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Air Pollution Emissions and Control Technology. Cement Industry

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

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AIR POLLUTION EMISSIONS AND CONTROL TECHNOLOGY.
CEMENT INDUSTRY

by

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Air Pollution Control Directorate

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ABSTRACT

This study was initiated to evaluate the present and future contributions to air pollution by the Canadian cement industry and to define the best practicable technology to control these air pollution emissions. Actual atmospheric emissions of particulate matter from the production of cement in Canada during 1970 were 170 544 tons and estimated emissions for 1975 are 89 927 tons.

Cement manufacture, a heavy industry associated with all major construction projects, is directly geared to the industrial growth of the Canadian economy. Previously, many cement plants had been established close to the expected markets provided by large urban areas. With subsequent urban development these plants often became incorporated into industrial or residential communities. This situation prompted these plants to strive to reduce particulate emissions to acceptable levels. Their effort has demonstrated that application of best practicable technology will result in excellent control of emissions sufficient to satisfy regulatory limits established or 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 cement industry.

Increases in production planned for 1975 amount to 61% of the total clinker produced by the industry in 1970. To achieve this aim, inefficient plants in urban areas will be replaced by new facilities elsewhere and operation of other plants will be upgraded at increased capacities. New improvements in process and pollution control will result in reduced emissions of particulate matter. Installation of pollution control equipment scheduled by the cement industry for 1975 will reduce particulate emissions from this industry in Canada to a small fraction of the total now emitted by heavy industries.

RÉSUMÉ

La présente étude a pour but d'évaluer la part actuelle et future de l'industrie canadienne du ciment dans la pollution atmosphérique et de définir la meilleure technologie praticable pour contrôler ces émissions. En 1970, les émissions atmosphériques de particules attribuables à la production de ciment au Canada ont été de 170 544 tonnes et on prévoit qu'elles seront de 89 927 tonnes en 1975.

Les cimenteries, industrie lourde liée à tous les importants chantiers de construction, visent en droite ligne la croissance industrielle de l'économie canadienne. Autrefois, bon nombre de fabriques de ciment étaient construites à proximité des marchés sûrs qu'étaient les grands centres urbains. Avec l'expansion urbaine, ces usines se sont souvent retrouvées dans des communautés industrielles ou résidentielles. A cause de cette situation, les fabriques ont été obligées de réduire les émissions de particules à des niveaux acceptables. Leurs efforts ont montré que l'application de la meilleure technologie praticable permettra de réaliser un excellent contrôle des émissions qui satisfera aux limites réglementaires établies ou à l'étude par les organismes gouvernementaux. Le présent rapport contient les renseignements de base nécessaires à la création de lignes directrices nationales sur les émissions, comme celles présentées à l'article 8 de la Loi sur la lutte contre la pollution atmosphérique concernant l'industrie canadienne du ciment.

Pour 1975, on prévoit une augmentation de la production totale de mâchefer de l'ordre de 61 p. cent comparativement à 1970. Pour atteindre cet objectif les usines qui fonctionnent mal et sont situées dans les centres urbains seront remplacées ailleurs par de nouvelles installations, et les opérations de certaines autres usines seront portées à leur pleine capacité. L'amélioration du procédé et du contrôle de la pollution permettra de réduire davantage les émissions de particules. Le matériel de contrôle, dont l'installation est prévue pour 1975, réduira les émissions de particules de cette industrie au Canada à une fraction minime du total de particules actuellement émises par l'industrie lourde.

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1 INTRODUCTION

1.1 Scope

This study pertains to air pollution control in the cement industry during the base year of 1970 with changes projected to 1975. Size and location of plants, products, and relative importance of the industry to the Canadian economy are discussed. Results from a national emission inventory and relevant air quality objectives are included. Cost of pollution control is estimated, based on data found in literature supplemented by information supplied by the cement industry.

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 cement industry. The information has been assembled to enable assessment of the impact of emission control on the ambient air in the vicinity of cement 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 cement 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 cement plants have evolved from information given in this report and from reports and studies oriented towards the socio-economic aspects of the industry.

A secondary purpose of this report is to provide information to update the national emissions inventory published by the Air Pollution Control Directorate and to assist in the development of federal briefs, state-of-the-art reviews, and other documents related to air pollution emanating from cement plants.

1.3 Information Sources

A computer search of the literature (search 0074) was conducted by the National Science Library. 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. The third edition of Lea's 'classical' book on cement was used as a general source of information (1).

Personal contacts were established with members of the National Research Council of Canada and the following Departments of the Federal Government: Energy, Mines, and Resources; Industry, Trade, and Commerce; and Statistics Canada.

A questionnaire was then drawn up by the Abatement and Compliance Branch. Input on water pollution aspects was supplied by the Water Pollution Control Directorate. A draft was given to Statistics Canada for review and comments. Discussion also took place with a cement industry committee set up by the Portland Cement Association before final revisions were made. Approval was then given by the Air Pollution Control Directorate to distribute the questionnaire to the cement industry. Copies available in English and French were mailed to the headquarters of the cement companies in December 1972. The English version of the questionnaire is reproduced in Appendix I.

2 INDUSTRY DESCRIPTION

2.1 Size

Total capacity of the 24 plants operating in Canada during 1970 was 14 572 200 tons.* The largest single plant was rated at 1 750 000 tons and the smallest at 175 000 tons per year (2). The production figures indicate that cement manufacturing must be classified as heavy industry.

During 1970 the cement industry purchased electricity worth $7 559 000 (3), considerably more than that spent on fuels firing the kilns (coal, oil, or natural gas).

The cement industry operated at only about 55% capacity during the base year, but shipments of cement still amounted to a total of 8 244 561 tons with a value of $165 604 000 (3). The industry is strongly influenced by seasonal demands for cement. Most plants operate at or near capacity only during periods of peak construction activity. Emissions during typical peak production have been used in this study to obtain results pertaining to conditions which maximize the air pollution problem. The national inventory, however, pertains to emissions from actual cement production during the year.

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* Units cited are short tons throughout the report.

2.2 Employment

The total number of employees in the cement industry, which has been relatively steady during the 1960's, was 3887 in 1970 (3). Of this total 2520 or about 65% were classified as manufacturing or production-related workers. Employment in the cement industry is further broken down in Table 1.

TABLE 1 EMPLOYMENT IN CANADIAN CEMENT PLANTS

Job classification	No. of employees		
	Males	Females	Total
Manufacturing	2519	1	2520
Production-related	46	13	59
Administrative and office	815	215	1030
Sales and distribution	235	43	278
TOTAL	3615	272	3887

Regional breakdown for the Provinces of Ontario and Quebec can be found in Reference 3.

2.3 Products

Cement is produced when pulverized mixed raw materials react in a kiln upon application of heat to form clinker. This product is blended with a small amount of gypsum and ground to a specified mesh size. The final product is known as portland cement. Table 2 lists the five types of portland cement produced, all of which are manufactured in Canada.

TABLE 2 TYPES OF PORTLAND CEMENT

Type	CSA category
Normal	10
Moderate (heat of hydration and sulphate resistance)	20
High early strength	30
Low heat of hydration	40
Sulphate resistant	50

The chemical and physical properties of these cements are described in CSA Standard A5-1971 (4). Normal portland cement has the following approximate composition (5):

tricalcium silicate	50%
dicalcium silicate	23%
tricalcium aluminate	10%
tetracalcium alumino-ferrite	8%
calcium sulphates	4%
magnesia	3%
minor constituents	2%

High early strength portland cement, high in tricalcium silicate, is produced by finely grinding specially burned clinker. Sulphate resistant portland cement is very low in tricalcium aluminate. Some normal portland cement clinker is further processed to produce masonry cement by finely grinding it with limestone and plasticizer to satisfy CSA Standard A8-1970 (6).

2.4 Geographic Distribution

The geographic distribution of cement plants across Canada is shown in Figure 1. The plants are numbered in the figure to correspond with the numbering in Table 3, which lists the plants by location (2). Most of the plants have been built near major markets to keep transportation costs, and accordingly the total purchase price to the consumer, as low as possible.

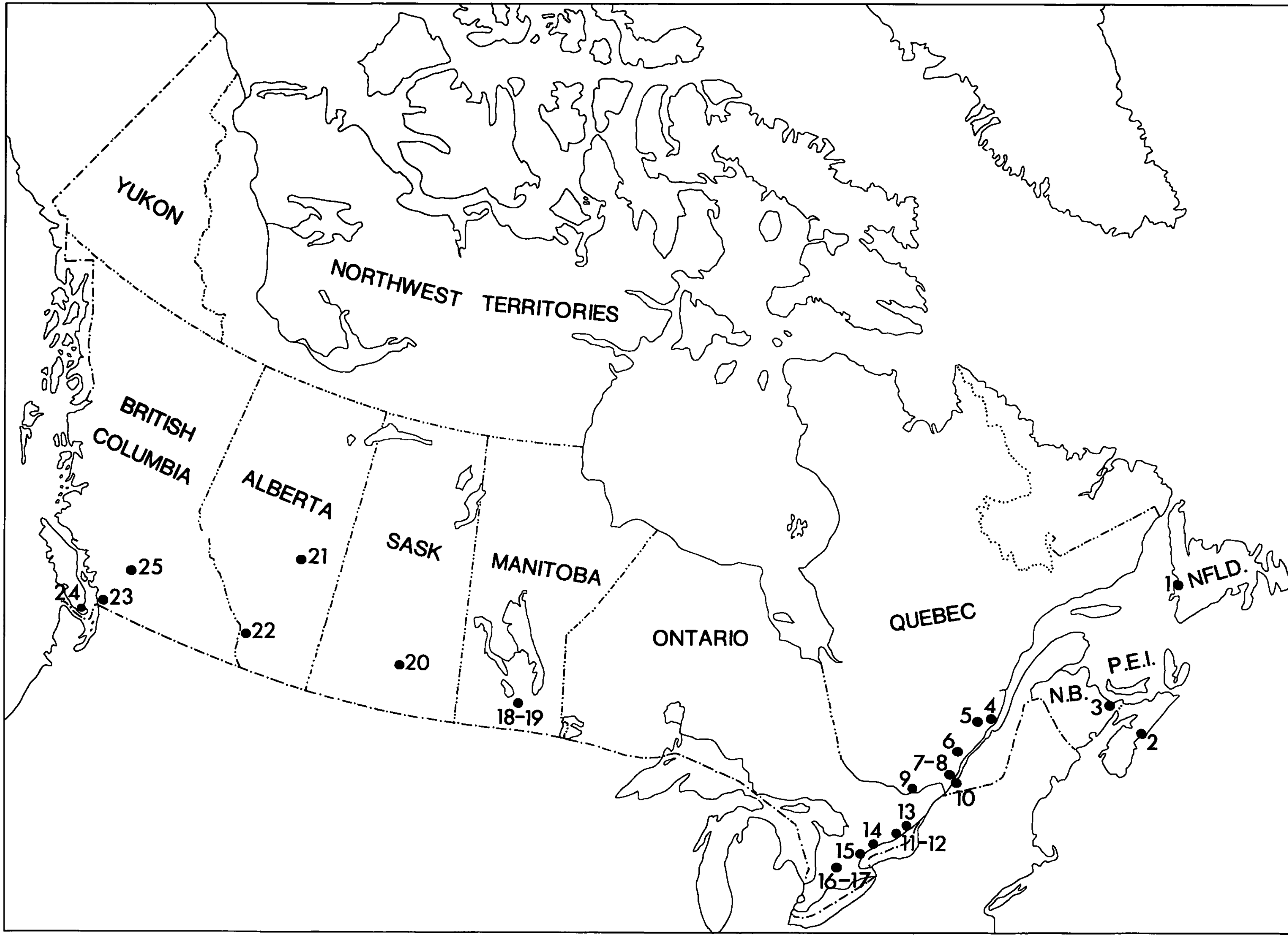

FIGURE 1 CEMENT PLANTS IN CANADA 1970 (2)

TABLE 3 LOCATION AND APPROXIMATE ANNUAL CAPACITY OF CANADIAN CEMENT PLANTS, 1970 (2)

Plant No.	Company by province	Plant location	Process	Tons
	Newfoundland			
1	North Star Cement Ltd.	Corner Brook	Dry	175 000
	Nova Scotia			
2	Canada Cement Lafarge Ltd.	Brookfield	Dry	246 000
	New Brunswick			
3	Canada Cement Lafarge Ltd.	Havelock	Dry	350 000
	Quebec			
4	St. Lawrence Cement Co.	Villeneuve	Wet	787 500
5	Ciment Quebec Inc.	St. Basile	Wet	437 500
6	Independent Cement Inc.	Joliette	Dry	656 200*
7	Miron Co. Ltd.	St. Michel	Dry	1 050 000
8	Canada Cement Lafarge Ltd.	Montreal	Wet	1 400 000
9	Canada Cement Lafarge Ltd.	Hull	Wet	210 000
10	Lafarge Canada Ltd.	St. Constant	Dry	525 000
	Ontario			
11	Lake Ontario Cement Ltd.	Picton	Dry	875 000
12	Canada Cement Lafarge Ltd.	Belleville	Wet	770 000
13	Canada Cement Lafarge Ltd.	Bath	Dry	1 100 000**
14	St. Mary's Cement Ltd.	Bowmanville	Wet	385 000
15	St. Lawrence Cement Co.	Clarkson	Wet/Dry	1 750 000
16	Canada Cement Lafarge Ltd.	Woodstock	Wet	525 000
17	St. Mary's Cement Ltd.	St. Mary's	Wet	752 000
—	Medusa Products Co. of Canada	Paris	Grinding only	
	Manitoba			
18	Canada Cement Lafarge Ltd.	Fort Whyte	Wet	525 000
19	Inland Cement Industries Ltd.	Winnipeg	Wet	350 000
	Saskatchewan			
20	Inland Cement Industries Ltd.	Regina	Dry	227 000
—	Canada Cement Lafarge Ltd.	Floral	Grinding only	
	Alberta			
21	Inland Cement Industries Ltd.	Edmonton	Wet	577 500
22	Canada Cement Lafarge Ltd.	Exshaw	Wet	475 000
—	Canada Cement Lafarge Ltd.	Edmonton	Grinding only	
	British Columbia			
23	Lafarge Canada Ltd.	Lulu Island	Wet	612 500
24	Ocean Cement Ltd.	Bamberton	Wet	700 000
25	Lafarge Canada Ltd.	Kamloops	Dry	210 000
TOTAL (58 kilns)				14 572 200

* Adding approximately 220 000 tons capacity (1 kiln) in 1971.
** Not included in total; planned for 1973.

Figure 1 shows that plants are also located in relatively low population areas along navigable waters, which provide low cost transportation to major marketing centres.

2.5 Relative Importance

The cement industry, along with the steel industry, may be described as the backbone of the construction industry. Therefore, production in the cement industry is subject to variations in construction of new housing, highways, dams, and other large projects. Portland cement is used mainly to produce concrete. The concrete can either be poured in place or be precast to make blocks, bricks, panels, heavy reinforced beams, and other structures. Many cement companies are directly involved in these activities. Some also produce and sell aggregate materials used in making concrete. Construction in Canada during 1970 was valued at $13.2 billion. Shipments of cement amounted to $165.6 million (3), and of finished products $215.0 million.

3 INDUSTRIAL PROCESSES

3.1 General

Both dry and wet processes are used in Canadian cement plants. These processes differ only in the preparation of kiln feed. Thereafter, the same procedure is followed in manufacturing the different types of portland cement. Of the plants operating in Canada during 1970, nine using the dry process had a total capacity of 4 314 700 tons compared with 14 plants using the wet process which had a capacity of 8 507 500 tons. One additional plant using both wet and dry processes had a capacity of 1 750 000 tons (2). The wet process was formerly favored because a consistent kiln feed was easy to maintain and dust control equipment required during raw material processing was minimal. However, advances in the techniques of dust control and blending of dry materials make the dry process more desirable because better fuel economy is achieved than is with the wet process when firing the kiln. Fuel consumption can be reduced by up to 50% of that required by wet process kilns. A large portion of the dust collected can be returned to the process. Typical dry process and wet process flow sheets showing dust control methods are presented in Figures 2 and 3, respectively (5).

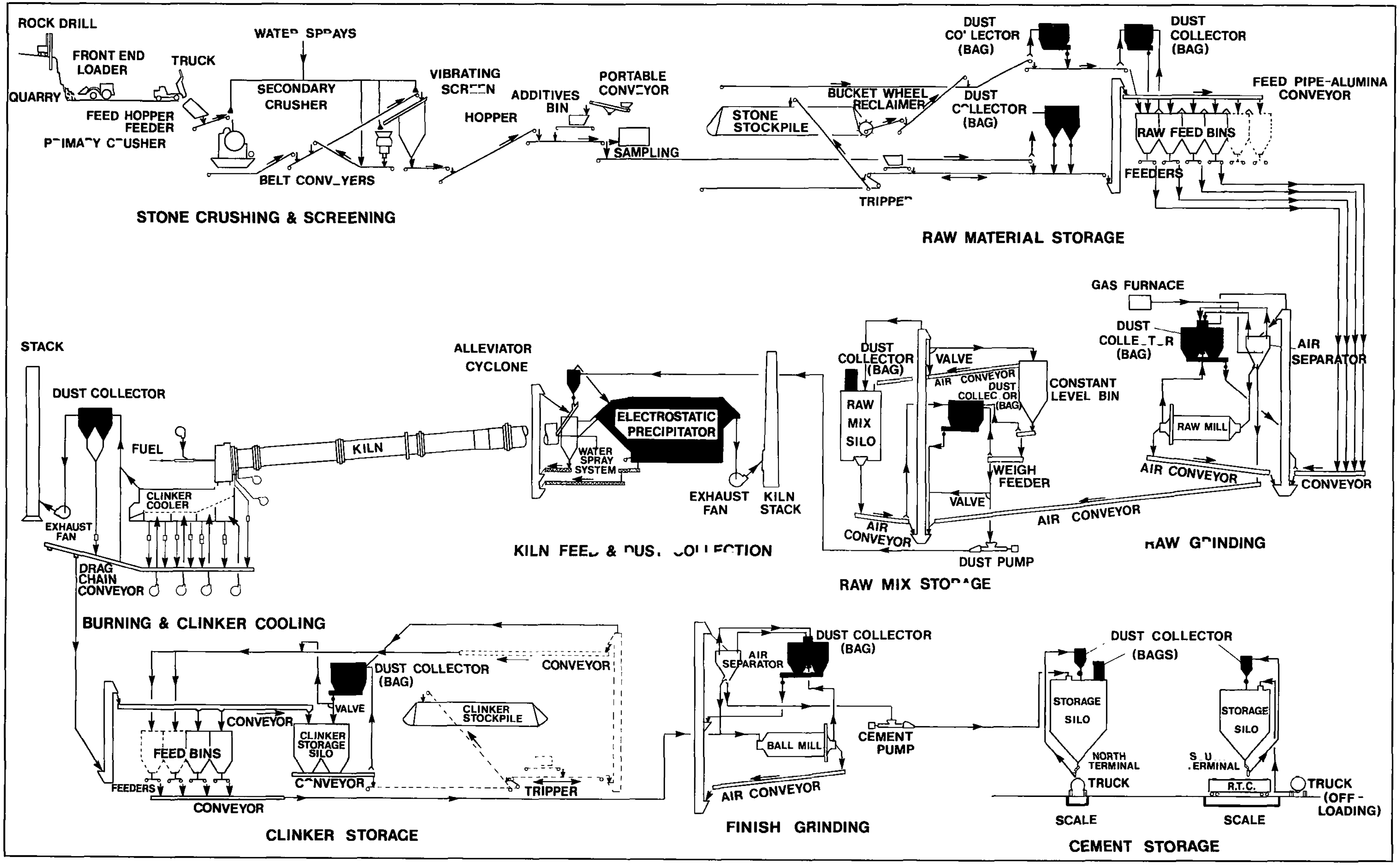

FIGURE 2 TYPICAL CEMENT PLANT - DRY PROCESS

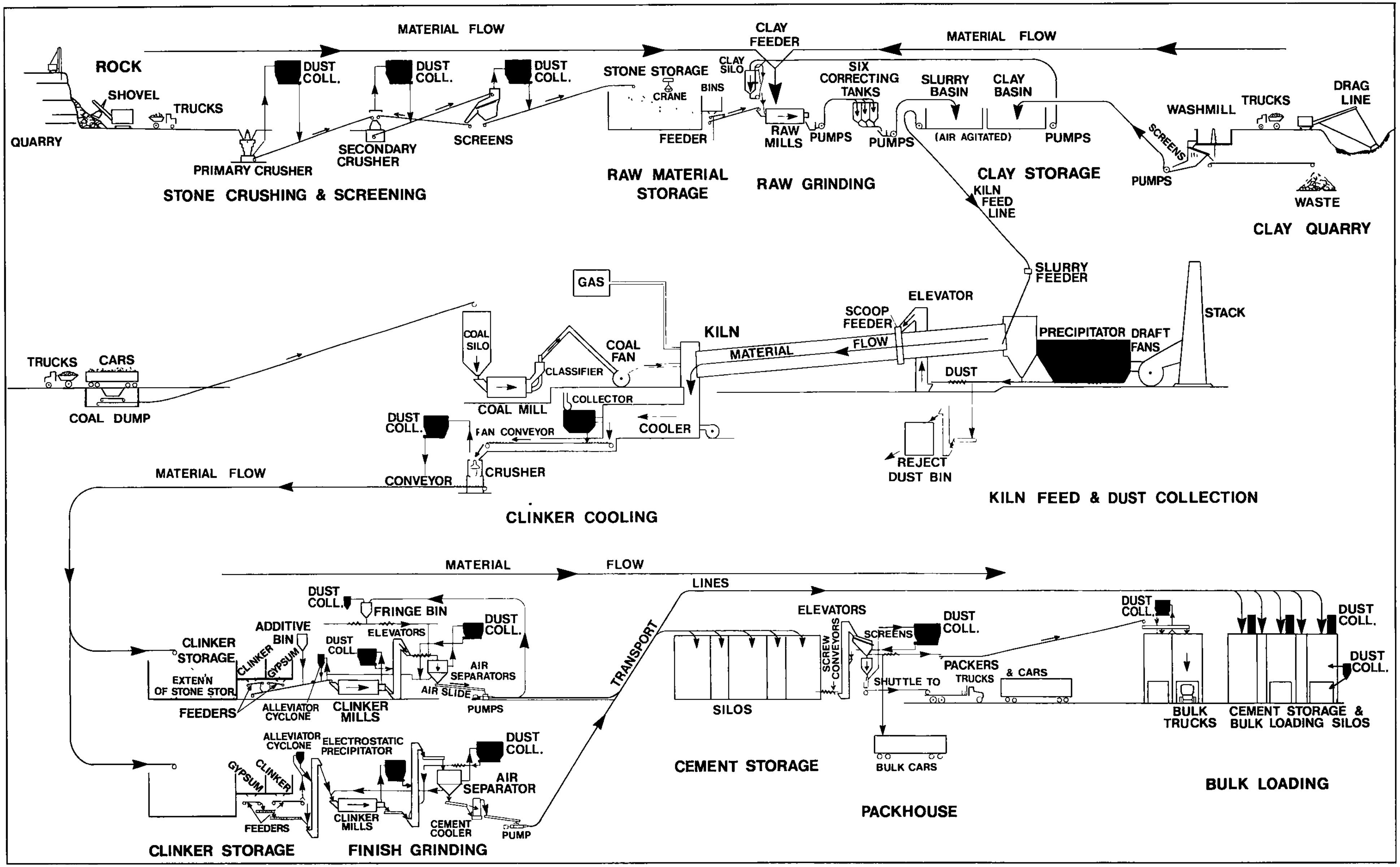

FIGURE 3 TYPICAL CEMENT PLANT - WET PROCESS

3.2 Capacity

Among the 25 cement plants listed in Table 3, nine use the dry process and 14 use the wet process. One plant was not yet in operation and one used both wet and dry processes. Production capacities of Canadian plants are listed regionally in Table 4 according to the type of process used.

TABLE 4 APPROXIMATE ANNUAL CAPACITIES BY PROCESS AND REGION, 1970 (2)

	Type of process					
	Wet		Dry		Wet and dry	
Region	No. of plants	Capacity (tons)	No. of plants	Capacity (tons)	No. of plants	Capacity (tons)
Atlantic provinces		-	3	771 000		-
Quebec	4	2 835 000	3	2 231 200		-
Ontario	4	2 432 500	1	875 000	1	1 750 000
Prairie provinces	4	1 927 500	1	227 500		-
British Columbia	2	1 312 500	1	210 000		-
TOTAL	14	8 507 500	9	4 314 700	1	1 750 000

3.3 Preparation of Raw Materials

The major constituents of raw kiln feed are limestone and shale or clay mixed in proper proportions. When cement with special characteristics is required, additives such as iron oxide or silica sand may be introduced into the kiln feed to produce clinker with the desired chemical composition.

Limestone is quarried and transported to the plant. There it is crushed to about 100% minus 3/4 in. and conveyed to a storage area. Shale is handled similarly. Clay, if used in the wet process, is passed through a wash mill; foreign material is removed by screens and disposed of as waste. The clay solution is then pumped to a clay-holding basin.

In the next stage of kiln feed preparation, blended raw materials are ground to about 80% minus 200 mesh. In the wet process, predetermined ideal proportions of raw material are fed to the mill. Sufficient water is added to create a slurry, which allows intimate blending and dispersion during the grinding cycle. The finished slurry, containing about 35% water, is pumped to several correcting tanks. The composition of the slurries in each tank is determined by sampling so that the contents of the tanks can be combined in proportions that would yield consistent kiln feed at all times. In the dry process water is not used in grinding blended raw material for kiln feed. On the contrary, raw materials are often dried before milling. Either waste process heat or an independent source of heat applied to a rotary dryer or an air separator is used to dry the raw materials. Dried raw materials are generally stored in silos and drawn in controlled proportions to the milling circuit. The mill discharge then passes through an air separator where the fines are transported to the raw mix silo which is installed ahead of the kiln. The oversize is returned to the mill for further reduction. All dust generated in the crushing and grinding operations is collected at different locations and returned to the process to become part of the kiln feed.

3.4 Rotary Kiln Operation

A rotary kiln consists of a slowly revolving cylindrical tube inclined to the horizontal at a slope of about 1 in. in 20 or 30 ft. The tube is lined internally with refractory material. To employ the counterflow principle, raw material enters the kiln at the top of the tube (the feed end) and the firing system is installed at the bottom (the discharge end). Pulverized coal, oil, or natural gas may be used as fuel.

Slurry or dry raw material is fed to the kiln. When slurry is used, the contained moisture is first driven off. Thereafter, the action of the kiln is similar in both wet and dry processes. As the material moves down the kiln, the temperature rises until the limestone portion of the feed, calcium carbonate ($CaCO_3$), decomposes to form lime (CaO) and carbon dioxide (CO_2). The CO_2 is exhausted from the kiln. As the temperature is further increased, some of the materials react to the point of incipient fusion, causing clinker formation (5). The clinker is discharged to coolers and then transferred either to storage or to the finish-grinding mills. Rotary cement kilns produce large quantities of cement clinker daily.

Exhaust gases from the kilns are the main potential source of air pollution from the cement industry. Before entering the dust collectors, the concentration of particulates in the gas stream at the temperature of emission is 10 to 25 grains per actual cubic foot (gr/acf). From 75 000 to 150 000 dry standard cubic feet (dscf) per ton of clinker produced are exhausted from the kiln through the dust collectors to the atmosphere.

Various methods of collection are employed to remove particulates from the gas stream and the collected material is generally returned to the process. Some operations, however, waste a fraction of dust collected, to remove the concentrated sulphate and alkali compounds.

Clinker coolers, an integral part of the kiln operation, may be of two basic designs. Satellite coolers consist of several tubes mounted around the periphery of the kiln at the discharge end. The upper ends of the cooler tubes receive clinker from the kiln. All counterflow cooling air enters the kiln as heated combustion air and presents no air pollution problem at the clinker cooler. In the other cooler design, clinker discharges from the kiln onto a grate where cooling air is blown through it under pressure. Some of the air enters the kiln for combustion purposes. The excess air from cooling operations is exhausted through dust collectors to the atmosphere. Normal operations entrain from 2 to 7 gr/acf of air at about 350 ^{o}F. However, this might reach 25 gr/acf with temperatures up to 700 ^{o}F during upset conditions. Excess air flow going to the dust collector is about 100 000 dscf/ton clinker produced but could reach 150 000 dscf/ton during upset conditions (5). Collected dust is returned directly to the clinker stream for processing into cement.

3.5 Grinding and Shipping Finished Products

The clinker from storage is blended with a small carefully controlled amount of gypsum while being fed to the finish-grinding mill. There it is ground to a specific mesh size in a dry state. The finish-grinding mill is usually a compartmentalized ball mill in a closed circuit with an air separator. The final fine cement product is pumped to storage silos. Dust generated during cement transfer to the storage silos is usually well controlled and recirculated to the process. The finished product is shipped by railroad cars, trucks, or boat. Some dust is generated in bagging and shipping, but emissions can be controlled by standard procedures. Dust collected is returned to storage.

3.6 New Technology

3.6.1 Other Rotary Kilns. To obtain maximum heat efficiency, various other types of apparatus have been installed before the rotary kiln to utilize the exit gas heat; they serve to dry, preheat, and partially calcine the raw meal or slurry. None of these are at present operating in Canada but are used extensively in other parts of the world.

The Lepol grate, for example, which is suitable only for the dry process, is a travelling grate carrying a bed of nodulized raw meal through which kiln gases are passed in the downward direction to ensure excellent heat utilization. By the time the nodules have reached the kiln, they have been dried, have attained a high temperature, and become partially calcined. When this grate is used, the rotary kiln need only be about half the length of an ordinary kiln since no preheating zone and only part of the calcining zone are necessary. Lepol kilns of recent design employ the so-called double-pass system, in which kiln gases are passed twice through the bed of nodules to enhance heat efficiency and reduce dust content of exit gases.

3.6.2 Vertical Air-Suspension Preheater

3.6.2.1 General. The air-suspension preheater consists of two parallel systems of cyclones connected by pipes through which the exit gases of the rotary kiln are drawn by means of a fan. The raw meal is fed into the preheater at the top of the system in a direction opposite to the gas flow (counterflow). It is conveyed through the system as described in section 3.6.2.2 and as illustrated in Figure 4. During its progress through the preheater the raw material acquires a high temperature and reaches the rotary kiln in a partially calcined state. At present two of these units are in service in Canada.

The air-suspension preheater offers several advantages over other systems in operation today. Because the powdered feed is suspended in the gas flow, each particle becomes totally enveloped by the gas. Efficiency of heat transfer from the hot gas flow to the powdered feed is thereby increased substantially. Also, the raw material does not have to be nodulized and can be fed to the preheater completely dry. The moistureless exit gases yielded by the system may then be recycled to dry raw materials. Finally, the rotary kiln need only be about half the length of an ordinary one when this preheater is used, because it eliminates the requirement for a preheating zone in the kiln and considerably shortens the necessary length of the calcining zone.

One cautionary note must be added, however; if the alkali content of the raw material is sufficiently high, buildup can occur. Buildup problems can be minimized by controlling the alkali content of the clinker to predetermined limits through the use of continuous preheater bypass systems. Whether or not a raw material is suited for preheater operation may be predicted from knowledge of improved material chemistry.

3.6.2.2 Preheating method. A four-stage late-type air-suspension preheater is illustrated in Figure 4. Gas and material flow through the four stages of the system as described in the five steps below. Corresponding numbers 1 to 5 are marked on Figure 4 for easy reference.

(1) Raw mix enters the gas stream through a feed pipe at a constant controlled rate.

(2) Mix recovers heat from gases rising from second-stage cyclones. It is carried upward into first-stage cyclones where it is separated from the gas flow.

(3) Mix then enters gas ducts rising from the third-stage cyclones. Additional heat is transferred to the mix in the ducts and the mix is separated from the gas flow by the second-stage cyclones.

(4) Mix enters the upper section of the fourth-stage conical shaft for further heat transfer.

(5) Recycled mix from the fourth-stage conical shaft is separated from the gas stream by the third-stage cyclones and returned to the shaft. This recirculation results in cumulative concentration of the mix and its gradual descent through the shaft until it finally enters the rotary kiln. To explain further, kiln exit gas enters the smaller diameter base of the conical shaft and exits

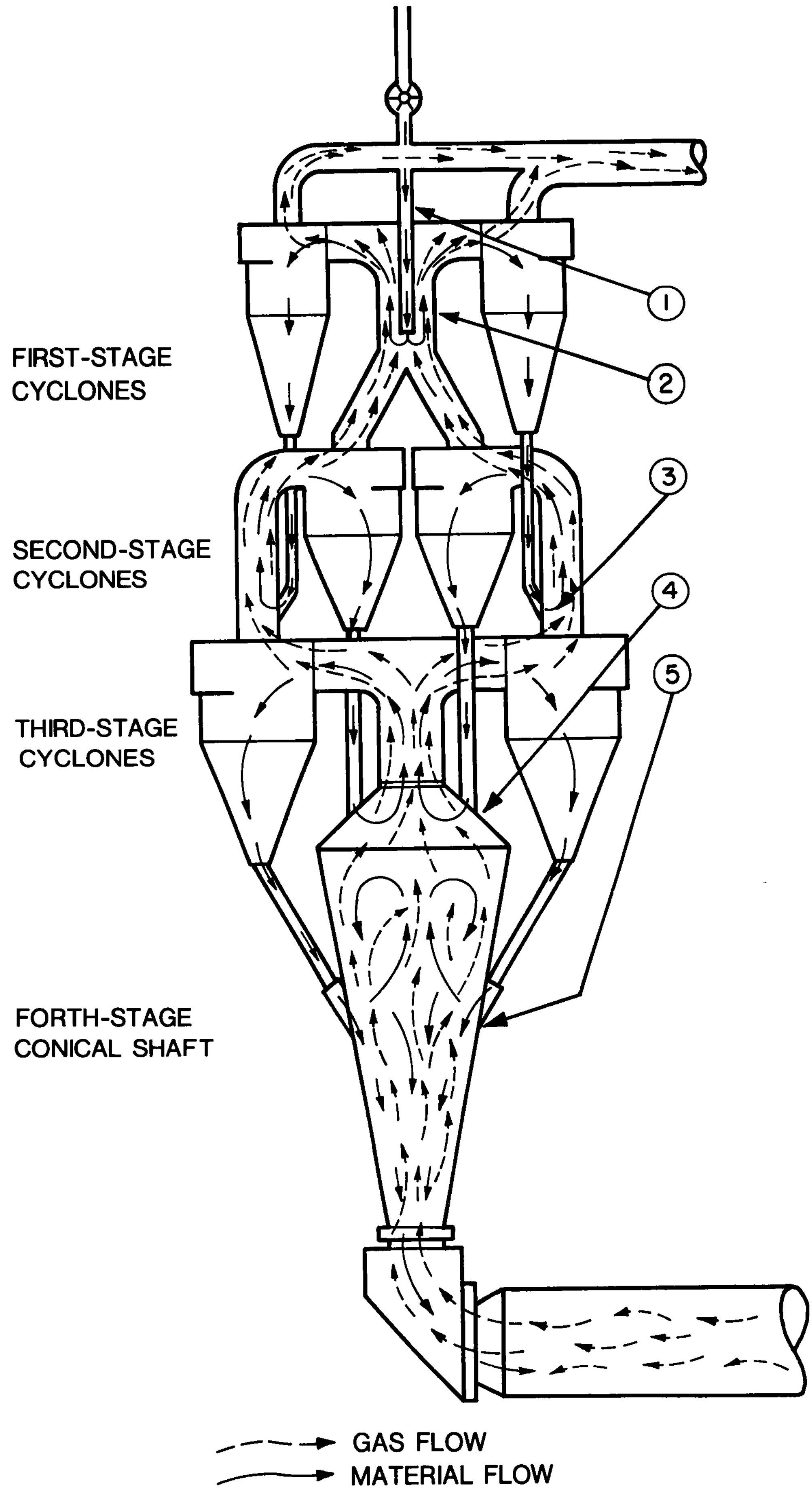

FIGURE 4 FOUR-STAGE LATE-TYPE AIR-SUSPENSION PREHEATER

through the larger section at the top. This results in a decrease in velocity of the gas as it progresses upward through the shaft. The mix fed into the shaft drops against the upward gas flow resulting in effective countercurrent heat exchange. When the mix reaches the lower section of the cone where gas velocity is higher, it is lifted by the rising gases. It drops again in the upper section as the gas velocity decreases.

The raw material enters first-stage cyclones at about 160 ^{o}F. It is heated in stages to about 600^{o}, 920^{o}, 1230^{o}, and 1475^{o} and enters the rotary kiln in a partially calcined condition. The kiln exhaust gas enters the fourth-stage conical shaft at 1900 - 2000 ^{o}F and is finally reduced from 990 ^{o}F to 650 ^{o}F in the first-stage cyclones before being exhausted from the preheater unit.

3.6.3 Other Preheating Systems. The last few years have seen the development, mainly by the Japanese, of several new systems that can be added to or incorporated into the vertical air-suspension preheater. The new developments are intended to increase the productivity of the rotary kiln, improve fuel economy, and give better refractory life and smoother operation. Four of these systems now under development in Japan will be described briefly.

3.6.3.1 Ishikawajima-Harima heavy industries - flash furnace (IHI-SF) (7). This system, developed by Ishikawajima-Harima Heavy Industries and Chichibu Cement Co., consists of a flash furnace connected to the fourth stage of the suspension preheater. The addition of the flash furnace increases production through the rotary kiln, and results in smoother operation, longer brick life, less stoppage, and a slightly lower fuel usage than are obtained without it. The final product is generally equal in quality or better than that produced without the IHI-SF. When this system is used, the entire production cycle must be redesigned for increased capacity or bottlenecks in the preheater, precipitators, and clinker coolers will occur.

3.6.3.2 Reinforced suspension preheater (RSP). The RSP was developed by the Onado Cement Co. and Kawasaki Heavy Industries. Onada Cement Co. will market it. A swirl calciner is built into the basic preheater design to take feed from the second-stage (up from the bottom) cyclone and accomplish precalcination.

3.6.3.3 Mitsubishi fluid bed calciner (MFC). The MFC was developed by Mitsubishi Mining and Cement Co. It consists of a fluid bed reactor built on or near the ground which takes feed from the second preheater section up from the bottom. The degree of precalcination and the specific production is not improved to the same degree with this system as with the others discussed. However, this system is claimed to give improved continuity of operation and better brick life with comparable economy.

3.6.3.4 Kawasaki spouted bed vortex (KSV) calciner. The KSV calciner is a development of Kawasaki Heavy Industries. It differs from the others described in the point of insertion of fuel burners and method of using the recuperative air from the clinker cooler.

4 POLLUTION ASPECTS

The main pollution problem for cement plants is the emission of particulates during the manufacturing process. In order of magnitude and importance are emissions from the kiln(s), clinker cooler(s), finish-grinding circuit(s), preparation of raw materials, and bagging and shipping operations. Possible sources of particulate emissions, listed in production sequence, are as follows:

1. Quarry Operations
   - (a) Drilling
   - (b) Blasting
   - (c) Loading broken rock
   - (d) Transporting or conveying to cement plants
2. Crushing Operations
   - (a) Unloading rock from quarry
   - (b) Crushing rock
   - (c) Screening rock
   - (d) Conveying to and from storage
   - (e) Storage

3.	Preparation of Raw Materials	(a)	Drying operations
		(b)	Conveying and feeding to grinding circuit
		(c)	Grinding of raw materials and conveying of ground material (dry process)
4.	Kiln Operation	(a)	Feeding raw material to kiln(s) - dry process
		(b)	Gases exhausted from kiln(s)
5.	Clinker Cooling	(a)	Excess air exhausted from clinker cooler(s)
		(b)	Conveying clinker from cooler(s) to storage, including storage
6.	Finish Grinding	(a)	Conveying clinker from storage to finish-grinding mill(s)
		(b)	Finish grinding of clinker, gypsum, and additives
		(c)	Air classification of finished product and conveying to storage
		(d)	Storage
		(e)	Bulk loading operations
		(f)	Bagging and loading operations
7.	Waste Dust Handling and Disposal		
8.	Fugitive Dust		

5 NATIONAL EMISSION INVENTORY DATA - PARTICULATES

5.1 Data Previously Published

Emissions of particulates from all heavy industry during 1970 amounted to 1 309 000 tons as reported in a nationwide inventory of air pollutant emissions (8). Figure 5 illustrates graphically the percentage contributions of particulate emissions by cement plants to the total emissions of major pollutants released by heavy industry in 1970. Table 5 shows the number of tons per year of particulates emitted by heavy industry in 1970. It shows that the cement industry contributed 248 000 tons of particulate emissions in 1970, or 0.8% of the total emissions in Canada (Figure 5).

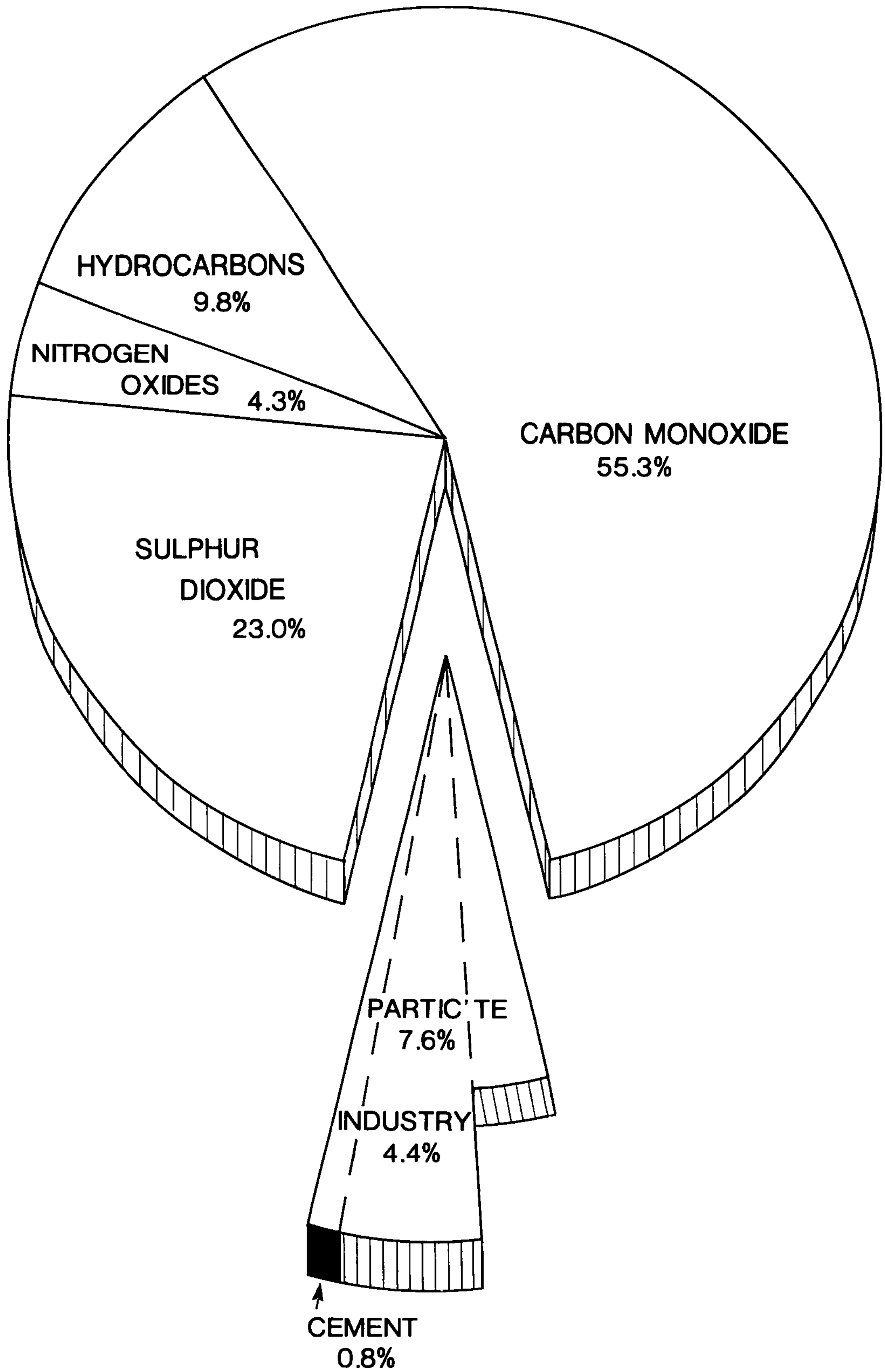

FIGURE 5 TOTAL EMISSIONS OF MAJOR POLLUTANTS IN CANADA IN 1970 (8)

TABLE 5 PARTICULATE EMISSIONS FROM INDUSTRIAL PROCESSES, 1970 (8)*

Industry	Emissions (tons/year)
Iron and steel	153 000
Other primary metals	111 000
Metallurgical coke	11 000
Petroleum refineries	1 000
Cement	248 000
Lime	54 000
Kraft pulp mills	86 000
Asbestos	80 000
Stone, sand, gravel	401 000
Grain handling	83 000
Grain mills	4 000
Other	77 000

* These figures were based on the results of a paper search of published information from various sources.

5.2 Data Obtained from Cement Industry Questionnaires, 1973

Data reported in Air Pollution Control Directorate questionnaires, 1973, resulted in the compilation of total particulate emissions from the Canadian cement industry in 1970, as given in Table 6. Estimated particulate emissions for 1975 are given in Table 7. Emission factors for various regions in Canada are shown in Table 8 for 1970 and in Table 9 for 1975.

Of the total particulate emissions released by the Canadian industry in 1970, 61% was from kiln operations and 38% from clinker coolers. Compilation of data received in Air Pollution Control Directorate questionnaires, 1973, showed that 29% of Canadian plants had kiln emissions of less than 1 lb/ton clinker; however, 29% emitted more than 10 lb/ton clinker, 50% of which emitted greater than 50 lb/ton clinker. Cooler operations at 19% of the plants had emission rates of less than 1 lb/ton clinker and 43% had rates of more than 10 lb/ton clinker. None reported emission factors of greater than 40 lb/ton clinker. Scheduled changes and improvements would result in kiln emissions in 1975 of less than 1 lb/ton clinker from 70% of the Canadian plants in operation; only 5% would have emissions of greater than 10 lb/ton clinker and none greater than 21 lb/ton clinker. Cooler operations would also be improved so that 70% of the plants would have emission rates of less than 1 lb/ton clinker and only 15% greater than 10 lb/ton clinker; none would have emission factors greater than 27 lb/ton clinker.

Particulate emissions from finish grinding of cement, loading operations, and the preparation of raw materials for kiln feed were of a relatively minor nature in 1970 because of extensive use of bag filters, with most of the dust so collected returned to the process. Some exceptions were noted in data received in questionnaires completed by the Canadian cement industry at plants where raw materials were dried in rotary kiln dryers before being prepared for kiln feed. When rotary kiln dryers equipped with inefficient mechanical collectors were used, total emissions during preparation of raw kiln feed were several times that from plants not using rotary dryers.

In operations during 1970, the emission rates of the four plants reporting the lowest emissions and the four plants reporting the highest emissions are shown in Table 10. Scheduled improvements would result in a change of emission rates estimated for 1975 operations as shown in Table 11.

TABLE 6 REPORTED PARTICULATE EMISSIONS FROM THE CANADIAN CEMENT INDUSTRY, 1970*

Region	No. of plants	Production (tons)		No. of kilns	No. of coolers	Emissions (tons)				
		Cement	Clinker			Raw material	Kiln	Cooler	Finish grinding	Total
Ontario	7	3 329 000	3 391 000	16	13	46	39 314	15 375	165	54 900
Quebec	7	2 018 000	2 065 000	11	10	34	40 431	34 867	94	75 426
Balance of Canada	13	2 739 000	2 623 000	20	18	772	25 047	14 320	79	40 218
TOTAL	27	8 086 000	8 079 000	47	41	852	104 792	64 562	338	170 544

* Based on normal operations, fugitive dust not included, from data reported in Air Pollution Control Directorate questionnaires, 1973,from 24 plants and estimated data from 3 plants.

TABLE 7 ESTIMATED PARTICULATE EMISSIONS FROM THE CANADIAN CEMENT INDUSTRY, 1975*

Region	No. of plants	Production (tons)		No. of kilns	No. of coolers	Emissions (tons)				
		Cement	Clinker			Raw material	Kiln	Cooler	Finish grinding	Total
Ontario	7	5 440 000	5 965 000	17	13	168	1 651	827	198	2 844
Quebec	6	3 391 000	3 237 000	10	9	74	30 154	38 681	66	68 975
Balance of Canada	13	4 005 000	3 806 000	20	18	358	10 186	7 483	82	18 109
TOTAL	26	12 836 000	13 008 000	47	40	600	41 990	46 991	346	89 927

* Based on normal operations, fugitive dust not included, from data reported in Air Pollution Control Directorate questionnaires, 1973, from 23 plants and estimated data from 3 plants.

TABLE 8 AVERAGE REPORTED EMISSION FACTORS FOR PARTICULATES FROM THE CANADIAN CEMENT INDUSTRY, 1970*

Region	No. of plants	Emissions (lb/ton clinker)				
		Raw material	Kiln(s)	Cooler(s)	Finish grinding	Total
Ontario	7	0.02	19.83	8.14	0.09	28.07
Quebec	5	0.04	43.29	14.14	0.08	57.56
Balance of Canada	12	0.03	17.12	9.98	0.06	27.17
	24					
AVERAGE		0.03	23.36	10.31	0.07	33.77

* Based on data reported in Air Pollution Control Directorate questionnaires, 1973, 24 plants reporting out of 26.

TABLE 9 AVERAGE ESTIMATED EMISSION FACTORS FOR PARTICULATES FROM THE CANADIAN CEMENT INDUSTRY, 1975*

Region	No. of plants	Emissions (lb/ton clinker)				
		Raw material	Kiln(s)	Cooler(s)	Finish grinding	Total
Ontario	7	0.04	0.42	0.23	0.07	0.76
Quebec	4	0.04	1.05	6.43	0.04	7.57
Balance of Canada	12	0.02	3.68	4.18	0.04	7.92
	23					
AVERAGE		0.03	2.23	3.37	0.05	5.68

* Based on data reported in Air Pollution Control Directorate questionnaires, 1973, on estimated cement plant emissions for 1975, rotary kiln dryers included in total only, 23 plants reporting out of 26.

TABLE 10 EMISSION FACTORS FOR CANADIAN CEMENT PLANTS REPORTING LOWEST AND HIGHEST PARTICULATE EMISSIONS, 1970*

	Emission factor (lb particulates/ton of clinker produced)				
Plant	Raw material	Kiln(s)	Cooler(s)	Finish grinding	Total
LOWEST EMISSIONS					
A	0.038	0.27	0.55	0.06	0.92
B	0.028	1.40	0.18	0.11	1.72
C	0.053	0.41	2.71	0.05	3.22
D	0.002	1.32	2.45	0.08	3.85
HIGHEST EMISSIONS					
E	0.036	180.08	-	0.01	180.13
F	0.112	144.44	21.40	0.08	166.03
G	0.016	133.25	24.80	0.13	158.20
H	0.010	58.11	28.50	0.08	86.70

* Based on data reported in Air Pollution Control Directorate questionnaires, 1973.

TABLE 11 EMISSION FACTORS ESTIMATED FOR 1975 FOR CANADIAN CEMENT PLANTS REPORTING LOWEST AND HIGHEST PARTICULATE EMISSIONS*

	Emission factor (lb particulates/ton of clinker produced)				
Plant	Raw material	Kiln(s)	Cooler(s)	Finish grinding	Total
LOWEST EMISSIONS					
A	0.035	0.18	0.13	0.05	0.40
B	0.002	0.30	0.42	0.03	0.75
C	0.119	0.37	0.17	0.09	0.75
D	0.036	0.70	-	0.07	0.81
HIGHEST EMISSIONS					
E	0.070	0.70	26.67	0.07	27.51
F	0.006	2.46	24.87	0.01	27.35
G	-	20.16	0.50	0.06	20.72
H	0.076	0.61	14.00	0.07	14.76

* Based on data reported in Air Pollution Control Directorate questionnaires, 1973.

6 CONTROL METHODS

6.1 General

Emissions of particulate matter, especially those released from the kiln, are the most significant air pollution control problem faced by the cement industry. Control of alkali salts, in particular, presents a specific challenge because they are formed as a finely divided fume through condensation of reaction products in the vapor phase (1). Another bothersome source of particulate emissions is the excess air exhausted from clinker coolers. A large amount of air from clinker coolers is recycled as heated combustion air for the kiln and presents no problem. The excess air, however, is exhausted to the atmosphere and contains a large amount of particulate matter which must be controlled. Particulates emitted at other points in cement production are efficiently controlled by dust collection systems utilizing mechanical collectors and/or fabric filters; all dust so collected is returned to the process.

6.2 Existing Installations

6.2.1 Quarrying. At the quarries, dust control, while drilling, can be achieved by mounting collectors on the drills. Emissions, when blasting, are uncontrolled but because blasting is infrequent and of short duration, emissions are usually not significant. Dust generated while loading trucks and hauling raw material to cement plants is not controlled but is considered minor. Fugitive dust raised from roads is controlled by wetting the travel surface.

6.2.2 Crushing. Pit run rock is reduced in size by crushing before grinding in preparation of kiln feed material. In wet process plants dust generated in crushing is often controlled by water sprays. In dry process plants it is controlled by cyclone separators or bag filters. Bag filters are more common in modern plants. They are highly efficient and all dust collected is returned to the process.

6.2.3 Drying operations. Kiln-type rotary dryers are sometimes used to dry crushed raw material before grinding it to a size suitable for kiln feed. Much dust is generated during this operation and is carried in the hot humid air exhausted from the dryer. This dust has been partially controlled by mechanical cyclones or multiclone collectors, but emissions, when using these units, are still excessive. Further control to lower emissions to acceptable levels can be achieved by installing either fabric filters or another type of very high efficiency collector.

6.2.4 Raw Material Grinding. In wet process plants grinding takes place in water to produce a blended slurry suitable for kiln feed. No emissions emanate from this operation. In dry process plants much dust is generated in grinding raw materials to a size suitable for kiln feed. High efficiency fabric filters, however, can be used to control the large amount of dust generated, all of which is recycled to the process.

6.2.5 Kiln Exhaust. Kiln exhaust gases in older plants were channelled through cyclone collectors or multiclones before being vented to the stack. These collectors were employed mainly to recover usable product for process recycling, although they also afforded some operational protection for the induced draft fan. As air pollution standards became more stringent, the use of more efficient equipment became essential.

Electrostatic precipitators have been preferred in Canada for the control of particulate emissions in kiln exhaust gases. All plants in Canada that reported efficient kiln dust collection used electrostatic precipitators. This collector allows some segregation of alkaline dusts from the other particulates; alkalis are mostly concentrated in the final hoppers of the precipitator. Only the highest alkali fraction may sometimes be discarded for quality control reasons; the balance can be returned to the process (9). Efficiency of the precipitator is greatly affected by the moisture content of the gas being treated. Sufficient moisture is present in exhaust gases from wet process kilns to maintain ideal operating conditions. Exhaust gases from dry process kilns, however, must be cooled and conditioned with water sprays before being passed through the precipitator. Water cooling improves precipitator performance by reducing the volume of air to be treated as well as by decreasing the resistivity of the dust (9). Pressure drop across the precipitator is low and higher temperatures during upset conditions will not harm these units. However, electrostatic precipitators must be turned off during cold start-up or during some operating conditions of the kiln that could cause fires or explosions in the precipitator (10). The frequency and duration of such shutdowns become important when considering pollution control. Emissions during precipitator shutdowns are decreased substantially at plants where precipitators are installed after mechanical cyclones or multiclone collectors. When the precipitators are inoperative, a large part of the particulates can still be returned to the process by the mechanical collectors.

Bag filters have been successfully used in other countries to clean exhaust gases from both wet and dry process kilns. Bag collectors equipped with fibre-glass filters, however, can only operate efficiently at temperatures up to 500 ^{o}F (11). Under normal conditions operating temperatures are held above the dew point in wet process plants, but usually below 450 ^{o}F. Upset conditions, however, could result in higher temperatures and destruction of bags. The use of bag collectors also results in inclusion of all alkali salts in the collected dust, which makes recirculation of particulates undesirable or impossible under some circumstances.

In a recent report from the United States (12), 36 new electrostatic precipitators were installed on kilns, as compared with installation of only 11 fabric filters. At other plants, existing electrostatic precipitators were reworked and improved to conform with new emission standards.

Emissions of gaseous pollutants from cement kilns might be expected to be comparable to those from thermal plants burning similar fuels, but such is not the case. Limestone, which represents a large part of the raw material fed to the kiln in the manufacture of cement clinker, significantly reduces the actual sulphur dioxide emissions from the kiln because of its inherent chemical capacity to react with sulphur oxides. Data obtained in a study which measured uptake of fuel sulphur by portland cement clinker and collected dust compared to that released as gaseous emissions are summarized in Table 12. From 86.2 to 99.8% of the total fuel sulphur input was observed to be retained in the process. The portland cement industry is in the unusual position of being able to utilize high sulphur fuels while still maintaining low sulphur dioxide emissions, a situation in sharp contrast to that of the power-generating stations and other major industries using fossil fuels.

TABLE 12 ANALYSIS OF RETENTION AND EMISSION OF FUEL SULPHUR IN MANUFACTURE OF PORTLAND CEMENT*

	Fuel				Exit gas		% Total fuel sulphur	
Plant	Type(s)	% Sulphur	Portland cement clinker (tons/day)	Total sulphur input (lb/day)	lb SO_2/day	lb S/day	Retained in clinker or collected dust	Emitted in exit gas
A	Coal	1.4	637	6 192	98	49	99.2	0.8
B	Coal	2.0	1 237	9 262	117	58.5	99.4	0.6
C	Coal	1.6	950	9 903	168	84	99.2	0.8
D	Coal	2.5	794	10 620	50	25	99.8	0.2
E	Coal	3.0	683	12 877	1 265	632.5	95.1	4.9
F	Oil-gas	3.0 - neg	702	5 095	1 410	705	86.2	13.8
G	Gas	neg	533	1 630	0	0	100.0	0
H	Coal	1.7	1 561	16 816	401	200.5	98.8	1.2
I	Oil	2.2	2 700	-	7 744	3 872	-	-
J	Coal-gas	1.6 - 0.47	1 186	22 469	4 430	2 215	90.1	9.9

* Presented at the joint meeting of the TS-3.3 Subcommittee of the Air Pollution Control Association and Cement Technical Committee of the American Mining Congress.

6.2.6 Clinker Coolers. Vented gases from clinker coolers are the second largest source of particulate emissions from the cement industry. Although some of the air from the clinker cooler is used as preheated secondary combustion air in the kiln, untreated emissions in that portion of air to be exhausted to the atmosphere would reach about 7 gr/acf at 350 ^{o}F and could increase to 25 gr/acf at 700 ^{o}F under upset conditions. These variations create problems in the selection of equipment for necessary air pollution control (5).

Because high temperatures may be attained in the exit gases vented from the cooler, cyclone or multiclone collectors have often been used to treat the gas stream before exhausting it to the atmosphere. Because of the relatively coarse size of the particles, emissions are greatly reduced by these collectors and the material recovered is returned to the product stream. However, additional control is required to further reduce emissions to desirable levels.

High efficiency fabric filters are now being used on exhaust gases but cooling may be required especially during periods of high temperature.

Electrostatic precipitators can also be used depending upon the resistivity of the clinker particles. Water is usually added to condition the gases for better efficiency.

Gravel bed filters are also now being installed because they seem to require low maintenance and can resist high temperatures, without cooling being required.

Some plants use planetary coolers, which consist of several long large tubes mounted longitudinally around the perimeter of the kiln at the discharge end. The hot clinker drops into these tubes and moves down them to point of discharge. All cold air drawn through the tubes enters the kiln as preheated combustion air and no emission problem is created. This type of cooler had fallen into disfavor for some time but is again becoming popular (5).

6.2.7 Finish Grinding. Fabric filters are commonly used to control emissions but the mill can also be vented through electrostatic precipitators. Water sprays are located within the mill to control gas temperatures and to condition the air to increase the efficiency of the precipitator.

6.2.8 Other Sources. Dust generated in material handling and shipping is controlled by regular dust control systems utilizing high efficiency fabric filters, water sprays, and chemical additives.

6.3 New Technology

New or improved equipment has recently been developed for air pollution control at cement plants. However, control of emissions from kilns and clinker coolers can be improved by proper application and improvement of methods that have been in full-scale use for some time.

Electrostatic precipitators are now commonly used on kiln exhaust gases and occasionally on clinker cooler gases. Some conditioning is required on excess air exhausted from the clinker cooler and on gases exhausted from kilns in dry process cement plants. High efficiency has also been achieved when electrostatic precipitators have been installed following existing mechanical separators. When the electrostatic precipitators must be shut off during cold start-up or upset conditions, mechanical separators, consisting of a parallel series of cyclones or multiclone collectors, would still recover about 70% of the particulates that would otherwise have been exhausted to the stack and atmosphere. Technical improvements on electrostatic precipitators have increased efficiency and reliability while decreasing maintenance. These improvements include more durable materials of construction, better methods of flow distribution, and addition of solid state electrical controls. Recent electrostatic precipitator installations have reported design efficiencies in excess of 99.99%.

Bag filters have been used on exhaust gases from both the kiln and clinker cooler with an efficiency in excess of 99.5%. Bag filters equipped with fibre-glass bags are limited to a maximum operating temperature of 500 ^{o}F. Emergency water spray coolers or a bypass system are almost mandatory when using bag filters to protect them during high temperatures sometimes reached under upset conditions. Technical improvements to fabric filters, such as new fabrics, improved cleaning properties, and higher air-to-cloth ratios have increased efficiency and reliability.

Renewed interest in planetary coolers resulted from more stringent air pollution control requirements, and several satellite and planetary coolers are being used on new kilns to eliminate all emissions from the clinker cooler operations.

Gravel-bed dust collectors are being introduced to control particulate emissions from clinker cooling operations at Canadian cement plants. Although the pressure drop might be higher than that attained with other types of collectors, they are highly efficient and the effluent quality of gas for specific installations has been as low as 0.003 gr/ft^3. However, manufacturers will only guarantee an efficiency of 0.01 gr/ft^3. No water or bags are required, they have minimum maintenance requirements, and they can operate at inlet gas temperatures of 900 ^{o}F or higher. They can withstand such high temperatures because the filter medium consists of a heat-resistant granular gravel-like material than can resist temperatures well in excess of any that might be anticipated during severe upset conditions.

Elsewhere in cement plant processes, fabric filters are either replacing or supplementing mechanical collectors to reduce particulate emissions.

6.4 Evaluation of Control Technology

6.4.1 General. The degree of control of particulate emissions in kiln exhaust gases has been given at 70% for a parallel series of cyclones, 80% for multiclones, 90% for old electrostatic precipitators, 95% for multiclones plus old precipitators, 99 - 99.9% for new electrostatic precipitators either alone or in combination with existing multiclones, and more than 99.5% for fabric filters. When used in conjunction with electrostatic precipitators, multiclones reduce the load and actually improve the operation of electrostatic precipitators, making an optimum efficiency possible. Multiclones will also greatly reduce emissions when the electrostatic precipitators must be turned off.

A recent test at a Canadian cement plant (5) showed that emissions from an electrostatic precipitator on a kiln were 0.045 gr/dscf or 0.43 lb/ton of clinker produced. Emissions from a multiclone unit handling gases from a clinker cooler showed a test level of 0.35 gr/dscf or 2.77 lb/ton of clinker. The average particulate emission level of gases from fabric filters installed at other sources in the plant was found to be 0.026 lb/ton of kiln feed or 0.040 lb/ton of clinker produced. Since this plant was relatively new, however, it had not operated at full production until very recently, and the test results are not considered to be representative by the cement industry.

6.4.2 Cost of Pollution Control. Cost of installing pollution control equipment in a recently completed Canadian cement plant amounted to 8½% of the total capital cost. Of total expenditures in current plant expansion programs, about 10% will be for additional or improved pollution control. In new plant construction, expenditures for control of particulate emissions would be between 8½ and 12% of the total capital cost. Part of such an expenditure, however, would be recovered from efficient, economic operation of the plant because of minimal raw material loss. As a result, the percentage of capital cost required solely for pollution control could be considerably less than that shown above.

Cost of operating pollution control equipment would vary from plant to plant. Higher costs could be expected in older plants where additional control equipment had been added to satisfy more stringent local requirements. In new well-designed plants incorporating latest process improvements, operation of pollution control equipment would be much less provided a good maintenance program was established, but reliable figures for operating costs are not available.

6.4.3 Best Practicable Technology. Control of emissions of particulates during raw material preparation is achieved by using various types of fabric filters. Sometimes, water sprays are used with fabric filters especially during crushing and conveying. In dry process plants electrostatic precipitators as well as fabric filters are used during raw material grinding and on finish-grinding mills. Emissions in exhaust gases from cement kilns in Canada are controlled by high efficiency electrostatic precipitators either with or without multiclone collectors. Other countries report some use of glass fabric filters for this purpose. Fabric filters or gravel-bed filters are used to control emissions from clinker coolers in Canada. Electrostatic precipitators for this purpose can be used but gases must be conditioned before entering the collector. Fabric filters or electrostatic precipitators are used to control emissions from finish grinding, packing, and loading of cement products. Water spray systems, sometimes with wetting agents added, are used in the crushing, screening, and rock-handling systems.

The emission factors which are attainable using this control technology are shown in Table 13 (13).

TABLE 13 EMISSION FACTORS ATTAINABLE BY USE OF BEST PRACTICABLE CONTROL TECHNOLOGY

	Emission factor (lb/ton clinker)	
Source	New plants	Existing plants
Kiln	0.9	1.6
Clinker cooler*	0.6	0.6
Balance of plant	0.2	0.2
Finish-grinding plant (no clinker production)	0.1	0.1

*Where the clinker cooler exhaust is fully utilized in the kiln, only the kiln factor will be used.

The use of this control technology in 1975 would reduce total particulate emissions from the cement industry to 15 224 tons. Detailed emissions for 1975 if this control technology were used in all plants are shown in Table 14.

TABLE 14 ESTIMATED PARTICULATE EMISSIONS FOR 1975 FOR THE CANADIAN CEMENT INDUSTRY IF BEST PRACTICABLE TECHNOLOGY WERE USED

	Emissions (tons/year)		
Province	Estimated 1975	If proposed guidelines are used	Percentage reduction required
Ontario	2 844	6 773	0
Quebec	68 975	3 884	94
Balance of Canada	18 109	4 567	75
TOTAL	89 927	15 224	83

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APPENDIX I THE QUESTIONNAIRE

CONFIDENTIAL

Keep one copy

ENVIRONMENT CANADA

OTTAWA

AIR POLLUTION CONTROL DIRECTORATE

CEMENT INDUSTRY STUDY

IMPORTANT

Please complete and return within 60 days of receipt

Name of company

Address of plant

Name of contact

Name of person responsible for this report

___________Please print or type_____________

Telephone (Area code and number)

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.

1. Sketch.
Please provide a plant view and elevations of emissions listed under Sections E, F, G and H showing the points of emissions, land usage, nearby buildings and changes in terrain which can be expected to affect plume rise. Alternatively, supply photographs showing these pertinent features and identifying the points of emissions.

2. Efficiency of Pollution Control.
Please show input and output for each unit operation in simplified flow sheets (Section E) under typical rate of peak production, including air pollution control devices.

3. Data.
Report actual data for 1970 (base year) and 1975 projections.

4. Certification.
Data should be authorized by a responsible officer.

5. One questionnaire should be compiled for each plant.

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

A. LOCATION OF PLANT

Province ______________________

County ______________________

Municipality ______________________

Street Address ______________________

B. FUEL USED

report annual consumption by type of fuel and sulfur content

Type of Fuel	Unit of Measure	Sulfur Content, %	Usage 1970	Usage 1975 (1)	Maximum Rate (2) 1970	Maximum Rate (2) 1975 (1)
Coal						
Oil						
Natural Gas						
Other Fuel (specify)						

(1) Estimate
(2) Typical rate during the period of peak production (24 hour basis).

C. PRODUCTION OF CEMENT AND CLINKER

(Report in net tons of 2000 pounds)

	Actual Production 1970 (net tons)	Actual Production 1975 (1) (net tons)	Capacity (2) 1970 (net tons)	Capacity (2) 1975 (1) (net tons)
Cement(s)				
Clinker				

(1) Estimate
(2) Typical rate during the period of peak production (24 hour basis)

D. COST OF AIR POLLUTION CONTROL

Expenditures for any pollution abatement or installation affecting the quality of air in 1970 dollars

	Canadian dollars (in thousands)
(i) Expenditures charged to capital account	
Total during 1970	
Total during 1971	
Total during 1972	
Total during 1973 (forecast)	
Total during 1974 (forecast)	
Total during 1975 (forecast)	
(ii) Expenditures charged to current operating account	
Total during 1970	
Total during 1975 (forecast)	

E. EFFICIENCY OF CONTROL OF PARTICULATE MATTER UNDER TYPICAL RATE OF PEAK PRODUCTION (DRY BASIS)

Unit Operation	1970 Base Year Control Methods (see note below)	Production Capacity (short tons/day)	Total Dust to Collectors (short tons/day)	Overall Efficiency of Collectors (percent, %)
Fuel unloading and conveying				
Raw materials' crushing and conveying				
Raw materials' drying				
Raw materials' grinding and conveying				
Raw materials' storage and feeding				
Burning (Process A), dry feed basis				
Burning (Process B), dry feed basis				
Clinker cooling				
Clinker conveying and storage				
Handling of kiln dust collected (A)				
- dust returned to kiln				
- dust removed from the process				
Handling of kiln dust collected (B)				
- dust returned to kiln				
- dust removed from the process				
Finish grinding of cement				
Conveying and storage of cement				
Loading, Bags				
Loading, Bulk				

E. EFFICIENCY OF CONTROL PARTICULATE MATTER UNDER TYPICAL RATE OF PEAK PRODUCTION (DRY BASIS) (continued)

Unit Operation	1975 (estimate)			
	Control Methods (see note below)	Production Capacity (short tons/day)	Total Dust Collectors (short tons/day)	Overall efficiency of Collectors (percent, %)
Fuel unloading and conveying				
Raw materials' crushing and conveying				
Raw materials' drying				
Raw materials' grinding and conveying				
Raw materials' storage and feeding				
Burning (Process A), dry feed basis				
Burning (Process B), dry feed basis				
Clinker cooling				
Clinker conveying and storage				
Handling of kiln dust collected (A)				
- dust returned to kiln				
- dust removed from the process				
Handling of kiln dust collected (B)				
- dust returned to kiln				
- dust removed from the process				
Finish grinding of cement				
Conveying and storage of cement				
Loading, Bags				
Loading, Bulk				

E. EFFICIENCY OF CONTROL OF PARTICULATE MATTER UNDER TYPICAL RATE OF PEAK PRODUCTION (continued)

NOTE: Control Methods

Please complete this item in the above tables using one or more of the following numbers to describe the control methods used in each unit operation.

1. Bag filters
2. Electrostatic precipitators
3. Cyclones
4. Multiple cyclones
5. Settling chambers
6. Sprays
7. Sprays with additives
8 Wet scrubbers
9. Gravel bed filter
10. Other (specify)

F. GASEOUS EMISSIONS UNDER TYPICAL RATE OF PEAK PRODUCTION

	Parts per Million 1970 Base Year Stack No. 1	2	3	4	5	6
Oxides of sulfur (as SO_2)						
Total reduced sulfides (as H_2S)						
Oxides of nitrogen (as NO_2)						
Cyanides (as HCN)						
Chlorides (as HCl)						
Ammonia and Ammonium salts (as NH_3)						
Hydrocarbons (as CH_4)						
Mercury (as Hg)						
	1975 (estimate) Stack No. 1	2	3	4	5	6
Oxides of sulfur (as SO_2)						
Total reduced sulfides (as H_2S)						
Oxides of nitrogen (as NO_2)						
Cyanides (as HCN)						
Chlorides (as HCl)						
Ammonia and Ammonium salts (as NH_3)						
Hydrocarbons (as CH_4)						
Mercury (as Hg)						

G. STACK DETAILS (INCLUDING CLINKER COOLER AND DRYER)

Identify stacks on sketch by number

	Unit of Measure	Stack No 1	2	3	4	5	6
Height above grade	feet						
Height above roof	feet						
Exit dimensions	feet						
Exit velocity (1)	feet/second						
Exit temperatures (1)	degrees F						
Dust loading (1)	grains/ACF						
Moisture (1)	% by volume						
Rate of exit gas (1)	ACF/sec.						

(1) Under typical rate of peak production

H. ANALYSIS OF DUST EMISSIONS

(i) Do you have a stack sampling program? Yes ☐ No ☐
If you do, outline the program

(ii) Provide emission data on sources including

- stack number where applicable
- rate of emissions (grams/second)
- chemical analysis and size distribution of emissions

NOTE: Where data on stack sampling is not available, please give best estimates (in brackets).

K. USE OF WATER UNDER TYPICAL RATE OF PEAK PRODUCTION

	Unit of Measure	
Domestic water	gallons/day	
Cooling water	gallons/day	
Other process water	gallons/day	
How used?		

L. WATER EFFLUENT UNDER TYPICAL RATE OF PEAK PRODUCTION

	Unit of Measure	Stream 1	Stream 2
Rate of discharge	gallons/day		
Suspended solids	milligrams/liter		
Dissolved solids	milligrams/liter		
pH			
Point of eventual discharge			
How treated before discharge?			

M. CONTROL OF SOLIDS WASTES, NATURE, ANNUAL QUANTITY AND METHOD OF DISPOSAL

N. SOURCES, QUANTITIES AND CONTROLS FOR FUGITIVE DUST

O. POLLUTION CONTROL PROGRAM 1971-75.

Please supply a list of the pollution control improvements, including a brief description and expected improvement in efficiency, installed in 1971-2 or planned for 1973-5.

P. LIST AND COMMENTS REGARDING POLLUTION CONTROL PROBLEMS NOT SOLVED ON RECEIPT OF THIS QUESTIONNAIRE.

DATE: ______________________ SIGNATURE: ______________________

TITLE : ______________________

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