EPA-450/2-74-017a

# BACKGROUND INFORMATION FOR STANDARDS OF PERFORMANCE: ELECTRIC ARC FURNACES IN THE STEEL INDUSTRY

# VOLUME 1: PROPOSED STANDARDS

Emission Standards and Engineering Division

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# PREFACE

## A. Purpose of this Report

Standards of performance under section 111 of the Clean Air Act[1/] are proposed only after a very detailed investigation of air pollution control methods available to the affected industry and the impact of their costs on the industry. This report summarizes the information obtained from such a study of electric arc furnaces in the steel industry. It is being distributed in connection with formal proposal of standards for that industry in the Federal Register. Its purpose is to explain the background and basis of the proposal in greater detail than could be included in the Federal Register, and to facilitate analysis of the proposal by interested persons, including those who may not be familiar with the many technical aspects of the industry. For additional information, for copies of documents (other than published literature) cited in the Background Information Document, or to comment on the proposed standards, contact Mr. Don R. Goodwin, Director, Emission Standards and Engineering Division, United States Environmental Protection Agency, Research Triangle Park, North Carolina 27711 [(919)688-8146].

## B. Authority for the Standards

Standards of performance for new stationary sources are promulgated in accordance with section 111 of the Clean Air Act (42 USC 1857c-6), as amended in 1970. Section 111 requires

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1/ Sometimes referred to as "new source performance standards" (NSPS).

the establishment of standards of performance for new stationary sources of air pollution which "... may contribute significantly to air pollution which causes or contributes to the endangerment of public health or welfare." The Act requires that standards of performance for such sources reflect "... the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction) the Administrator determines has been adequately demonstrated." The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

Section 111 prescribes three steps to follow in establishing standards of performance.

1. The Administrator must identify those categories of stationary sources for which standards of performance will ultimately be promulgated by listing them in the Federal Register.
2. The regulations applicable to a category so listed must be proposed by publication in the Federal Register within 120 days of its listing. This proposal provides interested persons an opportunity for comment.
3. Within 90 days after the proposal, the Administrator must promulgate standards with any alterations he deems appropriate.

It is important to realize that standards of performance, by themselves, do not guarantee protection of health or welfare; that is, they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect best demonstrated technology (taking into account costs) for the affected sources. The overriding purpose of the collective body of standards is to maintain existing air quality and to prevent new pollution problems from developing.

Previous legal challenges to standards of performance for portland cement plants, steam generators, and sulfuric acid plants have resulted in several court decisions[2/] of importance in developing future standards. In those cases, the principal issues were whether EPA: (1) made reasoned decisions and fully explained the basis of the standards, (2) made available to interested parties the information on which the standards were based, and (3) adequately considered significant comments from interested parties.

Among other things, the court decisions established: (1) that preparation of environmental impact statements is not necessary for standards developed under section 111 of the Clean Air Act because, under that section, EPA must consider any counter-productive environmental effects of a standard in determining what system of control is "best;" (2) in considering costs it is not necessary to provide a cost-benefit analysis;

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2/ Portlant Cement Association v Ruckelshaus, 486 F. 2nd 375 (D.C. Cir. 1973); Essex Chemical Corp. v Ruckelshaus, 486 F. 2nd 427 (D.C. Cir. 1973).

(3) EPA is not required to justify standards that require different levels of control in different industries unless such different standards may be unfairly discriminatory; and (4) it is sufficient for EPA to show that a standard can be achieved rather than that it has been achieved by existing sources.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. On the contrary section 116 of the Act (42 USC 1857-D-1) makes clear that States and other political subdivisions may enact more restrictive standards. Furthermore, for heavily polluted areas, more stringent standards may be required under section 110 of the Act (42 USC 1857c-5) in order to attain or maintain national ambient air quality standards prescribed under section 109 (42 USC 1857c-4). Finally, section 11 makes clear that a State may not adopt or enforce less stringent standards than those adopted by EPA under section 111.

Although it is clear that standards of performance should be in terms of limits on emissions where feasible,[3/] an alternative method of requiring control of air pollution is sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive.

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3/ "'Standards of performance,' ... refers to the degree of emission control which can be achieved through process changes, operation changes, direct emission control, or other methods. The Secretary [Administrator] should not make a technical judgment as to how the standard should be implemented. He should determine the achievable limits and let the owner or operator determine the most economical technique to apply." Senate Report 91-1196.

For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during storage and tank filling. The nature of the emissions (high concentrations for short periods during filling and low concentrations for longer periods during storage) and the configuration of storage tanks make direct emission measurement highly impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

C. Selection of Categories of Stationary Sources

Section 111 directs the Administrator to publish and from time to time revise a list of categories of sources for which standards of performance are to be proposed. A category is to be selected "... if [the Administrator] determines it may contribute significantly to air pollution which causes or contributes to the endangerment of public health or welfare."

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a svstem for assigning priorities to various source categories. In brief, the approach that has evolved is as follows.

First, we assess any areas of emphasis by considering the broad EPA strategy for implementing the Clean Air Act. Often, these "areas" are actually pollutants which are primarily emitted by stationary sources. Source categories which emit these pollutants are then evaluated and ranked by a process involving such factors as (1) the level of emission control (if any) already required by State regulations; (2) estimated levels of control that might result from standards of performance for the source category; (3) projections of growth and replacement of existing facilities for the source category; and (4) the estimated incremental amount of air pollution that could be prevented, in a preselected future year, by standards of performance for the source category.

After the relative ranking is complete, an estimate must be made of a schedule of activities required to develop a standard. In some cases, it may not be feasible to immediately develop a standard for a source category with a very high priority. This might occur because a program of research and development is needed or because techniques for sampling and measuring emissions may require refinement before study of the industry can be initiated. The schedule of activities must also consider differences in the time required to complete the necessary investigation for different source categores. Substantially more time may be necessary, for example, if a number of pollutants must be investigated in a single source category. Even late in the development process the schedule for completion of a standard may change. For example, inability to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling.

Selection of the source category leads to another major decision: determination of the types of sources or facilities to which the standard will apply. A source category often has several facilities that cause air pollution. Emissions from some of these facilities may be insignificant and, at the same time, very expensive to control. An investigation of economics may show that, within the costs that an owner could reasonably afford, air pollution control is better served by applying standards to the more severe pollution problems. For this reason (or perhaps because there may be no adequately demonstrated system for controlling emissions from certain facilities), standards often do not apply to all sources within a category. For similar reasons, the standards may not apply to all air pollutants emitted by such sources. Consequently, although a source category may be selected to be covered by a standard of performance, treatment of some of the pollutants or facilities within that source category may be deferred.

D. Procedure for Development of Standards of Performance

Congress mandated that sources regulated under section 111 of the Clean Air Act be required to utilize the best practicable air pollution control technology that has been adequately demonstrated at the time of their design and construction. In so doing, Congress sought to:

1. maintain existing high-quality air,
2. prevent new air pollution problems, and
3. ensure uniform national standards for new facilities.

The selection of standards of performance to achieve the intent of Congress has been surprisingly difficult. In general, the standards must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost of such control; (3) be applicable to existing sources that are modified as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

A major portion of the program for development of standards is spent identifying the best system of emission reduction which "has been adequately demonstrated" and quantifying the emission rates achievable with the system. The legislative history of section 111 and the court decisions referred to above make clear that the Administrator's judgment of what is adequately demonstrated is not limited to systems that are in actual routine use. Consequently, the search may include a technical assessment of control systems which have been adequately demonstrated but for which there is limited operational experience. To date, determination of the "degree of emission limitation achievable" has been commonly based on (but not restricted to) results of tests of emissions from existing sources. This has required worldwide investigation and measurement of emissions from control systems. Other countries with heavily populated, industrialized areas have sometimes developed more effective systems of control than those used in the United States.

Because the best demonstrated systems of emission reduction may not be in widespread use, the data base upon which the standards are established will necessarily be somewhat limited. Test data on existing well-controlled sources are an obvious starting point in developing emission limits for new sources. However, since the control of existing sources generally represents retrofit technology or was originally designed to meet an existing State or local regulation, new sources may be able to meet more stringent emission standards. Accordingly, other information must be considered and judgment is necessarily involved in setting proposed standards.

Since passage of the Clean Air Amendments of 1970, a process for the development of a standard has evolved. In general, it follows the guidelines below.

1. Emissions from existing well-controlled sources are measured.
2. Data on emissions from such sources are assessed with consideration of such factors as: (a) the representativeness

of the source tested (feedstock, operation, size, age, etc.); (b) the age and maintenance of the control equipment tested (and possible degradation in the efficiency of control of similar new equipment even with good maintenance procedures); (c) the design uncertainties for the type of control equipment being considered; and (d) the degree of uncertainty affecting the judgment that new sources will be able to achieve similar levels of control.

3. During development of the standards, information from pilot and prototype installations, guarantees by vendors of control equipment, contracted (but not yet constructed) projects, foreign technology, and published literature are considered, especially for sources where "emerging" technology appears significant.

4. Where possible, standards are set at a level that is achievable with more than one control technique or licensed process.

5. Where possible, standards are set to encourage (or at least permit) the use of process modifications or new processes as a method of control rather than "add-on" systems of air pollution control.

6. Where possible, standards are set to permit use of

systems capable of controlling more than one pollutant (for example, a scrubber can remove both gaseous and particulate matter emissions, whereas an electrostatic precipitator is specific to particulate matter).

7. Where appropriate, standards for visible emissions are established in conjunction with mass emission standards. In such cases, the standards are set in such a way that a source meeting the mass emission standard will be able to meet the visible emission standard without additional controls. (In some cases, such as fugitive dust, there is no mass standard).

Finally, when all pertinent data are available, judgment is again required. Numerical tests may not be transposed directly into regulations. The design and operating conditions of those sources from which emissions were actually measured cannot be reproduced exactly by each new source to which the standard of performance will apply.

E. <u>How Costs are Considered</u>

Section 111 of the Clean Air Act requires that cost be considered in setting standards of performance. To do this requires an assessment of the possible economic effects of implementing various levels of control technology in new plants within a given industry. The first step in this analysis requires the generation of estimates of installed capital costs and annual operating costs for various demonstrated control systems, each control system alternative having a different overall control capability. The final step in the analysis is to determine the economic impact of the various control alternatives upon a new plant in the industry. The fundamental question to be addressed in this step is whether or not a new plant would be constructed given that a certain level of control costs would be incurred. Other issues that would be analyzed in this step would be the effects of control costs upon product prices and the effects on product and raw material supplies and producer profitability.

The economic impact upon an industry of a proposed standard is usually addressed both in absolute terms and by comparison with the control costs that would be incurred as a result of compliance with typical existing State control regulations. This incremental approach is taken since a new plant would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the impact upon the industry resulting from the cost differential that usually exists between the standard of performance and the typical State standard.

It should be noted that the costs for control of air pollutants are not the only control costs considered. Total environmental costs for control of water pollutants as well as air pollutants are analyzed wherever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made. It is also essential to know the capital requirements placed on plants in the absence of Federal standards of performance so that the additional capital requirements necessitated by these standards can be placed in the proper perspective. Finally, it is necessary to recognize any constraints on capital availability within an industry as this factor also influences the ability of new plants to generate the capital required for installation of the additional control equipment needed to meet the standards of performance.

The end result of the analysis is a presentation of costs and potential economic impacts for a series of control alternatives. This information is then a major factor which the Administrator considers in selecting a standard.

F. Impact on Existing Sources

Proposal of standards of performance may affect an existing source in either of two ways. First, if modified after proposal of the standards, with a subsequent increase in air pollution, it is subject to standards of performance as if it were a new source. (Section 111 of the Act defines a new source as "any stationary source, the construction or modification of which is commenced after the regulations are proposed.")[4/]

Second, promulgation of a standard of performance requires States to establish standards of performance for the same pollutant for existing sources in the same industry under section 111(d) of the Act; unless the pollutant limited by the standard for new sources is one listed under section 108 (requiring promulgation of national ambient air quality standards) or one listed as a hazardous pollutant under section 112. If a State does not act, EPA must establish such standards. Regulations prescribing procedures for control of existing sources under section 111(d) will be proposed as Subpart B of 40 CFR Part 60.

G. Revision of Standards of Performance

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, section 111 of the Act provides that the Administrator may revise such standards from time to time. Although standards proposed and promulgated by EPA under section 111 are designed to require installation of the "... best system of emission reduction ... (taking into account the cost)..." the standards will be reviewed periodically. Revisions will be proposed and promulgated as necessary to assure that the standards

4/ Specific provisions dealing with modifications to existing facilities are being proposed by the Administrator under the General Provisions of 40 CFR Part 60.

continue to reflect the best systems that become available in the future. Such revisions will not be retroactive but will apply to stationary sources constructed or modified after proposal of the revised standards.

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# I. THE STEEL INDUSTRY (ELECTRIC ARC FURNACES)

## A. General

Major sources of air pollution in the steel industry are basic oxygen process, electric arc and open hearth steel production furnaces; blast furnaces; and coke and sintering plants (Figure I-1). All will emit large quantities of air pollutants (primarily particulate matter) if not properly controlled. The first standards of performance for the industry were promulgated for basic oxygen process furnaces on March 8, 1974. This document discusses standards for electric arc furnaces. EPA has now initiated an investigation of emissions from coke plants and still other sources will be considered as potential candidates for standards at a future date.

Standards for the basic oxygen process furnace (BOPF) were developed first because the BOPF is projected to experience the greatest share of the future growth in steel production. Electric arc furnaces (EAF) will also participate in the growth. Steel production in open hearth furnaces (OHF), however, is declining. These projected growth rates result from both increased demand for steel and replacement of obsolete open hearth furnaces. Trends in the production of steel from these three furnace types are shown in Figure I-2.[1]

A BOPF can produce much more steel in a shorter time than the other types of furnaces. Because of this, most OHF's, which have relatively low productivity, will be replaced by BOPF's. The BOPF is somewhat unique in

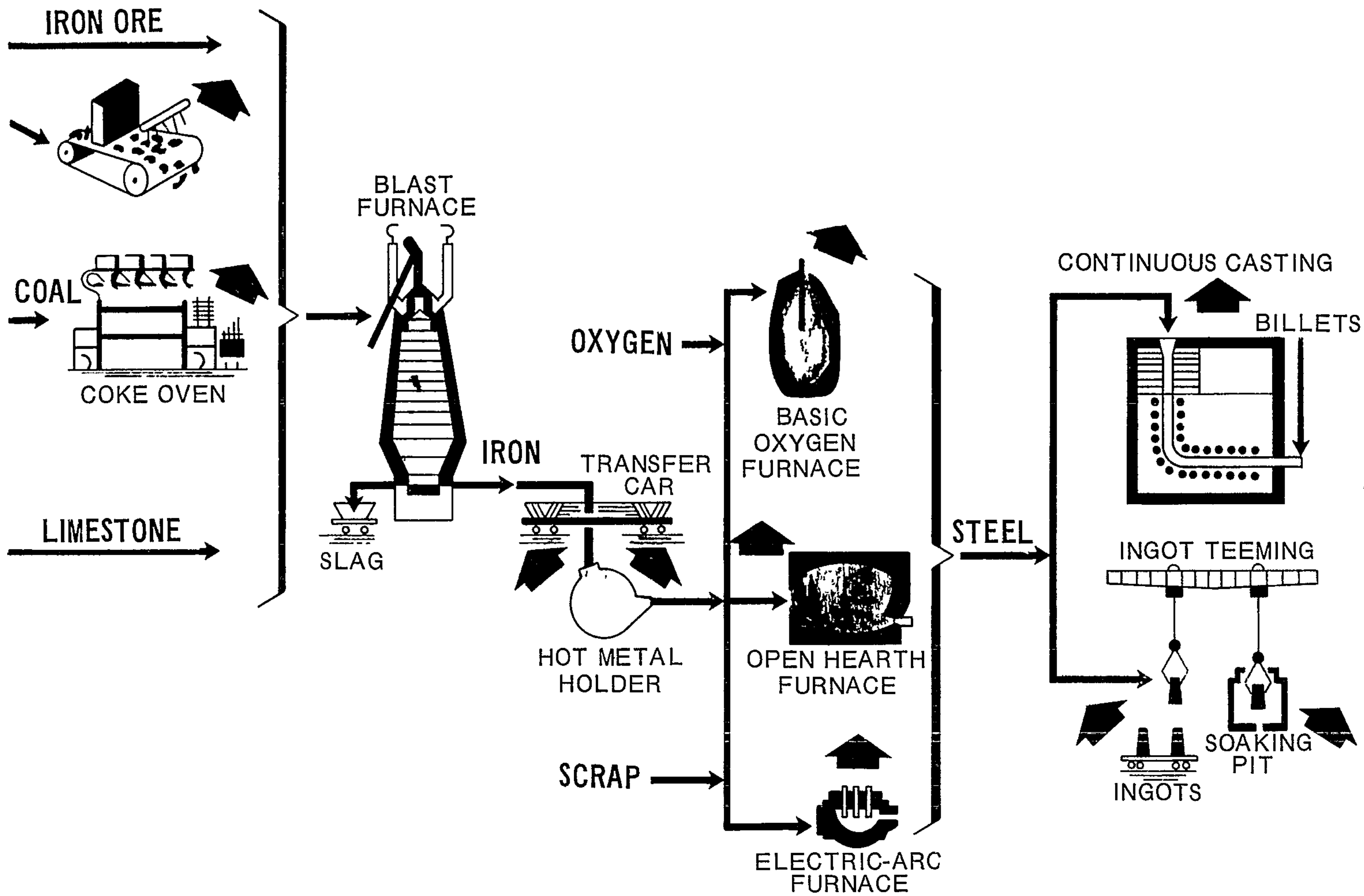


Figure I-1. Flow diagram of an iron and steel plant.

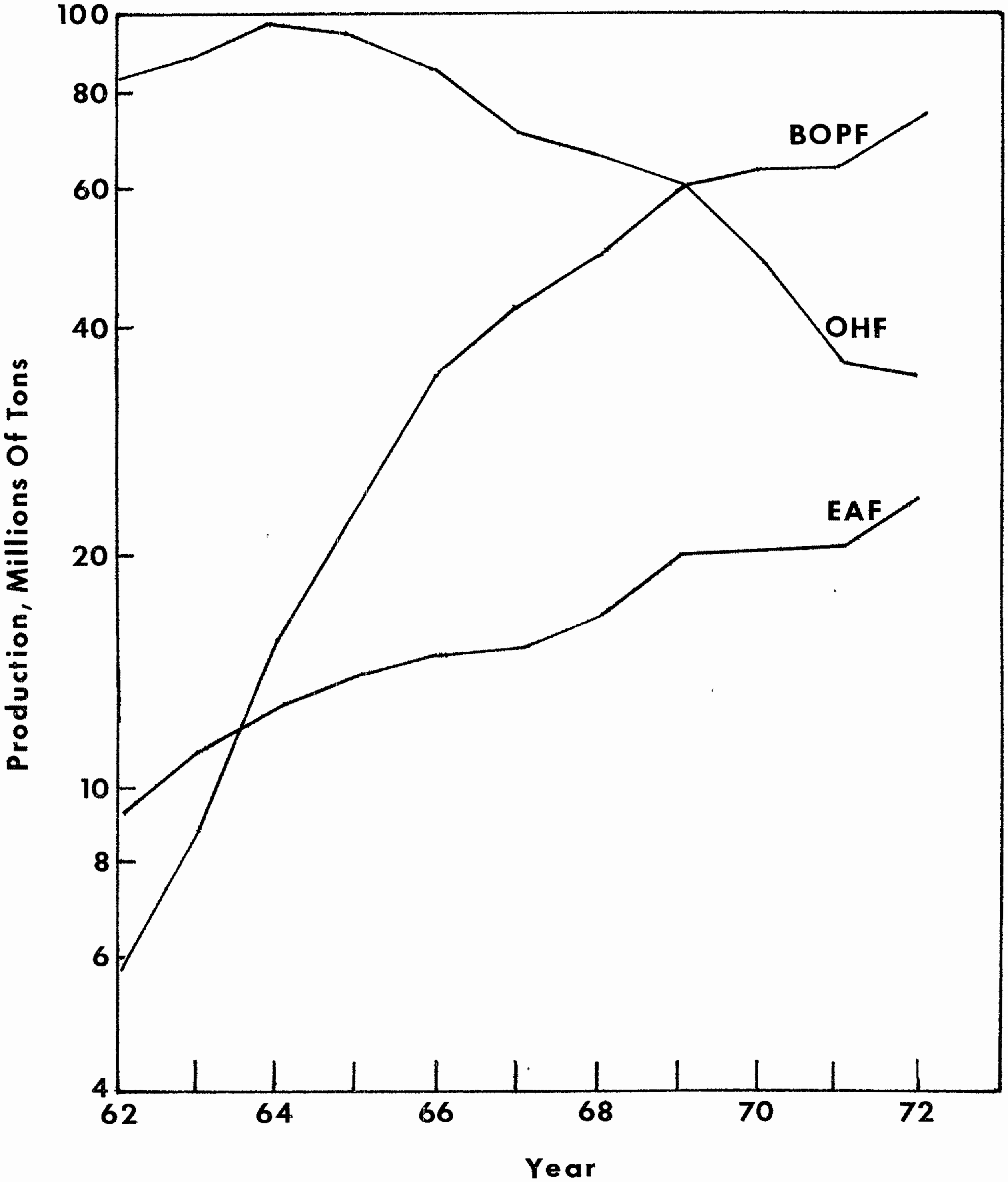


Figure I-2, Production Trends By Type Of Furnace that it has no exterior source of heat. Consequently, a BOPF can only be operated in conjunction with a blast furnace because it requires a high percentage of molten pig iron as part of the charge. This limits the amount of steel scrap that can be recycled. The availability of large quantities of scrap has made the EAF very attractive because it can accept a charge that is all scrap. In fact, about 98 percent of the steel produced by EAF's in 1971 was recycled steel scrap.(2) EAF's are also particularly suited to production of alloy steels where only small batches are needed.

In 1972, 23,721,000 tons of steel were produced in electric arc furnaces. Of this, 69 percent was carbon steel, 24 percent alloy steel, and 7 percent stainless steel. This accounts for 14 percent of the carbon, 41 percent of the alloy and all of the stainless steel produced in all furnace types.(1) Production of steel in EAF's is projected to nearly double from 1970 to 1980. In this same period, 150 new furnaces are expected to be constructed.(3)

Many finished products are produced from the steel made in electric arc furnaces. The value of these products varies considerably. Table I-1 shows some common carbon steel products and their price in 1972. In general, alloy and stainless steels have a much higher value than carbon steels.

TABLE I-1

PRICES OF MAJOR FINISHED CARBON STEEL PRODUCTS
(F.O.B. Mill Pittsburgh, dollars per 100 pounds)

| Product | 1972 Price |
|---|---|
| Plates | 8.15 |
| Steel Rods | 8.80 |
| Hot Rolled Sheets, 10 Gauge | 8.36 |
| Hot Rolled Sheets, 20 Gauge | 9.31 |
| Cold Finished Bars | 11.50 |
| Cold Rolled Strip | 10.94 |
| Hot Rolled Strip | 8.15 |

REFERENCE: 1973 Metal Statistics, The American Metal Market

In 1972, the 299 EAF's in the United States were operated by 99 companies at 121 locations. Distribution of the furnaces by size is shown below.[4]

| Tons of Capacity | Number of Furnaces Smaller |
|---|---|
| 10 | 23 |
| 50 | 170 |
| 100 | 233 |
| 200 | 280 |
| 300 | 298 |
| 400 | 299 |

Larger furnaces are usually located in integrated steel mills. Many of the smaller furnaces are in small plants that produce a limited variety of products or small quantities of specialty steels.

Many of these furnaces are located in industrial urban areas of Pennsylvania, Ohio, and Indiana. These States account for about 57 percent of all domestic steel production. Illinois and Michigan are the next largest steel producing States.

No data were available on employment in EAF shops. However, about 478,000 employees are engaged in the production and sale of iron and steel products.[5] Of course this figure includes many operations in addition to production of steel in EAF's.

Section 111(b)(1) of the Clean Air Act, as amended, requires that the Environmental Protection Agency develop standards of performance for sources which " ... cause or contribute to the endangerment of public health or welfare." The major pollutant from EAF's is particulate matter, a pollutant for which ambient air quality standards were promulgated in 40 CFR 50. In addition to the deleterious health effects, particulate matter emissions cause soiling, reduction of visibility, and general nuisance. Iron and steel plants were specifically mentioned in a report of the Committee on Public Works, United States Senate, as a source category to which standards of performance for new sources could be expected to apply.[6]

There are several sources of air pollutants in an EAF shop, however, the vast majority of emissions are from the furnace, so it is the prime candidate for standards of performance. Chapter V presents information on the other sources.

## B. Description of the Process

Electric arc furnaces are cylindrical refractory-lined vessels with carbon electrodes suspended from above which can be lowered to extend through the furnace roof (Figure I-3). With the electrodes retracted, the furnace roof can be rotated aside to permit the charge of scrap steel to be dropped into the furnace. Alloying agents and slag materials are usually added through the doors on the side of the furnace (Some

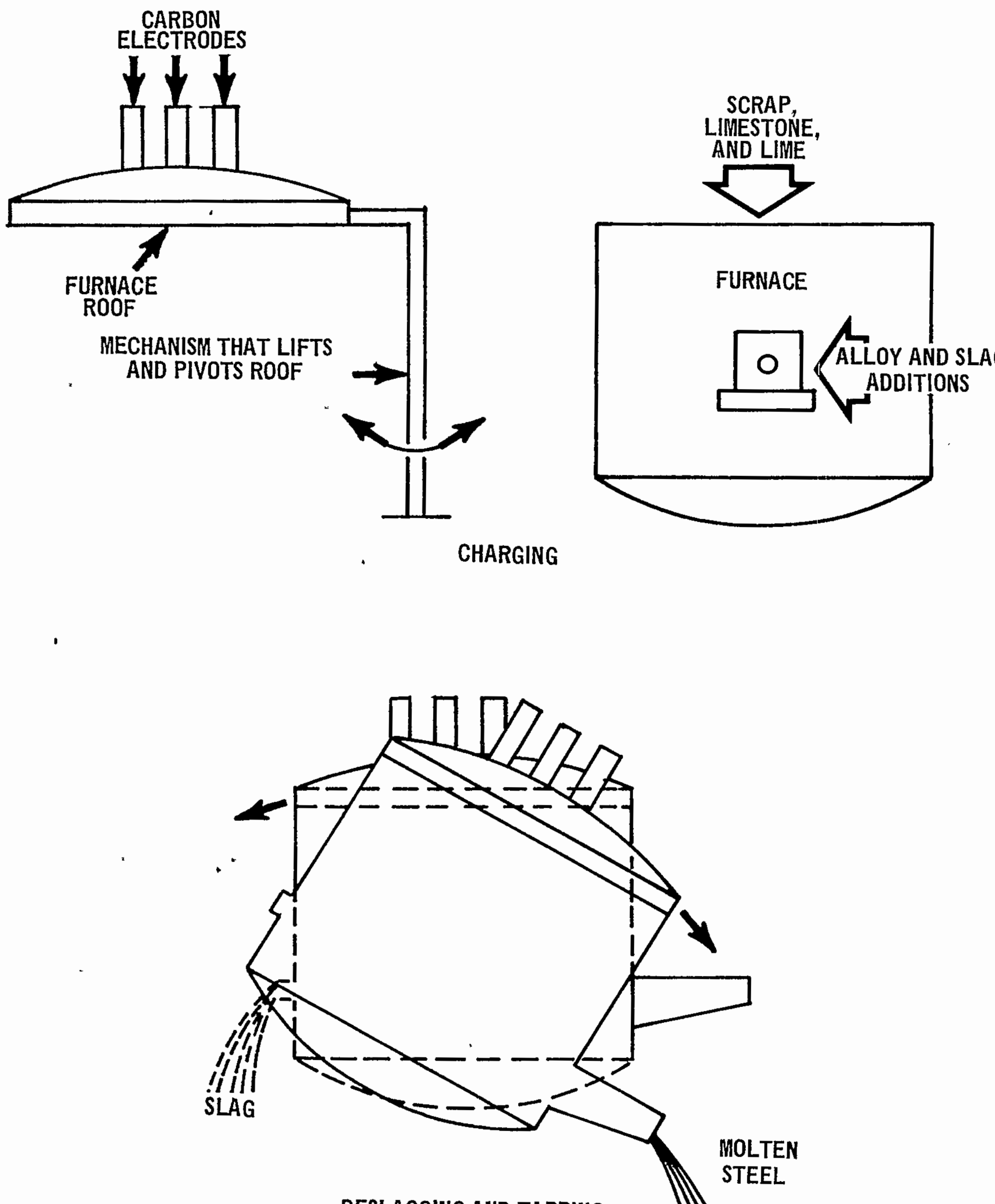


**FIGURE I-3**

**ELECTRIC-ARC STEEL FURNACE**

smaller or older furnaces are charged through these side doors.) Current is then switched to the electrodes as they descend into the furnace. The heat generated by the arc as it shorts between the electrodes through the scrap, melts the scrap. The slag and melt are poured from the furnace by tilting it.

The production of steel in an EAF is a batch process. Cycles or "heats" range from about 1 1/2 to 5 hours to produce carbon steel and from about 5 to 10 hours or more to produce alloy steel. Scrap steel is charged to begin a cycle and alloying agents and slag materials are added for refining. Each cycle normally consists of alternate charging and melting operations, refining (which usually includes oxygen blowing), and tapping.

## C. Emissions

During a furnace cycle, both particulate matter and carbon monoxide are evolved. The rate of particulate matter emissions varies considerably during a furnace cycle. Most emissions occur during the early "melting" portion, although significant quantities are also emitted during charging, tapping and oxygen blowing operations. Literature references report evolution of up to 30 pounds of particulate matter per ton of steel produced.[7],[8],[9] Information supplied by steel manufacturers on the quantity of particulate matter collected by control devices suggest that 30 pounds per ton may actually be conservative[1/] for production of carbon steel and 15 pounds per ton a more reasonable value for alloy steels.

Particulate matter emissions may also vary from cycle to cycle because of several factors, some of which are:

a. Contamination of the scrap steel with dust, oil, or volatile metals will increase emissions during charging.

b. An increase in electrical power to a furnace will increase emissions during the scrap melting.

c. An increase in the quantity of oxygen blown will increase emissions during the blow.

Carbon monoxide is generated by reaction of the carbon electrodes or carbon in the steel with the oxygen blown or with iron oxides. Much of the carbon monoxide is oxidized to carbon dioxide as it leaves the furnace. Limited data indicate carbon monoxide emissions can be as high as 6 pounds per ton of steel produced.[10] These emissions vary considerably during a furnace cycle. Peaks are observed during scrap melting when maximum electrical power is on and during oxygen blows.

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1/ Information from six steel plants indicates a range in uncontrolled emissions from production of carbon steel from 23 to 58 pounds per ton of steel production.

All States have general regulations that limit particulate matter emissions and a few have regulations specific to EAF's. No regulations for carbon monoxide emissions were found. More detail on the emissions allowed by these State limitations is presented in Chapter IV.

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## II. PROPOSED STANDARDS OF PERFORMANCE

### A. Standards as Proposed

The proposed standards of performance would limit particulate matter emissions to the atmosphere from electric arc furnaces and dust handling equipment as follows:

1. No more than 12 mg/dscm (0.0052 gr/dscf) of particulate matter from the control device.

2. Less than 5 percent opacity from the control device.

3. No visible emissions from the building except for one minute per furnace in any one hour and as specified below.

4. No more than 20 percent average opacity during and as a direct result of charging a furnace and for three minutes after completion of the charge.

5. No more than 40 percent average opacity during and as a direct result of tapping a furnace and for three minutes after completion of the tap.

6. If adjustable monitors in the roof of the building are closed during a charge or tap, the allowable period of visible emissions permitted in 4 and 5 above will start when the monitors are opened.

These standards are the result of revisions from the levels presented at the National Air Pollution Control Techniques Advisory Committee (NAPCTAC) meeting on January 9, 1974. The levels presented to the Committee are discussed in Chapter VIII of this report. The changes are:

1. Relaxation of the limitation on the concentration emitted from a control device to 12 milligrams per dry standard cubic meter (mg/dscm) from 9.0 mg/dscm [0.0052 from 0.0039 grains per dry standard cubic foot (gr/dscf)].

2. A change in the visible emission limitation on the control device to less than 5 percent opacity.

3. Incorporation of a short time exemption to the standard which limits the visibility of emissions from the building housing the furnaces.

4. Separation of the visible emission limitation on the shop during charging and tapping into two separate standards: 20 percent average opacity during charging and 40 percent during tapping.

5. Addition of a special provision to allow closing of select monitors in the roof of the building during a charge or tap.

B. Discussion of the Concentration Standard

At the January 9 NAPCTAC meeting, available emission data indicated that a 9 mg/dscm (0.0039 gr/dscf) standard could be easily achieved. These data were supported by a vendor guarantee of 0.004 gr/dscf on fabric filters at three building evacuation systems at three similar shops. These shops, owned by one company at one location, produce alloy steel. Another vendor had also signed a statement that he would guarantee 0.004 gr/dscf on a system planned for the capture of charging and tapping emissions at a plant which produces carbon steel. (Emissions during the remainder of the process cycle at this plant are captured by an existing control system.)

In correspondence to the operator of this plant, two other vendors stated that 1) although 0.004 gr/dscf was achievable they would not guarantee it and 2) they would guarantee 0.004 gr/actual cubic foot, approximately equivalent to 0.005 gr/dscf (see Chapter VI for a more detailed description of these guarantees). All of these guarantees were for fabric filters designed to treat large volumes of exhaust gas with low concentrations of particulates. Industry representatives at the meeting and at least one member of the NAPCTAC commented that the 0.0039 gr/dscf level was too stringent for the industry to meet at all times. The industry representatives suggested the limitation be 0.008 gr/dscf.

Since the meeting, information on another guarantee has been obtained. A vendor has guaranteed to achieve no visible emissions from a fabric filter controlling a direct shell evacuation system with a relatively high inlet concentration of particulate. This guarantee somewhat indirectly implies by the following quote that 0.005 gr/dscf is a reasonable level to guarantee; "In the event tests are necessary to determine compliance with the invisible discharge requirement, a concentration of 0.005 grains/scf or less at the baghouse waste gas discharge shall be considered invisible." The guarantee further specified that the tests would be conducted with multiple high-volume samplers in the roof monitor on the fabric filter.

Considering this additional information, it is the Administrator's judgment that the concentration standard be changed to 12 mg/dscm (0.0052 gr/dscf). Raising the standard to this level will not relax the design requirements of the control devices installed to meet the standard. It will allow a greater buffer which many vendors and plant operators claim necessary to insure the recommended standard can be met at all times with a well designed and maintained control device.

## C. Discussion of Opacity Standard on the Control Device

Opacity restrictions are promulgated concurrently with most particulate matter standards to provide a readily enforceable means of maintaining standards of performance. The opacity restrictions are selected such that a violation of the opacity standard almost certainly assures that the particulate matter standard is also being exceeded.

Although no quantitative data are currently available, the threshold of visibility for emissions from electric arc furnaces is estimated to be from 0.01 to 0.03 gr/dscf[1/]. Since the proposed standard is only 0.005 gr/dscf or at least 50 percent below the threshold for visible emissions, the opacity restriction has been changed to prohibit any visible emissions.

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[1/] This estimate is based on information from control equipment manufacturers. News Focus, JAPCA, 23(7): 608(1973).

## D. Discussion of the Opacity Standards on the Building

An opacity limitation on the emissions from the shop which houses the furnaces was proposed to assure that emissions from the furnace are captured by the control system. At the January 9 meeting, data were not yet available to specify limits for these standards. These data are discussed in Chapter VI of this report.

Three separate visible emission standards are proposed for the shop. Three standards are necessary because the efficiency of a DSE-CH control system varies with the various operations during a process cycle. The standards will apply during 1) charging, 2) tapping and 3) the remainder of a process cycle. Each of these is discussed separately below.

A time exemption of "one minute per electric arc furnace in any one hour" was added to the "no visible" limitation at times other than charging and tapping. This exemption will permit emissions during furnace "cave-ins" or additions of iron ore or burnt lime through the slag door. These can cause short bursts of emissions which a DSE-CH system cannot always contain. A 30 second period of emissions observed at Plant M was probably caused by a "cave-in," however, a positive identification of the cause could not be made.

"Cave-ins" occur when a "bridge" of scrap in the furnace falls into a molten pool of steel. When the electrodes are dropped and power to the furnace is turned on after a scrap charge, the hot electrodes "bore" holes in the scrap until a molten pool forms at the bottom of the furnace.

The scrap pile then melts from the bottom up. At some point the "bridge" of scrap that forms as the scrap near the bottom of the furnace melts, collapses. As the cold scrap hits the hot molten steel, a rapid evolution of gas and fume occurs due to chemical reactions and volatilization of moisture, oils or dirt on the scrap. The resultant sudden increase in gas volume overloads the DSE system and causes the emissions to escape the furnace. The larger of these bursts of emissions are not entirely contained by CH's and they escape the shop as a visible emission from the building roof. Industry representatives claim that a similar situation results from addition of iron ore or burnt lime to a furnace. Data have not been provided to substantiate this.

A time exemption of one minute per furnace in any one hour was judged sufficient to allow for the emissions described above. The relation of the exemption to the number of furnaces in a building is provided since the potential for these emissions is directly related to the number of furnaces. In lieu of an hourly exemption, one based on the length of a furnace cycle was considered. However, this would require more field time and place a larger burden on enforcement.

An allowance for emissions during charging and tapping is also provided by the standards. The magnitude of tapping emissions is much greater than that for charging, as the data in Chapter VI show. For this reason two different limitations are proposed instead of a single one for both charging and tapping. The limits proposed, based on the available data, are not to exceed 20 percent average opacity for charging and 40 percent for tapping.

Some operators of new plants may opt for a control system with adjustable louvers on the roof monitors. The monitors can then be closed during charging and tapping and later reopened to permit natural ventilation of the building. This can increase the effectiveness of the capture system. The emissions that initially escape the CH and are contained below the roof of the building during peak evolution from the furnace can be drawn into a scavenger opening in the ductwork from the CH. This system could be expected to be only partially effective and some visible emissions may still be emitted after the monitors are opened. A special provision in the regulation is needed for this system. It will allow emissions for the same length of time as other cases but will delay the start of the allowable period until the louvers on the roof monitors are opened.

The standard of performance is not designed to require this type of monitor system because the staggered furnace cycles in a shop with many furnaces would force it to keep the roof monitors closed most of the time. The staggered cycle would result in at least one furnace being charged or tapped at any particular time. The result would essentially be a building evacuation system, which has been determined not the most desirable control system for reasons given in Chapter VIII. However, a system which permits selective closing of the roof monitors should be considered in any new installation since it can result in better control of air pollution.

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## III. EMISSION CONTROL TECHNOLOGY

In addition to achieving compliance with air pollution control regulations, air pollution control systems for electric arc steel furnaces must also meet other criteria. They must:

- Be compatible with processes used to make many types of steel.

- Not prevent attainment or maintenance of a healthful and acceptable work environment for employees. Control of pollution generated within the shop is inextricably affected by the ventilating air system and vice versa.

  - A control system which minimizes ambient air pollution can result in increased concentrations within the work area. Such increases in particulate would not only endanger the respiratory health of employees, but also decrease visibility thereby increasing the opportunity for serious operating errors with their attendant risk of injury.

  - Such effects of air pollution control might also manifest themselves as restricting ventilation air, thereby increasing the possibility of serious injury through heat stress.

Several systems are used to control air pollution in the industry and to meet these additional criteria. The major difference between these systems is the method(s) used to capture the dust emitted by the furnaces. The capture systems are described below.

## A. Direct Shell Evacuation System in Combination With Natural Ventilation Through the Open Roof (See Figure III-1)

The direct shell evacuation (DSE) system withdraws all potential emissions directly from within the furnace before they escape and are diluted by the ventilation air. A water-cooled duct which extends through the furnace roof is jointed near the furnace with a gap of one to several inches separating the ends. This separation permits the furnace roof to be elevated and rotated aside to permit top charging and tilting of the furnace for tapping and slagging. (During such times, DSE systems are ineffectual and emissions rise directly through the roof of the shop.) A few DSE systems remain in operation while the furnace is tilted. The incremental improvement in the capture of emissions is very small, however, because the bulk of tapping and slagging emissions are from the ladle or slag pot. During operation, the DSE system maintains a negative pressure within the furnace. As a result, air is drawn into the furnace around the electrodes and through the gap into the exhaust duct. This air not only cools the exhaust gas, but it permits combustion of the large amounts of carbon monoxide present.

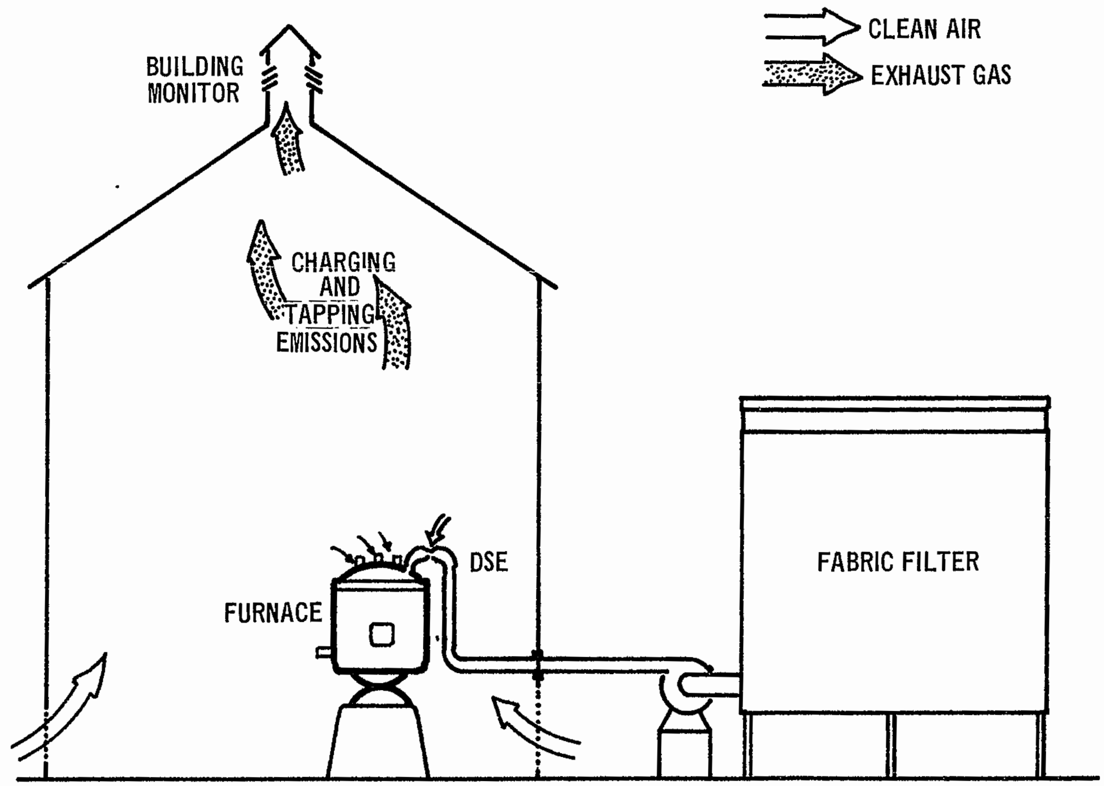



Figure 111-1. Direct shell evacuation (DSE) system open roof.

More carbon monoxide is oxidized to carbon dioxide in this manner than from furnaces without DSE. Certainly some of the carbon monoxide that evolves from the annular spaces around the electrodes in furnaces which do not have DSE is also oxidized as the gases contact ambient air. In this case, however, the gases are rapidly cooled and diluted. This limits the degree of combustion achieved. The DSE system achieves more complete combustion because the exhaust gases are not so quickly diluted and they mix with oxygen at a high temperature for a longer period of time. Combustion of carbon monoxide is now incidental to the design of DSE systems. Much lower emission levels may be achieved if future systems are designed to maximize the combustion of CO.

The most commonly used device to clean the gas after capture is fabric filters, but venturi scrubbers and electrostatic precipitators are also occasionally used. If the control device is a fabric filter, the hot furnace gas must first be cooled by water sprays, radiant coolers, dilution air or some combination of these to prevent degradation of the fabric. If a precipitator is used, the gas is humidified to maximize the efficiency of the precipitator. Only the scrubber does not require any special treatment of the exhaust gas.

A well designed and operated DSE system is desirable not only because it can capture essentially all the dust generated during meltdown and refining (including emissions during the oxygen blow), but also because it inherently restricts the gas volume which must be cleaned, thereby maximizing removal efficiency with minimal energy requirements. Unfortunately, as mentioned earlier, DSE is totally ineffectual when the furnace is being charged or tapped. During these periods, emissions billow to the roof. If the roof is open, they exhaust directly to the atmosphere in a very visible plume.

The DSE system has a second favorable effect on the worker's environment. It contains and exhausts a considerable part of the heat generated in the furnace which would otherwise escape into the building. In combination with natural ventilation through the roof, DSE generally maintains an acceptable working environment in a shop.

In summary, any new furnace for production of carbon steel (except perhaps extremely small ones) would almost certainly be equipped with a DSE system for two reasons. First, because of its excellent capture efficiency and second, containment of the pollution within such low gas volumes minimizes the investment required for the cleaning equipment.

Unfortunately, the DSE cannot be used in the manufacture of all steels. During the production of some alloys, a second slagging operation takes place. A "reducing" slag is used to remove impurities from the melt. Air will oxidize these slags and render them ineffectual. At such times, induction of air into the furnace is intolerable. Although it would appear that the fan on the DSE system could be turned off when the "reducing slag" is in the furnace, the industry advances a theory that the configuration of the furnace roof which is required to accommodate the DSE system interferes with the required temperature homogeneity of the melt. The absence of refractory where the discharge duct enters the roof is alleged to act as a "black" surface which absorbs radiant heat from the melt and results in a cold spot in the molten steel.

## B. Building Evacuation in a Shop With a Sealed Roof (See Figure III-2)

With the building evacuation system (BE), the entire building is used to capture dust from the furnaces. Hot exhaust gases containing dust billow to the roof of the shop where they are drawn into ducts to a fabric filter. Although the removal capacity of the duct may be less than the furnace release rate, the dust-laden gas will accumulate beneath the sealed roof during

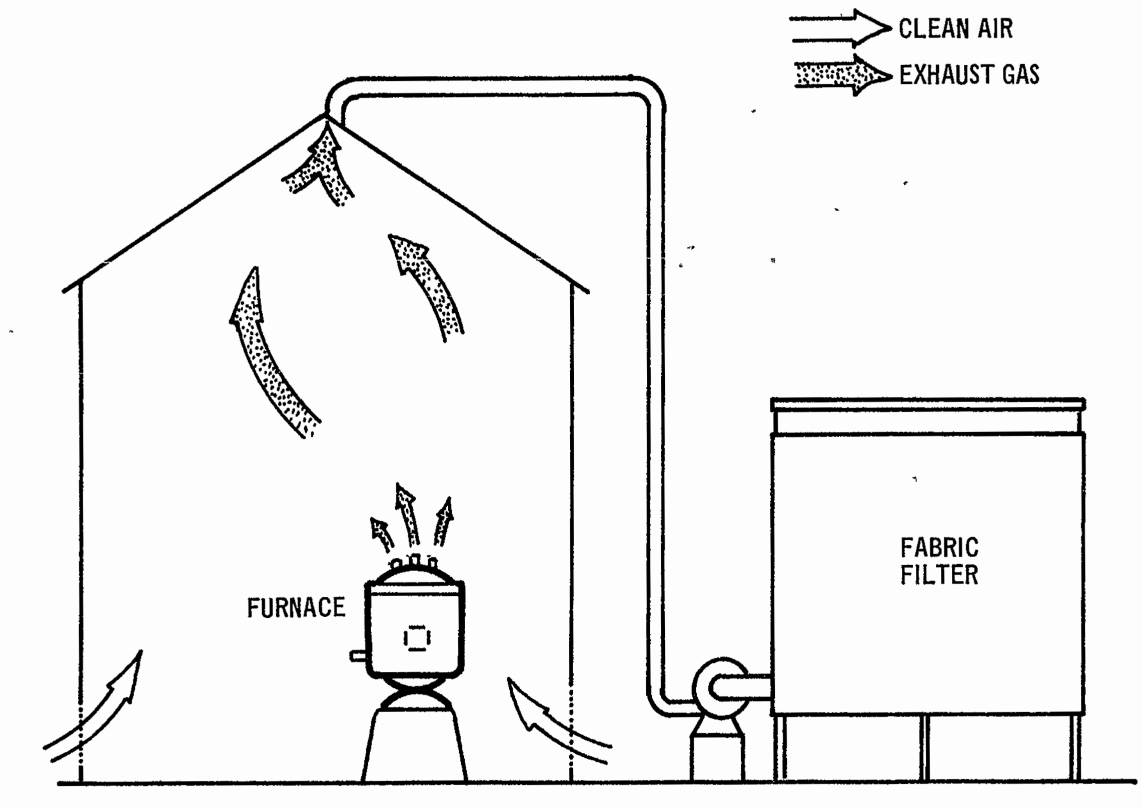



Figure III-2. Building evacuation (BE) system closed roof.

periods of high dust generation. Since it cannot escape except through the control device, it does not create a pollution problem.

Since all ventilation air must exhaust through the control device, operating costs have limited these systems to fabric filter collectors. Gas cooling systems have not been necessary because the ambient air drawn into the building mixes with and cools the dust-laden gases.

In two aspects, BE systems appear to be superior to DSE systems. They capture fumes from the charging and tapping operation, and they operate without any visible emissions from the building. They also have no effect on "reducing slags" and are often the choice of shops that produce alloy steels.

C. Canopy Hoods in a Shop With a Sealed Roof (See Figure III-3)

The canopy hood (CH) system is very similar in principle, operation, performance, and applicability to the building evacuation system. Instead of using the building roof, however, a canopy hood is suspended directly above each furnace. Since these hoods must not restrict movement of the crane which charges raw materials to the furnaces, they must allow 30 to 40 feet of clear area immediately above the furnaces. (Furnaces which are charged through doors in the side or fed through a chute do not

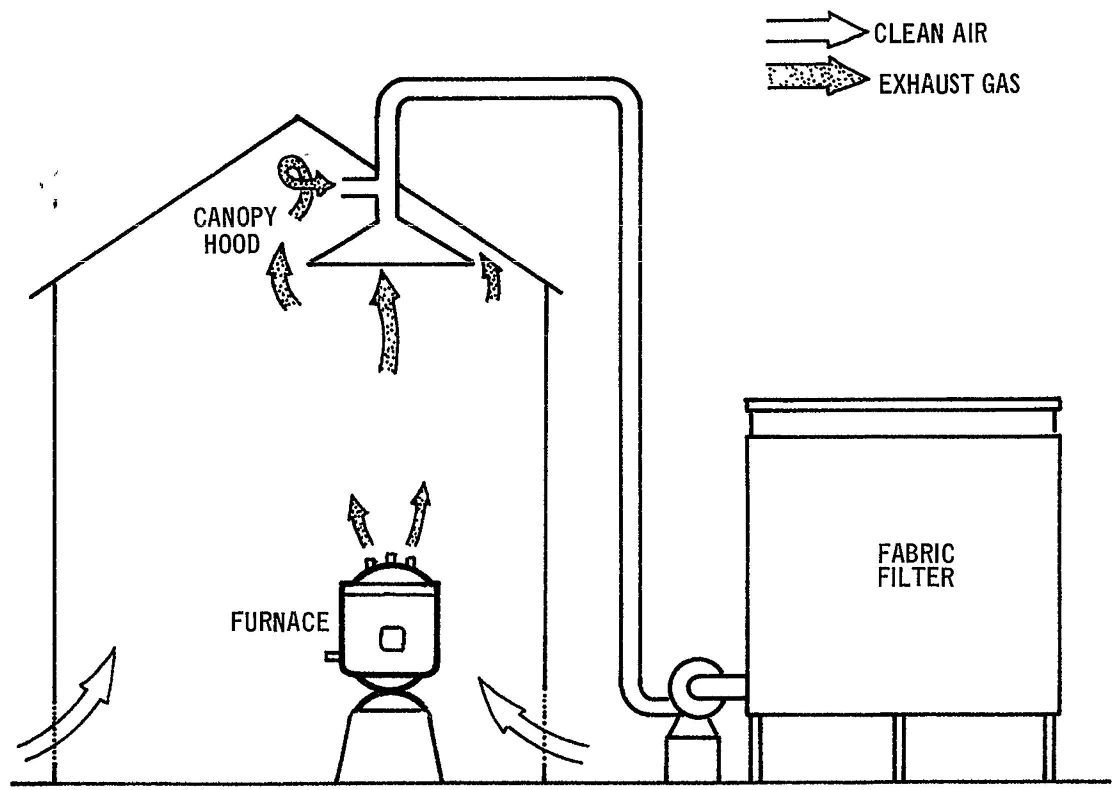



Figure III-3. Canopy hood (CH) closed roof.

require this free board and hoods can be built nearer the furnace. Unfortunately, side charging is too slow and continuous feeding systems have not been perfected.)

During charging, the fumes rapidly rising from the furnace are often deflected from the hood by the crane and its charging bucket. Cross drafts within the building and large fluctuations in emissions that sometimes exceed the capacity of the hood also cause a great deal of dust to bypass the hood. Since the building is sealed, fume not captured in the hood accumulates in the upper part of the building and is gradually removed through appropriate "scavenger" openings in the ductwork for the CH system.

Canopy hoods are sometimes divided into sections in an attempt to improve their efficiency. Dampers are used to maximize draft directly above the point of greatest emissions during charging, tapping or slagging operations.

## D. Canopy Hoods in Combination With Natural Ventilation Through the Open Roof (See Figure III-4)

The canopy hoods (CH) are identical to those described previously, but in these shops the roof monitors allow natural ventilation to augment ventilation which results from the hood suction. Unfortunately, they also allow any fume which bypasses the hoods to escape the building as a very obvious visible

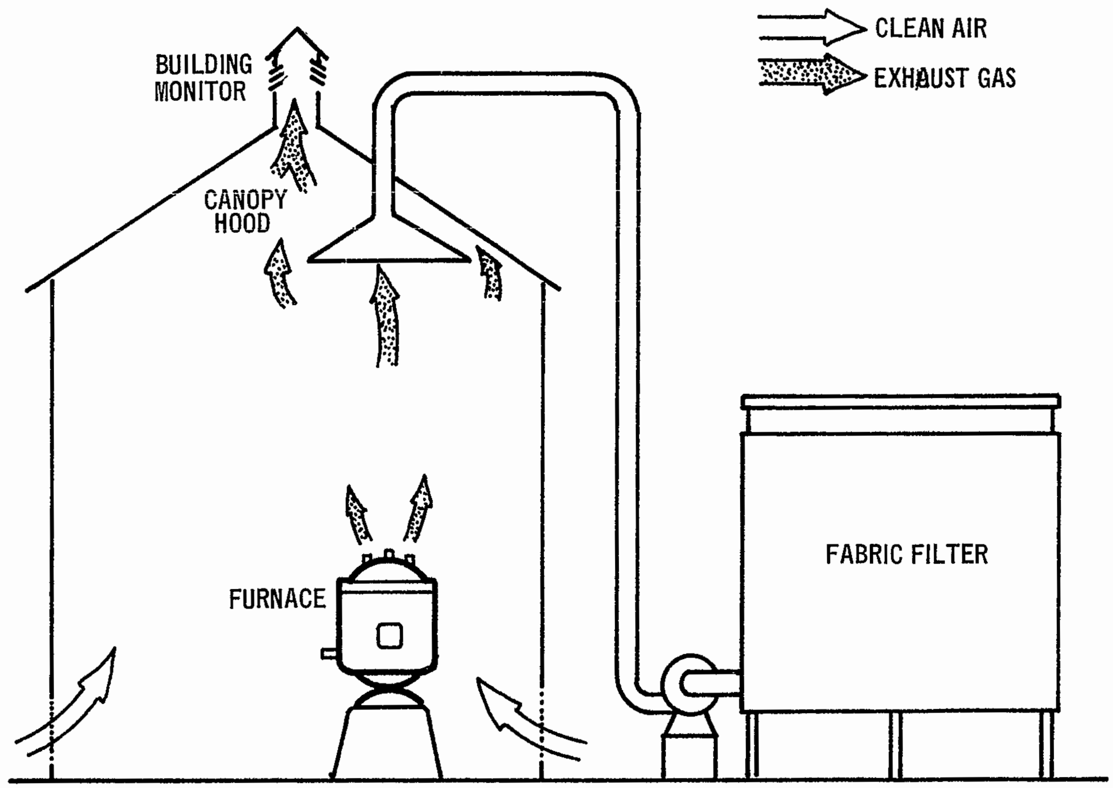



Figure III-4. Canopy hood (CH) open roof.

emission. Air flows through canopy hoods in this type of system are quite high, but less than required with a sealed roof. Only fabric filters are known to be used with this system.

## E. Combinations

### 1. Direct shell evacuation in a shop with either 1) building evacuation or 2) canopy hoods and a sealed roof.

The union of these two systems combines the advantages of both. The DSE unquestionably provides the best control during meltdown and refining and either of the other systems (canopy hoods or building evacuation) captures emissions during charging and tapping. The air flow to the canopy hoods or various strategically located inlets to building evacuation ducts can be shifted as ventilation requirements and emissions of dust from different furnaces dictate. Separate control devices can be used or a single one can serve both systems.

This combination requires lower average air flow rates than a canopy hood or building evacuation system alone because fewer emissions are released into the shop building and part of the heat load is removed by the direct shell system. However, the air flow must still be quite high to assure adequate ventilation and an acceptable working environment. Peak air flow rates are used for the building evacuation or canopy hood system during charging and tapping when the DSE system is ineffectual. At other times these peak flows can be reduced.

The earlier discussion of the DSE system and the capability of sealed roof systems to preclude visible emissions also applies to this combination of systems.

2. Direct shell evacuation in a shop with canopy hoods and natural ventilation through the open roof.

This combination is identical to the preceding with one notable exception; the open roof monitors permit natural ventilation. Because the open roof will satisfy ventilation requirements, continuous air flow through the canopy hood is not required. As a result, the hoods can be operated on demand to capture charging and tapping emissions.

Any fume not captured by the hoods will escape as a visible emission through the open roof monitors. Shops with many furnaces which have staggered charging and tapping cycles will probably have visible emissions through some portion of the roof monitors much of the time.

Such losses can be minimized. Louvers on the openings in the roof can be automated to close during periods when the DSE is out of service to preclude emissions from the shop of fumes which may bypass the canopy. "Scavenger" openings in the exhaust ductwork of the canopy hood could extract the fume that is trapped in the roof. Such a system will probably not eliminate all visible emissions as some fume will still be trapped in the roof when it is reopened for ventilation. Also, in a shop with many furnaces where many charges and taps occur, the louvers may have to be closed most of the time. The system would then approach a BE system.

Because the forced ventilation is supplemented by natural ventilation, this combination system requires less forced air flow, hence demands less energy, than systems with a sealed roof on the shop.

## F. General Discussion

A totally new concept for containing air pollution from electric arc furnaces has been developed for a shop that is scheduled to start construction in early 1974. The shop will produce carbon steels in two furnaces with 200 tons of capacity each.[11] The furnaces are equipped with conventional DSE and CH systems. The major innovations are: 1) enclosures around each furnace that act as chimneys to direct charging fumes up into the CH's and 2) hoods that will capture emissions from the tapping ladle and slag pot. The shop roof will be closed above and between the two furnaces. Figure III-5 shows these new concepts.

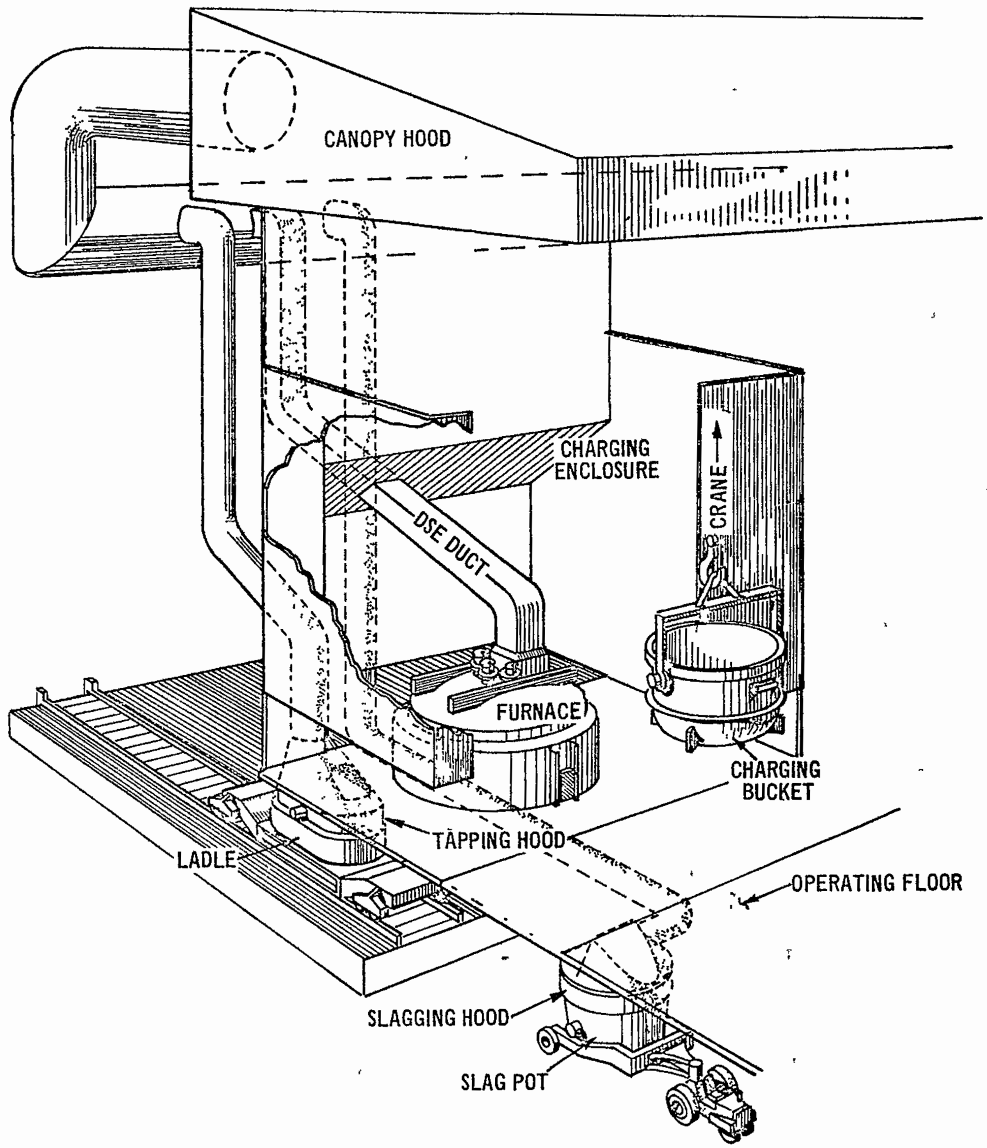



Figure III -5 New system for capture of emissions from electric arc furnaces.

The enclosure around the furnace is designed to restrict and direct the charging emissions to the canopy hood but still allow the crane to travel between the hood and the furnace to permit the charging bucket to be positioned over the furnace. The enclosure is much larger than the furnace. It allows the furnace roof to swing open and extends over the tapping area where it can capture emissions from the pouring spout or any fumes that bypass the tapping hood.

In anticipation of initial problems in training the crane operators, the enclosure walls will be built to permit easy replacement when damaged. The enclosure will partially protect the integrity of the emission plume from cross drafts in the building as it rises to the CH. Although cross drafts may still cause some disturbance of the plume before it reaches the CH, its capture efficiency will certainly be improved.

The most significant advance in technology embodied in this new system is the use of a stationary hood that fits close over the tapping ladle. The empty ladle will be moved by crane to a railcar which is rolled under the hood. Molten steel will be poured into the ladle through an opening in one side of the hood. This type of hood cannot presently be used on electric arc furnaces because the crane cables interfere with placement of a hood. Industry has been reluctant to part with the traditional method of tapping where the crane holds the ladle and lowers it as it fills to minimize the freefall distance of molten metal. A longer stream allows more heat and product loss by oxidation. This concern was compromised by the designer of the new system to achieve better air pollution control.

The new system also has a stationary hood over the slag pot through which the slag drops. (Although slagging is a minor source of emissions, the hood will provide some improvement in their control.)

The total air flow design for this system is 630,000 dry standard cubic feet per minute (dscfm) or 1600 dscfm per ton of furnace capacity. This is about the same as used for conventional DSE-CH systems in shops with open roofs. This system combines the lower cost and energy requirements of a DSE-CH system with the higher capture efficiency of systems with high air flow rates. Although this new system will certainly achieve better control than existing CH systems, the exact level cannot be quantified until the system is operational.

Tapping hoods that fit close over a ladle have been very effective in other metallurgical industries. Either a retractable hood or a ladle mounted on a railcar allow close hooding.

It is difficult to compare the effectiveness of these air pollution capture systems. Because of the many variables involved, their measurement has been very limited and the difficulty of making such measurements is imposing. These variables include the capture efficiency of hoods and DSE systems, the rate of air flow for the control system, and the particulate concentrations out of the control device. Estimates of emission rates for the various systems are extremely sensitive to the values assumed for any of the variables.

Table III-1 was developed to show the effect of the type and capture efficiency of a control system on emissions from an alloy and a carbon steel shop equipped with furnaces of comparable size. The carbon steel shop produces an average of 86 tons of steel per hour, the alloy steel shop produces only 43 tons of steel per hour. The difference in production rate is a consequence of the heat length which is about twice as long in an alloy shop. The calculations are based on the following:

. Uncontrolled emissions are 30 pounds of particulate per ton of carbon steel produced and 15 pounds per ton of alloy steel.

. Charging and tapping emissions are 10 percent of the total or 3.0 and 1.5 pounds per ton respectively for carbon and alloy steel. (They have been estimated at 5 to 15 percent of the total.[12])

. A DSE system cannot be used in the alloy shop.

. Particulate concentrations from the control devices are based on data obtained by EPA and industry.

. Air flows through the control devices are based on data provided by industry. These data are presented in Figure III-6.

Table III-1. Calculated Emissions From Electric Arc Furnace Shops With Various Control Systems

| Type of System | Average Control System Air Flow, sdcfm per ton of furnace capacity | Particulate Concentration in Control System Exhaust, gr/dscf | Emissions: Carbon Steel Shop, 300 tons furnace capacity, 3 1/2 hr. average heat time, 86 ton/hr production | | Emissions: Alloy Steel Shop 300 tons furnace capacity, 7 hr. average heat time, 43 ton/hr production | |
|---|---|---|---|---|---|---|
| | | | lb/hr | lb/ton | lb/hr | lb/ton |
| Uncontrolled | - | - | 2580 | 30 | 645 | 15 |
| 70% efficient canopy hoods, open roof | 2500 | 0.003 | - | - | 213 | 4.95 |
| 80% efficient canopy hoods, open roof | 2500 | 0.003 | - | - | 149 | 3.47 |
| 90% efficient canopy hoods, open roof | 2500 | 0.003 | - | - | 84.0 | 1.95 |
| Building evacuation or canopy hoods with closed roof | 5000 | 0.003 | - | - | 38.6 | 0.897 |
| Direct shell evacuation only, open roof | 350 | 0.005 | 263 | 3.05 | - | - |
| Direct shell evacuation and 70% efficient canopy hoods, open roof | 2000 | 0.003 | 92.8 | 1.08 | - | - |
| Direct shell evacuation and 80% efficient canopy hoods, open roof | 2000 | 0.003 | 67.0 | 0.779 | - | - |
| Direct shell evacuation and 90% efficient canopy hoods, open roof | 2000 | 0.003 | 41.2 | 0.479 | - | - |
| Direct shell evacuation and building evacuation or canopy hoods, closed roof | 4000 | 0.003 | 30.9 | 0.359 | - | - |

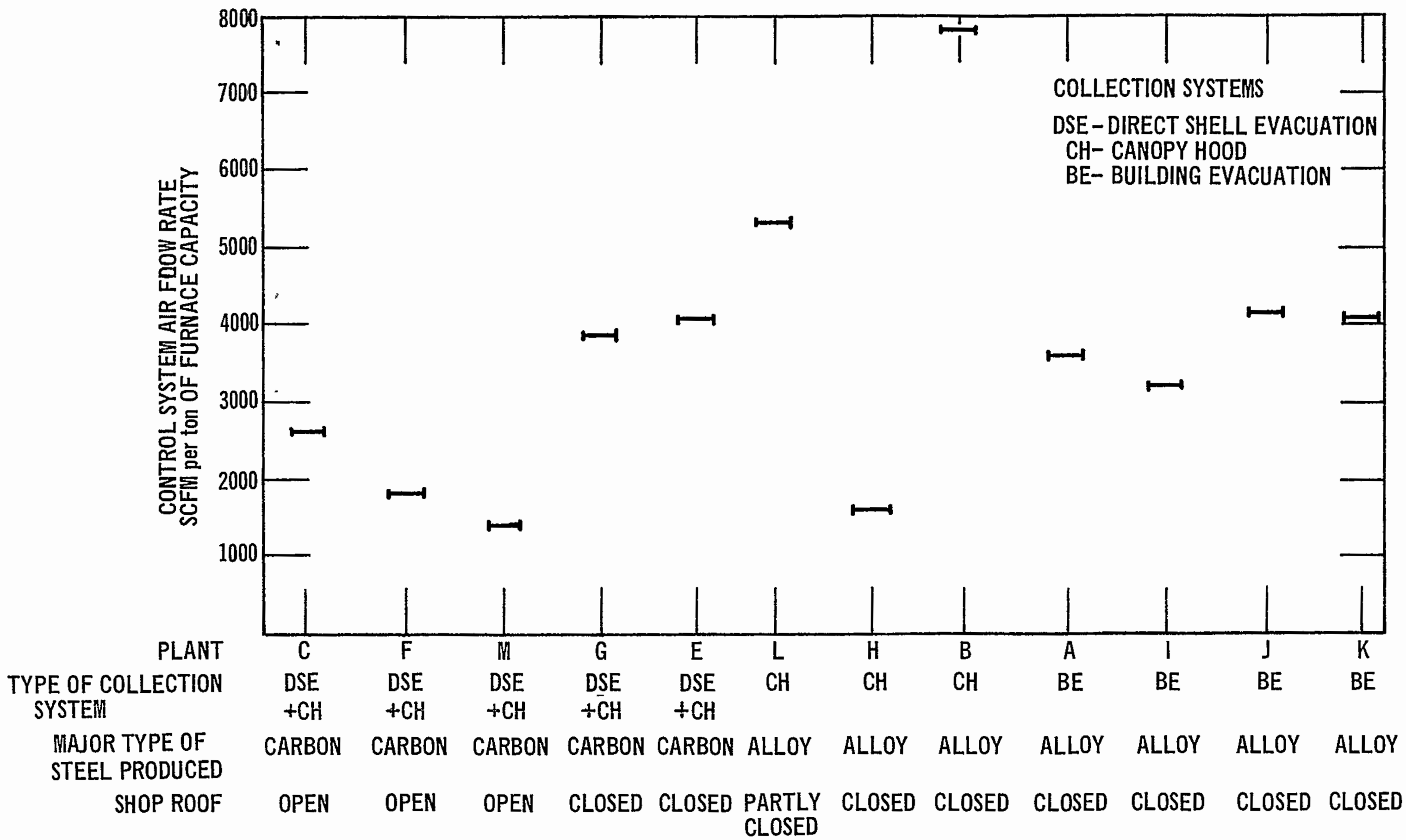



Figure III-6. Control system air flow rates for electric arc furnaces.

Notes for Figure III-6

Plant C - The roof monitors at this plant are closed during charging and tapping and for a short period after these operations, and are opened at other times.

Plant F - Roof monitors at this plant are opened for ventilation in the summer and when necessary to clear dust from the shop atmosphere. They are generally closed in the winter.

Plant G - Roof monitors at the ends of the shop building are open, but partitions in the roof trusses isolate the open monitors from the furnaces sufficiently to consider this a closed-roof shop.

Plant E - Air flows are design values for a system under construction. Design of the shop is similar to Plant G.

Plant L - This shop is in two sections. One section with a lower roof has open monitors and the other section is closed. Furnaces are in both sections.

Plant H - The roof monitors are equipped with motorized louvers, but they are generally closed.

Plant B - Furnaces are in two separate buildings, but one control system is used.

The most common collection device used with the capture systems described above is the pressurized fabric filter which normally has an open top or "monitor" discharge. This type, which has no exhaust stack, is cheaper than closed filters. Although fabric filters are commonly used regardless of the type of capture device, they are used exclusively with those systems that require large air flows.

The design air flow rate for a fabric filter is directly proportional to the level of mass emissions achieved. Higher design flows result in lower inlet concentrations; however, the outlet concentration remains relatively constant. One reference reports that a "fabric filter might well operate with the same outlet concentration when the inlet loading changed tenfold."[13] Since mass emissions are a product of the concentration and air flow rates, minimizing air flow will minimize emissions.

Control of visible emissions from unloading of dust collected by a fabric filter can be achieved with a closed system by pneumatically conveying the dust to a closed truck which is vented to the inlet of the fabric filter.

# IV. ENVIRONMENTAL EFFECTS

## A. Impact on Air Pollution

Table III-1 presents particulate matter emission rates for the various control systems discussed in Chapter III. Using values from that table, Table IV-1 shows the reduction from uncontrolled particulate matter emission rates each system can achieve. Reductions in carbon monoxide (CO) emissions (based on data presented in Chapter VI) are also shown.

The objective of standards of performance under section 111 of the Act, as amended, is to prevent new air pollution problems from developing by requiring affected facilities to use the best systems of emission reduction available at a cost and within a time that is reasonable. These standards pertain directly to emissions and are only indirectly related to ambient air quality. Attainment and maintenance of national ambient air quality standards is specifically covered by State implementation plans as provided under section 110 of the Act. Nevertheless, the impact of a new electric arc furnace on local ambient air quality should be closely investigated. Such an investigation necessarily depends upon many specific factors such as topography, meteorological conditions, proximity of other sources of pollution and the mass of pollutants emitted from all sources in the local area. As an illustrative example, maximum ground-level concentrations of particulate matter and CO were estimated for emissions from a hypothetical source employing the control devices of interest using an atmospheric dispersion model. These estimates are shown in Table IV-2.for these

TABLE IV-1

Reduction in Uncontrolled Emissions From Electric Arc Furnaces For Various Control Systems

| Type of System | Percent Reduction in Emissions | | | |
|---|---|---|---|---|
| | Carbon Steel Production | | Alloy Steel Production | |
| | Particulates | Carbon Monoxide | Particulates | Carbon Monoxide |
| 80% efficient canopy hoods, open roof | - | - | 76.9 | none |
| Building evacuation or canopy hoods, closed roof | - | - | 94.0 | none |
| Direct shell evacuation only, open roof | 89.8 | 84 | - | - |
| Direct shell evacuation and 80% efficient canopy hoods, open roof | 97.4 | 84 | - | - |
| Direct shell evacuation and building evacuation or canopy hoods, closed roof | 98.8 | 84 | - | - |

TABLE IV-2. Estimated Ground-Level Particulate and Carbon Monoxide Concentrations Resulting From Electric Arc Furnace Snops at Various Downwind Distances

| Total Furnace Capacity tons/heat | Control System | Source(s) of Emission | Pollutant | Emission Rate, g/sec. | Averaging Times | Estimated Ground-Level Particulate Concentration at Specified Distance from Source, mg/m$^3$ for CO, µg/m$^3$ for Particulate: 0 km. | 0.3 km | 2.0 km. | 20 km. |
|---|---|---|---|---|---|---|---|---|---|
| 100 | BE | Baghouse with Monitor Discharge | CO | 14 | 1 hr | 20 | 4 | 0.4 | 0.03 |
| | | | | | 8 hrs. | 20 | 3 | 0.3 | 0.02 |
| 400 | BE | Baghouse with Monitor Discharge | CO | 57 | 1 hr. | 40 | 15 | 1.8 | 0.1 |
| | | | | | 8 hrs. | 40 | 10 | 1.3 | 0.1 |
| 1250 | BE | Baghouse with Monitor Discharge | CO | 180 | 1 hr | 70 | 35 | 6 | 0.4 |
| | | | | | 8 hrs. | 70 | 25 | 4 | 0.3 |
| 100 | DSE | Baghouse with Monitor Discharge | CO | 6.6 | 1 hr. | 30 | 2.5 | 0.2 | 0.02 |
| | | | | | 8 hrs. | 30 | 2 | 0.2 | 0.01 |
| 400 | DSE | Baghouse with Monitor Discharge | CO | 26 | 1 hr. | 60 | 9 | 0.8 | 0.06 |
| | | | | | 8 hrs. | 60 | 6 | 0.6 | 0.04 |
| 1250 | DSE | Baghouse with Monitor Discharge | CO | 83 | 1 hr. | 90 | 25 | 2.5 | 0.2 |
| | | | | | 8 hrs. | 90 | 20 | 2 | 0.1 |
| 100 | BE | Baghouse with Monitor Discharge | Particulate | 1.3 | 24 hrs. | 2000 | 300 | 20 | 2 |
| | | | | | 1 yr. | 200 | 30 | 2 | 0.1 |
| 400 | BE | Baghouse with Monitor Discharge | Particulate | 5.2 | 24 hrs. | 6000 | 1000 | 100 | 10 |
| | | | | | 1 yr. | 700 | 120 | 10 | 0.4 |
| 1250 | BE | Baghouse with Monitor Discharge | Particulate | 16 | 24 hrs. | 11000 | 3000 | 300 | 30 |
| | | | | | 1 yr. | 1500 | 400 | 30 | 1 |
| 100 | DSE-CH | Monitor Discharges on Baghouse and Shop Building | Particulate | 2.8 | 24 hrs. | 1000 | 300 | 40 | 5 |
| | | | | | 1 yr. | 140 | 30 | 4 | 0.2 |
| 400 | DSE-CH | Monitor Discharges on Baghouse and Shop Building | Particulate | 11 | 24 hrs. | 3000 | 1100 | 160 | 20 |
| | | | | | 1 yr. | 400 | 120 | 15 | 0.8 |
| 1250 | DSE-CH | Monitor Discharges on Baghouse and Shop Building | Particulate | 35 | 24 hrs. | 5000 | 4000 | 500 | 70 |
| | | | | | 1 yr. | 600 | 400 | 50 | 2 |
| 100 | DSE | Monitor Discharges on Baghouse and Shop Building | Particulate | 11 | 24 hrs | 4000 | 1100 | 160 | 20 |
| | | | | | 1 yr. | 600 | 120 | 15 | 0.8 |
| 400 | DSE | Monitor Discharges on Baghouse and Shop Building | Particulate | 44 | 24 hrs | 12000 | 4000 | 700 | 80 |
| | | | | | 1 yr. | 1500 | 500 | 60 | 3 |
| 1250 | DSE | Monitor Discharges on Baghouse and Shop Building | Particulate | 142 | 24 hrs. | 20000 | 14000 | 2000 | 300 |
| | | | | | 1 yr. | 2000 | 1600 | 200 | 10 |

NOTES: 1. The abbreviations for the control systems are BE for building evacuation, DSE for direct shell evacuation, and DSE-CH for direct shell evacuation in conjunction with canopy hoods

2. The proposed standards of performance can be achieved by application of the BE or DSE-CH control systems. The emission rates are calculated assuming compliance with the proposed standards of performance.

3. For carbon monoxide, the National Ambient Air Quality Standards are 40 mg/m$^3$ (maximum 1 hr. average), and 10 mg/m$^3$ (maximum 8 hr. average).

4. For particulate matter, the National Ambient Air Quality Standards are 260 µg/m$^3$ (maximum 24 hr. average), and 75 µg/m$^3$ (maximum annual average).

hypothetical point sources - control device cases. Differing source configurations and surrounding terrain can cause significantly different results. The maximum concentrations were estimated for 24-hour and 1-year averaging periods for particulate matter and for 1-hour and 8-hour averaging periods for CO. These averaging periods were selected to permit direct comparison with the respective ambient air quality standards. Comparison of these maximum ground-level concentration estimates with the national ambient air quality standards will not necessarily indicate whether or not these standards (NAAQS) will be met unless there is an estimate of background concentration arising from natural and manmade sources available for the specific site.

The dispersion analysis considered the effect of aerodynamic downwash because the pollutants typically emit from a monitor (no stack) on the control device or a building and thus aerodynamic downwash is likely to be a chronic problem. Aerodynamic downwash will most likely be a problem for wind speeds exceeding 2 or 3 meters per second (mps). At lower wind speeds, the effluents studied generally would not be affected by downwash.

The CO concentration estimates were made through application of a dispersion equation (ASME Guide for the Prediction of the Dispersion of Airborne Effluents, Equation IV-8) that considers aerodynamic downwash close to the source as well as Gaussian dispersion further downwind. For the zero and 0.3 kilometers downwind distances on Table IV-2, stability D and a wind speed of 3 mps were assumed. That was the downwash condition likely to result in the highest 1 and 8 hour concentrations at those distances. At 20 kilometers, stability E and a wind speed of 2 mps were assumed. Those values were chosen based on the results of an analysis using a point source Gaussian dispersion model. At the 2 kilometer distance, intermediate values of the stability parameter and wind speed were used.

The particulate dispersion estimates were made through application of a Gaussian point source dispersion model recently developed by the Meteorology Laboratory of EPA. The model generates, for any given year, maximum 1-hour, 24-hour, and annual ground-level concentrations.

Downwash primarily affected the results of the dispersion calculations for both CO and particulate matter at zero and 0.3 kilometers, and had little or no effect at 2.0 and 20 kilometers.

Since many of the facilities under consideration in this study are located in valleys in Pennsylvania and Ohio for the particulate dispersion estimates, it was necessary to use meteorological data representative of the dispersion conditions in such locations. Hourly surface stability-wind data for a one year period from Harrisburg, Pennsylvania, were determined to be appropriate.

Table IV-2 shows that at the zero distance the national ambient air quality standards (NAAQS) (noted at the bottom of the table) may be exceeded in most cases. In some cases (primarily particulate concentrations), the NAAQS may be exceeded at greater distances. Since the dispersion calculations result in maximum, time-averaged, ground-level concentrations for adverse meteorological and topographical conditions, the concentrations in Table IV-2 do not represent typical values. Ground-level concentrations may exceed the 1-hour and 8-hour NAAQS for CO several times per year, and the 24-hour average ground-level particulate concentrations may be considered typical high values during any given year.

The reductions estimated in Table IV-1 are based on rates from uncontrolled furnaces. However, very few furnaces in the United States now have no control device. The true environmental benefit of a standard of performance is the reduction over average control already required by State and local regulations. This average level of control is very difficult to derive since those agencies use many different types of regulations. However, a comparison can be made with particulate regulations of those States which contain relatively large numbers of EAFs. (Carbon monoxide emissions do not appear to be regulated by any State or local agency.) This comparison is made in Table IV-3 for the various control systems that the alternative standards in Chapter VIII

Table IV-3

Comparison of Emissions Allowed By State and Local Regulations
And Emissions From Various Control Systems

| Regulations | Emissions, pounds per hour | |
|---|---|---|
| | Carbon Steel Production[a] | Alloy Steel Production[b] |
| Illinois-process weight regulation | 29 | 20 |
| Indiana-process weight regulation | 46 | 43 |
| Los Angeles County-process weight regulation | 21 | 17 |
| New York-process weight regulation | 55 | 47 |
| Ohio-collection efficiency regulation | 50 | 37 |
| Pennsylvania-concentration regulation | 206[c] | 257[c] |
| Texas-process weight regulation | 94 | 76 |
| Control Systems | | |
| 80% efficient canopy hoods, open roof | - | 149 |
| Building evacuation, closed roof | - | 39 |
| Direct shell evacuation and 80% efficient canopy hoods, open roof | 67 | - |
| Direct shell evacuation and building evacuation or canopy hoods, closed roof | 31 | - |

[a]Based on 300 tons of furnace capacity and a 3.5 hour cycle.

[b]Based on 300 tons of furnace capacity and a 7 hour cycle.

[c]For a concentration regulation the mass rate of emissions is dependent on the flow rate of exhaust gas. Values were calculated for 4000 and 5000 standard cubic feet per minute per ton of furnace capacity for carbon and alloy steel production respectively.

would require. The regulations shown, although not specific for EAF's, are the more stringent ones for those localities where the most furnaces are operating. The comparison is for shops with 300 tons of furnace capacity. Most of the regulations are based on process weight curves which are progressively more stringent for larger plants. Therefore, the comparison will vary with the size of a shop. To show this more clearly, Figure III-1 presents allowable emissions for the Illinois regulation as a function of capacity of the furnaces. Superimposed on that curve are curves showing estimated emissions from two alternate control systems for a shop producing carbon steel. Notice that the process weight curve is very stringent for large shops (about 55 lb/hr for a shop with 1000 tons of furnace capacity). The alternative standards in Chapter VIII are based on existing technology (the control systems shown), for which emissions are estimated as 100 and 220 lb/hr.

Wisconsin and Michigan have regulations which are specific for electric arc furnaces. They limit emissions to 0.10 and 0.20 pounds of particulate per 1000 pounds of exhaust gas, respectively. These limits are approximately equivalent to 20 and 40 pounds per hour for a direct shell evacuation-building evacuation (DSE-BE) system on a 300 ton shop producing carbon steel or 25 and 50 pounds per hour for a BE system on a 300 ton shop producing alloy steel. The effect of these regulations cannot be directly compared to emissions from control systems with open roof monitors on the shop, since the rate of gas flow through the monitors is not known.

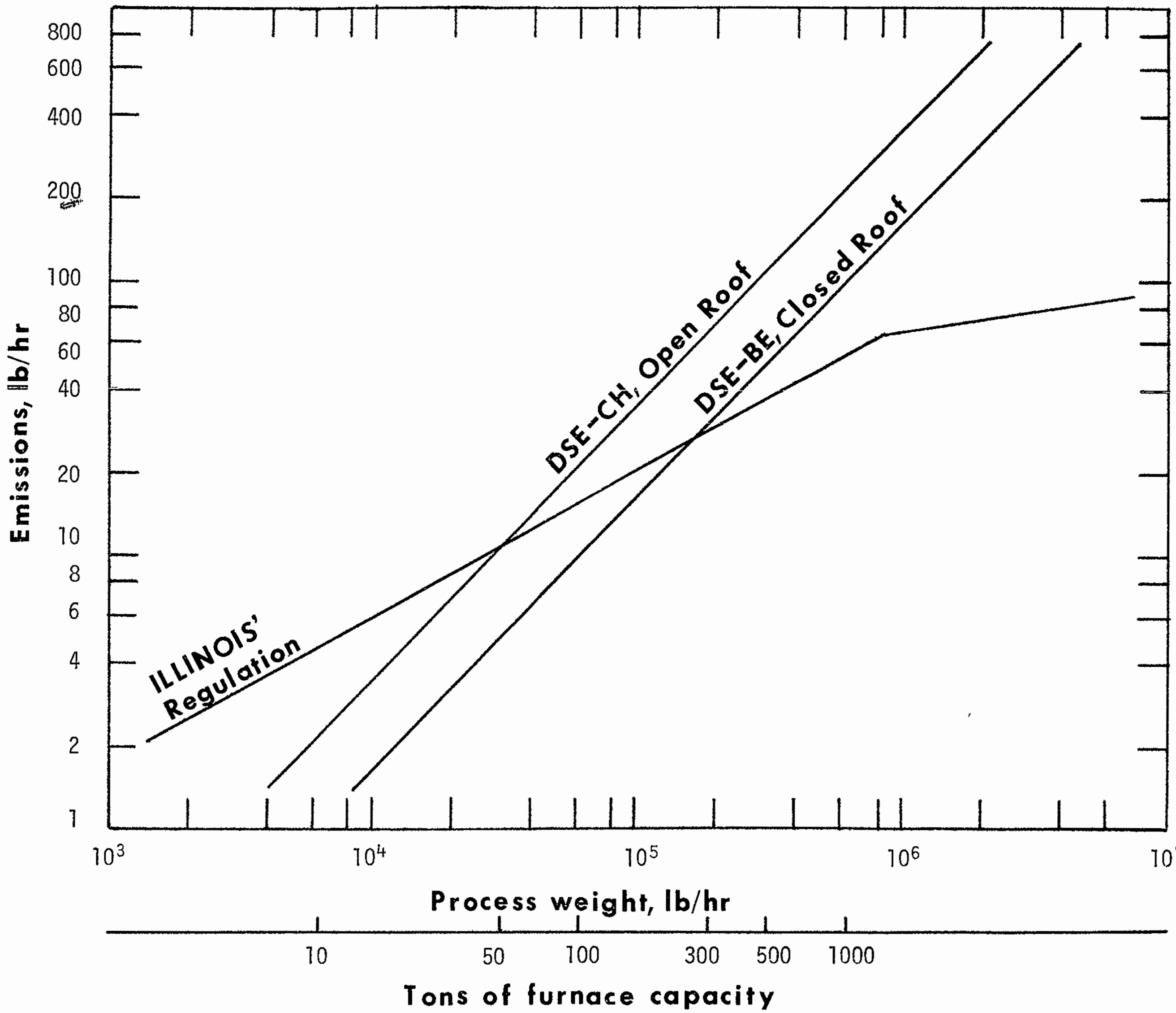



**Figure IV-1**
**Comparison Of A Process Weight Regulation With Estimated Emissions From Two Control Systems**

Nor is it known how any of these State or local regulations will be enforced for facilities with an open roof on the shop, since no technique for measuring emissions from roof monitors is specified. Such techniques are complex requiring either an inordinate number of sampling personnel or a built-in multipoint sampling system. It is possible the regulations may be applied only to emissions from the control device. In this case, compare the allowable emissions with emissions from the control device of 19 lb/hr for an 80 percent efficient canopy hood (CH) on an alloy shop and 15 lb/hr for DSE and an 80 percent efficient CH on a carbon shop. All emissions for the BE system, as shown on Table IV-3, are emitted from a control device.

Many States also have general visible emission limitations of 20 percent opacity. BE systems can achieve these regulations easily, however, existing open roof systems may not be able to comply during charging and tapping operations even if CH's are used. These visible emissions may last longer than the two or three minute exemption some States have.

From the above comparisons, one may conclude that standards of performance which require use of BE or CH-DSE systems will have little impact on those States that presently have strict particulate regulations. However, the standards and their supporting documentation, based on "best demonstrated technology," will provide valuable guidance to State and local governments, and industry on the capability and techniques of available technology.

Installation of systems representing best air pollution control technology on all new plants will minimize the increase in emissions from growth of the steel industry. The standard of performance will negate any incentive for a plant to locate in areas with less stringent standards. (Without uniform standards of performance, such incentives by State and local agencies could tend to create concentrations of industry which could result in significant deterioration of air quality in those areas.)

B. Impact on Water, Solid Waste, and Noise Pollution

Standards based on the control systems described in Chapter III will have no impact on water pollution. The overwhelming majority of control devices used will be fabric filters which have no liquid effluent. A few scrubbers may be used on DSE systems; however, in those cases, the decision to install is not the result of the standard of performance. They would be installed even without a standard of performance.

Although solid waste will be generated by the control systems that use fabric filters, the increase in quantity over present systems is small. The waste captured by a control device is nearly insignificant compared to the slag waste generated by the furnaces.

The solid wastes contain potentially harmful constituents such as cadmium, chromium or lead compounds. Consequently, landfill sites should be selected to prevent horizontal or vertical migration of these contaminants to surface or ground waters. Where geologic conditions may not reasonably ensure this, adequate precautions, such as the use of impervious liners, should be taken to ensure long term protection of the environment. The location of solid hazardous materials disposed of in this manner should be permanently recorded in the appropriate office of the legal jurisdiction in which the site is located.

Large fans are required to move the huge volumes of air which must be treated at an EAF facility. They generate high noise levels. The industry has historically used fans of this type so the standard does not introduce new noise problems. Silencing baffles can be installed around the fan housing. The EAF process is itself a source of high noise levels. Consequently, in most cases, the relative contribution of noise from the fans is small.

### C. Impact on Energy Considerations

Energy requirements for air pollution control systems on electric arc steel furnaces are almost completely determined by the amount of air which must be moved through the system. There is considerable variation in air flow from one type of control system to another, so power requirements vary widely.

Tables IV-4 and IV-5 show the calculated power requirements of various control systems and the estimated emissions which will result from generation of electric power to operate each control system. The tables are based

Table IV-4

Calculated Power Requirements and Emissions from Production of Power to Operate Air Pollution Control Systems

(86 ton/hr carbon steel electric arc furnace shop)

| Type of system (Air flow-sdcfm per ton furnace capacity) | BTU's heat input for power generation | KWH per ton of steel produced | Tons of coal needed to generate power | Particulate emissions from power generation | | Total particulate, $NO_x$, and $SO_2$ emissions from power generation | | Particulate emissions from furnaces | | Combined particulate from furnaces and power plants | | Combined total emissions from furnace and power plant | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $10^6$ BTU/hr | KWH/ton | ton/day | lb/hr | lb/ton | lb/hr | lb/ton | lb/hr | lb/ton | lb/hr | lb/ton | lb/hr | lb/ton |
| No control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2580 | 30 | 2580 | 30 | 2580 | 30 |
| Direct shell evacuation (DSE), open roof (350) | 2.85 | 3.31 | 2.61 | 0.285 | 0.00331 | 5.69 | 0.0662 | 263 | 3.05 | 263 | 3.06 | 269 | 3.12 |
| DSE and 70% efficient canopy hood, open roof (2000) | 16.3 | 18.9 | 14.9 | 1.63 | 0.0189 | 32.5 | 0.378 | 92.8 | 1.08 | 94.5 | 1.10 | 125 | 1.46 |
| DSE and 80% efficient canopy hood, open roof (2000) | 16.3 | 18.9 | 14.9 | 1.63 | 0.0189 | 32.5 | 0.378 | 67.0 | 0.779 | 68.7 | 0.798 | 99.5 | 1.16 |
| DSE and 90% efficient canopy hood, open roof (2000) | 16.3 | 18.9 | 14.9 | 1.63 | 0.0189 | 32.5 | 0.378 | 41.2 | 0.479 | 42.9 | 0.498 | 73.7 | 0.857 |
| DSE and building evacuation or canopy hoods, closed roof (4000) | 32.5 | 37.8 | 29.8 | 3.25 | 0.0378 | 65.0 | 0.756 | 30.9 | 0.359 | 34.2 | 0.397 | 95.9 | 1.12 |

Table IV-5

Calculated Power Requirements and Emissions from Production of Power to Operate Air Pollution Control Systems

(43 ton/hr alloy steel electric arc furnace shop)

| Type of system (Air flow-sdcfm per ton furnace capacity) | BTU's heat input for power generation | KWH per ton of steel produced | Tons of coal needed to generate power | Particulate emissions from power generation | | Total particulate $NO_x$, and $SO_2$ emissions from power generation | | Particulate emissions from furnaces | | Combined particulate from furnaces and power plants | | Combined total emissions from furnace and power plant | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $10^6$ BTU/hr | KWH/ton | ton/day | lb/hr | lb/ton | lb/hr | lb/ton | lb/hr | lb/ton | lb/hr | lb/ton | lb/hr | lb/ton |
| No control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 645 | 15 | 645 | 15 | 645 | 15 |
| 70% efficient canopy hood, open roof (2500) | 20.3 | 47.2 | 18.6 | 2.03 | 0.0472 | 40.6 | 0.944 | 213 | 4.95 | 215 | 5.00 | 254 | 5.89 |
| 80% efficient canopy hood, open roof (2500) | 20.3 | 47.2 | 18.6 | 2.03 | 0.0472 | 40.6 | 0.944 | 149 | 3.47 | 151 | 3.51 | 190 | 4.42 |
| 90% efficient canopy hood, open roof (2500) | 20.3 | 47.2 | 18.6 | 2.03 | 0.0472 | 40.6 | 0.944 | 84.0 | 1.95 | 86.0 | 2.00 | 125 | 2.91 |
| Building evacuation or canopy hoods, closed roof (5000) | 40.6 | 94.5 | 37.2 | 4.06 | 0.0945 | 81.3 | 1.89 | 38.6 | 0.897 | 42.7 | 0.992 | 120 | 2.79 |

on the same conditions and model plants assumed for Table III-1. Tables IV-4 and IV-5 are conservative since they presume the power is generated wholly by new coal-fired power plants which comply with the standards of performance. Emissions from fossil fuel-fired power plants are shown for both particulate matter and combined emissions of particulate matter, sulfur dioxide, and nitrogen oxides.

An alternate method to estimate emissions which will result from power generated by future power plants is to project a realistic mix of the types of plants. Coal, oil and natural gas fired, nuclear, and hydro-electric plants built from 1974 to 1980 would be included. This projection shows the emissions estimated in Tables IV-4 and IV-5 are high by almost 100 percent. Nuclear plants which will account for about 40 percent of such new plants, have no significant amount of air pollutants. (Their potential environmental impact is from hot water discharges and potential radiation hazards.)

Figures IV-2 and IV-3 show the total air pollution emissions for the various control systems. The bar chart sums the air pollution emissions from electric arc furnaces and those from the coal-fired power plant which generates the power for the various control systems. These figures reveal that incremental capture efficiency of the closed roof or BE system over the CH-DSE system are more than off-set by the additional air pollution generated at the power plant. The additional power is required to move the larger volumes of air required by the BE system.

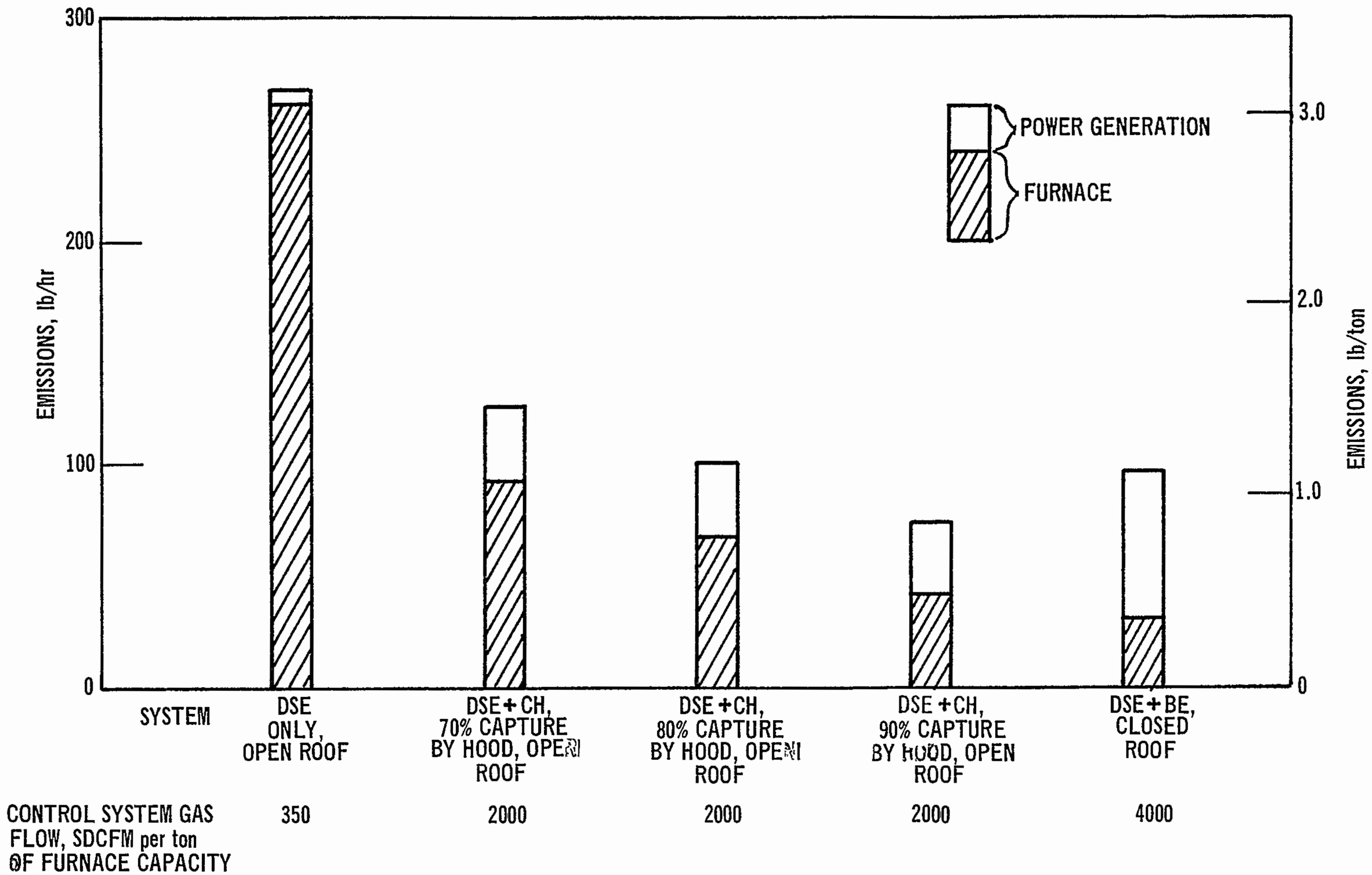



Figure IV-2. Emissions from electric arc furnaces plus emissions from generation of power to operate the air pollution control system (carbon steel production, 300 tons furnace capacity, 86 ton/hour produced)

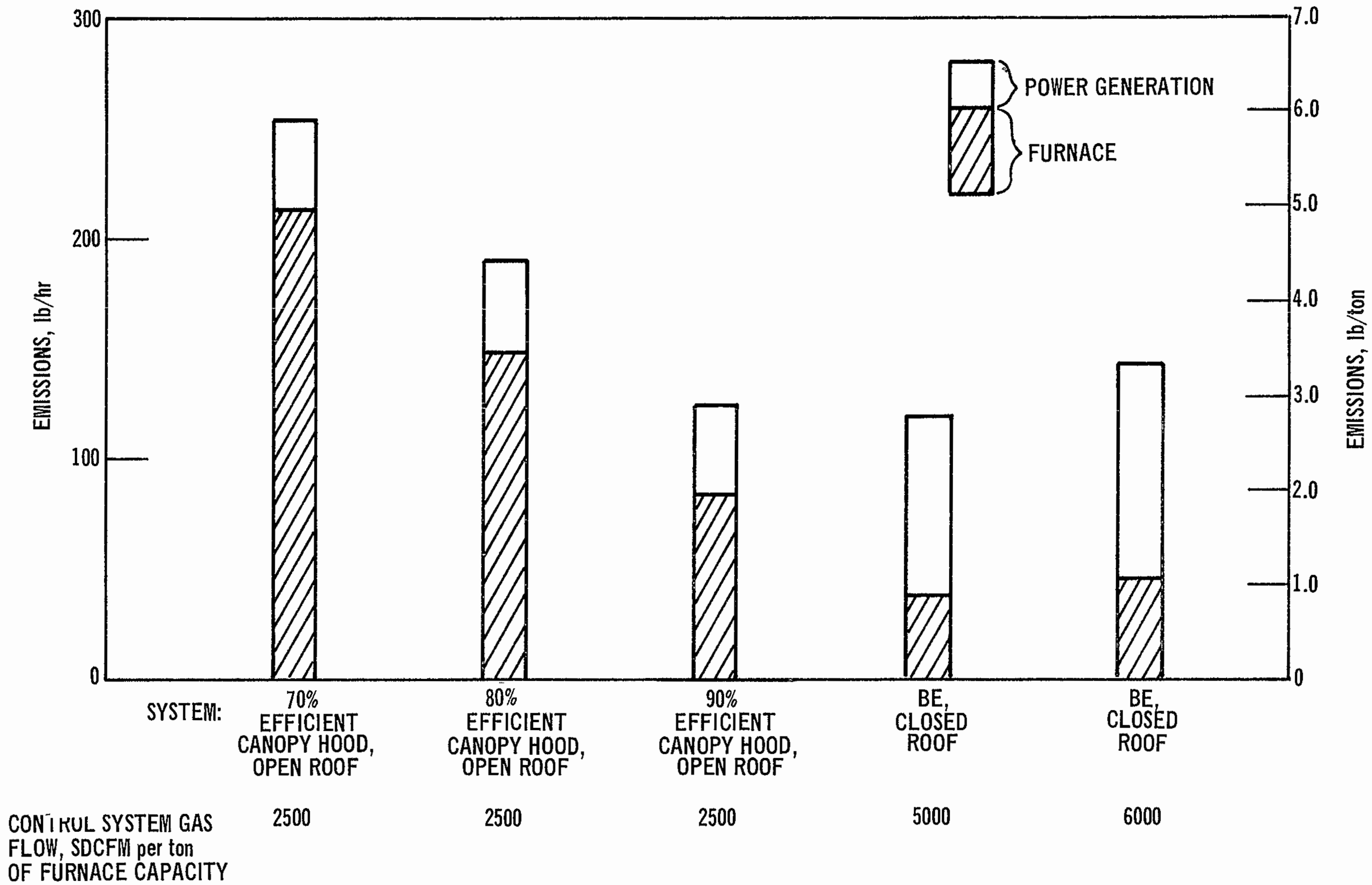
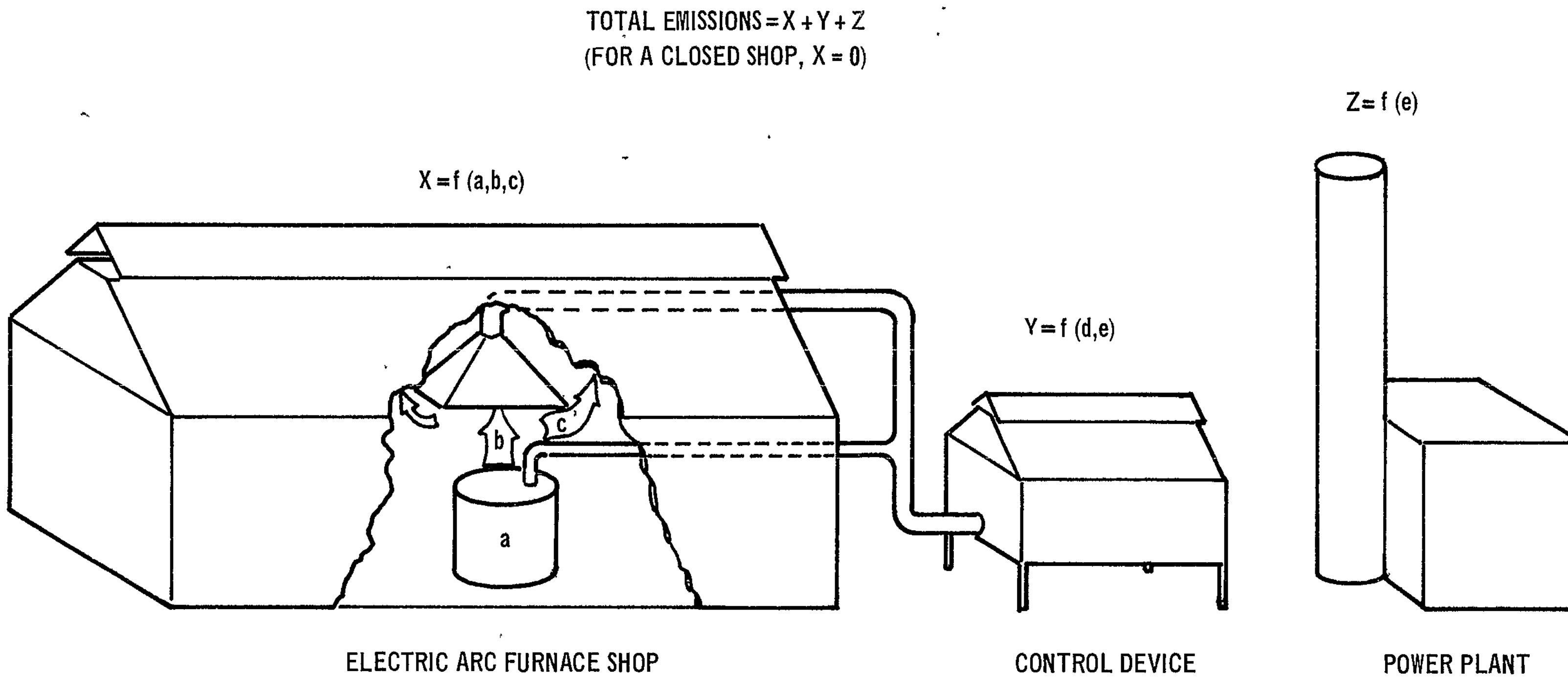



Figure IV-3. Emissions from electric arc furnaces plus emissions from generation of power to operate the air pollution control system (alloy steel production, 300 tons furnace capacity, 43 ton/hour produced).

Several values of capture efficiency of a canopy hood were examined to determine how it influences the overall control efficiency of an open roof system. To do so, the null point where the environmental impact of open and closed roof systems is equivalent was calculated. This proves to be when the canopy hood captures 81 percent of the emissions that escape a DSE system in a carbon steel shop and 91 percent of uncontrolled emissions in an alloy shop which has no DSE system. If a mix of power sources is used instead of just coal-fired power plants, the null points increase to 89 and 94 percent respectively.

Notice that on Figure IV-3, the effect of increasing the air flow through a BE from 5000 to 6000 dscfm/ton is presented in the last two bars. Figure IV-4 depicts the variables that must be considered in any investigation of prospective control schemes. Each has an effect on the total emission rate. The discussion above was limited to the most significant variable, C which is also the most difficult to quantify or estimate.




a - EMISSION FACTOR.
b - FRACTION OF EMISSIONS THAT ESCAPE THE DIRECT SHELL EVACUATION.
c - FRACTION OF EMISSIONS THAT ESCAPE THE CANOPY HOOD.
d - CONCENTRATION AT THE CONTROL DEVICE OUTLET.
e - GAS FLOW RATE THROUGH THE CONTROL DEVICE.

Figure IV-4. Variables that affect comparisons of various control systems

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## V. SUMMARY OF THE PROCEDURE FOR DEVELOPING STANDARDS

### A. Literature Review and Industrial Contacts

Available literature was reviewed to gather background information on the industry and its processes. The locations of well-controlled facilities, their design and data on emissions were noted. A prime literature source was the Air Pollution Technical Information Center, EPA, which routinely abstracts and catalogues literature related to air pollution. Other sources were air pollution and industry oriented periodicals, meetings of technical societies and pertinent textbooks.

Several meetings were held with an Ad Hoc Committee of the American Iron and Steel Institute, which was formed to provide any technical information that EPA might require. In addition, contacts were made with owners of electric arc furnaces, manufacturers of control equipment and other people knowledgeable about the industry.

### B. Selection of Pollutants

Air pollutants considered as candidates for the development of standards of performance for electric arc furnaces (EAF) include particulate matter, carbon monoxide, fluorides, nitrogen oxides, and sulfur oxides. Of these, particulate matter has the potential of being emitted in the greatest quantity if not properly controlled (see Chapter I).

Significant quantities of carbon monoxide (CO) may also be emitted. If uncontrolled, emissions are six pounds per ton of steel produced (based on EPA's test at Plant A). Assuming this emission rate for production of all steel from electric arc furnaces, the CO emissions would be 0.5 percent of the total industrial CO emissions in the United States (based on 10 million tons per year total industrial CO emissions in 1968[14] and 15 million tons per year electric arc furnace steel production in 1967[15]). Near very large shops, the maximum ground level concentration (under worst meteorological conditions) of CO may exceed the air quality standard of 40 mg/$m^3$ (one hour average).

The only known technique to control CO emissions is a DSE system. The alternative particulate matter standards considered in Chapter VIII encourage the use of this technique whenever it has been technically demonstrated, thereby indirectly achieving control of CO. Chapter VIII also discusses a possible CO standard.

Data provided by industry on emissions of nitrogen oxides indicate they are less than 0.1 pound per ton of steel produced (lb/ton).[16] Emissions of sulfur oxides have been estimated as 0.01 lb/ton.[17] No attempt is now being made to minimize the emissions of these pollutants. Because of the low emission levels and the absence of demonstrated emission control techniques, standards for these two pollutants have not been considered in Chapter VIII.

Emissions of fluorides from controlled facilities have been estimated at levels from 0.004[18] to 0.7[19] lb/ton of steel produced and are evolved from EAF furnaces only when fluorspar is used to form a slag. Since fluorides are thought to be emitted from EAF's primarily as insoluble particulate, the efficiency of control would be expected to be essentially the same as that of particulate control. No separate standard is recommended, since fluorides may be controlled by the standard for particulates.

## C. Affected Facilities

The electric arc furnace is the primary facility and overwhelmingly the major source of air pollutant emissions in an electric arc furnace shop. However, there are also other facilities that emit air pollutants. They include:

1. Argon-oxygen decarburizing vessels.

2. Vacuum-arc remelting furnaces.

3. Inert atmosphere remelting furnaces.

4. Electroslag remelting furnaces.

5. Teeming.

6. Continuous casters.

Of these, only argon-oxygen decarburizing vessels emit large quantities of pollutants, primarily particulate matter. They and the three types of remelting furnaces produce only small quantities of a few specialty steels.

Each process is distinctly different and parallel efforts would be required to develop standards for each. Since electric arc production furnaces contribute most of the pollutants emitted from a shop, they were selected as the initial affected facility. The others may be candidates for standards of performance in the future but are not now considered because of their small contribution to the total emissions from a shop.

One other affected facility was selected; the equipment for on-site handling of dust collected by the air pollution control device. Although this is usually a small source, there is potential for large quantities of collected dust to become airborne if it is handled improperly.

Although the furnace is the only affected facility within a shop (the building which houses the furnaces), the recommended standards apply to one emission point other than those directly connected to the furnace. A portion of the emissions from the furnace evolve into the shop atmosphere and emit from a monitor on the roof of the shop. A standard applied only to the control device would not limit these emissions.

## D. Plant Inspections

Preliminary investigations of 30 plants identified from a review of the literature and contacts with industry revealed the location of 11 plants reportedly well-controlled (BE or CH systems) for particulate emissions. Ten were visited, visible emissions evaluated, and information obtained on the process and control equipment. Although many of these practiced good control techniques, the facilities at only three plants (Plants A, I and J) were amenable to testing with EPA Method 5. Others were not suitable for emission measurements because they use pressure baghouses which have no stacks. Although development work is in progress, sampling methodology for this type installation has not been standardized.

These three plants were nearly identical except for size. They all produced alloy steels and controlled particulate emissions with a building evacuation system. Each had a fabric filter control device that exhausted through multiple stacks. Rather than spread the test program effort over three tests at nearly identical plants, it was decided a more comprehensive test of one plant would provide more information. The middle sized plant offered the best possibilities for this comprehensive test. Its size was typical of the mid-range for the industry, and the fabric filter did not have an inordinately large number of exhaust stacks. This permitted simultaneous sampling of a higher percentage of the total stacks with much less effort than required for the large plant.

Six additional plants were visited to obtain more information on the process and those systems which capture only a portion of the furnace emissions. Of the 15 plants visited, 10 had DSE systems, the only known control technique for carbon monoxide emissions. Two were sampled to determine the carbon monoxide emission rates. These two plants were selected primarily on the basis of ease of testing. Design parameters that affect removal of carbon monoxide were not well known and, of course, visual indications of performance were not possible.

E. Emission Measurement Program

The one installation from which particulate matter emissions were measured by EPA used a fabric filter collection system and a BE capture system. The filter system had six discharge stacks. The filter compartments and stacks were inspected for evidence of any difference in emission rate from the stacks. None was found, therefore, three stacks, selected for convenience, were sampled simultaneously.

The particulate samples were collected for four hours. Usually the sampling period was chosen to coincide with one complete furnace cycle. However, the plant had two furnaces with staggered cycles served by a common control system. The sampling period could not coincide with the cycles of both furnaces. Four hours was selected to provide capture of a sufficient amount of sample to obtain an accurate measurement. The sampling periods were selected to include furnace operations expected to generate above-average emissions, thus insuring an average or higher particulate loading to the filter. These operations were scrap melting, oxygen blowing, charging and tapping.

During each sampling period, operation of the process was monitored. A log of operations was kept for each furnace which included:

1. The level of power to the furnaces.

2. The type and amount of furnace additions.

3. The occurrence of charges, taps, oxygen blows or other furnace operations.

The tons of steel poured and the amount and description of scrap charged were also recorded for each cycle.

Measurements of carbon monoxide emissions were conducted by EPA at Plants D and E. Since the tests were designed to measure emissions only when a DSE system was operating, the sampling periods were selected to coincide with one complete furnace cycle. After further evaluation of an alternative standard for carbon monoxide, the data was recalculated for a sampling period of the first 90 minutes of a cycle excluding periods when the DSE system is shut off. This is discussed further in the next section on units. Monitoring of the process was the same as during the particulate test.

## F. Units of the Standard

The two principal types of units considered are units of mass rate and concentration. The basic difference is that a standard which restricts the mass rate of emissions would minimize the total mass emitted, whereas concentration units allow the mass emission rate to vary with the volume of gas through the control device.

Concentration units are completely unsuitable for a carbon monoxide standard because controlled emissions are emitted in higher concentrations (smaller gas volume) than for no control.



emissions in lb/hr-ton. The process information required is furnace capacity and the times when a cycle starts and ends, which can easily be obtained from plant lots. The capacity of a single furnace is determined by averaging the tons of steel produced for all cycles which contribute to a sample obtained during a performance test. Capacities would be additive for multi-furnace shops. The figure for tons-of-steel-produced must include both whole ingots and

Concentration is easy to measure, requires no reliance on plant records, and eliminates any potential conflict with OSHA's standards (unlike mass units, there is no restriction on gas volume). Concentration units allow the operator some latitude in the gas volume used to insure good capture velocity at the canopy hood. Good capture at the canopy hoods minimizes emissions through the open roof.

Two types of mass units were considered; Kg of emissions/metric ton of production and Kg of emissions/hr-metric ton of furnace capacity. Equivalent

butts. (The steel remaining after ingot molds are filled is called a butt.) Figure V-I illustrates the calculation of furnace capacity.

Units of "pounds per hour per megawatt of transformer capacity" (lb/hr-Mw), suggested by one manufacturer, are no more accurate, hence have no advantage over lb/hr-ton.

G. Development of the Proposed Standards

On February 22, 1973, the Agency presented to the National Air Pollution Control Techniques Advisory Committee (NAPCTAC) a draft technical report and standard for electric arc furnaces in the steel industry. In summary, the draft report concluded that best demonstrated technology for control of emissions from electric arc furnaces in the steel industry is the building evacuation (BE) system or the combination BE-direct shell evacuation (DSE) system in conjunction with appropriate control equipment. The draft standard recommended a particulate matter limitation of 0.06 lb/hr-ton and 10 percent opacity and a carbon monoxide limitation of 0.80 lb/hr-ton. Representatives of the steel industry attended the meeting and expressed their comments to the committee, suggesting that the particulate matter standard be 0.244 lb/hr-ton and allowing 30 percent opacity for 20 minutes per furnace cycle. The representatives commented that data representative of the carbon steel industry were not used in the development of the draft standard and it is unrealistic to apply data from a low productivity alloy shop to a carbon steel shop where production rates are two to three times

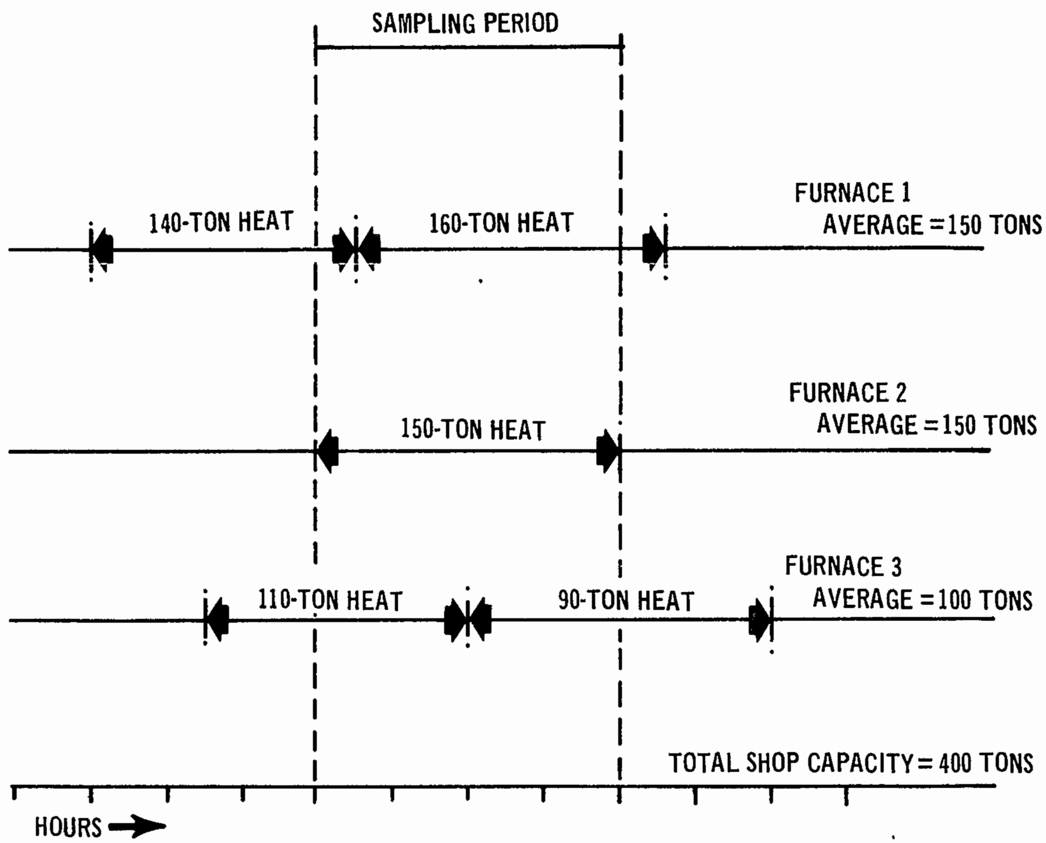


Figure V-1. Sample calculation of furnace shop capacity.

greater. The representatives stated that the CO standard was untenable and recommended deferral of a standard until more data are obtained. Concern was expressed regarding the effects of reduced building ventilation rate on the visibility and working conditions in the shop. The representatives pointed out that the large air volumes from the BE system would require large quantities of electrical power, thus increasing the severity of the energy crisis, power plant emissions and operating costs.

The revised draft technical report and standard were presented at the NAPCTAC meeting on May 30 and 31, 1973. The particulate matter standard was changed from 0.06 lb/hr-ton to 0.10 lb/hr-ton. The carbon monoxide and the opacity standards were the same as presented at the previous meeting. Steel industry representatives expressed their objections to the units of the standard and the resultant effects of restricted ventilation rate on workers in shops in hot climates. The representatives argued that the fallacy in the Agency's analysis was the assumption that ventilation rates were the same regardless of shop productivity. The industry representatives suggested that the standard be expressed on a concentration basis and be set at 0.008 gr/dscf. Difficulties of use of DSE systems when reducing slags are used were discussed.

A revised draft standard and technical report were presented at the NAPCTAC meeting on January 9, 1974. The draft standard recommended that emissions be limited as follows:

1. No more than 9 mg/dscm (0.004 gr/dscf) from the air pollution control device.

2. Less than 10 percent opacity from the air pollution control device.

3. No visible emissions from the shop.

4. No more than __ percent average opacity from the shop as a direct result of charging or tapping of a furnace and for 3 minutes thereafter.

5. Less than 10 percent opacity of any gases from dust-handling equipment.

This draft standard can be achieved by use of either the building evacuation system or a combination of a system utilizing direct shell evacuation and a canopy hood which are considered to be best systems of emission reduction when all relevant factors are considered. At this meeting industry representatives suggested a standard of 0.008 gr/dscf for a dry collector and 10 percent opacity, and 0.02 gr/dscf for a wet collector and 20 percent opacity. A 20 percent opacity standard for visible emissions from the shop was also suggested. The rationale for this draft standard is discussed in Chapter VIII. The proposed standards of performance differ slightly from the draft standards and the rationale for the changes is discussed in Chapter II.

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## VI. DATA TO SUBSTANTIATE A STANDARD

### A. Particulate Emission Data

Figure VI-1 presents the results of measurements of particulate emissions gathered for standards development. Many of the tests were conducted on fabric filter collectors with multiple stacks or in a large open area or "monitor" through which several filter compartments exhaust. Separate samples were collected in one or more stacks or above one or more compartments. Unless otherwise noted in the following discussions, each vertical "set" of data in Figure VI-1 is for a single stack or compartment. This presentation recognizes that each compartment filters independently and each "set" of data is representative of levels achievable by fabric filters.

Figure VI-2 presents the results of the same measurements in pounds per hour per ton of furnace capacity (lb/hr-ton). On this figure all of the data for each plant is grouped in one vertical data bar (except Plant A which was sampled by two different methods) to allow a comparison of the mass emission rate from each plant. Each data point represents a separate test, combining samples collected at different sampling locations. The average of the concentrations for all samples and the total gas flow to the control device(s) were used to calculate mass emissions.

Pressurized baghouses which discharge the cleaned gases through a large open area or monitor are typical at electric arc

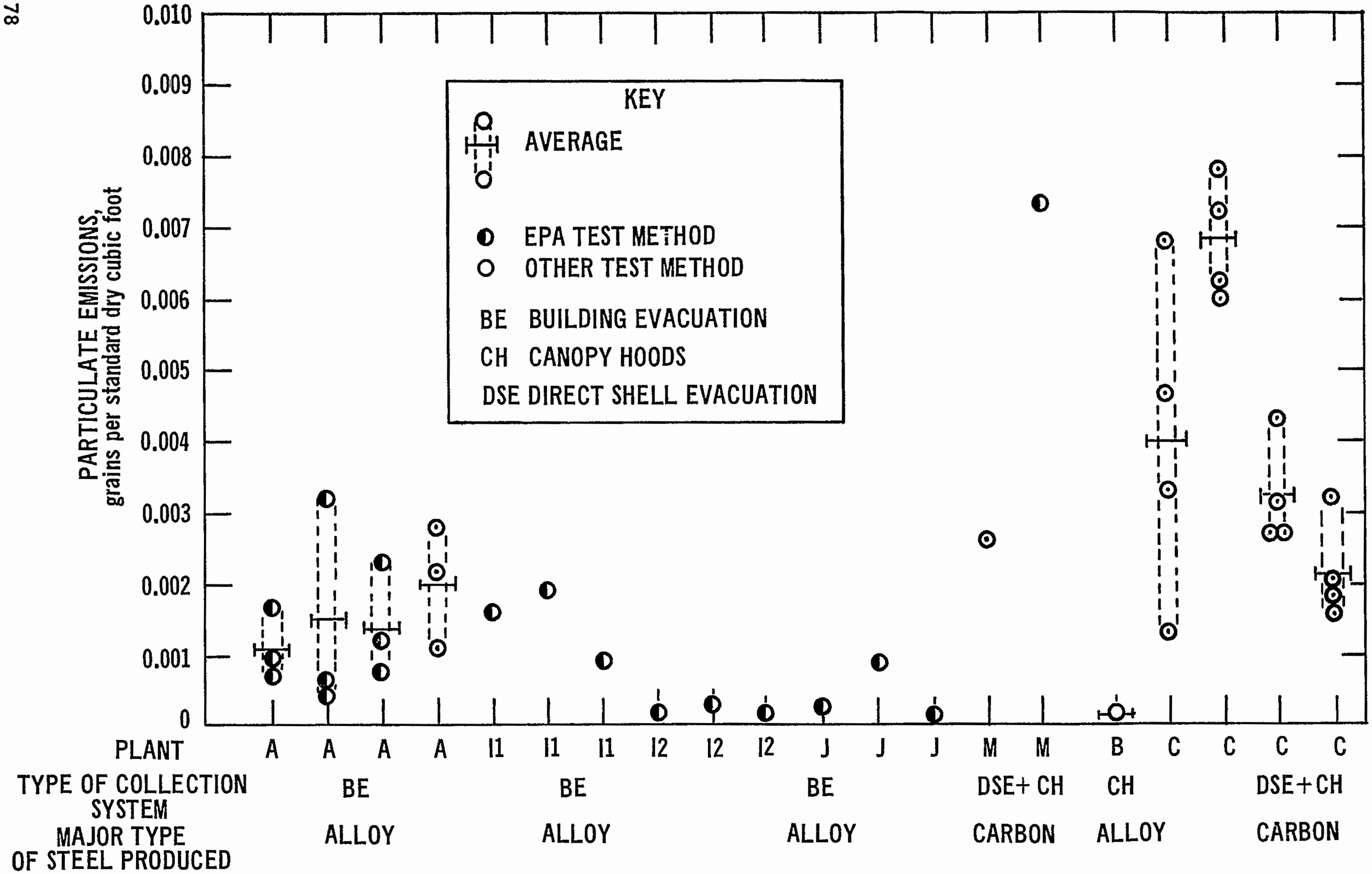


FIGURE VI-1
PARTICULATE EMISSIONS FROM ELECTRIC ARC FURNACE SHOPS

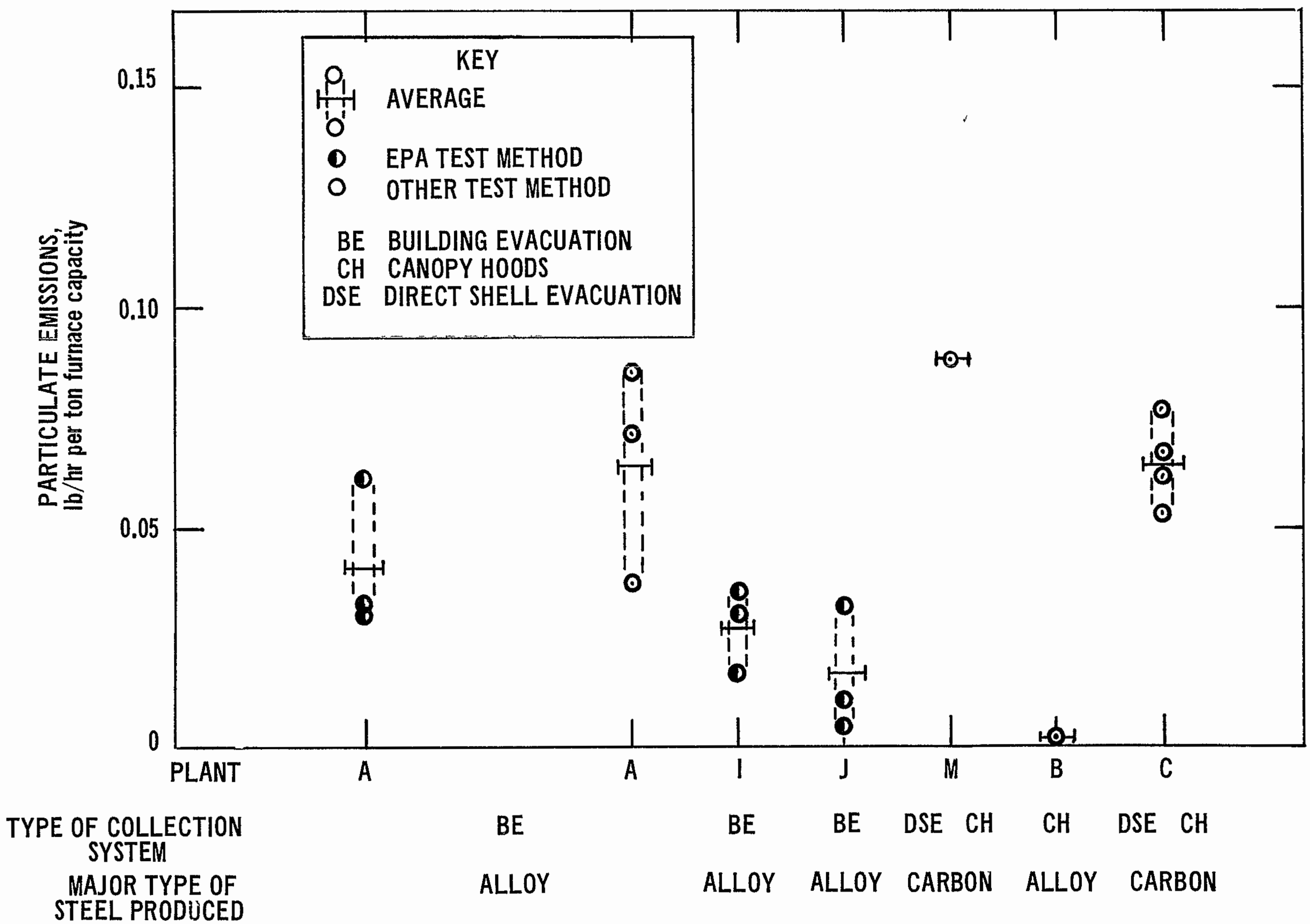


FIGURE VI-2
PARTICULATE EMISSIONS FROM ELECTRIC ARC FURNACE SHOPS

furnace shops. Since they have no stacks, they present a difficult sampling situation which does not meet the criteria for use of EPA Method 5. EPA identified only three plants with stacks and only one was tested, Plant A.[10] Plants I and J have a similar stack configuration. All three plants are very similar, however, and the decision to measure emissions from A was based primarily on its size and ease of sampling. Plants I and J were later sampled using EPA's Method 5. The owners provided the data to EPA.

Plant A has two electric-arc furnaces with capacities of 50 and 75 tons. Particulate emissions from the furnaces, which were producing alloy steels, are controlled with a BE system and a fabric filter. Measurements of emissions were made simultaneously on three of the six stacks on the fabric filter. Each stack serves two filter compartments. The stacks, only one diameter tall, precluded compliance with the criteria in EPA Method 5 for minimum distances from the sampling location to the nearest flow disturbance. However, the uniform velocity profile found in the stack indicates the samples are representative. All other criteria of Method 5 were met. As shown by the first three bars on Figure VI-1, average results of the three samples for each stack were 0.0011, 0.0014 and 0.0015, for a combined average of 0.0013 gr/dscf. Individual results from the nine samples ranged from 0.0005 to 0.0032 gr/dscf.

On one stack, simultaneous samples were collected with an ASME particulate sampling train. Its results are shown as the fourth bar in Figure VI-1 and the second bar in Figure VI-2 to permit a comparison with the results of the EPA train shown as the third bar on Figure VI-1. The ASME sample included particulate matter from a nozzle wash and alundum thimble catch which are commonly measured, plus a probe wash and glass fiber filter catch. The nozzle and thimble catch averaged 27 percent of the total.

Each sample run was approximately four hours. The sampling periods were selected to include furnace operations expected to generate above-average emissions. These operations were oxygen blowing, scrap melting, charging, and tapping. Process operation was normal during the test.

Plants I and J on Figures VI-1 and VI-2 differ from Plant A primarily in size. Plant I has three furnaces with 100 tons of capacity each, one with 75 tons and one with 50 tons. Plant J has two furnaces with 25 tons capacity each. The data were supplied by the plant operators who stated the tests were conducted according to Method 5.[23] No abnormal process conditions during the tests were reported. All samples were collected for about two hours.

At Plant I, two parrallel fabric filters are used (indicated by $I_1$ and $I_2$ on Figure VI-1). One fabric filter has 7 stacks and the other 10. Three runs, consisting of samples from one stack on each fabric filter, were conducted. Different stacks were sampled for each test. Plant J has 10 exhaust stacks on one fabric filter. Each run consisted of a sample from one stack. A different stack was sampled for each run. All of the concentrations measured at Plants I and J were below 0.002 gr/dscf.

Plant M produces carbon steels in two furnaces with 100 tons capacity each and one with 150 tons of capacity. The 150 ton furnace was not operating during the test and its dampers in the control system were shut. Emissions are controlled with a DSE-CH system and fabric filters. Monitors on the building roof were open. The CH is ducted to one filter and each DSE system is ducted to a separate filter. One four-hour sample was collected from the CH filter and one three-hour sample from one of the DSE filters. No abnormal process conditions during the test were reported. The data were supplied by the vendor of the fabric filter.[24]

The first point for Plant M on Figure VI-1 shows the result of the sample collected from the filter servicing the DSE. The sampling was conducted by traversing a monitor with a Method 5 sampling train. The sample was collected isokinetically. Results showed 0.0026 gr/dscf. The filter servicing the CH has a stack. The test report stated it was sampled according to Method 5. Results shown by the second point on Figure VI-2 were 0.0073 gr/dscf. The reasons for the high emissions are assignable. The filter was reconditioned from a previous use where a lower air flow rate was used. It now has a 4:1 air-to-cloth ratio compared to 2 or 3:1 usually used. Also, an open weave bag is used to prevent excessive pressure drop because of the high air flow. On Figure VI-2 the total emissions from Plant M were calculated based on an emission concentration of 0.0073 gr/dscf from the CH and by assuming both DSE filters achieve 0.0026 gr/dscf and have the same flow rate.

At Plant B, alloy steels are produced in five small furnaces (only three were operating during the test) and emissions are controlled with a CH system, closed roof on the shop and a fabric filter with a monitor exhaust (no stack). No abnormal process conditions during the test were reported. The data were provided by the plant and collected according to the standard procedures of the vendor of the control device.[25] The samples were collected above the center of one filter compartment. Isokinetic sampling conditions were not maintained. Results of the two samples were reported as "negligible" and "2.0 X $10^{-5}$ gr/dscf."

Plant C produces carbon steels in three furnaces, two with 100 tons of capacity each and one with 75 tons capacity. A DSE-CH control system and fabric filter are used. The data were collected by a local control agency using their own test method.[26] The test train consisted of a probe, paper thimble, dry gas meter and vacuum pump. Results were reported in terms of wet gas. Sampling was conducted at a single point in various filter compartments above the bags. Four consecutive tests were run for about one hour each. The four hour period coincided with a full cycle on one furnace. Each test consisted of one sample from each of four selected compartments. No abnormal process conditions during the test were reported. Results for the 16 samples ranged from 0.0013 to 0.0079 gr/scf (wet).

Visible emission data were also obtained for several plants. Contunuous observations were made at plants C and G for about one hour each.[27] Emissions from two fabric filters were observed at Plant G and from one at Plant C according to EPA Method 9. No visible emissions were observed from one filter (on a DSE system) at Plant G. Puffs of about five seconds duration were visible from the other filter at Plant G and from the filter at Plant C. They appeared to coincide with the bag cleaning cycle of the filter servicing a BE system at Plant G and thus were believed to be non-representative of a well maintained and operated fabric filter. Short observations during plant visits showed 12 other fabric filters, one electrostatic precipitator and one scrubber with no visible emissions. Method 9 was not used for observations at these 14 installations.

The buildings at plants C and G were also observed according to Method 9 for about one hour.[27] No visible emissions were observed at Plant G. At Plant C, visible emissions up to 20 percent opacity were observed for one or two minutes after monitors on the roof of the building were opened. The monitors were closed during periods of high dust evolution in the shop (e.g., charging and tapping) and reopened after these periods. Process operations during these observations were not recorded.

Visible emissions from the shop were observed at Plant M.[1/] This plant uses a direct shell evacuation (DSE)- canopy hood (CH) control system similar to that on which the proposed standard is based. Monitors on the roof of the building are open. Readings of the visibility of emissions observed for each charge and tap are presented in Table VI-1. Except for periods of charging and tapping, emissions were visible from the roof of the building for only 30 seconds during observations over 15 hours of furnace operation. Emissions were visible within the building during many other short periods, however, they were not discernible as they left the building. Operation of both the furnace and control equipment was normal except for one short period with a DSE damper closed. Power to a control instrument was disrupted and caused the malfunction. Observations during this upset were not considered.

---

1/ Trip report for tests of visible emissions at Plant M, May 20, 1974.

TABLE VI-1

VISIBLE EMISSIONS FROM CHARGING AND TAPPING
PLANT M

| Charges | | Taps | |
|---|---|---|---|
| Maximum Opacity Reading, Percent | Average Opacity,[a] Percent | Maximum Opacity Reading, Percent | Average Opacity,[a] Percent |
| 10 | 1 | 60 | 16 |
| 0 | 0 | 80 | 24 |
| 25 | 7 | 75 | 21 |
| 35 | 12 | 65 | 21 |
| 15 | 5 | 75 | 33 |
| 60 | 10 | | |
| 0 | 0 | | |
| 25 | 6 | | |
| 5 | 1 | | |
| 35 | 8 | | |

a. Arithmetic average of readings every 15 seconds (including all zero readings) from the beginning of the process operation until three minutes after the end of the operation.

Visible emissions were observed from the building at Plant F during a tap and a charge.[28] Plant F has a DSE-CH system with open monitors on the building roof. Ten to 40 percent opacity for 17 minutes was observed during the tap and up to 10 percent for four minutes during the charge.

Control of particulate matter emissions from fabric filters has been guaranteed at levels as low as 0.004 gr/dscf on plants A, I and J; alloy shops with building evacuation systems.[29] The guarantee applied if the inlet loading to the fabric filter was below 0.3 gr/dscf. The EPA measured inlet loading was 0.05 gr/dscf. Above this inlet loading the guarantee specified 99 percent efficiency. One vendor has stated they would also guarantee this level for Plant E as discussed below.

A survey of several vendors was conducted by the owners of Plant E[30],[31] to determine the lowest guarantee they could obtain for a new control system now under construction at their plant. The system is BE (similar to Plant G) to assure control of charging and tapping fumes. DSE systems are already in operation at the plant. Although monitors will be open in the roof near the ends of the building, partitions will sufficiently isolate the center portion of the roof to render it similar to a BE system.

Four vendors responded to the inquiries which asked if they would guarantee "a concentration lower than 0.004 gr/scf." None would guarantee a lower concentration. One stated they would guarantee this level and that they expected it can be maintained " . . . over a lengthy period assuming proper maintenance . . ." A second vendor stated they would guarantee 0.004 gr/actual cubic foot (about 0.005 gr/dscf). Following are quotes from the responses of the other two vendors.

> "[The vendor] is confident that the proposed dust collector for [Plant E] is capable of a discharge meeting or exceeding 0.004 grains per SCF for solid particulate. This performance is expected to be maintained over lengthy periods of time if the unit is properly serviced." " . . . it is not within the limits of good engineering judgment to guarantee such levels."

> ". . . to guarantee [0.004 gr/dscf] would leave an insufficient margin of safety."

## B. Carbon Monoxide Emission Data

Figure VI-3 presents the carbon monoxide (CO) data collected by EPA.[10], [32],[33] The data are presented in units of pounds per ton of steel produced (lb/ton) for two plants with DSE control and one with BE control (a BE system does not reduce CO emissions). These units permit a comparison of the emissions of CO from BE and DSE systems. Emissions from the two plants controlled by DSE's are also presented in units of lb/hr-ton of furnace capacity on the right of Figure VI-3. The average emissions over the first 90 minutes of a furnace cycle (excluding times when the DSE system is shut off during charging) in lb/hr is divided by the tons of furnace capacity. These units for a standard are discussed in more detail in Chapter V.

CO emissions from the BE system at Plant A averaged 5.6 lb/ton and ranged from 4.9 to 6.5 lb/ton. Emissions from the DSE systems at plants D and E averaged 0.76 and 1.04 lb/ton, respectively. They ranged from 0.52 to 1.07 lb/ton for Plant D and from 0.54 to 1.39 lb/ton for Plant E. For all three tests, the emissions were continuously monitored with a non-dispersive infrared analyzer. Operation of the processes was normal except for a short period at Plant D when sampling was discontinued because of a fan failure.

The sampling locations at plants D and E were well downstream of the high temperature zones where combustion of the CO occurs. At Plant D, samples were collected before the scrubber to avoid any bias that absorption of CO in the scrubber would cause. The collector more commonly found on DSE's, the fabric filter, does not collect CO. At Plant E, the effluent from three furnaces is manifolded to a single fabric filter. Samples were collected upstream of where the ducts combine. This provided data representative of the average emissions from a single furnace cycle.

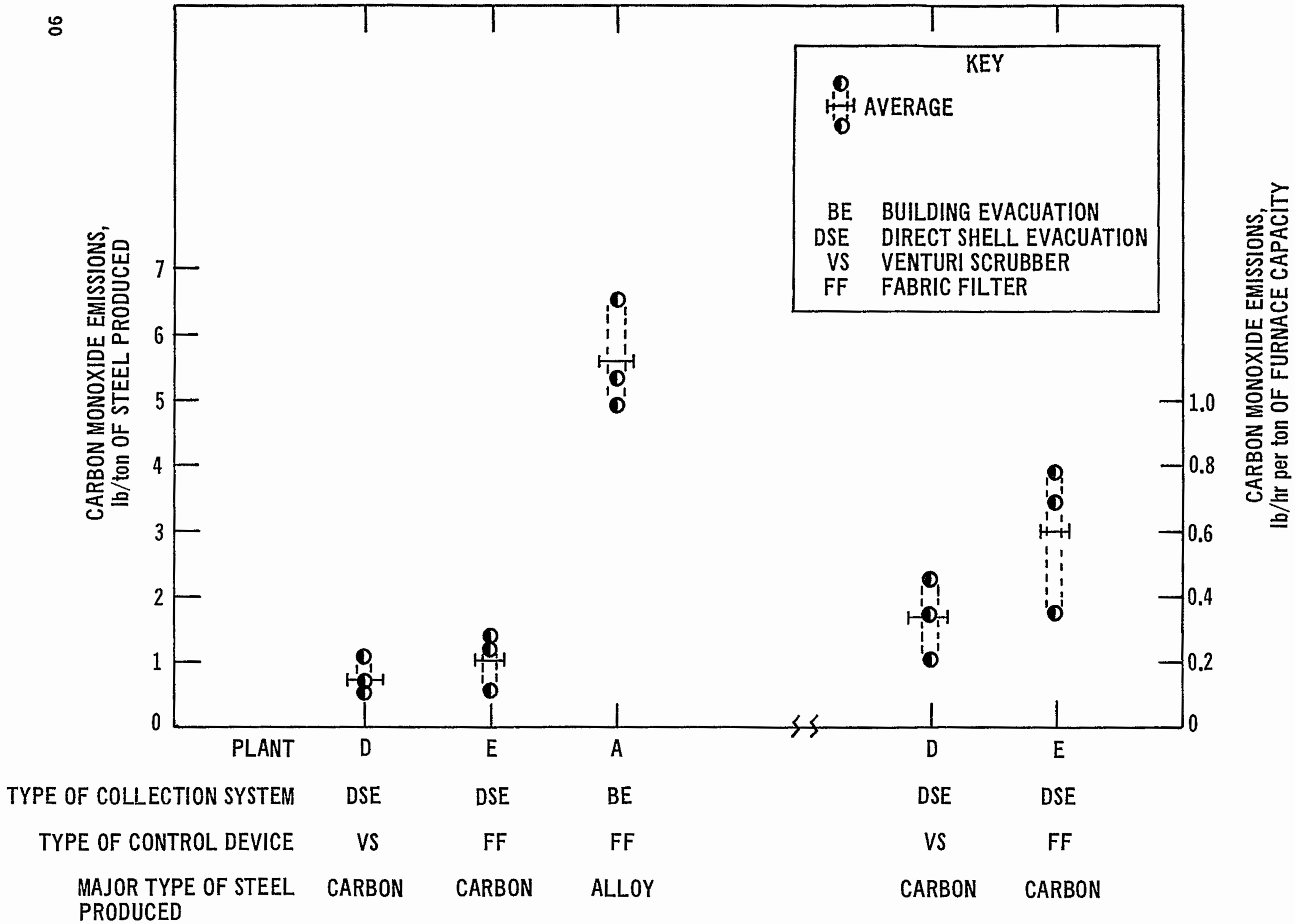


FIGURE VI-3
CARBON MONOXIDE EMISSIONS FROM ELECTRIC ARC FURNACES

Sampling at plants D and E was conducted only during operation of the DSE system. Emissions were not measured during charging and tapping, or between heats when the DSE system was shut off. Sampling facilities were inadequate to obtain data during these periods. Sampling at monitors on the roof of the building would have been required. An analysis of data from Plant A showed that CO emissions at these times are very low, less than five percent of the total emissions from a cycle. If the sampling were conducted over the entire cycle, as at Plant A, average emissions at Plants D and E in lb/ton could be up to 20 percent lower than shown on Figure VI-3, because an average that includes the periods of low emissions will lower the average for the entire cycle.

The average CO concentration measured at Plant A was 55 parts per million (ppm) by volume, and the maximum five-minute average during the test was 320 ppm. For Plants D and E, the average concentrations and the maximum five-minute average concentrations were 200 and 1,090 ppm, and 440 and 3,200 ppm, respectively. Concentrations are lower for a BE system because of the large volume of building air that dilutes the exhaust gas stream. However, mass emissions are lower for DSE systems as Figure VI-3 shows. Peak concentrations generally occurred during scrap melting and oxygen blowing.

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## VII. SUMMARY OF ECONOMIC INFORMATION

### A. Cost

#### 1. Cost of air pollution control.

A majority of the electric furnace installations are controlled by fabric filters. There are a few venturi scrubbers and one electrostatic precipitator in service. In addition to the variations in control devices, there are several methods of collecting the fumes for cleaning. Figure VII-1 depicts the major cost items for three. First is the direct shell evacuation method whereby fumes are drawn from the shell of the furnace, the carbon monoxide burned, the fumes cooled, and then routed to the control device. This method has the advantage of the lowest flow rate but when fabric filters are used, requires a cooling system for temperature adjustment to preclude damage to the control device. However, when the furnace lid is off during charging, the control system is inoperative. At the end of the cycle, when the furnace is tilted for tapping, fumes emerge from the molten metal. Because of these periods of uncontrolled emissions, direct shell evacuation is not considered a viable control method by itself.

The second method incorporates a canopy hood to capture charging and tapping emissions to supplement the direct evacuation system. A greater total flow of air results. The cooler air from the canopy hood is normally mixed with the fumes in the direct shell evacuation system to cool the fumes and lower the volume of water needed to cool the dust laden stream prior to cleaning. (For alloy furnaces, in which a reducing slag is used, direct evacuation cannot be used, and a canopy hood must be used by itself.)

The third method is total building evacuation which results in the greatest air flow but the costs of gas conditioning are the least.

Industry practice varies widely in the amount of air flow per ton of furnace capacity for each of the collection configurations; however, the following figures approximated general usage and formed the basis of the economic studies:

| | |
|---|---|
| Alloy Shops | |
| Canopy Hoods | 2500 SCFM/Ton of Capacity |
| Building Evacuation | 5000 SCFM/Ton of Capacity |
| Carbon Steel Shops | |
| Direct Evacuation plus Canopy Hoods | 2000 SCFM/Ton of Capacity |
| Building Evacuation | 5000 SCFM/Ton of Capacity |

The present size distribution of furnaces is skewed to the smaller size (63% are 50 tons or less and 87% are 100 tons per heat or less). In order to provide an adequate spread, costs were obtained for 25 ton and 100 ton per heat furnaces.

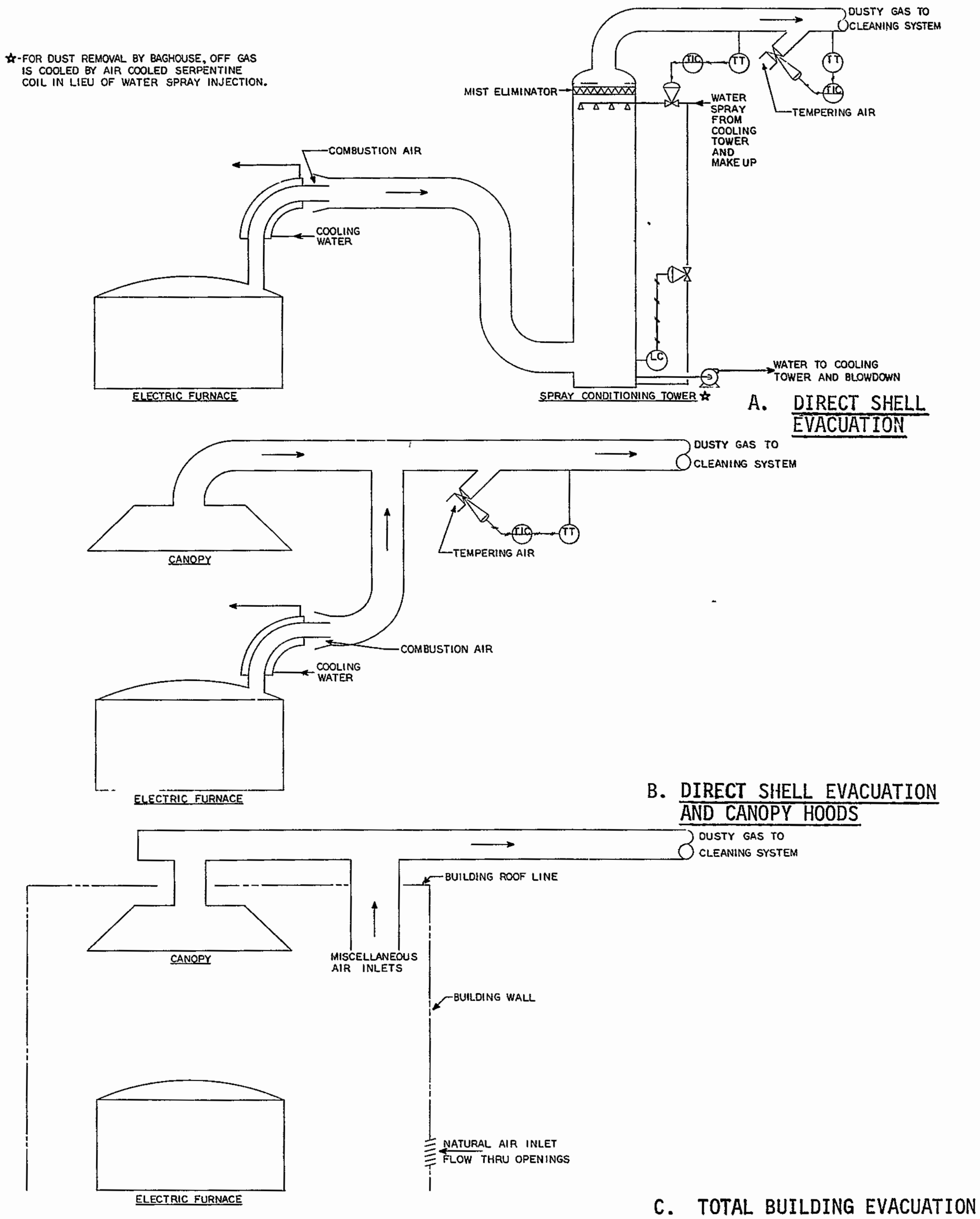


FIGURE Nº VII-I

ELECTRIC ARC FURNACE GAS COLLECTION CONFIGURATIONS

Tables VII-1 and VII-2 set forth detailed cost estimates for fabric filter control in each collection configuration. Costs for precipitators and wet scrubbers are not included since not enough cost information is available for these methods at higher air flow rates.

2. Cost effectiveness.

Tables VII-3 and VII-4 depict the cost effectiveness of the control systems for carbon steel and alloys, respectively. Since it is difficult to judge capture efficiency when a canopy hood is involved, efficiencies of 70%, 80%, and 90% are assumed. If the canopy hood is 80% efficient, the costs are $1.45/ton of steel produced and 4.9¢/pound of particulate matter captured for a carbon steel shop. When total building evacuation is used, the costs rise to $2.49/ton of steel produced and 8.4¢/pound of particulate captured. It should be noted, however, that it costs $2.47 for each incremental pound of particulate captured in going from the direct evacuation with canopies to total building evacuation.

The costs in Table VII-4 for the alloy shop show the same trends at a higher level. If the canopy hood is 80% efficient, the costs are $3.19/ton of alloy produced, and 28¢/pound of particulate captured. Total building evacuation costs $4.97/ton of alloy produced and 35¢/pound of particulate captured. However, in this case the cost for the incremental pound of particulate captured is only 69¢.

TABLE VII-1

ELECTRIC ARC FURNACE CONTROL COSTS FOR SHOP WITH THREE 100 TON FURNACES USING FABRIC FILTER CONTROL DEVICE

| | CARBON STEEL | | ALLOYS | |
|---|---|---|---|---|
| | Direct Evacuation & Canopy Hoods | Building Evacuations | Canopy Hoods Only | Building Evacuation |
| Gas Flow, SCFM (Design) | 600,000 | 1,500,000 | 750,000 | 1,500,000 |
| Investment | | | | |
| Gas Cleaning Device, $ | $1,038,500 | $1,969,700 | $1,246,200 | $1,969,700 |
| Auxiliary Equipment, $ | 433,000 | 651,200 | 440,300 | 651,200 |
| Ductwork, Utilities, $ | 1,265,500 | 1,965,200 | 1,321,400 | 1,965,200 |
| Engineering, Overheads, Etc.,$ | 583,000 | 976,900 | 700,900 | 976,900 |
| Total Investment, $ | $3,320,000 | $5,563,000 | $3,708,800 | $5,563,000 |
| $/Annual Ton Capacity | $9.78 | $16.40 | $10.93 | $16.40 |
| Operating Costs | | | | |
| Operating Labor & Supervision, $/Yr | $ 2,240 | $ 2,240 | $ 2,240 | $ 2,240 |
| Power @ 1.2¢/KWH, $/Yr | 168,370 | 294,520 | 201,600 | 368,020 |
| Make-up Water @ 25¢/1000 Gal, $/Yr | 23,080 | - | - | - |
| Cooling Water Treatment @ 0.2¢/1000 Gal, $/Yr | 1,850 | - | - | - |
| Maintenance @ 6% Inv, $/Yr | 199,200 | 333,780 | 222,530 | 333,780 |
| Property Tax, Insur, G & A, @ 6% Inv, $/Yr | 199,200 | 333,780 | 222,530 | 333,780 |
| 8% Interest (Averaged to 5%), $/Yr | 166,000 | 278,150 | 185,440 | 278,150 |
| Depreciation, 15 Yr. St. Line, $/Yr | 221,330 | 370,870 | 247,250 | 370,870 |
| Total Annualized Cost, $/Yr | $ 981,270 | $1,613,340 | $1,081,590 | $1,686,840 |
| Tons/Yr (7920 Hrs/Yr, 7 Hrs/Heat for Alloys & 3.5 Hrs/Heat for C.S.) | 678,600 | 678,600 | 339,300 | 339,300 |
| Cost/Ton Produced, $ | $1.45 | $2.38 | $3.19 | $4.97 |

TABLE VII-3

COST EFFECTIVENESS: 300 TON CARBON STEEL SHOP[a]
(678,600 Tons/Year Production)

| Type of Control | Dir. Evac. with Open Roof | Direct Evacuation with Open Roof Plus Canopies 70% Eff. | Direct Evacuation with Open Roof Plus Canopies 80% Eff. | Direct Evacuation with Open Roof Plus Canopies 90% Eff. | Building Evacuation | Δ Bldg. Evac. -80% Eff. D.E. & Can. |
|---|---|---|---|---|---|---|
| Particulates: | | | | | | |
| W/O Control, lbs/yr | 20,358,000 | 20,358,000 | 20,358,000 | 20,358,000 | 20,358,000 | 528,600 |
| With Control, lbs/yr | 2,069,700 | 732,900 | 528,600 | 325,000 | 243,600 | 243,600 |
| Controlled, lbs/yr | 18,288,300 | 19,625,100 | 19,829,400 | 20,033,000 | 20,114,400 | 285,000 |
| Net % Efficient | 90 | 96 | 97 | 98 | 99 | |
| Investment, $ | 1,946,900 | 3,320,000 | 3,320,000 | 3,320,000 | 5,563,000 | 2,243,000 |
| $/Ton Annual Capacity | 2.87 | 4.89 | 4.89 | 4.89 | 8.20 | 3.31 |
| Annual Cost, $ | 643,340 | 981,270 | 981,270 | 981,270 | 1,686,840 | 705,510 |
| $/Ton Steel Produced | 0.95 | 1.45 | 1.45 | 1.45 | 2.49 | 1.04 |
| $/lb Particulates Removed | 0.035 | 0.050 | 0.049 | 0.049 | 0.084 | 2.47 |

[a]Emission data from Table II-1.

## TABLE VII-4

### COST EFFECTIVENESS: 300 TON ALLOY SHOP[a] (339,300 Tons/Year Production)

| Type of Control | Canopies with Open Roof 70% Eff. | Canopies with Open Roof 80% Eff. | Canopies with Open Roof 90% Eff. | Evacuation | Δ Bldg. Evac. - 80% Eff. Can. |
|---|---|---|---|---|---|
| Particulates: | | | | | |
| W/O Control, lbs/yr | 5,089,500 | 5,089,500 | 5,089,500 | 5,089,500 | 1,180,100 |
| With Control, lbs/yr | 1,687,000 | 1,180,100 | 665,300 | 305,700 | 305,700 |
| Controlled, lbs/yr | 3,402,500 | 3,909,400 | 4,424,200 | 4,783,800 | 874,400 |
| Net % Efficient | 67 | 77 | 87 | 94 | -- |
| Investment, $ | 3,708,800 | 3,708,800 | 3,708,800 | 5,563,000 | 1,854,200 |
| $/Ton Annual Capacity | 10.93 | 10.93 | 10.93 | 16.40 | 5.47 |
| Annual Cost, $ | 1,081,590 | 1,081,590 | 1,081,590 | 1,686,840 | 605,250 |
| $/Ton Steel Produced | 3.19 | 3.19 | 3.19 | 4.97 | 1.78 |
| $/Lb Particulate Removed | 0.32 | 0.28 | 0.24 | 0.35 | 0.69 |

[a]Emission data from Table II-1.

## B. Economic Impact

Seventy percent of the electric arc furnaces are concentrated in six States: Pennsylvania, Illinois, Ohio, Texas, Indiana, and New York. Their emission limitations for 25 and 100 ton furnaces are compared in Table VII-5 with the proposed standards of performance. The type of equipment and cost of operation are similar to that required by the proposed standard of performance. Due to opacity restrictions which vary from 20% to 40%, a direct shell evacuation system cannot be used as the sole control method since it is inoperative during charging and tapping. These two operations consume more than the usual three to five minutes per hour which are exempt from the normal opacity restrictions in most jurisdictions. Systems with canopy hoods and open monitors may also violate the opacity standards due to emissions that escape capture by the hoods.

For these States, therefore, the proposed standards of performance will have no economic impact. However, the promulgation of a standard of performance will result in the uniform, nation-wide, application of the best available technology. Thus if a company installs a new electric furnace in a jurisdiction with less stringent regulations, the standard of performance will require that the company invest as much in controls as if the unit were installed in Pennsylvania or Illinois.

## C. Overall Economic Considerations

Even though the incremental cost of the proposed standards of performance is not great, the combined cost of State and standards of performance regulations is appreciable.

Table VII-5

SAMPLE STATE EMISSION LIMITATIONS

Kgs/Hr. (Lbs/Hr.)

| | % U.S. Furnaces | Furnace Size: 25 Tons per heat | | | | Furnace Size: 100 Tons per heat | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Carbon Steel[1] | | Alloy[2] | | Carbon Steel[3] | | Alloy[4] | |
| Pennsylvania[5] | 31 | 3.9 | (8.6) | 9.7 | (21.4) | 15.5 | (34.3) | 38.9 | (85.7) |
| Illinois[6] | 10 | 3.4 | (7.5) | 2.4 | (5.2) | 7.2 | (15.8) | 5.0 | (10.9) |
| Ohio[6] | 11 | 7.3 | (16.1) | 4.6 | (10.1) | 18.2 | (40.2) | 11.6 | (25.6) |
| Texas[7] | 8 | 19.7 | (43.4) | 22.6 | (49.9) | 46.5 | (103.0) | 53.4 | (118.0) |
| Indiana[6] | 5 | 7.3 | (16.1) | 4.6 | (10.1) | 18.2 | (40.2) | 11.6 | (25.6) |
| New York[6] | 5 | 6.6 | (14.6) | 4.2 | (9.2) | 16.6 | (36.7) | 10.5 | (23.1) |
| TOTAL | 70 | | | | | | | | |
| Federal Proposal[8] | | 2.7 | (6.0) | 1.9 | (4.3) | 10.9 | (24.1) | 7.8 | (17.1) |

NOTES:

1. 3.5 Hour Heat, 50,000 SCFM
2. 7.0 Hour Heat, 125,000 SCFM
3. 3.5 Hour Heat, 200,000 SCFM
4. 7.0 Hour Heat, 500,000 SCFM
5. Concentration standard
6. Mass Standard
7. Stack Height Correction Not Applied
8. Concentration standard of 0.004 gr/dscf on the control device and assuming 80% efficiency of canopy hoods

Estimates of annual steel capacity from all types of furnaces totaled 157 million ingot tons in 1971.[34] The median estimated for 1976 is 166.9 million ingot tons.[35] It is anticipated that the electric furnace share of this volume will be 17.7%,[36] or 29.5 million ingot tons. This is an increase of 5.5 million tons over the estimated 1971 capacity[34].

The investment required for each incremental ton of steel made is estimated at $246 per ton up to 16 million tons. The amount required for BOF or electric furnaces is $76 per ton.[37] Since 5.5 million more tons of new electric furnace capacity and 0.8 million tons of replacement capacity will be required in the five-year period, the total cost will approximate $480,000,000. In recent years carbon steel has made up about two-thirds of electric furnace production. Assuming average tap to tap cycles of 3.5 and 7 hours for carbon steel and alloy, respectively, and 7,920 operating hours a year, 330 tons of alloy capacity and 320 tons of carbon steel capacity will be required each year.

In order to simulate the economic effect on the industry of the 320 tons of carbon steel and 330 tons of alloy capacity as well as 50 tons of each as replacement capacity, the furnace distribution shown in Table VII-6 was used. For the building evacuation configuration for alloys and the direct evacuation plus canopy hood for the carbon steel shops, the required control investment of $18,670,000 amounts to an additional 19% over the basic $96,000,000 cost per year of production

Table VII-6

INDUSTRY-WIDE AIR POLLUTION CONTROL COSTS

| Furnaces | Strategy 1[1] Investment | Strategy 1[1] Annual Cost[3] | Strategy 2[2] Investment | Strategy 2[2] Annual Cost[3] |
|---|---|---|---|---|
| Carbon Steel: | | | | |
| 2@ 100 tons/heat | $3,000,000 | $ 640,000 | $ 5,500,000 | $1,195,000 |
| 1@ 65 tons/heat | 1,120,000 | 233,000 | 1,980,000 | 388,000 |
| 2@ 50 tons/heat | 1,740,000 | 390,000 | 3,200,000 | 647,000 |
| Sub-Total | $5,860,000 | $1,263,000 | $10,680,000 | $2,230,000 |
| Alloy: | | | | |
| 2@ 65 tons/heat | $3,960,000 | $ 816,000 | $ 3,960,000 | $ 816,000 |
| 2@ 50 tons/heat | 3,200,000 | 667,000 | 3,200,000 | 667,000 |
| 6@ 25 tons/heat | 5,650,000 | 1,123,000 | 5,650,000 | 1,123,000 |
| Sub-Total | $12,810,000 | $2,606,000 | $12,810,000 | $2,606,000 |
| Grand Total | $18,670,000 | $3,869,000 | $23,490,000 | $4,836,000 |
| Grand Total, with Depreciation | | $5,114,000 | | $6,402,000 |

(1) Strategy 1 involves direct evacuation and canopy hoods for carbon steel furnaces, and building evacuation for alloy units.

(2) Strategy 2 involves total building evacuation for both types.

(3) Without depreciation.

equipment with no controls. The annual cost, with depreciation added back in, amounts to $2.00/ton of carbon steel and $8.05/ton for alloys in Strategy 1, which involves building evacuation for alloy and canopy hoods with direct evacuation for carbon steels. Strategy 2, which involves building evacuation for both product groups requires a 26% greater investment and the annual costs with depreciation added back in are $3.65/ton for carbon steel and still $8.05/ton for alloys.

Considering the significant difference in cost and the slight improvement in control, it appears unjustified to set a standard which would require total building evacuation for both product groups.

The annual costs for the canopy hood combinations amount to only about two to four percent of the product values. With the ending of the Phase Four price controls it will be possible to pass this cost forward to the steel consumer. The ending of Phase Four controls should also ease the capital availability problem which has plagued the steel industry the last few years. Rate of return on capital has been difficult to raise. However, with profits regaining a normal level, availability of capital should improve.

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# VIII. ALTERNATIVE STANDARDS

This chapter discusses the alternatives from which the draft standards of performance were selected for presentation to the National Air Pollution Control Techniques Advisory Committee meeting on January 9, 1974. Obviously, the objective of the standard of performance for particulate matter is to minimize the total mass of emissions which a facility releases to the atmosphere. Viable alternatives considered included a concentration limit and standards based on a mass limit. Two overall approaches were considered possible: a single standard for both carbon and alloy shops or separate standards for carbon and alloy shops. Alternatives 1 through 4 in section A were considered for both carbon and alloy shops and can be used in any combination. Alternative 5 of section A was developed as a separate standard for alloy shops. The alternatives considered are grouped according to pollutant and source of emissions.

## A. Alternate Standards for Particulate Matter and Visible Emissions from the Electric Arc Furnace

### 1. Alternative No. 1.[1/]

This option would limit emissions to the atmosphere as follows:

- No more than 0.05 kilogram of particulate matter per hour per metric ton of furnace capacity (0.10 pound per hour per ton).

---

1/ The roof of the building housing the furnace(s) must be sealed (building evacuation) to insure capture of all emissions by the control system. The numerical value of the particulate standard is based on 0.003 grains per dry standard cubic foot (gr/dscf) in an exhaust gas volume of 4000 standard cubic feet per minute per ton of furnace capacity (scfm/ton).

- Less than 10 percent opacity visible emissions, excluding uncombined water, from the air pollution control device.

- No visible emissions, excluding uncombined water, from the building housing the electric arc furnace(s) except for two minutes in any one hour.

a. Advantages.

1) This option is consistent with section 111 of the Clean Air Act.[2/]

2) A sealed building roof (BE) which the limitation on visible emissions from the building requires, insures nearly 100 percent capture of emissions from the furnace.

3) The base concentration of 0.003 gr/dscf includes some buffer since outlet particulate loadings at three alloy shops have been measured at or below 0.0013 gr/dscf.

4) The mass standard will restrict the air flow rate of the control system thereby minimizing total emissions. For fabric filters (the predominant type of control device used) a higher flow rate results in a comparable increase in the mass rate of emissions.

---

[2/] Standards of performance are to reflect "the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction), the Administrator determines is adequately demonstrated." The standard is based on outlet particulate loadings from fabric filters measured by EPA Method 5 at three plants and data on control system air flow rates for existing well controlled plants.

5) The units of this option require use of "best control" independent of the varying cycle length for this batch process. (See Chapter V for a complete review of the alternative units.)

b. <u>Disadvantages</u>.

1) This option, when applied to furnaces producing carbon steel, may result in higher total emissions to the atmosphere than alternatives that allow an open building roof because of the attendant emissions from generation of power necessary to move the greater volumes of air through the air pollution control system.

2) Restriction of the air flow rate through the control system, which may be necessary to achieve this standard, might

a) hamper compliance with heat stress regulations being developed by the Occupational Safety and Health Administration (OSHA).

b) increase concentrations of air contaminants (including dust and carbon monoxide) in the building. OSHA has promulgated "Occupational Safety and Health Standards" for air contaminants.

3) All ventilation air must exit through the control device. Forced draft of these large gas volumes consumes large amounts of energy.

4) Without direct-shell evacuation (alloy shops), more emissions and heat will have to be removed by ventilation of the building (through the control system) than for carbon steel production. Therefore, this candidate would be slightly more stringent for alloy shops.

5) The lowest guarantee by a vendor for a fabric filter on an electric arc furnace shop is 0.004 gr/scf.

6) Collection of dust from the large gas volumes required, necessitates a high investment in the control system and high operating costs.

2. Alternative No. 2.[3/]

This option would limit emissions to the atmosphere as follows:

No more than 9.0 milligrams of particulate matter per dry standard cubic meter (0.0039 grains per dry standard cubic foot) from the air pollution control device.

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[3/] The first two alternatives require an efficient control device, the third a direct-shell evacuation system, and the fourth an efficient canopy hood. A building evacuation system can also achieve the standard.

- Less than 10 percent opacity visible emissions, excluding uncombined water, from the air pollution control device.

- No visible emissions, excluding uncombined water, from the building housing the electric arc furnace(s) except as noted below.

- No more than ____ percent average opacity of visible emissions, excluding uncombined water, from the building directly above and as a direct result of charging or tapping a furnace. The emissions shall not exceed the charging or tapping period by more than three minutes. (Data gathered after the January 9 NAPCTAC meeting were used to develop the level for this alternative. These data are discussed in Chapter VI.)

a. Advantages.

1) This option results in the least total emissions to the atmosphere when emissions from the generation of power necessary to operate the air pollution control system are considered.[4/]

2) Since this option permits open roof shops, it will avoid any impact on control of heat stress of workers or

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[4/] The results of this type of analysis are highly dependent on the capture efficiency of the canopy hood. For about 80 percent capture efficiency and above, advantage 1 is true (see Chapter IV, Section C).

dust and carbon monoxide concentrations in the building.[5/]

3) Vendors have guaranteed 0.004 gr/scf for fabric filters on electric arc furnace shops.

4) Outlet particulate loadings at several shops have been measured at less than half the level of this alternative.

5) This option will result in less consumption of electrical power than Alternative No. 1, because smaller quantities of gas must be moved by mechanical draft.

6) This option will have a lesser economic impact on the steel industry than Alternative No. 1, because smaller quantities of gas have to be cleaned.

7) This option is achievable by either of two control systems.

8) This option will encourage use of a direct shell evacuation system with its attendant reduction of carbon monoxide emissions.

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[5/] If a direct shell evacuation cannot be used or an equivalent system cannot be developed for use with "reducing slags," the roof of the building will have to be closed. In these cases, should higher ventilation rates be required to meet OSHA's regulations, increased gas flow, cost and energy consumption will result for the control system.

b. Disadvantages.

1) This option is not consistent with the concept of applying best technology (taking into account costs) to the affected facility.[6/]

2) The quantity of emissions that will result from this option is not accurately known. Emissions from the building are estimated from assumed values for parameters such as the capture efficiency of the canopy. No method exists to measure these parameters.

3) This option will allow some visible emissions from the open roof. Measurement of these emissions is more difficult than for those from a stack.

4) A standard based on average opacity would be more difficult to enforce than a maximum. Continuous readings would have to be made over the specified period and synchronized with process operations.

3. Alternative No. 3.[7/]

This option would limit emissions to the atmosphere as follows:

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[6/] Alternative No. 1 will result in lower emissions from the electric arc furnace shop than Alternative No. 2.

[7/] This candidate would require the same control systems as Alternative No. 2. Only the method of enforcing use of an efficient canopy hood or equivalent is changed.

- No more than 9.0 milligrams of particulate per dry standard cubic meter (0.0039 grains per dry standard cubic foot) from the air pollution control device.

- Less than 10 percent opacity visible emissions, excluding uncombined water, from the air pollution control device.

- No visible emissions, excluding uncombined water, from the building housing the electric arc furnace(s) except from the building directly above and as a direct result of charging or tapping a furnace. The emissions shall not exceed the charging or tapping period by more than three minutes.

- A canopy hood shall be installed above each furnace. The hood should be designed according to the equations and criteria in sections 4.2.3 and 5.4.4 of Steel Mill Ventilation, May 1965, published by the Committee on Industrial Hygiene, American Iron and Steel Institute. Other equipment may be used if demonstrated to the Administrator's satisfaction that it will capture at least an equivalent amount of the furnace emissions during charging and tapping.

a. Advantages.

1) All the advantages for Alternative No. 2 apply.

2) Measurement of visible emissions from a building roof is not required.

b. Disadvantages.

1) Disadvantages 1 and 2 for Alternative No. 2 apply.

2) An "equipment" standard is not consistent with the "emission limitations" concept in section 111 of the Clean Air Act.

3) This option presumes a canopy hood designed in this manner will always achieve a capture efficiency of 81 percent or greater. In reality, the efficiency of any such hood cannot be accurately determined.

4. Alternative No. 4.[8/]

This option would limit emissions to the atmosphere as follows:

- No more than 9.0 milligrams of particulate per dry standard cubic meter (0.0039 grains per dry standard cubic foot).

- Less than 10 percent opacity visible emissions, excluding uncombined water, from the air pollution control device.

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[8/] The same control system would be required as for Alternative No. 1, except there is no restriction on gas volume.

No visible emissions, excluding uncombined water, from the building housing the electric arc furnace(s) except for two minutes in any one hour.

a. Advantages.

1) This option will avoid any conflict with considerations of heat stress of workers or dust and carbon monoxide concentrations in the building. (This option does not restrict the ventilation rate for the building.)

2) A sealed building roof, which the standard requires, insures nearly 100 percent capture of emissions from the furnace.

3) Vendors have guaranteed 0.004 gr/scf for fabric filters on electric arc furnace shops.

4) The standard is clearly achievable since, outlet particulate loadings at several shops have been measured at less than half the level of this alternative.

b. Disadvantages.

1) This option, which does not restrict the air flow rate through the control system, permits high mass emission rates from fabric filters, the predominant type of control device used.

2) Disadvantages 1, 5 and 6 for Alternative No. 1 apply.

5. <u>Alternative No. 5</u>. (for alloy steel production only)[9/]

This option would limit emissions to the atmosphere as follows:

- No more than 0.065 kilograms of particulate per hour per metric ton of furnace capacity (0.13 pound per hour per ton).

- Less than 10 percent opacity visible emissions, excluding uncombined water, from the air pollution control device.

- No visible emissions, excluding uncombined water, from the building housing the electric arc furnace(s) except for two minutes in any one hour.

a. <u>Advantages</u>.

1) All the advantages for Alternative No. 1 apply.

2) This option allows higher ventilation rates which will remove additional heat and pollutants (normally captured by a direct shell evacuation system in a carbon shop) from the shop atmosphere.

b. <u>Disadvantages</u>.

1) Disadvantages 1, 2, 4, 5 and 6 for Alternative No. 1 apply.

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[9/] This candidate is the same as Candidate No. 1 except the numerical value of the particulate standard is based on an exhaust gas volume of 5000 scfm/ton.

2) This option would not provide as much incentive for industry to minimize air flow rates as Alternative No. 1.

B. Alternative Standards for Carbon Monoxide Emissions from the Electric Arc Furnace

1. Alternative No. 1.

Do not promulgate a standard of performance.

a. Advantages.

1) Limited information is available to define a standard. The contribution to CO emissions from sources other than the furnace and the process parameters that affect CO formation in a furnace are not well known.

2) Accurate measurement of the mass rate of carbon monoxide emissions, as a standard would require, is difficult. Because of extreme and rapid variation, both concentration and gas flow must be continuously measured to accurately determine mass emissions during a compliance test. Continuous measurement of gas flow may require an in-line meter in the control system duct.

3) If a particulate standard is proposed that requires or encourages use of a direct shell evacuation system, carbon monoxide emissions will be minimized without a standard.

b. Disadvantages.

1) A standard would require use of a direct shell evacuation system. This system can achieve a substantial reduction not only in carbon monoxide emissions but also particulates.

2) A standard may result in even better control than required. Control of carbon monoxide with present systems is incidental to the basic function of the system. Without a standard future systems may not be designed to optimize control of CO.

2. Alternative No. 2.[10/]

This option would limit emissions to the atmosphere as follows:

No more than 0.3 kilogram of carbon monoxide per hour per metric ton of furnace capacity (0.6 pound per hour per ton).

a. Advantages.

1) This option is consistent with the intent of section 111 of the Clean Air Act as amended to require the best control technology.

2) Emissions measured by EPA will support this limitation.

3) The disadvantages for Alternative No. 1 are advantages for this alternative.

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10/ A direct shell evacuation system would be required. The standard would not apply to furnaces where a "reducing slag" is used to produce alloy steels.

b. Disadvantages.

The advantages for Alternative No. 1 are disadvantages for this alternative.

C. Visible Emissions from Handling of Dust Collected by the Fabric Filter

1. Alternative No. 1.

This option would limit emissions to the atmosphere as follows:

Less than 10 percent opacity visible emissions from on-site handling of dust collected by the air pollution control device.

a. Advantages.

1) This option requires the best technology, consistent with section 111 of the Clean Air Act, as amended.

2) This option would require adequate procedures for removing dust from the control device to prevent escape to the atmosphere.

b. Disadvantage.

Dust which escapes to the atmosphere as it is removed from the control device is probably a minor source of total emissions from a steel plant.

2. Alternative No. 2.

Do not promulgate a standard of performance. The advantages and disadvantages are the inverse of those above.

## D. Discussion of the Alternative Standards

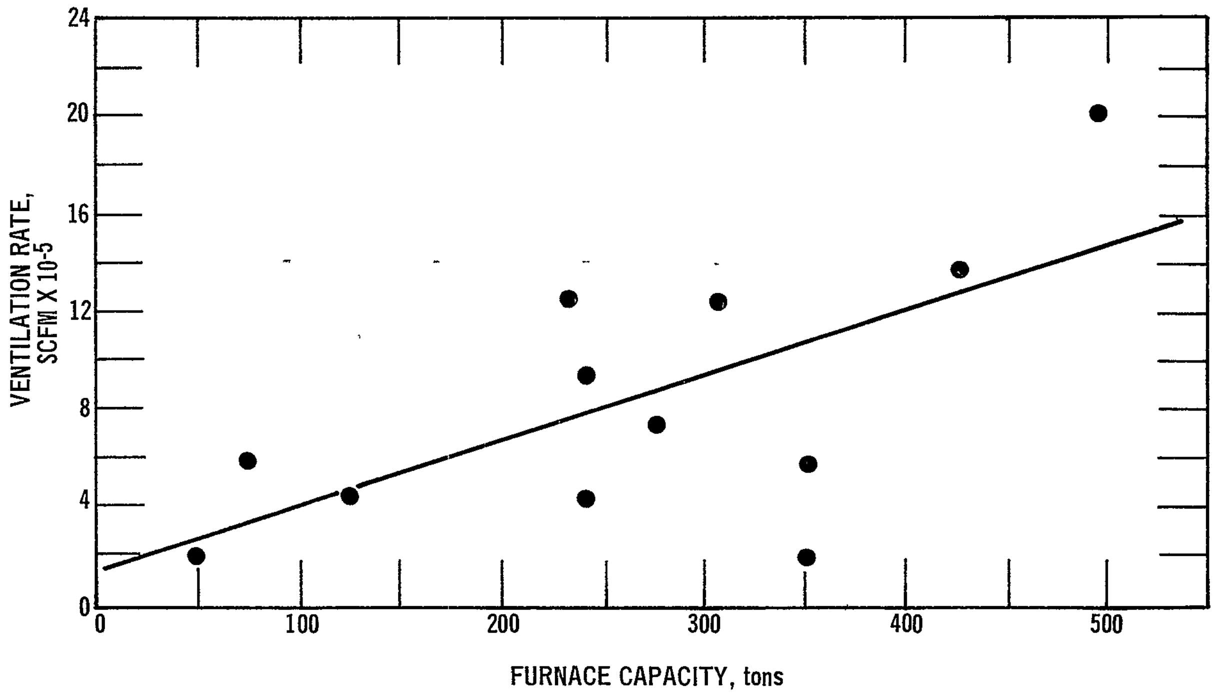
A concentration limit alone will not minimize emissions since the mass rate of emissions is equal to the product of concentration and air flow rate (grams/dscm x dscm/hour = grams/hour). A mass limit does minimize emissions for a given time period. There are, however, additional factors which make both types of limits viable options. Factors such as: 1) the potential interface between air pollution and occupational health standards when air flow rate is limited, and 2) economic incentives for industry to limit the flow rate without government regulations, are presented in the advantages and disadvantages of the alternative standards considered in this chapter.

Alternatives numbered 1 and 5 for the standard for particulate matter limit the mass rate of emissions, which indirectly restricts the shop ventilation rate. The limits were "back-calculated" based on an emission concentration of 0.003 gr/dscf. (Results of the only facility sampled by EPA showed average emissions from Plant A, an alloy shop, of 0.0013 gr/dscf. Two tests of other plants conducted by industry showed average emissions of even less.) Admittedly lenient, a basis of 0.003 grains per dscf includes a buffer which should accommodate any fluctuation in the discharge concentration from a fabric filter, that might result from the higher inlet concentrations found in high productivity carbon steel shops.

The second basis for alternatives 1 and 5 is the air flow rate. Before selecting a numerical level the best method of expressing the flow rate had to be determined. Two alternatives are furnace capacity, and production rate. Ventilation rates provided by operators of shops with closed roofs are presented as a function of both in Figure VIII-1. The correlation was calculated by the least squares method and the correlation measured by the root-mean square of the y-deviations. Although neither correlation is good, the correlation with furnace capacity is slightly better. Since production rate is dependent on both furnace capacity and heat length (productivity), it should have shown the best correlation if productivity were a significant factor in determining ventilation rates. This shows that shop productivity is not a large factor, however, furnace capacity still does not correlate well. About the same degree of correlation results from an examination of ventilation rates and the volume of the shop buildings. In the absence of a better yardstick, furnace capacity is used as the basis.

The 4000 scfm/ton basis for alternative 1 is based on ventilation rates (presented in Figure III-6) of existing plants or those under construction. Seven of these 12 plants use less than 4000 scfm/ton and three are just above this level. One plant under construction is designing a new closed roof control system with a ventilation rate of 4100 scfm/ton.

The volume restriction is increased to 5000 scfm/ton for alternative 5. If the data for ventilation rates of alloy shops with closed roofs are considered, only three of seven shops use less than 4000 scfm/ton. Five use less than 5000 scfm/ton and one is slightly greater than this value. Also, the only existing closed roof carbon shop uses a maximum flow of 5000 scfm/ton during periods when the DSE system is disconnected.



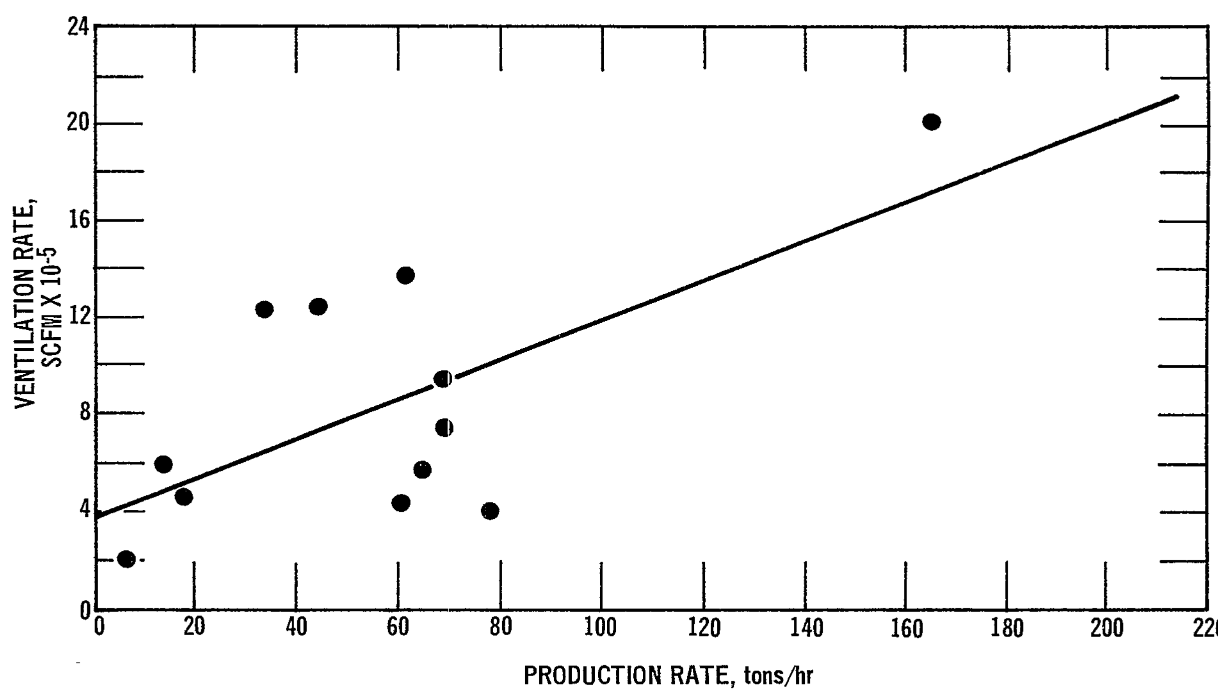




Figure VIII-1. Ventilation rate correlations

An average flow of 3900 scfm/ton is achieved by a reduction in flow when the DSE system is operating. A comparable alloy shop without a DSE system would need the maximum flow at all times.

A carbon steel shop may have an emission factor as much as six times that of an alloy steel shop. Although those knowledgeable in the design and operation of fabric filters generally agree that outlet concentrations should be nearly independent of the inlet concentration (after the fabric is precoated and the fabric cleaning variables are suitably adjusted), only one published article was found that discusses this topic. The author stated that a ". . . fabric filter might well operate with the same outlet concentration when the inlet loading changed tenfold."(13) Because of this limited amount of available information, the alternative of 0.003 gr/dscf was considered reasonable for the shop alone.

A disadvantage of a more liberal concentration basis is that the designer of the air pollution control system might well absorb the higher permissible emissions by designing for a higher flow rate through the control device, thereby, significantly increasing mass emissions. (Since the mass emission rate is the product of the concentration and air flow rate, an increase in a mass standard will allow an increase in either variable.) A designer is not likely to change his judgment of the concentration he expects from a fabric filter because the standard has a more lenient buffer on concentration. His judgment would be that he can use a higher air flow rate.

For alternatives 2 through 4, the alternative of 0.0039 gr/dscf was considered. This alternative will not result in a significant change in the air pollution control system required. The same type and design of control device (fabric filter) will be installed. A number too lax, however, could permit a decrease in emphasis on maintenance of the control device over a long period of time. The 0.0039 gr/dscf level corresponds to the lowest level that has been guaranteed by vendors of fabric filters.

## E. Draft Standards of Performance

The standards of performance presented to the National Air Pollution Control Techniques Advisory Committee on January 9, 1974, were selected from the previously discussed alternatives. The selection of one alternative over another necessarily involves matters of judgment on issues which cannot be precisely quantified. Consequently no one alternative is entirely without disadvantages, but when all factors were considered some alternatives were clearly more viable than others. The standards presented at the January 9 meeting consisted of the alternatives which were judged to be the more viable. The alternatives selected were alternative 2 for the standard of particulate matter and visible emissions, alternative 1 of the alternative standards for carbon monoxide emissions and alternative 1 of the alternative standards for visible emissions from the dust handling equipment. Since the January 9, 1974, NAPCTAC meeting the draft standards of performance have been revised to the proposed standards discussed in Chapter II.

1. The Draft Standards of Performance.

The draft standards presented at the January 9 meeting suggested limitation of emissions to the atmosphere as follows:

- No more than 9.0 milligrams of particulate per standard cubic meter (0.0039 grains per standard cubic foot) from the air pollution control device.

- Less than 10 percent opacity visible emissions, excluding uncombined water, from the air pollution control device.

- No visible emissions, excluding uncombined water, from the building housing the electric arc furnace(s) except as noted in the next paragraph.

- No more than _____ percent average opacity of visible emissions, excluding uncombined water, from the building directly above and as a direct result of charging or tapping a furnace. The emissions shall not exceed the charging or tapping period by more than three minutes.

- Less than 10 percent opacity visible emissions from on-site handling of dust collected by the air pollution control device.

2. Reasons for Selection of These Standards of Performance.

There are two distinct phases in the selection of a standard of performance. First, the system which best controls air pollution within the intent of the Act must be identified. Second, the regulation must be written to require use of this best system of air pollution control or equivalent alternative methods, yet not preclude improved control methods.

The proposed standard is based on installation of a direct shell evacuation (DSE) system in combination with an efficient canopy hood. However, it can also be achieved with a building evacuation (BE) system. If the owner elects to use the combination system, the roof can remain open for supplemental ventilation of the furnace shop.

a. The reasons for basing the standard on this combination system as representative of best emission reduction are:

1. The "total environmental impact"[11/] of the combination system with an open roof on the shop is potentially less than that from a closed roof system.

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[11/] "Total environmental impact" is the sum of particulate emissions from the electric arc furnaces and all incremental emissions, particulate, $SO_2$ and $NO_x$, from a new coal-fired power plant which provides electricity to run the air pollution control system. The power plant is assumed to meet the standards of performance for new fossil-fueled power plants. This analysis is highly dependent on the value assumed for the capture efficiency of canopy hoods. (Actual measurement would be extremely difficult.) The open roof system is optimum for hoods of 81 percent or greater capture efficiency.

2. This standard permits natural draft ventilation through the open roof thereby avoiding any potential impact of standards of performance on existing or pending occupational safety and health regulations.[12/]

Those operators of alloy steel shops who cannot use a direct shell evacuation system may elect to use a building evacuation system. Should higher ventilation rates be required to meet OSHA regulations, increased gas flow, cost and energy consumption will result.

3. This standard results in a lower economic impact than if all shops were restricted to a BE system.[13/]

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12/ One of many controllable variables used to assist in meeting standards for "Occupational Safety and Health" is the ventilation rate of the workers' environment. The value and amount of ventilation necessary to achieve specific standards is very difficult to quantify. This is particularly true for heat stress regulations still under development and which will be affected by climate.

13/ Supplemental ventilation through an open roof minimizes air flow through the control device. This results in a smaller capital investment in the control device, lower operational costs and lower energy consumption.

4. This standard will require less energy consumption than if all shops were restricted to a BE system.

5. This standard provides limited flexibility, as an operator may use either of two capture systems.

6. The 9.0 milligram per cubic meter (0.0039 grain per standard cubic foot) limit on particulate matter emissions from the control device is based on results of measurements by EPA.

7. The visible emission limitation on the control device is supported by EPA's observations.

8. Control of carbon monoxide emissions will be maximized because this standard encourages a DSE system. (See page III-3).

9. The visible limitation to minimize reentrainment of dust collected by the control device is supported by EPA's observations.

b. The wording of this regulation was selected for the following reasons:

1. Concentration units were selected for emissions from the control device to allow the operator the latitude to ensure good capture velocity at the canopy hood thereby minimizing emission losses through the open roof. Mass units would limit gas flow through the control device.

2. The opacity limit on emissions from the control device provides an easily enforceable standard minimizing the time and expense of periodic performance tests.

3. Absolute prohibition of visible emissions from the building roof for most of the furnace cycle ensures that the DSE system will be operated. For example, a standard of "less-than-10-percent-opacity," would not preclude emissions from escaping the furnace and becoming heavily diluted within the building before passing through the roof.

4. Two alternatives were considered to ensure maximum control during charging and tapping. These are a visible emission limitation and design specifications for a canopy hood. A visible standard is recommended because it does not discourage innovative improvements in design of future control systems and a standard that specifies a type or design of equipment has questionable legality.

5. This standard is based on the average opacity of emissions (the arithmetic average of reading every 15 seconds, including zeros) during the charge, or tap, and three minutes after. A charge is defined as the period when the furnace roof is open and a tap as the period when the furnace is tilted to tap molten steel.

An alternative to a limit based on "average opacity" is a maximum visibility that shall never be exceeded. This, of course, is by far the most common type of opacity regulation. In the present case, however, the concept of average opacity has an advantage.

This averaging technique acknowledges that the opacity of emissions may have large and rapid variations which may not relate well to mass emissions. Average opacity provides a more quantitative measure of emissions. The total mass of emissions from the building is a function of both the opacity and duration of emissions. The period specified over which the visibility of emissions is averaged is generally longer than the duration of the emissions. Therefore, if the emissions were 50 percent opacity for one-half the period and 0 percent for the other half of the period, the average opacity is 25 percent. If they last for three-fourths of the period, the average is 38 percent. In both examples, the maximum opacity is 50 percent; therefore, the maximum limit does not relate to the total quantity of emissions. This average opacity approach has added importance because opacity standards are the only restriction placed on charging and tapping emissions.

6. The opacity limit for on-site handling of dust collected by the control device provides an easily enforceable standard that assures proper precautions during transfer of this fine particulate.

3. Economic Impact.

As shown in Chapter VII, the per ton cost of air pollution control is approximately twice as great for a small shop with one 25 ton furnace as for a larger shop with three 100 ton furnaces, yet it amounts to only 2 to 4 percent of the current selling price of steel.

With the current high demand for steel and the prospective relaxation of price controls, there should be no problem in passing along the entire cost of both State standards and standards of performance.

# IX. ENFORCEMENT ASPECTS OF THE PROPOSED STANDARD

## A. General

One difficult situation that may be encountered during enforcement of the proposed standards of performance is an affected facility located in the same building with other sources of particulate matter emissions. Emissions from these other sources may mix with those from the affected facility. The proposed regulation specifies that when the other emissions are from existing furnaces, compliance may (subject to approval by the Administrator) be demonstrated for the new furnace without a test. The operator must show that the control system is equivalent or superior to that which would be required if the furnace were installed in a new shop. Another option for the operator is to base compliance on control of all the sources.

When the extraneous emissions are from sources other than furnaces, the plant operator may choose from the following options.

1. Base compliance on control of all emission sources.

2. Shut down the other emission sources during the compliance test.

3. Use a method acceptable to the enforcement agency to compensate for the effect of the other emission sources on results of the compliance test, or

4. Any combination of the above.

## B. Determination of Compliance With the Concentration Standard

The control system installed to comply with the proposed standards may have any of several configurations. One control device may serve several affected facilities, or several control devices may serve one affected facility. Where several control devices are involved, the proposed regulations provide for use of a flow-weighted average concentration to determine compliance. For the other case, the regulation provides that a common compliance test of the single control device is sufficient to show compliance for all the affected facilities. These provisions allow the proposed standards to be reasonably enforced without restricting options for the design of control systems.

From the standpoint of measuring the concentration of emissions, effluents containing particulate matter can be placed into three broad categories: (1) those confined within a single stack, (2) those exhausted through multiple stacks, and (3) those not constrained within a stack or duct after exiting the control device. The enforcement aspects of performance testing vary according to the category and are discussed below.

(1) Effluent confined within a single stack. The methods specified in 40 CFR 60 (36 FR 24876 - Methods 1, 2, 3, 4, and 5) provide specific

guidelines applicable for measurement of emissions from a stack. Unlike existing sources which sometimes require deviation from optimum sampling procedures due to the physical limitations of the facility, new sources can and should be designed for optimum accuracy of sampling. As an example, an optimum sampling location is 8 or more diameters downstream and 2 or more diameters upstream from anything that might disturb the flow of exhaust gas such as an orifice or elbow in the line. Although the reference methods allow deviation from this optimum criteria, new facilities should be designed for accurate and precise results from sampling. Furthermore, utility services and sample access points can also be incorporated in the design of new sources to facilitate sampling.

(2) Effluent exhausted through multiple stacks. Actual test procedures are similar to category 1 except the number of samples required and the attendant costs may become excessive. In such a case, a limited sampling plan may be suggested by the enforcement agency. Possible variations are: a) particulate tests of select representative stacks with concurrent velocity measurements at similar stacks; b) particulate tests on a limited number of stacks combined with an evaluation of design and operating parameters to determine comparability between those stacks sampled and those not sampled.

(3) Effluent not constrained within a stack. This category will include emissions from open or pressure baghouses. Performance

test methods applicable to these configurations have not been specified due to the limited experience and the lack of proven techniques available for testing.

Several problems are involved in such testing. First, due to large (and sometimes multiple) cross section areas through which emissions are exhausted, it is not practical to sample at enough points to totally define the flow profile. To overcome this limitation, assumptions are made to determine the minimum number of samples necessary to estimate the actual flow characteristics. When their locations are determined, the sub-areas they represent may then be sampled with Method 5 (or other sampling techniques, including high volume sampling). These individual points may be sampled by traversing, or by simultaneous sampling at multiple points. One scheme is to draw a high volume sampler across the horizontal cross-section of a roof monitor. Another, used in the aluminum industry, involves extraction of effluent from representative sampling points by use of a permanent multipoint sampling manifold. The manifold discharges into a single stack which can then be sampled with conventional techniques.

A second problem results from low flow rates common in large area discharges. They often cannot be measured with conventional equipment. Low flow rates preclude accurate isokinetic sampling and determination of actual volumetric flow rates. This problem is usually resolved by determining average velocities with sensitive measuring devices and then sampling at this average rate. Volumetric flow rate may be determined in a similar manner. (If dilution air is not present, volumetric flow rate may be more accurately determined on the inlet side of the control device.)

Use of dilution air presents a third and equally serious impediment to accurate emission measurements. Since a concentration limit (mass per volume) requires a correction for dilution air and a mass emission limit requires measurement of actual volumetric flow rates, in either case it is necessary to measure flow rates. This may prevent, or at least will seriously hamper accurate emission measurements.

Due to these problems, the accuracy and precision attainable in making mass determinations appears limited and, in fact, certain source configurations totally defy representative sampling. For most sources, however, plans can be developed which should yield sufficiently accurate data to determine compliance. Due to the potential cost, the owner and the enforcement agency should consider and agree, prior to construction of a new facility, on a specific means for determining compliance.

EPA is now examining typical configurations of exhaust systems being marketed to determine optimum test criteria. Until such criteria are available, owners should select exhaust systems which will allow representative sampling in accordance with 40 CFR 60.

## C. Determination of Compliance With Visible Emission Standards

Generally, visible emission limitations are standards that do not require that the plant be notified before a determination of compliance is made. Their prime function is to insure that air pollution control equipment is properly operated and maintained.

Enforcement of the standards for handling of dust collected by the control device and on emissions from the electric arc furnace shop (except during charging and tapping) require some knowledge of what operations are actually occurring during the test. Since dust removal from the control device, charging, and tapping operations are noncontinuous, the observer will have to determine when these operations are scheduled before visiting a plant for opacity readings or determine if such operations have been in progress during observations conducted without prior notice.

The visible emission standards limit the opacity during specifically defined charging and tapping periods. To properly enforce these standards, the periods of observation must be correlated with process operations which are actually taking place.

## D. Installation and Operation of an Opacity Monitoring Device

EPA proposed performance specifications for opacity monitors on September 11, 1974 (39 FR 32852). These specifications are based on commercial instruments now available which are capable of measuring opacity within a narrow path of 50 or more feet in length. Instruments which are installed and operated in accordance with the specifications will produce reliable opacity data. Effluent discharged through a stack or duct can be readily monitored.

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# X. MODIFICATIONS

If the equipment or operation at an affected facility is altered in a manner which increases air pollution, that existing facility may become subject to the standards of performance in accordance with section 111(a)(4) of the Clean Air Act as amended. This provision was interpreted in §60.2 of 40 CFR 60.

A change in the type of steel produced may be considered a modification if it increases the emission rate. An example would be a change from carbon to alloy steel production which may preclude further use of a direct shell evacuation system. A second possibility is increasing the transformer capacity to increase production. These changes, although economical ways of meeting market demands or increasing production with minimal investment, may still be considered modifications thereby rendering the facility subject to the standards of performance.

The following would not be considered a modification:

A. Changes in raw materials, types of scrap steel or use of slags to produce steels for which the furnace was originally designed.

B. Routine replacement of furnace linings, or other components of the furnace and air pollution control system.

The impact of upgrading an existing system will vary with each case. The ease of design and cost of hoods or other equipment for efficient capture of pollutants may vary significantly depending on the configuration of the building housing the furnaces.

# XI. MAJOR ISSUES CONSIDERED

Development of the alternative and proposed standards of performance discussed in Chapter VIII and Chapter II revolved around several key issues. These issues are:

A. What is the proper environmental and energy balance when the benefit of increasingly efficient air pollution control is weighed against the pollution caused by generation of the additional power required to achieve the better control?

B. Should improved air pollution control be required at the expense of ventilation air in an electric arc furnace (EAF) shop. If so, at what point is it incompatible with regulations of the Occupational Safety and Health Administration to protect and enhance the worker's environment?

C. Are visible emission standards applied to the shop the best method of assuring good capture of charging and tapping emissions?

D. How can a standard be enforced for a new furnace installed in an existing shop where emissions from the furnace often co-mingle?

These issues are discussed below:

## A. Issue No. 1. The Proper Balance Between Control of Air Pollution And Emissions Caused by Generation of the Power Required For Air Pollution Control

Chapter IV shows that a building evacuation (BE) system minimizes the particulate emissions from EAF's; however, it also requires the control device to clean a much larger volume of air than competitive control systems. Handling this large volume of air requires large amounts of energy which of course, indirectly results in more air pollution at the power plant which generates the energy. A comparison of the sum of emissions from EAF's and from generation of the power required by control systems for a BE and direct shell evacuation-canopy hood (DSE-CH) system is presented in Chapter IV It revealed that these two systems are equivalent if the CH achieves slightly over 80 percent capture of the emissions during charging and tapping of the furnace.[1/] The basic question then is, can a CH reasonably be expected to achieve over 80 percent capture efficiency? A BF system is required by Alternative Standards Number 1, 4 and 5 in Chapter VIII and a DSE-CH system can achieve the control limitations of Alternatives 2 and 3.

No method or techniques exist to measure or even to reliably estimate the capture efficiency of a CH. Visual observations show the capture efficiency varies considerably with each charge or tap. The hoods appear to capture from 50 to 90 percent of the emissions. It seemed reasonable, although not certain, that CH's may indeed capture over 80 percent of charging and tapping emissions. If so, a standard that requires BE might indirectly increase the air pollution generated by the manufacture of steel

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1/ With BE the roof ot a shop is closed and all air which leaves the shop must pass through the control device. The capture efficiency is 100 percent. With CH's, some emissions escape capture and are discharged through the monitors on the roof of the shop. If the monitors are closed, all ventilation air must discharge through the control device, which significantly increases the energy required to control the shop.

because of the contribution from the power plant. The lower energy requirements of the DSE-CH system also make it desirable. Consequently, the standard being proposed will allow use of the DSE-CH system.

## B. Issue No. 2. Restriction of Shop Ventilation

The total mass of emissions from an EAF is directly proportional to the volume of gas which must be cleaned, as explained in Chapter III. Since the mass emitted is equal to the product of the volumetric air flow and its concentration of particulate, a regulation expressed in mass units (Alternatives 1 and 5 in Chapter VIII) will limit the amount of air flow. Alternatives 2, 3 and 4, for a standard on particulate matter, based on concentration limits, place no restriction on the plant operator. He may use as high an air flow as he feels is necessary to ventilate the building. There remains an economic incentive for a plant operator to minimize air flow since the size, capital cost and operating cost of the control device is directly proportional to the flow. Alternatives 2, 3 and 4 also allow a DSE-CH system with an open roof on a shop. With this system, the air flow through the CH must exceed some minimal value to insure good capture of emissions. In this case, limiting the air flow through the control device is of secondary importance since any losses from inefficient capture efficiency of the CH's are of far greater magnitude. Any decision that a standard of performance should limit air flow through a BE system would require a determination of the effect of reduced ventilation on deterioration of the worker's environment.

The industry has indicated a very strong concern for their ability to comply with an environmental standard that restricts the volume of ventilation air and still comply with regulations of the Occupational Safety and Health Administration (OSHA). OSHA has promulgated the following standards for the workers' environment.[38]

| Material | Concentration |
|---|---|
| Iron oxide fume | 10 mg/m$^3$ (.0044 gr/dscf) |
| Inert or nuisance dust | |
| Respirable fraction | 5 mg/m$^3$ (.0022 gr/dscf) |
| Total dust | 15 mg/m$^3$ (.0066 gr/dscf) |
| Carbon monoxide | 50 ppm by volume |

These concentrations are eight hour time weighted averages.

OSHA is also developing a standard for workers in hot environments. Their "Standards Advisory Committee on Heat Stress" has recommended that specific work practices be required if the wet bulb globe temperature (WBGT) exceeds specified limits from 79 to 90, depending on workload and air velocity.[39] The temperature would be calculated as a two hour average. WBGT is calculated from the following equation:

$$WBGT = 0.7\ WB + 0.3\ GT$$

where:

WB = the natural wet-bulb temperature obtained with a wetted sensor exposed to the natural air movement

GT = globe thermometer temperature

(A globe thermometer primarily measures radiant heat.)

Although high air ventilation rates can lower the temperature in an electric arc furnace shop, they do not reduce the effects of radiant heat. Other means available to protect workers from heat stress and permit compliance with the standard ultimately promulgated are:

1. Decrease the number and duration of workers' exposures to the hot environment.

2. Provide an air conditioned rest area to decrease the time weighted average temperature.

3. Use portable fans to blow air on the workers.

4. Blow air ducted from outside the shop (and possibly cooled) on the workers.

5. Use radiation shields.

6. Use protective clothing.

In correspondence with EPA, OSHA has indicated that although they agree some ventilation air is requisite to achieve any standard ultimately promulgated, they do not have sufficient data to say how much. (They also point out that other means such as those listed above are available to control heat stress.)[40],[41] Neither is data available on pollutant concentrations in a shop to determine the amount of ventilation required to meet OSHA's standards for dust and carbon monoxide cited above. The industry has historically used the maximum air flow rates that can be achieved by natural ventilation to optimize the working environment at minimum cost. In hot climates, these natural rates may be much higher than 4000 scfm/ton of furnace capacity typical of most existing BE systems (see Figure III-6). Representatives of the steel industry have indicated that as much as 10,000 scfm/ton of furnace capacity may be a prerequisite to complying with OSHA standards.

The data on ventilation rates for existing BE systems indicates that 4000, when a DSE system is used to remove fumes and heat from a shop, or 5000 scfm/ton of furnace capacity would be reasonable limits for Alternative Standards Number 1 and 5 presented in Chapter VIII. However, Alternative 2, the draft standard, does avoid any possible conflicts over the quantity of ventilation air needed for EAF shops.

## C. Issue No. 3. Visible Emission Standards on the Shop

The standard being proposed allows a DSE-CH system and open monitors on the roof of the shop to be used. This control system is satisfactory only if the standard requires installation of efficient CH's. Two alternatives were discussed in Chapter VIII which would assure this. The first is through specification of the design of a CH. A second way would be through application of a visible emission standard to the shop during charging and tapping. A specification or "equipment" standard may discourage innovative approaches to air pollution control and thwart advancement of technology.

Unfortunately, the alternative of visible emission standards also has disadvantages when applied to large open areas such as a monitor on an EAF shop. Readings of opacity from such areas are difficult because the emissions may diffuse over a large area before leaving the shop and the plume emits at a low velocity. Collectively, they make the plume indistinct. Another disadvantage is that enforcement officials will have to contact the owner to obtain process data to assure that visible emissions occur only during those furnace operations when they are permissible.

## D. Issue No. 4. New Furnace in an Existing Shop

Many new EAF's will be installed in existing shops. In these cases or if one of several existing furnaces in a shop is modified, emissions from the new or modified furnace may be inseparable from the existing facilities' emissions. This is primarily true for a BE system which may be used by a shop producing alloy steel to meet the proposed standard. Emissions from all the furnaces diffuse together in the roof area of the shop. A compliance determination would be difficult, if possible at all. To insure collection of the new or modified furnace's emissions, the entire shop will have to be controlled; thus forcing control of existing sources. One alternative is to apply the proposed standard only to grass roots shops, however, this would significantly reduce the impact of the standard. Another alternative is to judge the facility in compliance (without a compliance test) if a control system equivalent to that necessary for a grass roots shop is installed. Even though this in essence requires an "equipment standard," which is of questionable legality for standards developed according to section 111 of the Clean Air Act, no other viable alternatives were identified. This alternative was selected for the proposed standard.

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16 ABSTRACT


This volume is the first in a series on the standard of performance for electric arc furnaces in the steel industry. This volume provides background information and rationale used in the development of the proposed standard of performance. The economic and environmental impacts of the standard are discussed.


17 KEY WORDS AND DOCUMENT ANALYSIS

| a DESCRIPTORS | b IDENTIFIERS/OPEN ENDED TERMS | c COSATI Field/Group |
|---|---|---|
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