ABSTRACT

AIR POLLUTION CONTROL IN THE CEMENT INDUSTRY

by

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Portland cement manufacturing plants - both old and new - located in congested and sparsely populated areas of the country have, for many years, installed the most modern and efficient emission control available at the time.

The process of selecting, proportioning, grinding, heating, cooling, and grinding again of materials sub-micron in size makes close emission control essential.

The technical difficulties of adapting presently available emission control devices to a complex manufacturing process and controlling emissions within the limits of recently enacted or pending air pollution control regulations are great in magnitude and cost.

Neglect of any one of a multitude of design parameters, or inadequate, improper design of control devices can make a continuous high level operating efficiency essentially impossible to attain.

In some instances, increased technology may permit further emission control improvements - at high cost. Proper emphasis should now be placed on the "technically feasible, economically reasonable, practically enforceable" air pollution control regulation, and logical priorities for achieving the same.

Only through the cooperative efforts of the control agency, the public and industry will we be able to achieve the goals of desirable air quality levels.

AIR POLLUTION CONTROL IN THE CEMENT INDUSTRY

In discussing air pollution control within the cement industry, we will touch upon the following:

A. Geographic Concentration of Manufacturing Plants

B. Manufacturing Process and Emission Control

C. Emission Control Costs

D. Technical and Legislative Control Difficulties

A. Geographic Concentration of Manufacturing Plants (V-1)

This slide illustrates the geographic location of producing plants. The concentration shown in some areas is a result of many influencing factors such as raw material availability, marketing potential, transportation, availability of utilities, etc.

Plants are located in the heart of major metropolitan areas as well as sparsely populated areas.

B. Manufacturing Process and Emission Sources (V-2) (not included in paper)

Reduced to its simplest terms, the process for manufacturing Portland Cement has been defined as "Select some raw materials, proportion them, grind, heat, cool and grind again."

Manufacturing can be by either the wet or dry process.

This is an aerial view of the General Portland Cement Company wet process plant located near Miami in Dade County, Florida. The appearance of a dry process plant from this view would be essentially the same.

(V-3)

Drilling is an emission source generally occurring deep within the plant and quarry property, thereby, virtually eliminating any effect off plant property. Where collection is required, drill dusting is controllable by means of a small cyclone or bag-type arrestor.

Emulsion type spraying may be employed to reduce emissions created as raw materials are dumped into the primary crusher. Excessive moisture

(NOTE: V = Visual)

V-1

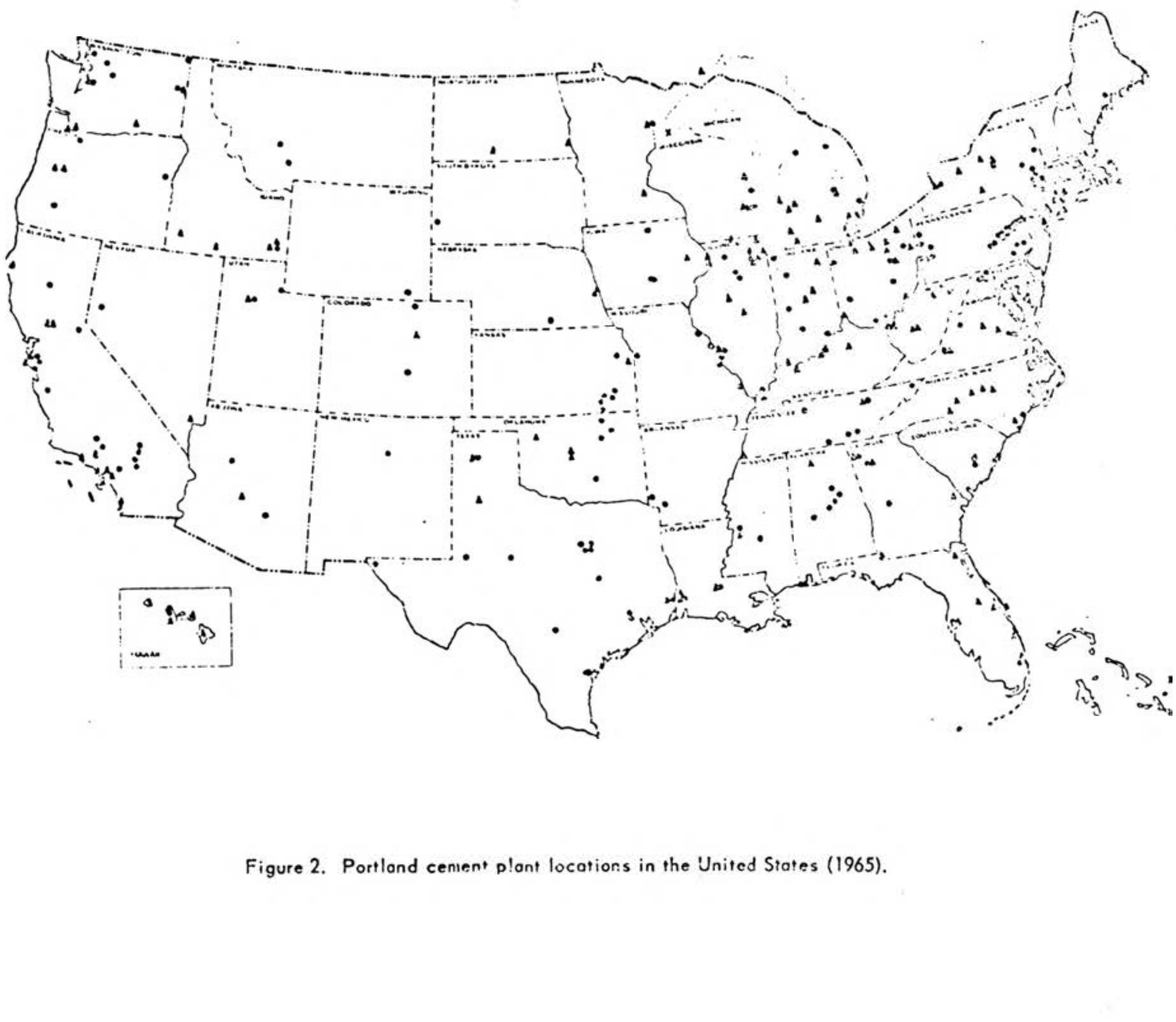
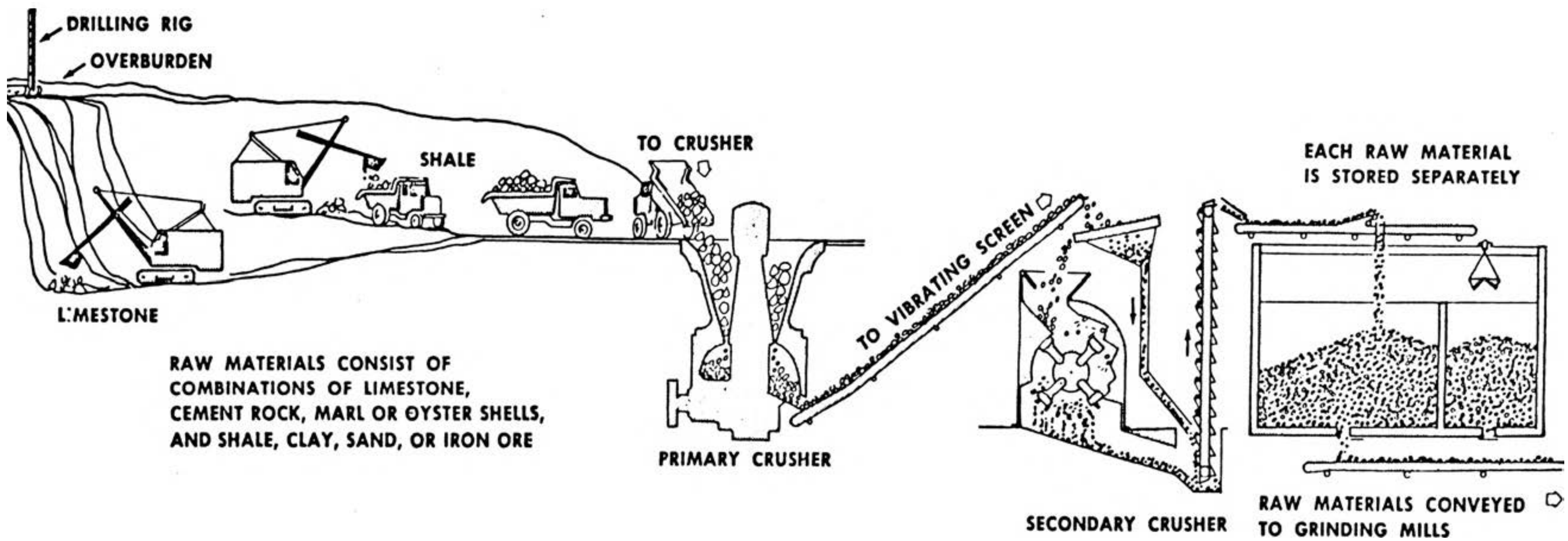


Figure 2. Portland cement plant locations in the United States (1965).



1 Stone is first reduced to 5-in. size, then ¾ in., and stored addition must be controlled, however.

Primary and secondary crushing and material conveyor transfer point emissions are usually controlled by means of cyclones or low temperature bag-type collectors.

Crushed materials, reduced to approximately 3/4" size, are stored in various ways preceding the raw grinding phase.

The method of emission control may vary depending upon the storage method used. Raw material characteristics oftentimes dictate storage and handling methods.

Grinding and Blending (V-4)

1) Dry Process - Stored, dried materials are accurately proportioned and conveyed to the raw mill grinding system which generally consists of a mill in closed circuit with an air separator for product classification. Partial drying may be accomplished in the mill circuit by supplemental heat. Materials in transit through the system are conveyed typically by means of screw conveyors, elevators and air slide equipment.

Raw grinding involves the process of reducing the size of the proportioned raw materials to approximately 85% - 90% passing through a 200 mesh sieve. The clear opening of such a sieve is approximately 0.0029 inches.

Close emission control is therefore essential. Emission control is normally accomplished by low temperature bag-type collectors - sometimes in combination with scalping cyclones.

2) Wet Process - Feed materials for the wet raw grinding circuit may involve materials stored relatively dry and, in the case of previously processed clay, in "slip" form at perhaps 60% - 70% moisture content.

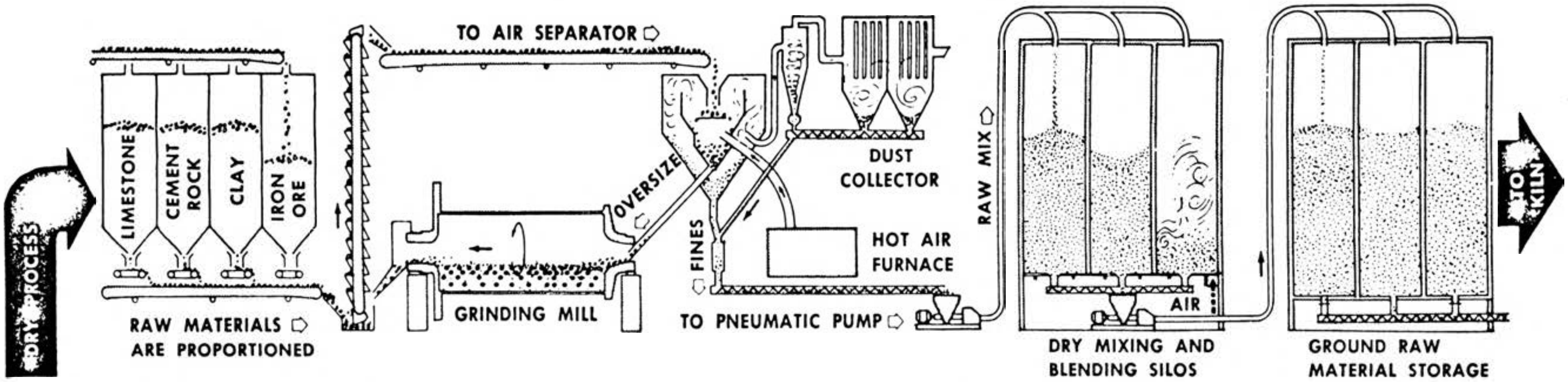
Emissions from the transfer of dry feed components to the mill are normally controlled by low temperature bag-type collectors.

The grinding system generally consists of a mill in closed circuit with some type screening device for classification.

Wet process raw grinding by its general nature is not a dust emission source.

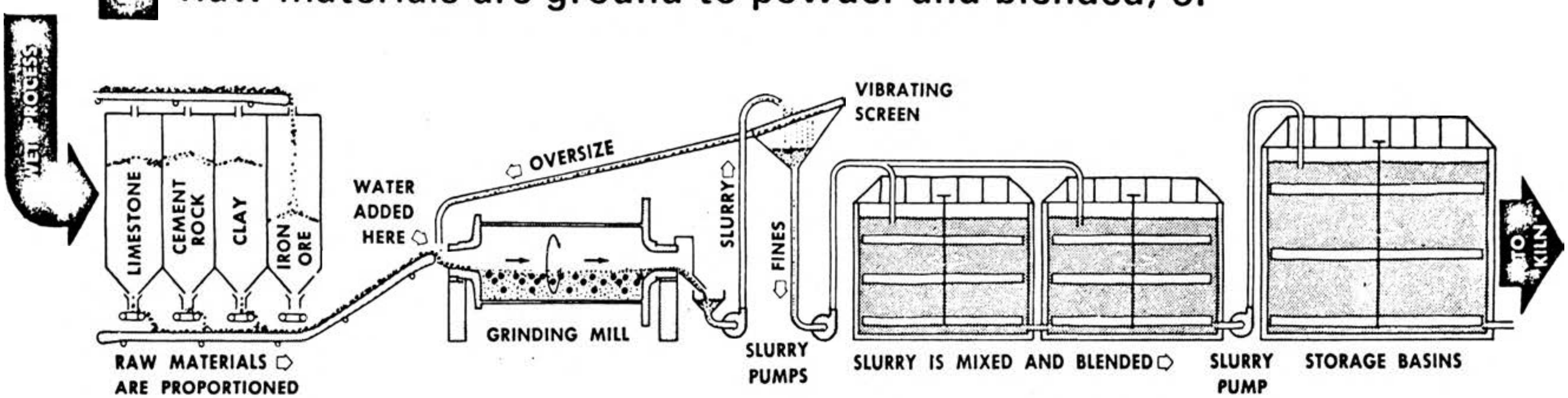
Slurried materials leaving the circuit are generally conveyed by pump to kiln feed blending and storage facilities.

(V-4)



OR

2 Raw materials are ground to powder and blended, or



2 Raw materials are ground, mixed with water to form slurry, and blended

Clinker Burning (V-5)

The heart of the manufacturing process is the clinker burning operation where raw mix is changed into clinker.

The system normally consists of a rotating kiln varying in size to as large as 25 feet in diameter by 760 feet in length. Such a kiln may process over 7,000 tons per day or over 600,000 pounds per hour of feed on a dry basis.

Fuel and combustion air are introduced at the discharge end of the kiln and dust laden exit gases are withdrawn from the kiln feed end by means of an induced draft fan.

Exit gases pass through a dust collecting device enroute to the stack.

Electrostatic precipitators and fiberglass filters, sometimes in combination with mechanical collectors, are normally employed.

Application of wet scrubbers is complicated by the cementitious properties of the kiln dust.

Cooled clinker is conveyed to storage with emissions normally controlled by low temperature bag-type collectors.

Finish Grinding (V-6)

The finish grind circuit is much the same as the dry raw grind system.

Mechanical scalpers and low temperature bag-type collectors are most frequently used, but electrostatic precipitators have been installed on occasion.

Control of emissions from conveying finished cement to packing and loading facilities is generally accomplished by the use of low temperature bag-type collectors.

Plant Equipment Views (V-7 thru V-12) (not included in paper)

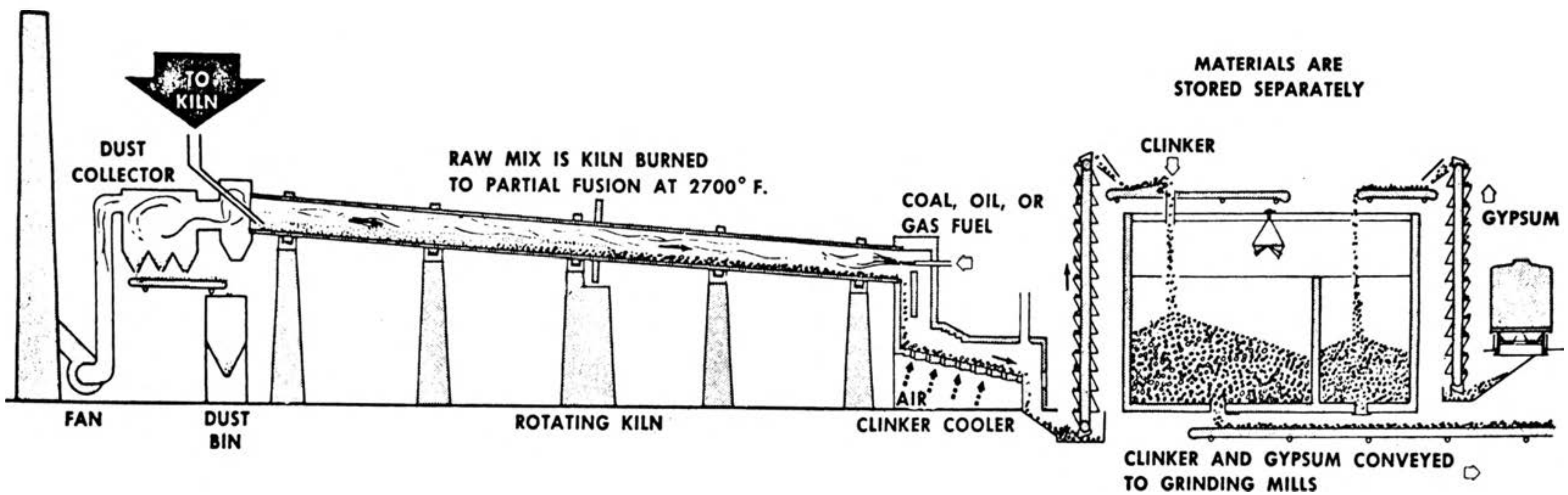
This group of actual plant view slides further illustrates the process equipment involved.

C. Emission Control Costs

It is difficult to generalize on emission control costs because of the limited amount of data presently available.

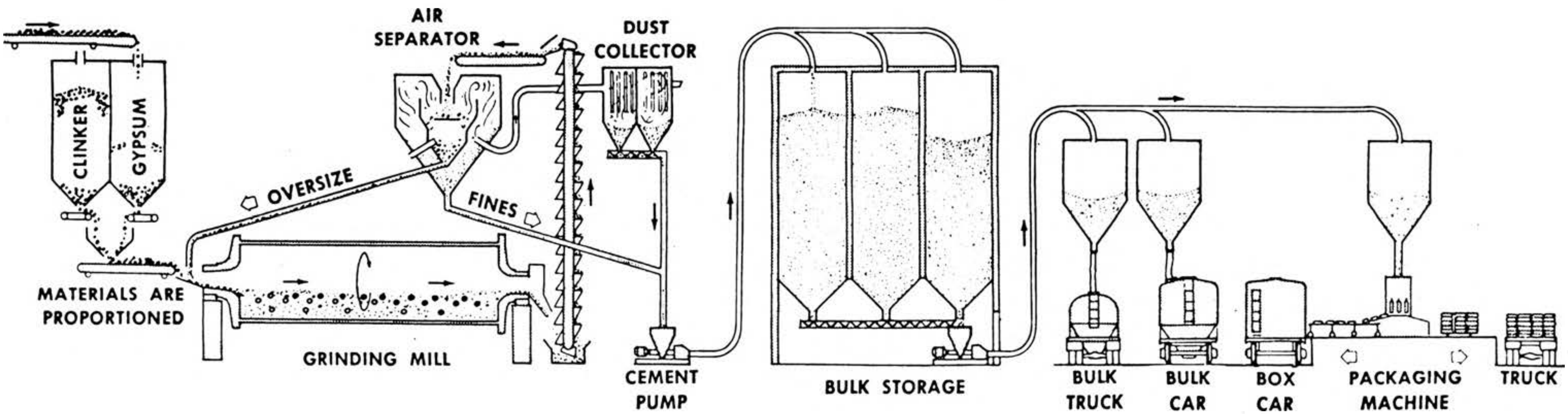
Accounting methods have, in many cases, incorporated emission control cost as part of larger account items.

(V-5)



3 Burning changes raw mix chemically into cement clinker

(V-6)



4 Clinker with gypsum added is ground into portland cement and shipped

Sufficient data have been accumulated, however, to reflect some specific installation costs. For example, one plant with an annual capacity of 2,700,000 barrels reports a total air pollution control investment of $2,500,000, or approximately $0.97 per barrel of plant capacity. Such an investment may represent approximately 10% of the total plant investment.

Companies have reported kiln dust collector "total installed costs" at 400-600% of the original equipment purchase cost.

The U. S. Department of Health, Education and Welfare document on "Control Techniques for Particulate Air Pollutants", N.A.P.C.A. Publication #AP-51, Table 6-3 shows an "extreme high" total installation cost for high voltage electrostatic precipitators at 400% of purchase cost - somewhat less than that frequently experienced in the cement industry. The "extreme high" for fabric filters is given at 400% - perhaps more in line with cement industry experience.

Table 6-5 of the H.E.W. publication gives the "high" annual maintenance costs for high voltage electrostatic precipitators at $0.03 per actual C.F.M. For 400,000 A.C.F.M., this would amount to $12,000 - $32,000 annual maintenance costs.

Figures 6-13 and 6-14 graphically indicate the purchase and installed costs of high voltage electrostatic precipitators.

The high efficiency curves on both graphs indicate for a 400,000 A.C.F.M. unit a $300,000 purchase cost and a $600,000 total installed cost. Applied to a cement kiln, such a unit would likely exceed a cost of $1,000,000.

(V-15)

Another cost of kiln emission control is that of dust return. Figure 6-26 of the H.E.W. Publication projects, for a hypothetical example, an economic break-even point of approximately 97% collection efficiency. In the case of cement kilns, the break-even point may require substantial or total discard of collected dust or water-leaching treatment which may create a secondary problem of water pollution control.

The Cement Environmental Matters Technical Subcommittee of the American Mining Congress has, for some time, been cooperating with the Economic Effects Research Division of N.A.P.C.A. in the development of a questionnaire intended to develop data from which expenditures incurred in reducing air pollutant emissions can be more accurately determined.

The completion of this study will provide more information of interest to all concerned with control of emissions from cement plant operations.

(V-13)

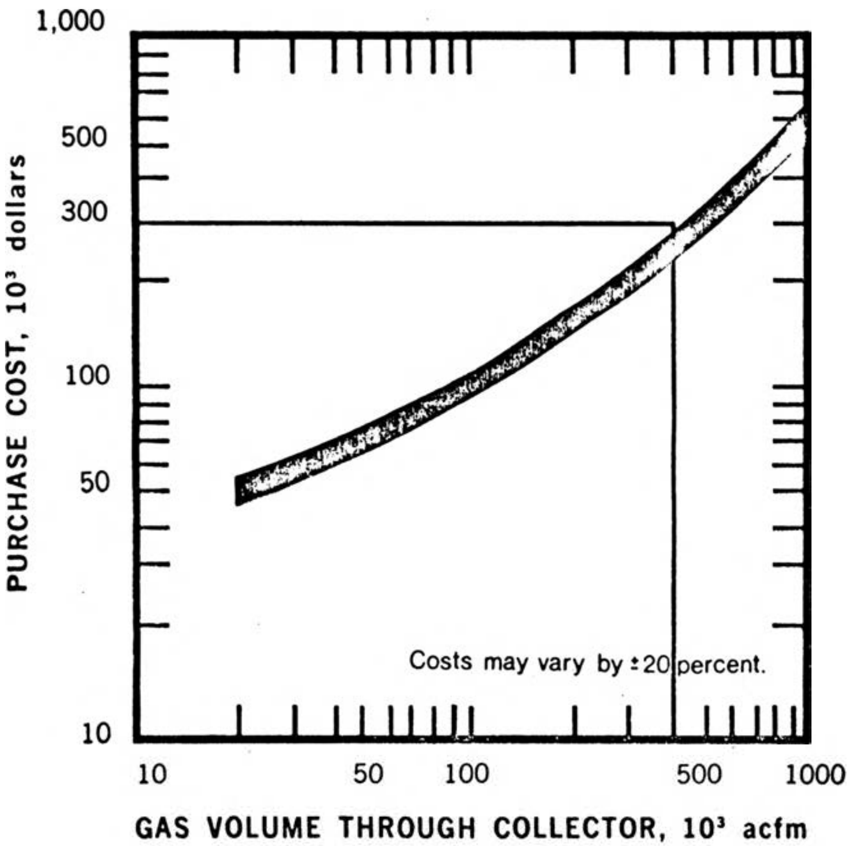


Figure 6-13. Purchase cost of high-voltage electrostatic precipitators.

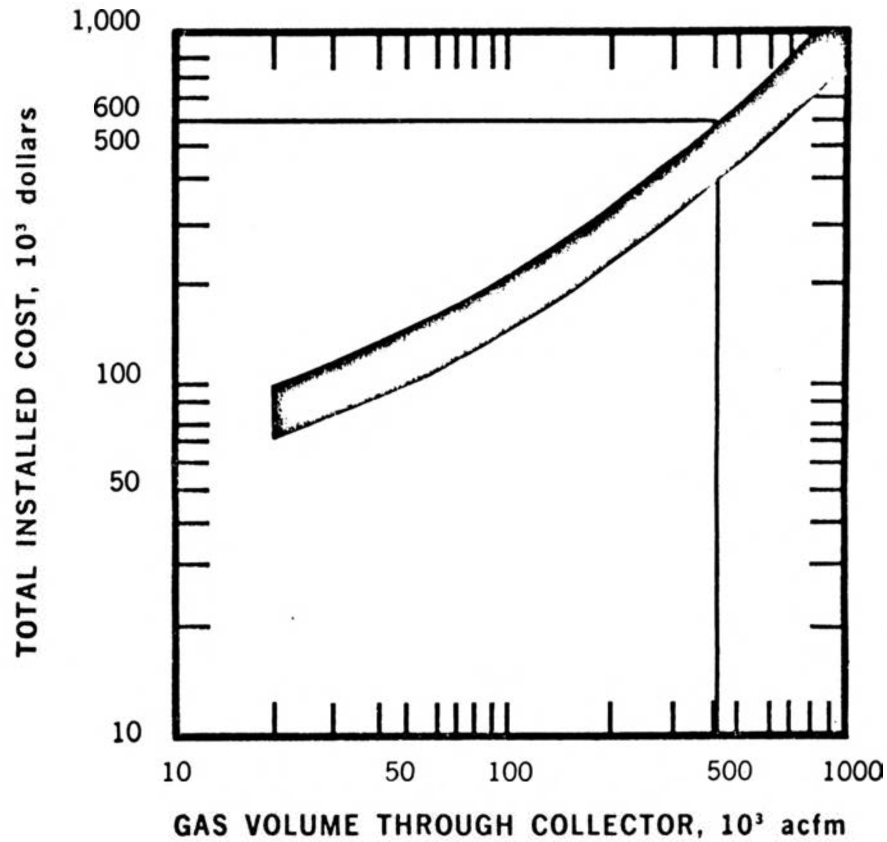
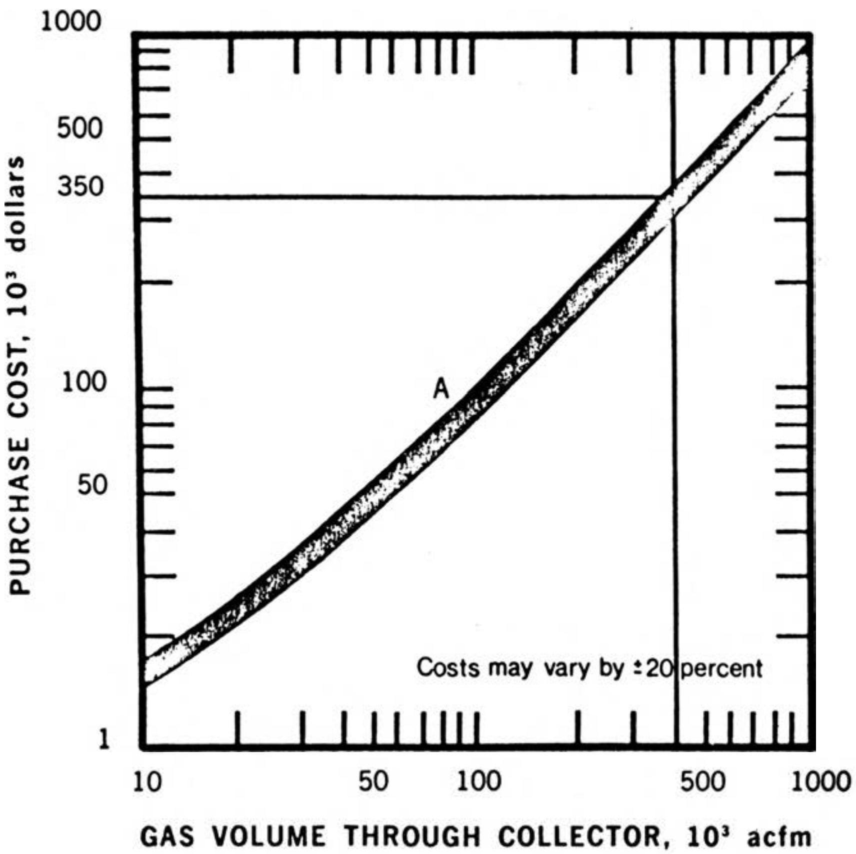
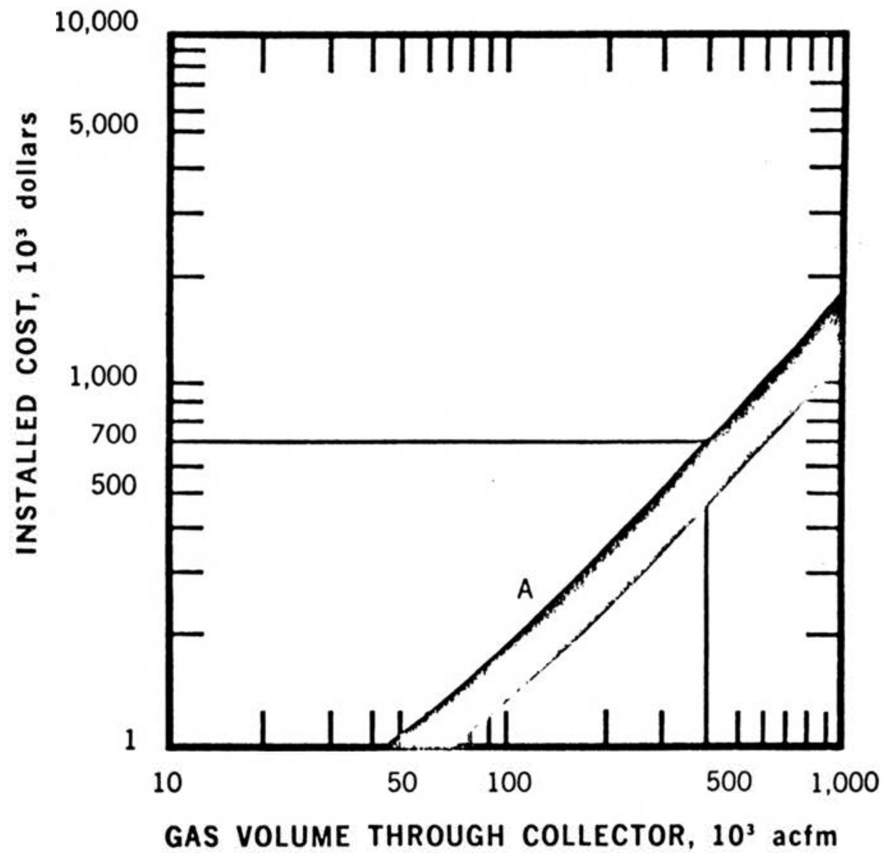


Figure 6-14. Installed cost of high-voltage electrostatic precipitators.



A — HIGH-TEMPERATURE SYNTHETICS, WOVEN AND FELT. CONTINUOUS AUTOMATIC CLEANING.

Figure 6-19. Purchase cost of fabric filters.



A — HIGH-TEMPERATURE SYNTHETICS, WOVEN AND FELT. CONTINUOUS AUTOMATIC CLEANING.

Figure 6-20. Installed cost of fabric filters.

(V-15)

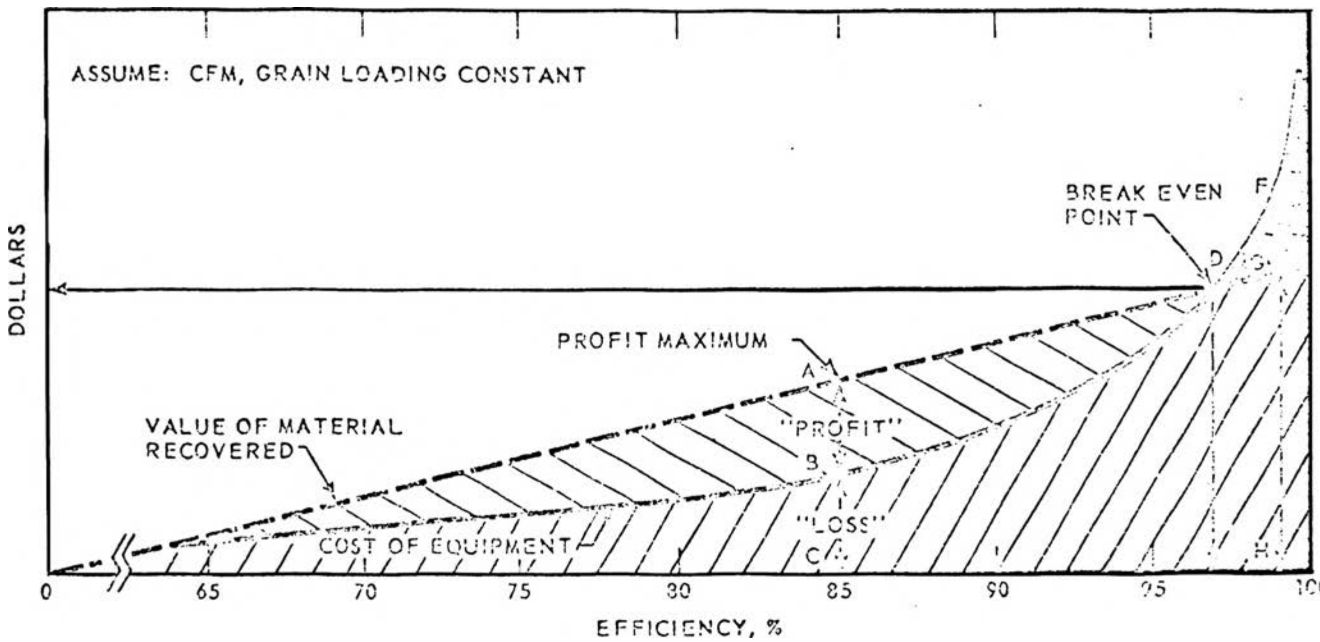


Figure 6-26. Theoretical effect of dust value on control cost.

(V-16)

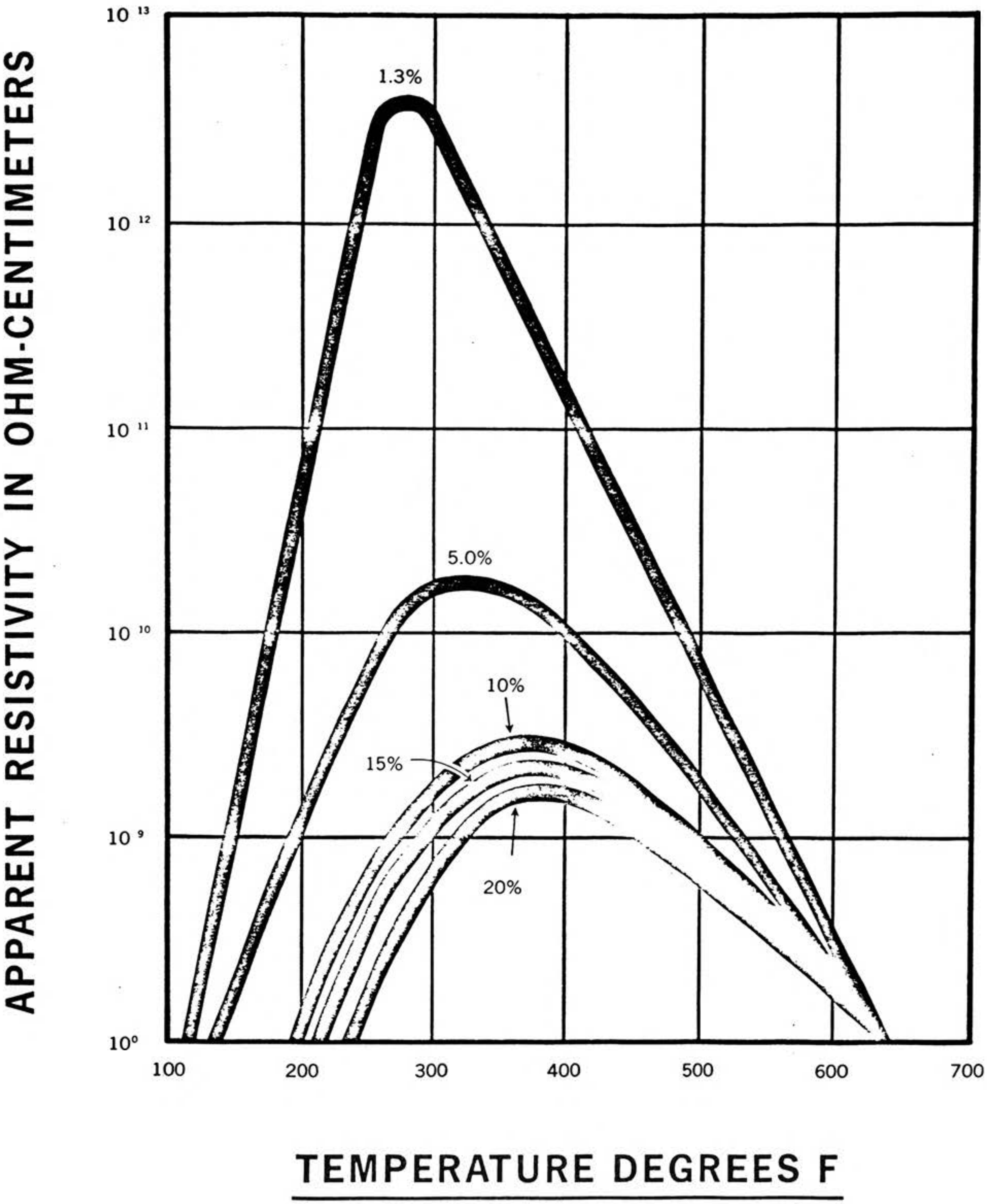


Fig. 6. Moisture and Temperature Effect on the Resistivity of a Cement Dust.

From Control of Dust Emission in Cement Plants,
R. J. PLASS, Mill Session Paper M-185
Portland Cement Association, Research and Development Division, 1966.

D. Technical and Legislative Control Difficulties

1) Technical - The problem of cement kiln exit gas dust emission control has been described as consisting of two phases. The first phase is the removal of particulates from the gas stream by forcing their accumulation on the collecting media.

In many cases, the collecting "first phase" is more easily accomplished than the second phase - getting the collected dust out of the emission control device.

Technical problems are further complicated by a third phase - dust disposal.

Long-established parameters essential to the proper design and application of precipitators and fabric filters are too numerous for discussion at this time.

Let us take a moment, however, to look at the problem of particulate resistivity which has become of increasing importance as we are faced with higher and higher operating efficiencies.

Resistivity - a measure of the difficulty with which a particle will take on electrical charge - is determined by the type particle involved and temperature and humidity of the exit gas stream.

Resistivity peaks often occur close to actual inlet gas temperatures of emission control devices.

Elevating gas temperatures to lower resistivity would increase fuel costs, gas volumes and precipitator sizes. Lowering gas temperature by infiltrating air tends to lower resistivity, but at the expense of increased gas volumes and precipitator size.

Resistivity reduction is generally accomplished by increasing the percent moisture in the exit gas stream through the use of high pressure atomizing water sprays. This has the multiple advantage of lowering gas temperature and volume, increasing gas moisture content, and lowering resistivity.

Any of the above methods involve substantial expense.

Neglect of any of a multitude of such design parameters, or inadequate, improper design can make a continuous high level operating efficiency essentially impossible to attain.

2) Legislative - Hastily conceived, illogical emission control regulations which are not "technically feasible, economically reasonable" or properly enforceable are equally perplexing when related to the technical problems previously mentioned.

Throughout the nation, there is an almost universal tendency to adopt the equivalent of the San Francisco Bay Area Process Weight Code and the Equivalent Opacity concept.

The differences in industrial processes leave the universal application of the process weight table and the equivalent opacity concept open to serious question.

The original process weight regulation concept was developed for application in March, 1949, to the metallurgical industries of Los Angeles County, California. The development is described in the November, 1949, issue of Industrial and Engineering Chemistry article on "Dust and Fume Standards".

The article describes how, for metallurgical industries, furnace process weight and stack losses were plotted graphically.

The average collecting efficiency required of small industrial units was approximately 80%; of large industrial plants, approximately 90%. Only the largest process unit having a 3% loss would be required to collect 98% of its stack discharge.

The maximum permissible emission of 40 pounds per hour was established at 60,000 pounds per hour of process weight under the Los Angeles code which was over three times the process weight of the largest industry involved.

The San Francisco Bay Area Process Weight Code is only slightly more lenient than the Los Angeles code.

It appears somewhat questionable to lift a rule that has been developed for one specific application and project it into an area with altogether different conditions.

For example, the 3% loss and 98% collecting efficiency applied to the "largest" metallurgical unit as described in the "Dust and Fume Standards" for Los Angeles County compares to approximately 18% loss and 99.8-99.9% collecting efficiency for pyro-processing industries such as cement manufacturing.

Careful consideration given to the development of the original Los Angeles process weight regulation logically must be given to the collection of process data for totally unrelated chemical and pyro-processing industries.

The selection of dust collecting equipment for pyro-processing industry is not a simple matter of asking the equipment manufacturer to select and erect the newest 1969 model and expecting it to operate satisfactorily.

Survey data has been compiled to show existing conditions for various cement plants operating throughout the United States. Data has been obtained from (1) H.E.W., U.S.P.H.S. Publication #999-AP-17, "Atmospheric Emissions From The Manufacture Of Portland Cement", and (2) members of the Technical Subcommittee, Cement Environmental Matters, American Mining Congress.

Average operating experience conservatively indicates approximately 10% of the total weight of the materials introduced in the cement manufacturing process at the feed end of the rotary cement kiln leaves the kiln and becomes gas-borne.

To appreciate the magnitude of this problem and emission control efficiencies requied, let us consider the previously mentioned survey data from 50 reports.

(V-17)

If we plot the average emission rate of 200 pounds per hour versus 115,000 pounds per hour process weight, we establish a point of reference.

We may then develop an equation for defining a relationship between emission and process weight. The equation developed is $E = 26.5 P^{0.5}$ and the values for emission are based on a related amount of process weight.

If we consider the average condition of 3,870 barrels per day of clinker production with an estimated process weight of 115,000 pounds per hour and an emission rate of 200 pounds per hour, a collecting efficiency of 98.2% is indicated.

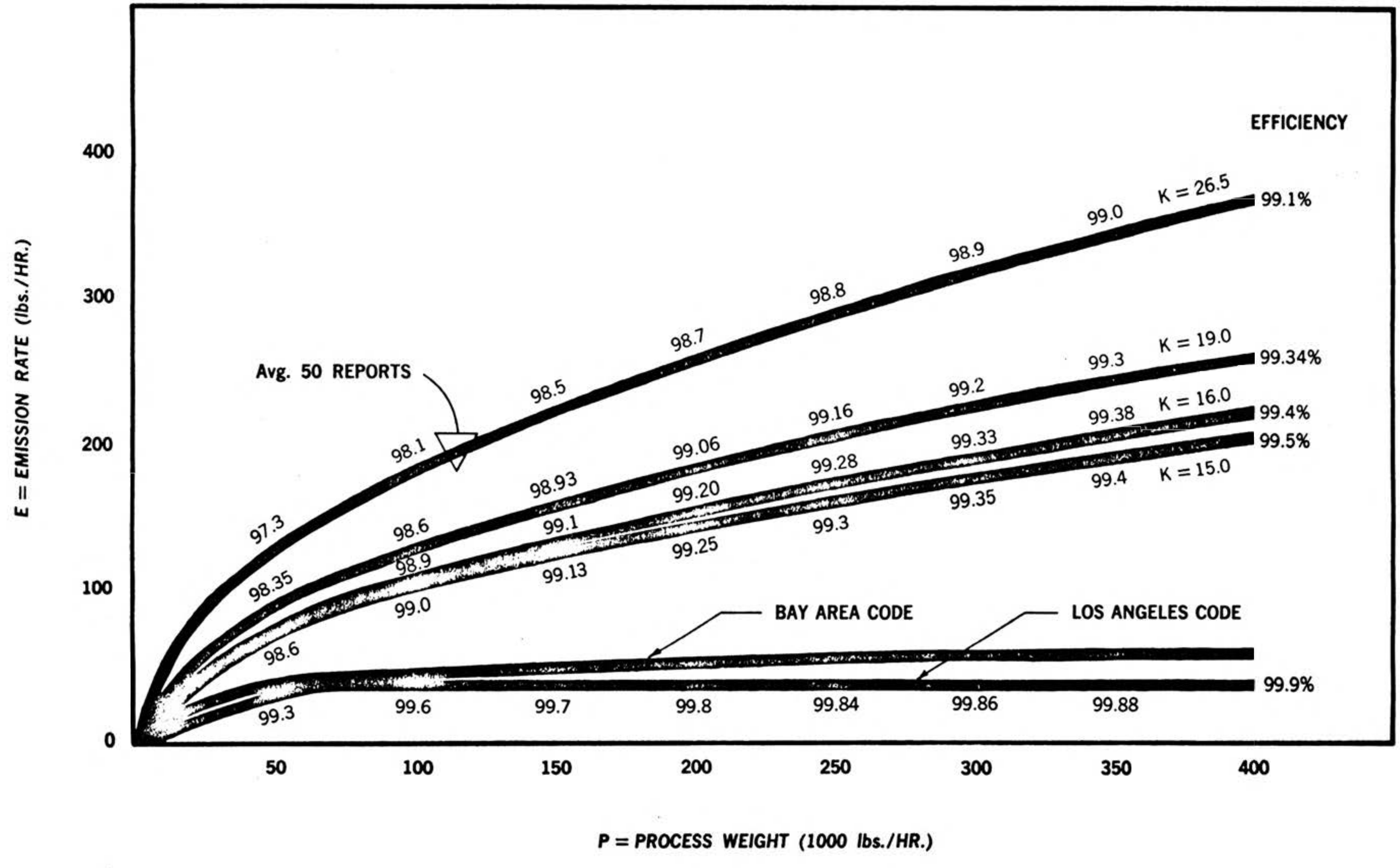
To comply with the Bay Area Code emission limitation of about 45 pounds per hour, the required efficiency would be 99.6%. The Los Angeles Code limitation of 400 pounds per hour would require an efficiency of 99.65%.

This means it would be necessary to modify the average existing collector to further reduce its exit gas dust loading by 80%. In some instances, this might be achieved by complete rehabilitation, but complete replacement would more often be required. In some instances, complete replacement by the higher efficiency, larger collector may be physically impossible.

The Clean Air Act of 1967 recognizes the needs for establishing cost-benefit relationships as well as the need for ambient air quality control by means which are "technically feasible and economically reasonable".

It is obvious from this slide that consideration of these factors is particularly important when considering the efficiencies

PROCESS WEIGHT EFFICIENCIES



required to achieve compliance under any of the control curves represented.

For example, the required efficiency for compliance under curve K = 16 or $E = 16.0\ P^{0.5}$ ranges from approximately 98.5% at 50,000 pounds per hour to 99.4% at 400,000 pounds per hour, for the average 10% loss of kiln product. At 15% dust loss, 99.7% efficiency is required at 400,000 pounds per hour. These data are typical for many existing kiln operating conditions.

Compliance under the Bay Area Code for the same process weight range would be from about 99.3% - 99.9%.

When considering the "Technically feasible, economically reasonable", cost-benefits aspects of pollution control legislation, the logic of the universal application of a specific process weight regulation is questionable.

For example, five small kilns each operating at a process weight of 30 tons per hour would be permitted a total emission of 200 pounds per hour, while one kiln operating at 150 tons per hour would be permitted an emission of only 53 pounds per hour - 1/4 the emission for the same process weight.

It is not "technically feasible, economically reasonable" nor does it seem logical to force industry into the position of installing a multiple number of small units rather than one large unit simply as a means of regulation compliance with no increased air pollution control benefits.

(V-18) (not included in paper)

The Ringelmann Chart used to regulate particulate emission or for Equivalent Opacity control of visibility is also an enforcement tool subject to question when related to cement kiln stack measurements.

The wet or dry process kiln stack plume are conditions far removed from the originally intended use of the Ringelmann Chart - black smoke.

This slide shows the appearance of a wet process stack plume with the sun at the back of the observer - as prescribed for Ringelmann Chart use. The plume was recorded to be a Ringelmann 0.25.

(V-19) (not included in paper)

This slide shows the same plume viewed by the observer as he faced the sun. In this instance, the plume was recorded as a Ringelmann 4.

Obviously, the position of the observer with respect to sun location is critical.

Conclusion

Long before air pollution control regulations were a factor, the cement industry in general recognized its responsibility for air pollution emission control.

Dust collection equipment representing the latest in control technology available at the time has been installed at substantial cost.

Technology has improved to the extent that, in some instances, emission control improvements can and should be made within our industry.

The cost of improved emission control will be substantial. The investment required by multi-plant companies with plants located in many different states will be tremendous; and remember there will be no financial return resulting from this investment.

The job will be done - the money will be spent, but proper emphasis should now be placed on the "technically feasible, economically reasonable, practically enforceable" air pollution control regulation and the logical priorities for achieving the same.

Obviously, the need for improved air quality will not dictate identical needs or priorities for every geographical location in this country.

The cement industry has offered its technical assistance to those engaged in the important task of developing logical air pollution control regulations.

Only through the cooperative efforts of the control agency, the public and industry will we be able to achieve the goals of desirable air quality levels.

In his preface to the recently issued H.E.W. publications on "Control Techniques for Sulphur Oxide and Particulate Air Pollutants", Dr. John T. Middleton stated: "The control of air pollutant emissions is a complex problem because of the variety of sources and source characteristics. Technical factors frequently make necessary the use of different control procedures for different types of sources. Many techniques are still in the developmental stage, and prudent control strategy may call for the use of interim methods until these techniques are perfected. Thus, we can expect that we will continue to improve, refine, and periodically revise the control technique information so that it will continue to reflect the most up-to-date knowledge available."

All those concerned with air quality control would do well to seriously consider the implication of Dr. Middleton's words and use caution in the universal application of pollution control concepts logically employed in some instances, but illogically applicable in other instances.

COMMENTS

QUESTION: One thing that occurred to me is that obviously the Rengleman chart was not intended for use of checking cement plants. Have you some recommendations as to what you think would be a preferable means of checking cement plants for enforcement against air pollution?

ANSWER (Mr. Hailstone): I personally prefer a process concept for the simplicity involved but the important aspect then becomes the numbers that you use, or the equation that you use for developing the curve of the data, or the table for allowable admissions. The use of the Rengleman chart concept is beased on visibility control of the mission which is becoming an increasingly imporatnt factor, I don't have as firm a conviction as to what the substitute measures should be.

QUESTION: How do the Texas regulations affect the cement industry?

ANSWER: Texas regulation based on an ambulant air level quality is a consideration or concept which as somebody said earlier this morning, we would like to think is a more logical approach to control. Now as I understand it, the Texas existant regulations are based upon what are called Sutton's equation. There are a couple of different ways to check and see whether they are within compliance of existing Texas regulations. One is to take up-wind and down-wind measurements of particulates and micrograms per cubic meter at ground level. The other is to measure you back discharge and see according to the sub equation that you would not exceed a certain level in micrograms per cubic meter at the point of concern. That is essentially what the Texas regulation consists of today.