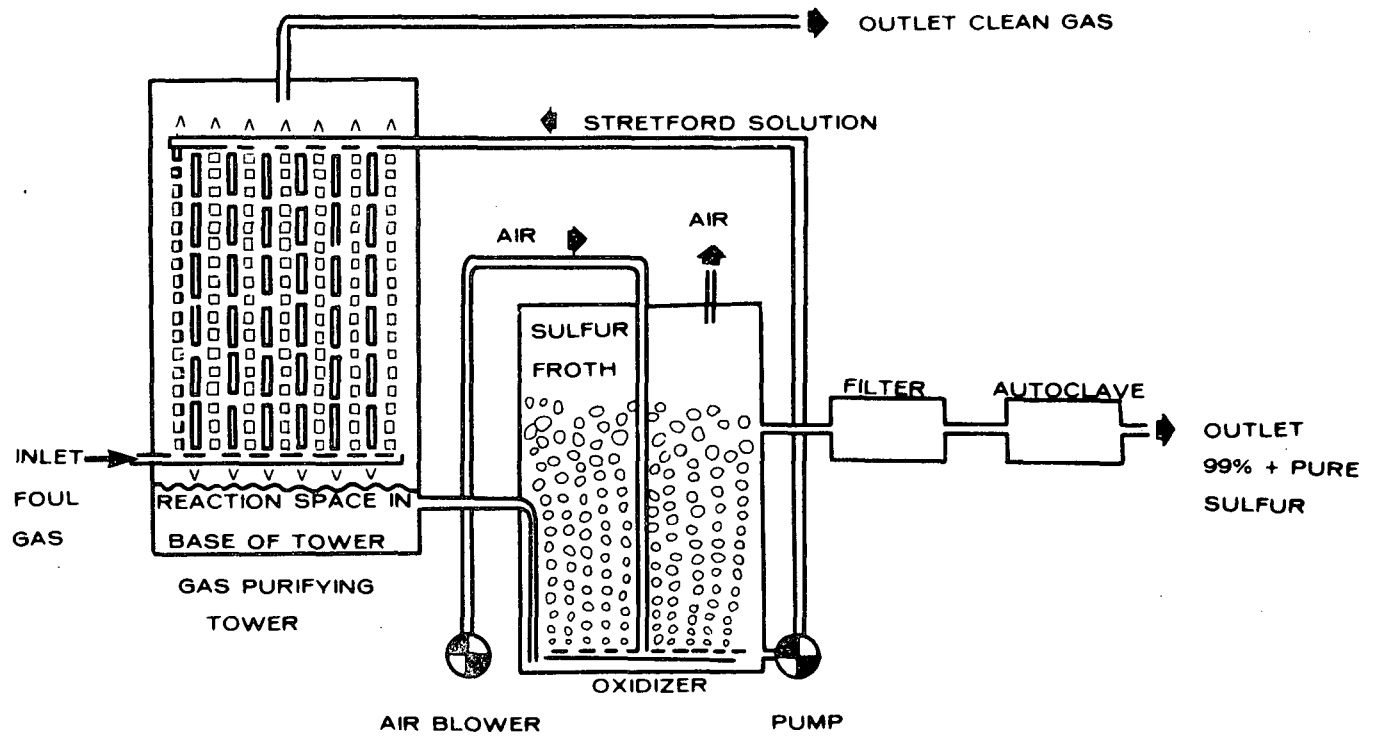
Figure 22 Stretford Process

Claus plants are typically designed to operate at efficiencies from about 92 to 96%. The bulk of the HCN entering the vacuum carbonate plant is delivered directly to the Claus plant along with the H_2S. There is evidence that the presence of 3 to 5% HCN in Claus feed gases will have adverse effects on the performance of these plants. Waste gases from the Claus plant contain from 2.4 to 8% sulphur, largely as unreacted H_2S and SO_2. These gases are usually not considered as a large source of sulphur emissions (about 0.75 tons/day for 60 mmcfd stream of coke oven gas), however, they can be treated with available 'tailgas' cleaning processes at an efficiency ranging from 80 to 99 + %. In the vacuum carbonate system raw coke oven gas counter-currently contacts an aqueous solution of Na_2CO_3 where absorption reactions occur and a $NaHCO_3$ solution is obtained. This solution passes to an actifier which is operated under a vacuum. Steam is produced at the bottom of the actifier and, as it countercurrently passes the absorption solution, it strips out the acid gases absorbed in the previous step. These gases are then passed through the Claus plant where H_2S is converted to elemental sulphur of high quality.

Recent information indicates that the vacuum carbonate process, with an H_2S removal efficiency of 91-93%, is proven, operates satisfactorily and is being adopted by more coke oven plants. Furthermore, Claus plants have operated satisfactorily with the vacuum carbonate process on coke oven gas when the HCN content of the off-gas is under 6%. In this instance, a special burner is required. When the HCN content exceeds 6%, and many off-gas streams contain 12-22% HCN, the Claus plant does not operate satisfactorily. To circumvent this situation, HCN may be removed from the off-gas either by catalytic conversion or water stripping. Claus plants are known to have operated satisfactorily using either method (at least five Claus plants are or will be operating in this manner in the United States). Finally, it should be noted that a new two-stage vacuum carbonate system, with an anticipated H_2S removal efficiency of 98-99%, is in the development stage at Koppers Engineering.

5.2.2.2   Stretford Process. This process is licensed by five American companies including Esso Research and Otto Construction. While the bulk of existing Stretford plants are in Europe, several plants have been built in North America. Among these, only the Dofasco plant in Canada operates on coke oven gas.

The Stretford process does not remove organic sulphur but consistent H_2S removal efficiencies of 99% are achieved for gas streams with sulphur loadings ranging from parts per million to parts per hundred. The process converts H_2S directly to elemental sulphur, so there are no secondary losses in efficiency. HCN must be removed from the coke oven gas prior to H_2S removal (polysulfide process), to minimize the production of thiocyanates and prolong the useful life of the absorbing solution.

The two major problems associated with the Stretford process are the disposal of thiocyanates and thiosulfates present in spent Stretford solution wastes and the disposal of HCN pretreatment wastes containing ammonium thiocyanates and elemental sulphur. These are not recognized problems in Europe where Stretford wastes are dumped into the sewers. No specific regulations on these materials exist in North America at the present time. Current problems with the Stretford solution could be essentially eliminated by improved operation of the HCN pretreatment process and by chlorination of spent absorbing solution to oxidize thiosulfate to sulfate. The serious problem of disposal of HCN pretreatment wastes could possibly be resolved by the recently developed Parsons pretreatment process for thiocyanate waste.

The Stretford process is basically a wet oxidative process and therefore quite different from the vacuum carbonate system. Hydrogen sulphide is not only removed from the coke oven gas but is also oxidized in solution to elemental sulphur. The initial absorption reaction is similar to that in the vacuum carbonate system except that in the Stretford process the H_2S undergoes a rapid oxidation with sodium vanadate to form elemental sulphur, whereas, in the vacuum carbonate system the hydro-sulfide remains and accumulates in the absorbtion solution. The absorbing solution contains ADA (2:7 anthraquinone-disulphonic acid) which regenerates the vanadium. As long as there is active ADA in the solution, absorption of H_2S can continue. Exhausted ADA is regenerated in an oxidizer tower where sulphur contained in the absorbing solution is also separated by a frothing action at the top of the tower.

5.3   Best Practicable Technology

Control of particulate emissions during the operations involved in the crushing and screening of coal and coke is achieved by using various types of gas cleaning equipment such as cyclones, wet scrubbers and fabric filters, listed in order of increasing overall reduction in emissions. Water sprays or wetting agents are sometimes used at transfer points and wherever a potential source of particulate emissions exists in the handling of coal and coke. Covered conveyors may also be used in some instances. Particulate and minor sulphur dioxide emissions generated during the charging operation in Canada are controlled by either a staged charging practice or by wet-type-scrubber larry-cars. The use of pipelines or enclosed conveyor systems for the charging of coals into by-product coke ovens will also adequately control charging emissions. Baffle-type installations are used to control particulate emissions from wet quenching towers. Particulate emissions arising from the pushing operation are controlled either by coke-side shed enclosures or by mobile-type hoods. Particulate emissions from the battery stacks are reduced by good operation and maintenance practices. Coke oven gas hydrogen sulphide removal processes are used to control emissions of sulphur dioxide.

Emission factors that are attainable using this control technology are shown in Table 14 (8). The use of this control technology in 1975 would reduce total particulate emissions from the metallurgical coke manufacturing industry to 3063 tons and sulphur dioxide emissions to 8218 tons. Detailed emissions for 1975 based on the use of this control technology in all plants are shown in Table 15.

Emissions of other types of pollutants such as nitrogen oxides, hydrocarbons and carbon monoxide will also be reduced by the use of best practicable technology in the charging and pushing operations. Estimated emissions of other pollutants in 1975 based on the use of this technology are given in Table 16.

TABLE 14   EMISSION FACTORS ATTAINABLE BY USE OF BEST PRACTICABLE
                  TECHNOLOGY FOR NEW AND EXISTING PLANTS

Source	Emission factor (lb/ton of dry coke)	
	Particulate	Sulphur dioxide
Crushing & screening of coal and coke	0.10	–
Charging	0.20	–
Quenching	0.10	–
Pushing	0.30	–
Battery stacks	0.34	–[1]
COG consumption	–	2.60

[1] Included in COG consumption

TABLE 15   ESTIMATED PARTICULATE AND SULPHUR DIOXIDE EMISSIONS FOR
                  1975 FOR THE CANADIAN COKE-MAKING INDUSTRY IF BEST
                  PRACTICABLE TECHNOLOGY WERE USED

Region	Emissions (tons)		% Reduction required
	Estimated 1975	If best practicable technology were used	
Particulate			
Ontario	5 914	2 478	58
Balance of Canada	2 902	585	80
TOTAL	8 816	3 063	65
Sulphur dioxide			
Ontario	19 102	6 757	65
Balance of Canada	6 991	1 461	79
TOTAL	26 093	8 218	69

TABLE 16   ESTIMATED EMISSIONS OF OTHER POLLUTANTS IN 1975 FOR. THE
CANADIAN COKE-MAKING INDUSTRY IF BEST PRACTICABLE
TECHNOLOGY WERE USED

Region	Emissions (tons)		
	Nitrogen oxides[1]	Hydrocarbons	Carbon monoxide
Ontario	7	541	482
Balance of Canada	2	145	120
TOTAL	9	686	602

[1] Expressed as NO_2

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ACKNOWLEDGEMENTS

APPENDIX I – THE QUESTIONNAIRE

APPENDIX I   THE QUESTIONNAIRE

CONFIDENTIAL	ENVIRONMENT CANADA	IMPORTANT
Keep one copy	OTTAWA	Please complete and
	AIR POLLUTION CONTROL DIRECTORATE	return within 60
	COKE OVEN INDUSTRY STUDY	days of receipt

Name of company   Name of person responsible for this report

Address of plant

Name of contact

Please print or type

Telephone (Area code & No.)

INFORMATION CONTAINED HEREIN WILL BE USED BY THE FEDERAL DEPARTMENT OF THE
ENVIRONMENT IN STUDIES DESIGNED TO ASSIST IN THE REALISTIC DEVELOPMENT OF
CANADA'S AIR POLLUTION ABATEMENT PROGRAMS

INSTRUCTIONS

Please supply the information requested where applicable. If actual data are not available, give estimated
values (in brackets) or mark NA if the question does not apply or if an estimate cannot be provided within
reason.

Please provide a plot plan, layout drawing, or aerial photograph of your plant with the pertinent facilities
and emission sources identified; identification should be the same as used in the questionnaire.

Note that costs requested (both capital and operating) are for the operations covered by the questionnaire
only.

One questionnaire is to be compiled for each plant.

When inadequate space has been provided on the questionnaire for your answer, please complete the
answer on a separate sheet.

Questionnaires should be signed by an authorized executive or the company.

I. RAW MATERIALS

Coal	High Volatile	Medium Volatile.	Low Volatile
Percent of consumption (1972)			
Source i.e. Virginia Cape Breton			
Rank			
Ash (%)			
Sulphur (%)			

      – Coke yield (average 1972)   _____ %

      – Gas yield (average 1972)   _____ scf/ton of coal

2. RAW MATERIALS HANDLING

    a) Storage – approximate amount (tons)   _____ Minimum

                                                  _____ Maximum

          – approximate exposed surface
             area of pile (ft^2)   _____ Minimum

                                                _____ Maximum

          – Is dust suppression used?   Yes ☐   No ☐

          – If yes, please describe.

    b) Handling:

          – Tons/h (average 1972)   _____

          – Do you have dust control facilities?   Yes ☐   No ☐

          – If yes,   – Type   _____

          – Capacity (acfm)   _____

          – Efficiency (%)   _____

          – Method of dust disposal   _____

3. COKE OVENS

    a) Battery No.

    b) Date of installation (year)

    c) Type: (i.e. Koppers, Wilputte, Otto)

    d) No. of ovens

    e) Oven size:

          – Length (ft)

          – Width (in)

          – Height (ft)

f) No. of charging holes

g) Coking time (hr)
   - Normal (1972)
   - Minimum (1972)

h) Coal Capacity — Tons per oven (coal)

i) Wall Temperature - °F.

j) Type of underfiring gas
   - coke oven gas (after processing
     in by-product plant)
   - uncleaned coke oven gas (not
     processed in by-product plant)
   - blast furnace gas
   - natural gas

k) Collecting main - Single
                   - Double
   - charging suction (in WG)
   - operating pressure (in WC)

l) Condition of ovens - Excellent
                      - Fair
                      - Poor

m) Type of door luted, sealing,
   Koppers, Wolfe, etc.

n) Leakage during coking cycle:
   (Note: Mark N for none, I for
   very minor, 2 for continuous
   minor and 3 for excessive)
   - Coal side doors.
   - Coke side doors.
   - Charging holes.
   - Other

o) Emission collection facilities
   for Charging   Yes/No
   - Type of unit
   - Capacity (,000 acfm)
   - Efficiency (%)
   - Estimated emission not
     collected (lb/day)
   - How was estimate obtained?
   - % of charges without emission
     control (1972)

p) Emission collection facilities.

for pushing.   Yes/No

  - Type of unit

  - Capacity (,000 acfm)

  - Efficiency (%)

  - Estimated emission not collected (lb/day)

  - How was estimate obtained?

  - % of pushes without emission control (1972)

  - Stack height (ft)

  - Exit temperature °F.

  - Exit diameter (ft)

q) Battery flue gas stacks:

  - Identification code on plan

  - Height (ft)

  - Exit diameter (inside) (ft)

  - Estimated exit temperature (°F)

  - Discharge volume (acfm)

  - Sulphur discharge (lb/day)

  - Particulate discharge (grain/scf)

4. QUENCH STATIONS

a) Station No.

b) Type

c) Height (ft)

d) Length (ft)

e) Width (ft)

f) Imp. gal   water/ton coke quenched.

g) Solids suppressor   Yes/No

                      - Type

h) Estimated emissions not collected

                      - lb/day

  - How was estimate obtained?

5. COKE HANDLING

Do you have dust collection facilities?   Yes   No

If no, estimated particulate emissions (lb/day)

If yes: - Type   _____

             - Capacity (,000 acfm)   _____

             - Efficiency (%)   _____

             - Estimated emissions not collected (lb/day)   _____

             - How was estimate obtained?   _____

6. BY PRODUCT PLANT

a) Plant No.

b) Capacity (million cfd)

c) Ammonia (in gas) (grain/100 cf)

    — Removal   Yes/No

    — Type of removal process

    — % removal

    — Ammonia incinerated (,000 cf/day)

                       — average 1972

                       — maximum 1972

d) Ammonia incinerator stack

    — Identification code on plan

    — Height (ft)

    — Exit diameter (ft)

    — Exit temperature (°F)

    — Exit volume (,000 acfm)

    — NO_x (ppm)

    — Sulphur compounds as S (ppm)

e) Light oil removal.   Yes/No

    If yes, what type?

f) Napthalene removal. Yes/No

    If yes, what type?

g) HCN in raw gas (grain /100 cf)

    — Removal   Yes/No

    — Type of removal process

    — % removal.

h) H_2S in raw gas (grain/100 cf)

    — Removal   Yes/No

    — Type of removal process

    — Efficiency (%)

7. FLARE STACKS

    — Identification code on plan

    — Height (ft)

    — Exit diameter (ft)

    — Gas flared (,000 scfd) Minimum (1972)

                           Maximum (1972)

    — Average for year 1972

    — Sulphur content as S (grain /100 scf)

8. FLUSHING LIQUOR

a) Phenol

       – Is phenol removed?   Yes ☐   No ☐

       – If yes., by what process? _____

b) Ammonia

       – Is ammonia removed?   Yes ☐   No ☐

       – If yes, by what process? _____

       – Is ammonia incinerated?   Yes ☐   No ☐

       – If yes: – Ammonia volume (scfh) _____

                   – Identification code on plan _____

                   – Stack Height (ft) _____

                   – Stack exit diameter (ft) _____

                   – Stack exit temperature (°F) _____

                   – Process temperature (°F) _____

                   – Exit volume (acfm) _____

                   – NO_x emissions (ppm) _____

                   – Sulphur dioxide emissions (ppm) _____

9. Do you monitor any air pollution emissions from the coke oven complex?   Yes ☐   No ☐

   If yes, please state which emission, and what method is used.

10. List changes in operating practice or technology which are planned for 1973–1975 which will result in major emission changes.

11. Estimated cost of air pollution control.

	CAPITAL ($000)	ANNUAL OPERATING ($000)
1971	_____	_____
1972	_____	_____
1973	_____	_____
1974	_____	_____
1975	_____	_____

12. Coke production in 1972 (tons).

APPENDIX II - COKE OVEN AND OTHER CARBONIZATION PLANTS IN CANADA IN 1972

Plant Name	Battery No. and number of ovens	Type	Date installed	Height (ft)	Width (in)	Length (ft)	Wall temp (^{0}F)	Coking rate (in/h)	Avg coal charge (tons)
Algoma Steel Corporation	5–86	Koppers B Underjet	1943	13.2	18	41	2249	0.90	17.75
Limited, Sault Ste. Marie,	6–57	Koppers B Underjet	1953	13.2	18	41	2287	0.95	17.75
Ontario	7–57	Wilputte Underjet	1958	13.2	18	41	2327	0.95	17.75
	8.60	Wilputte Underjet	1967	16.7	18	48	2396	1.06	25.9
Steel Company of Canada,	3–61	Wilputte Underjet	1947	12	18	40	2000	0.98	17
Limited, Hamilton	4.83	Wilputte Underjet	1952	12	18	40	2000	0.98	17
Ontario	5–47	Wilputte Underjet	1953	12	18	40	2000	0.98	17
	6–73	Otto Underjet	1967	16.4	18.5	47	1950	0.95	27
	7–83	Otto Underjet	1972	16.4	18.5	47	2100	1.06	27
Dominion Foundries and Steel	1–25	Koppers B Gun Flue Comb	1956	13	17	40	2280	0.81	16
Limited, Hamilton,	2–35	Koppers B Gun Flue Comb	1951	13	17	40	2280	0.81	16
Ontario	3–45	Koppers B Gun Flue Comb	1958	13	17	40	2280	0.81	16
	4–53	Koppers B Gun Flue Comb	1967	13	17	40	2365	1.06	16
	5–53	Koppers B Gun Flue Comb	1971	13	17	40	2365	1.06	16
Sydney Steel Company,	5–53	Koppers B Underjet	1949	13	17	43.8	2350	1.00	17
Limited, Sydney, Nova Scotia	6–61	Koppers B Underjet	1953	13	17	43.8	2350	1.00	17
Gaz Metropolitain, Inc.	1–59	Koppers B	1928	13	18.5	43.5	1900	0.56	17
Ville Lasalle, Quebec	2–15	Koppers B	1947	13	18.5	43.2	1900	0.56	17
Manitoba and Saskatchewan Coal Company (Limited) Char and Briquetting Division, Bienfait, Saskatchewan	2 units	Lurgi Carbonizing Retort	1925	40	16	20	1560	8.00	135
Kaiser Resources Ltd.	10 units	Curran–Knowles	1939	8	76	30	2550	0.90	5
Natal,	10 units	Curran–Knowles	1943	8	76	30	2550	0.97	5
British Columbia	16 units	Curran–Knowles	1949	8	120	40	2550	0.94	7.5
	16 units	Curran–Knowles	1952	8	120	40	2550	0.94	7.5
	3 units	Mitchell	1963	–	–	–	–	–	–

APPENDIX III – COKE OVEN COAL CHEMICALS

APPENDIX III   COKE OVEN COAL CHEMICALS

Constituent group	Name	Chemical formula	Boiling Point °C
Aromatics	Benzene	C_6H_6	80.1
	Toluene	$C_6H_5CH_3$	110.6
	Ethyl benzene	$C_6H_5C_2H_5$	136.2
	p–Xylene	$C_6H_4(CH_3)2$	138.4
	m–Xylene	$C_6H_4(CH_3)2$	139.1
	o–Xylene	$C_6H_4(CH_3)2$	144.0
	n–Propyl benzene	C_9H_{12}	158.6
	Ethyl toluenes	C_9H_{12}	161.2 to 164.9
	Mesitylene	$C_6H_3(CH_3)3$	164.6
	Pseudocumene	$C_6H_3(CH_3)3$	169.2
	Hemimellitene	$C_6H_3(CH_3)3$	176.2
	Cymenes	$C_{10}H_{14}$	175.5 to 177.3
	Durenes	$C_6H_2(CH_3)4$	196.0 to 198.0
Paraffins	n–Pentane	C_5H_{12}	36.1
	n–Hexene	C_6H_{14}	68.8
	2–Methylhexane	C_7H_{16}	90.3
	n–Heptane	C_7H_{16}	98.4
	n–Octane	C_8H_{18}	125.6
	n–Nonane	C_9H_{20}	150.7
	n–Decane	$C_{10}H_{22}$	174.0
Cycloparaffins Napthenes	Cyclopentane	C_5H_{10}	51.0
	Cyclohexane	C_6H_{12}	80.8
	Methylcyclohexane	$C_6H_{11}CH_3$	100.3
	Cycloheptane	C_7H_{14}	120.3
	Cyclooctane	C_8H_{16}	150.0
	Cyclononane	C_9H_{18}	172.0
Unsaturateds (Olefins – Diolefins and aromatic with unsaturated side chains)	Butadiene–1,3	C_4H_6	-5.0
	Butene–1	C_4H_8	-6.5
	Pentene–1	C_5H_{10}	30.1
	Amylenes	C_5H_{10}	20 to 41.0
	Cyclopentadiene–1,3	C_5H_6	42.0
	n–Hexylene	C_6H_{12}	64.0
	Hexene–2		

	Hexadiene-1,3		
	n-Heptylene	C_7H_{14}	99.0
	Cyclohexene		85.0
	Octylene	C_8H_{16}	126.0
	Styrene	C_8H_8	146.0
	Coumarone	C_8H_6O	175.0
	Dicyclopentadiene	$C_{10}H_{12}$	170.0
	Indene	C_9H_8	182.0
	Napthalene	$C_{10}H_8$	218.0
	2-Methyl naphthalene	$C_{10}H_7CH_3$	241
	1-Methyl naphthalene	$C_{10}H_7CH_3$	245
	Dimethyl	$C_{10}H_6(CH_3)2$	255 – 270
	Acenaphthene	$C_{12}H_{10}$	281
	Fluorene	$C_{13}H_{10}$	298
	Phenanthrene	$C_{14}H_{10}$	340
	Anthracene	$C_{14}H_{10}$	342
	Fluoranthene	$C_{16}H_{10}$	382
	Pyrene	$C_{16}H_{10}$	393
	Chrysene	$C_{18}H_{12}$	448
Sulphur compounds	Hydrogen sulphide	H_2S	-59.6
	Carbonyl sulphide	COS	-50.2
	Methyl mercaptan	CH_3SH	7.6
	Ethyl mercaptan	C_2H_5SH	34.7
	Dimethyl sulphide	$(CH_3)_2S$	36.2
	Carbon disulphide	CS_2	46.3
	Thiophene	C_4H_4S	85.0
	Diethyl sulphide	$(C_2H_5)_2S$	91.6
	Methylthiophene	C_5H_6S	112 to 115.0
	Thioxenes	C_6H_8S	137 to 146.0
	Trimethylthiophene		160 to 163.0
	Thiophenol		169.5
	Tetra methylthiophene		182 to 184.0
Phenolic compounds	Phenol	C_6H_5OH	181
	Ortho-cresol	$C_6H_4(CH_3)OH$	191
	Para-cresol	$C_6H_4(CH_3)OH$	201
	Meta-cresol	$C_6H_4(CH_3)OH$	202
	2,4-xylenol	$C_6H_3(CH_3)_2OH$	211.5
	3,5-xylenol	$C_6H_3(CH_3)_2OH$	219.5
	Alpha-naphtol	$C_{10}H_7OH$	280
	Beta-naphtol	$C_{10}H_7OH$	286

Nitrogen	Hydrogen cyanide	HCN	26.0
& oxygen	Pyridine	C_5H_5N	115.3
compounds	2-Methylpyridine (Alpha-picoline)	C_6H_7N	129
	Picolines	C_5H_7N	131 to 143.0
	Dimethyl pyridines	C_7H_9N	143 to 164.0
	3-Methylpyridine (Beta-picoline)	C_6H_7N	144
	2,6-Dimenthylpyridine (Alpha alpha lutidine)	C_7H_9N	144.4
	4-Methylpyridine (Gamma-picoline)	C_6H_7N	144.6
	2,4-Dimethylpyridine (Alpha-gamma lutidine)	C_7H_9N	157.1
	Phenol	C_6H_6O	182
	Cresols	C_7H_8O	190 to 203.0
	Quinoline	C_9H_7N	238
	Isoquinoline	C_9H_7N	243
	Quinaldine	$C_{10}H_9N$	247.6
	2-Methyl isoquinoline	$C_{10}H_9N$	252
	4-Methyl quinoline	$C_{10}H_9N$	264
	Acridine	$C_{13}H_9N$	346
	Carbazole	$C_{12}H_9N$	352

There are also other unidentified compounds.

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