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Air

Development of Air Pollution Control Cost Functions for the Integrated Iron and Steel Industry

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
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ABSTRACT

The capital and operating costs are determined for equipment to control air pollution from all significant emission sources in an integrated steel mill. The facilities of every integrated steel mill in the United States are tabulated. Control costs are examined as a function of increasing stringency of control. State and local air pollution regulations applicable to steel mill processes are presented for all jurisdictions in which facilities are located. The calculation of control costs is described as a function of design parameters such as flow, temperature, and efficiency.

ACKNOWLEDGMENT

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SECTION 1

INTRODUCTION

The integrated iron and steel industry is a major contributor to air pollutant emissions in the United States. It is estimated that 14 million tons of particulate matter was emitted from iron and steel production processes in 1971. Since that time industry operators have installed millions of dollars worth of air pollution control equipment and have phased out many open hearth furnaces that lacked control equipment. Still many facilities do not meet the requirements of the applicable state implementation plan (SIP).

The U.S. Environmental Protection Agency (EPA) has primary responsibility for enforcing the mandates of the Clean Air Act. The environmental problems posed by the iron and steel industry and the costs of achieving effective control are of major concern to the EPA. This study is designed to evaluate the integrated iron and steel industry with respect to compliance with applicable air pollution regulations and the costs of full compliance. The study provides an estimate of the capital and operating costs of controlling emissions from the various processes. These are study estimates (±35 percent precision) and will be used in another study that EPA is conducting to determine the economic impact of environmental regulation of the industry as a whole.

This study does not address the costs of water pollution control, per se, but does consider the water treatment necessitated by installation of air pollution control equipment. For example, where a scrubber is installed, a clarifier and recirculating system for control of suspended solids is included as an inherent part of the air pollution control system. The blowdown from such a system might, in addition, require treatment for dissolved compounds. Costs of such secondary treatment are not included.

In this study compliance with current state implementation plan (SIP) regulations as of late 1977 was determined on the basis of information provided by EPA regional office personnel. Compliance is a complex legal issue; in this study, an emission source was considered to be substantially in compliance with SIP regulations if an appropriate control device had been installed. The cost to achieve SIP-compliance was deemed to be zero for these sources.

1.1 BACKGROUND

Various studies have been conducted to determine the costs of air pollution control in the integrated iron and steel industry. Most of these have provided cost estimates on a broad aggregate basis. This study represents a departure from earlier work with respect to the scope of emission sources considered, the detail in which cost estimates are developed, and the development of a computer model that can calculate control cost for any size of plant. The reader of this report is assumed to have a general familiarity with the steel industry and steel processes. Background information can be found in many publications, a few of which are referenced herein; e.g., Section 1, Reference 1; Section 2, References 13, 17, 28, and 45; and Section 3, Reference 1.

The technologies defining RACT, BACT, and LAER in this report were selected, in part, to examine a wide range of alternatives. As such, they should not be interpreted as representing Agency policy because appropriate technology definitions are continually evolving. Furthermore, it should be noted that various steel plants have site-specific control requirements that are not intended to be addressed by this study.

The overall methodology, which is described in detail in the following sections, can be summarized as follows:

- The emission sources to be considered are defined in general [Production Process Subcategory Emission Sources (PPS-ES)].

- The specific number of these emission sources is defined (the census or inventory of emission sources).

- The control technology and resultant emission rate needed to achieve three degrees of control are defined. The three degrees of control are:

  Reasonably Available Control Technology (RACT)
  Best Available Control Technology (BACT)
  Lowest Achievable Emission Rate (LAER)

  Appendix D contains the emission factors and control technology definitions for RACT, BACT, and LAER.

  The control required for compliance with typical state regulations is characterized as either RACT, BACT, or LAER, depending on the strictness of the state implementation plan (SIP). SIP therefore is not a separate control level. The current SIP's do not address many of the fugitive sources considered in this study except in terms of visible emissions or opacity and general prohibitions against air pollution. The SIP control level in such cases is assigned RACT, BACT, LAER, or uncontrolled based on engineering judgment and interpretation of the regulations.

- Control equipment modules are defined. These modules are either individual pieces of equipment, complete control systems, or control subsystems. Examples are a fan module, a coke oven gas desulfurization plant module, and a water pumping subsystem module.

- A cost function is developed for each module. The function describes the cost of the module, given values for the relevant size parameters.

- These module cost functions are programmed into a computer model with supporting calculations including operating cost.

- The relationships between emission source capacity and physical size are determined and are programmed into the computer model.

- The combination of modules required to achieve each level of control at a small, medium, and large source is determined and entered into the model.
- The system cost function for each control level is determined as $y = Ax^B$ where y is cost and x is capacity.
- The number of emission sources requiring additional control to meet SIP regulations is based on information provided by EPA Regional Offices.

1.2 SCOPE

The plants included in this study are the integrated steel mills operating in the United States as of December 1977. They are listed in Table A-1, Appendix A. To be considered as integrated, the plant must include blast furnace and steelmaking operations. Some plants have no coke facility and purchase coke from an outside supplier. In such cases the coke plants of these outside suppliers are not included.

The plant ID number consists of the number of the Air Quality Control Region (AQCR) in which the plant is located followed by a two-digit number based on alphabetical order.

The emission sources considered in the study are numbered according to a production process subcategory (PPS), following the scheme used in a report on the steel industry prepared by Arthur D. Little, Inc., (ADL).[1] Emission sources (ES) within a process are then numbered consecutively. The resulting code is called a PPS-ES number. Although this numbering scheme is somewhat cumbersome, it was developed to retain the original ADL codes for consistency. The ADL codes are product-oriented, and the emission sources are process-oriented. Thus a situation may arise wherein, for example, PPS-ES 14-1 and 16-1 are equivalent. In this example, the PPS of 14 represents "primary breakdown to blooms" and 16 represents "primary breakdown to slabs." The ES however is "1-soaking pits." The emissions are a function of fuel used and of firing rate and are independent of the product being made. Soaking pits in one plant therefore may be labeled as 14-1, and a duplicate set of soaking pits in another plant could be labeled 16-1.

The definition of each PPS-ES considered in this study follows. (Note that the pollutants considered for each PPS-ES are shown in parentheses.)

PPS-ES	Definition
1-1	Ore Yard - Fugitive Wind Losses (TSP)
	Fugitive emissions arising from the ore yard either from windblown emissions or material transfer associated with the ore yard. This source includes material unloading and loading from ships, cars, or trucks; transfer at the trestle or onto conveyors; and transfer of sinter after leaving the sinter plant.
2-1	Coal Unloading (TSP)
	Windblown emissions from coal piles and coal unloading by whatever means. This source is separate from coal preparation (2-3) because most mills receive and store coal independently in facilities physically separated from coal preparation.
2-3*	Transfer Points - Coal Handling (TSP)
	Emissions from all transfer points in the coal preparation process, pulverizing, screening, and loadout to bunkers.
3-1	Scrap Yard
	Because an earlier study[2] determined that emissions from scrap yard operations are insignificant, these emissions are not included.
4-1	Sinter Plant Windbox (TSP, SO_2, HC)
	Emissions from the sinter windbox exhaust.
4-2	Sinter Plant Discharge End (TSP)
	Discharge end emissions from crushing, cooling, and screening and from direct discharge of the sinter from the strand.
4-3	Sinter Plant Fugitive Building Emissions (TSP)
	Emissions from internal transfer points, bins, and mixers that are housed in the sinter plant building.
5-1	Coking - Charging (TSP, SO_2, HC)
	Emissions caused by charging coal into by-product ovens.

*Nonsequential numbers have no significance.

PPS-ES	Definition
5-2	Pushing (TSP) Emissions from pushing and hot car travel to the quench station.
5-3	Quenching (TSP) Emissions from the quenching operations.
5-4	Door Emissions (TSP) Emissions from all doors in a battery.
5-5	Topside leaks (TSP) Emissions from standpipes and lids.
5-6	Coke Oven Combustion Stacks (TSP) Emissions from the underfire exhaust stacks.
5-7	Coke Handling (TSP) Emissions from the wharf, crushing, screening, and loadout of all coke products.
5-8	Coke Oven Gas (SO_2) Emissions of SO_2 arising from the combustion of coke oven gas.
5-9	Coal Preheat (TSP, HC) Emissions from the coal preheater in dry coal charging systems.
6-1	Direct Reduction Unit Emissions This PPS is omitted on the basis that only one unit is known to be operating or planned for integrated steel mills in the United States. The dependence on natural gas for most direct reduction processes and the current restrained steel market seem to rule out any significant change in this status in the near future.[3-5]
7-1	Blast Furnace Top Emissions Emissions from top leaks, slips, and dumping material from the skip hoist or conveyor into the receiving hopper. A previous study[6] indicates that slips are not

a significant source; also, it is considered that the other items mentioned are insignificant except in isolated local cases. This source is therefore excluded from the study.

7-2 Cast House Emissions (TSP)

Emissions from the tap hole or monkey, iron trough, iron and slag runners, and iron spout and receiving ladle.

7-3 Blast Furnace Slagging (TSP)

Emissions from pouring and granulating operations of molten blast furnace slags.

7-4 Blast Furnace Off-gas

This source is not included in this study because it is considered to be well controlled for process and safety reasons.

7-5 Blast Furnace Slag Processing (TSP)

Emissions arising from screening, crushing, and handling of blast furnace slag as a by-product operation.

8-1 Open Hearth Hot Metal Transfer (TSP)

Emissions from the pouring of hot metal from hot metal ladles into transfer ladles or into mixers.

8-2 Open Hearth Stack (TSP)

Emissions from the open hearth stack.

8-3 Open Hearth Fugitive Building (TSP)

Emissions that escape through the building monitor from tapping, teeming, furnace leaks, pit cleanup, and various other operations within the building.

8-4 Open Hearth Slag Pouring

Included in 8-3.

8-5 OH Slag Processing (TSP)

Emissions from slag handling, transfer, iron reclamation, crushing, and screening. The operations do not

PPS-ES	Definition
	vary among the three steelmaking processes, although the slag volume does vary. Therefore (8-5), (9-5), and (10-5) are considered equivalent with respect to control technology.
9-1	BOF (Q-BOF) Hot Metal Transfer (TSP)
	See discussion under 8-1. No distinction is made between top and bottom blown, i.e., BOF or Q-BOF.
9-2	BOF Stack (TSP)
	Emissions from the BOF stack.
9-3	BOF Charging, Tapping, and Furnace Emissions (TSP)
	Emissions from furnace when not in vertical position. These sources, if uncontrolled, are measured as roof monitor emissions.
9-4	BOF Slag Pouring (TSP)
	Emissions from pouring molten slag onto ground within the BOF building.
9-5	BOF Slag Handling (TSP)
	See discussion under 8-5.
10-1	Electric Arc Furnace Refining Emissions (TSP)
	Stack emission from control systems during entire heat cycle.
10-2	Electric Arc Furnace - Charging, Tapping, and Slagging (TSP)
	Emissions from these sources associated with the furnace proper, which are not captured by the primary control system. Note that this source is zero in the case of building evacuation, and all emissions shift to PPS-ES 10-1.
10-3	Electric Arc Furnace - Slag Pouring (TSP)
	Emissions from pouring molten slag onto the ground.
10-5	Electric Arc Furnace - Slag Handling (TSP)
	See discussion under 8-5.

PPS-ES	Definition
11-1	Conventional Casting (TSP)
	Emissions from ingot teeming; independent of the steel-making process.
12-1	Continuous Casting Billets (TSP)
13-1	Continuous Casting Slabs (TSP)
	Emissions from ladle, tundish, and casting unit for both types of product. There are no significant differences between these two PPS with respect to the nature of emissions or type of control device, and they are treated equally. Emissions depend on the tons of steel cast, not on the shape of the product.
14-1	Primary Breakdown to Blooms (Soaking Pits) (TSP, SO_2)
16-1	Primary Breakdown to Slabs (Soaking Pits) (TSP, SO_2)
	Emissions from fuel firing for ingot heating. There are no significant differences between these two PPS with respect to the nature of emissions or type of control device, if any; they are therefore treated equally.
14-3	Scarfing of Blooms (TSP)
16-3	Scarfing of Slabs (TSP)
	Emissions from automatic scarfing.
17-1	Heavy Structurals and Rails (Reheat Furnaces) (TSP, SO_2)
22-1	Hot Strip Mill (Reheat Furnaces) (TSP, SO_2)
28-1	Plate Mill (Reheat Furnaces) (TSP, SO_2)
18-1	Bar and Rod (Reheat Furnaces) (TSP, SO_2)
	Emissions from reheating furnaces for these operations.
19-1	Wire Products and Nails
21-1	Seamless Pipe, Tube
24-1	Welded Pipe
	Heating furnaces for these operations are not considered because their impact is considered to be relatively insignificant.
20	Cold Finished Bars
	This is not considered a significant emission source and is not included.

PPS-ES	Definition
23	Pickling and Oiling The only significant emission from this operation is HCl fume, which is not included in this study. It is assumed that pickling fume collection is a part of the process and not an add-on control feature.
25-1	Cold Reduction and Finishing - Annealing Process exhaust gas from both batch and continuous annealing is considered to be an insignificant source of pollutants and is not included.
26	Galvanizing This is not considered a significant source and is not included.
27	Tin Plating and Other Plating This is not considered a significant emission source and is not included.
29-1	Ancillary Facilities (On-site Power and/or Steam Generation) (TSP, SO_2) Includes boiler combustion stack emissions.

The following additional sources have been identified, but are not included because they occur relatively rarely in integrated steel plants:

Alloy blast furnaces or merchant iron blast furnaces

Lime kilns

Forging

Incinerators, either solid or liquid

Pelletizing processes other than conventional sintering

Pig machines

Vacuum degassing

Vacuum induction furnaces

Foundries

REFERENCES FOR SECTION 1

1. Steel and the Environment: A Cost Impact Analysis. Arthur D. Little, Inc. May 1975.

2. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. EPA-450/3-77-010. March 1977.

3. Miller, J.F. Global Status of Direct Reduction - 1977. Iron and Steel Engineer. September 1977.

4. Brown, J.W., and R. L. Reddy. Direct Reduction, What Does It Mean to the Steelmaker. Iron and Steel Engineer. June 1976.

5. Bertram, J.M. What, How, Who, Where - Direct Reduction. Iron and Steel Engineer. July 1972.

6. Blast Furnace Slips and Accompanying Emissions as an Air Pollution Source. EPA 600/2-76-268. October 1976.

SECTION 2

DEVELOPMENT OF CENSUS AND CAPACITY DATA

2.1 GENERAL

PEDCo has reviewed the following sources of capacity and/or production data:

<u>Source</u>

NEDS (National Emission Data System)[1]

Deily, Steel Industry in Brief: Data Book USA 1977[2]

Betz, Study of Blast Furnace Emission Control[3]

Industry responses to effluent guideline ("308") questionnaire

Varga, Control of Sinter Plants Using ESP[4]

AISI Directory of Steel Plants[5]

Battelle Screening Study-coking[6]

33 Magazine (Various news releases and articles)

AISE Magazine (Various news releases and articles)

AISI Coke Plant Data Book (By-product Coke Oven Dimensions)[7]

EPA Compliance Report for Steel Industry[8]

Evaluation of these data indicates two problems. First, different references list different values for capacity; second, different bases are used for capacity among the various processes. For example, heating furnaces are rated in tons per hour, square feet of heating area, Btu per hour; and steelmaking facilities are rated on a shop basis in tons per year or on a furnace basis in tons per heat. No single information source covers all the processes. Moreover, the completeness, accuracy, and reference years of the various information sources are variable.

A third point of difficulty is that pure capacity values may reflect an hourly or short-term rate of operation but not a yearly or long-term rate. The unit capacities of many steel mills are unbalanced; that is, various units must operate continuously and others intermittently to produce the finished product. Finishing operations such as reheat furnaces often run less than 7 days a week. Hot metal supply may limit effective steelmaking capacity. For example, although two identical BOF shops should have equal rated capacities, one may produce 20 heats per day and the other 30 heats per day because of differences in hot metal supply. Furthermore, a mill may operate a facility in excess of "nameplate" capacity because of innovations in raw materials or methods since the facility was designed.

The values selected for capacity and/or production are important because they influence both the cost of control and the amount of emissions. Furthermore, in evaluation of most control situations, the physical size and dimensions of the facility must be known. The relationships between physical size and capacity of the various emission sources are discussed later.

Capacity data for this study were excerpted from the references with priority given to those presenting data direct from the industry. These include References 3, 5, 7, and 9. Other sources were used to fill gaps in the industry-reported data. Considerable cross-checking of data sources was done to resolve discrepancies and develop a clean data base.

The starting point for the inventory of facilities was the AISI Directory; other sources were used to supplement the inventory. Because this project addresses specific emission sources within a process, a simple list of sinter plants or coke plants is not sufficient. One must consider the nature and size of the sources within these processes. Little information is available on ore yards, coal yards, and slag processing facilities. The procedure for calculating the capacity of ore yards and coal yards is described below. Capacity of slag handling and processing facilities is based on assumed slag volumes.

With this background, we now describe the specific approaches to defining census and capacity for each PPS-ES and also to determining physical size.

2.2 RELATIONSHIP BETWEEN CAPACITY AND PHYSICAL SIZE

Ore Yard and Coal Yard Handling and Storage

Emissions from handling and storage of ore and coal are conveniently discussed together because the control technique for both consists of dust suppression by watering with chemical additives. Depending upon material handling arrangements, some transfer points could be hooded and vented to a baghouse.[10] These could be considered only on a plant-specific basis.

For census purposes it is assumed that each blast furnace complex has one ore yard and each coke oven complex has one coal yard. Although it is known that many mills have more than one storage area, the key factors are total acres and total tons transferred and stored. For our purposes there is no significant difference between two 20-acre areas and one 40-acre area.

Capacity values presented here are based on the total plant ironmaking capacity and coking capacity. Certain calculations are needed to translate these capacities into raw material requirements and then into storage area requirements. The equations, with graphical representations, are given in Figure 2-1.

Clearly, the pile configurations and storage areas will vary widely among facilities. In general, the storage density (SD) values at larger storage facilities would be expected to be higher because of generally larger piles and smaller amounts of dead space.

Using these calculations, we derive the following values for effective storage density (SD):

Calculations of Ore Yard Sizes

Consider the idealized piles:

1) $\alpha = 37°$

$r = 100$ ft

$\tan \alpha = h/r \rightarrow h = 75$ ft

$V = 1/3\pi(100)^2(75) = 785{,}000$ ft^3

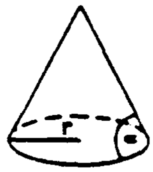
let density, ρ, of "ore" be 120 lb/ft^3

therefore, $W = 47{,}100$ tons

tons/ft^2 = $47{,}100/\pi(100)^2$ = 1.5 tons/ft^2 for ore

let ρ of coal = 45 lb/ft^3

tons/ft^2 = $17{,}700/\pi(100)^2$ = 0.56 ton/ft^2 for coal



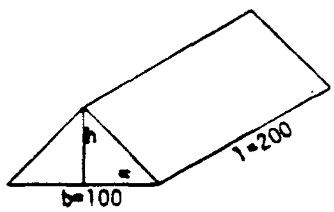
2) $V = 1/2$ bhl $\quad \alpha = 37°$

$h = b \tan \alpha/2 = 37.7$

$V = 1/2(100)(38)(200) = 380{,}000$ ft^3

at $\rho = 120$, tons/ft^2 (for ore) = 1.1

at $\rho = 45$, tons/ft^2 (for coal) = 0.4



Consider effective storage density (SD).

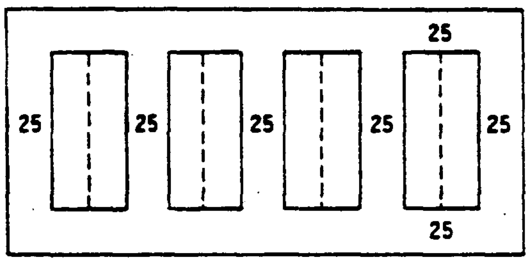
Four piles as above spaced 25 feet apart

$A = 525 \times 250 = 131{,}250$

$SD = \frac{4(120)(380{,}000)}{2000}/131{,}250$

= 0.69 ton ore/ft^2

= 0.26 ton coal/ft^2



STORAGE AREA

Three piles as in 1) with 25 ft spacing between:

$A = 700 \times 250$

$SD = 3 \times 47{,}100/700 \times 250$

= 0.81 ton ore/ft^2

= 0.31 ton coal/ft^2

OR

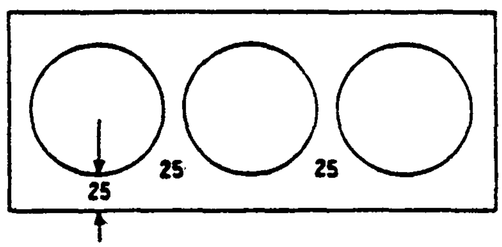


Figure 2-1. Material storage area requirements.

Ore	Coal	
0.69	0.26	effective density, pyrimidal piles
0.81	0.30	effective density, conical piles

It is reasonable to choose the average of each of the two values as an estimated value for effective storage density. Reference 10 yields a value of 0.82 ton/ft^2 for ore storage density. This value, applicable to a plant capacity of 5,000,000 ingot tons/yr, compares reasonably well with our calculated average value of 0.75 ton/ft^2. No other references were found on the matter. Given the value of effective storage density, one can use the following procedure to calculate the required storage area as a function of hot metal and coking capacities.

Assume that 2 tons of ironbearing raw materials and fluxes are required to make 1 ton of hot metal and that a 3-month supply is kept on hand. The ore yard storage area required is therefore equal to:

$$\frac{\text{annual hot metal capacity x 2}}{\text{4 x effective storage density}}$$

Assume the yield of coke from coal is 70 percent and that a 3-month supply of coal is kept on hand. The coal yard storage area required is therefore equal to:

$$\frac{\text{annual coking capacity}}{\text{0.7 x 4 x effective storage density}}$$

Storage areas are determined in this manner in the computer cost program. The area calculation is used to determine the number of spray towers and length of piping in dust suppression systems. The quantity of material stored controls both the emission rate and the amount of spraying and chemical dust retardant required.

Coal Handling and Crushing

Virtually no data are available on specific handling and crushing facilities. We therefore make the following assumptions:

- The census basis is one coal handling and crushing facility per plant site. The exceptions to this are plants with capacities above 8000 tons coal/day. For these plants, we assume one facility for every increment of 8000 tons coal/day capacity. The 8000-ton figure is based on the coal-carrying capacity of a 60-in. belt. (In general, the belt capacities shown below are used for sizing conveyor transfer point hooding systems).
- The control system assumes four transfer points sized according to coal handling capacity, with the belt sizes shown below. Exhaust rates are based on standard ventilation calculations for hooded transfer points.[11,12] The coal crusher is assumed to be completely enclosed and ventilated.

CONVEYOR BELT CAPACITIES*

Belt width, in.	18	30	42	60
Coal, tons/h	28	79	162	345
Ore, tons/h	70	198	405	863

Sinter Plant Windbox, Discharge End, and Fugitive Building Emissions

The census basis for these sources is one sinter plant building. Table B-1, Appendix B, lists the sintering plants considered. Plants that were shut down prior to 1978 are not included. One control device is assumed per building for windbox control, regardless of the number of strands. One control device per building is used for discharge-end control, and discharge-end hooding and ducting is based on one strand. Control of fugitive emissions, i.e., at material transfer points, is based on five transfer points per building.

Flow rate required for the windbox can be calculated from Figure 2-2, excerpted from the ADL study.[13] To relate this equation to capacity, we must determine the relationship between grate area and capacity (Figure 2-3). Using Figures 2-2 and

* Marks, Standard Handbook for Mechanical Engineers 7th Ed., McGraw-Hill.

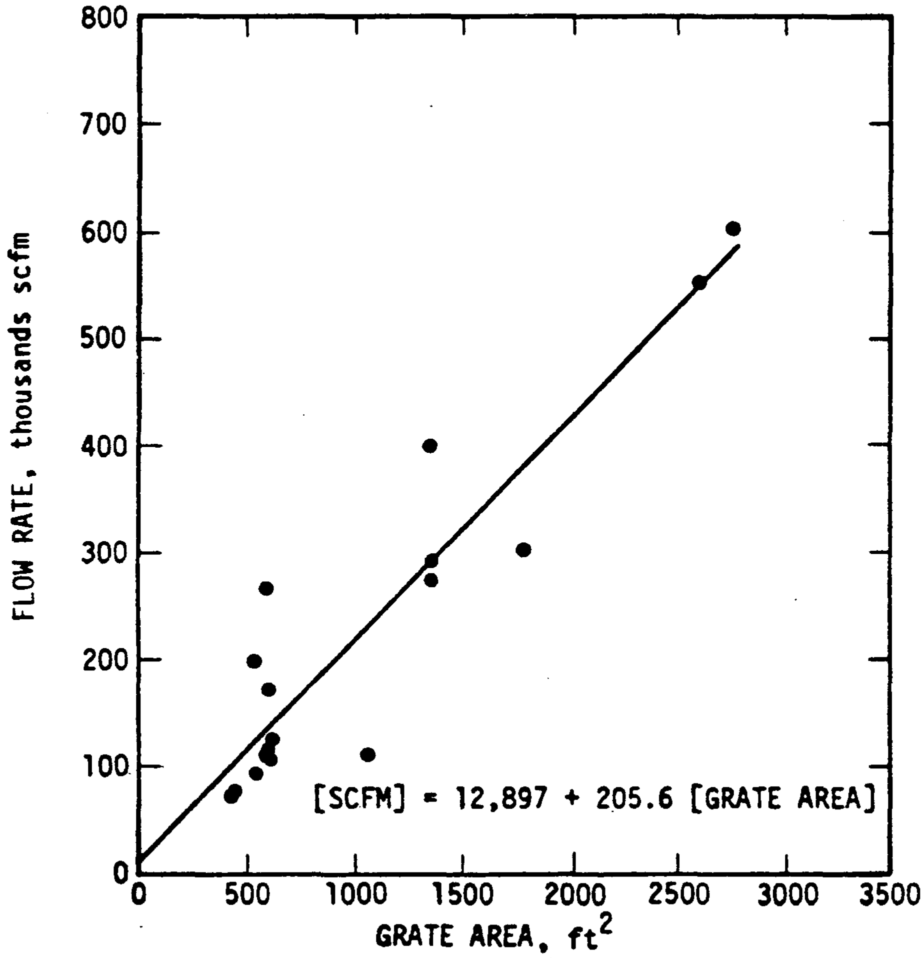


Figure 2-2. Flow required for sinter plant windbox control.[13]

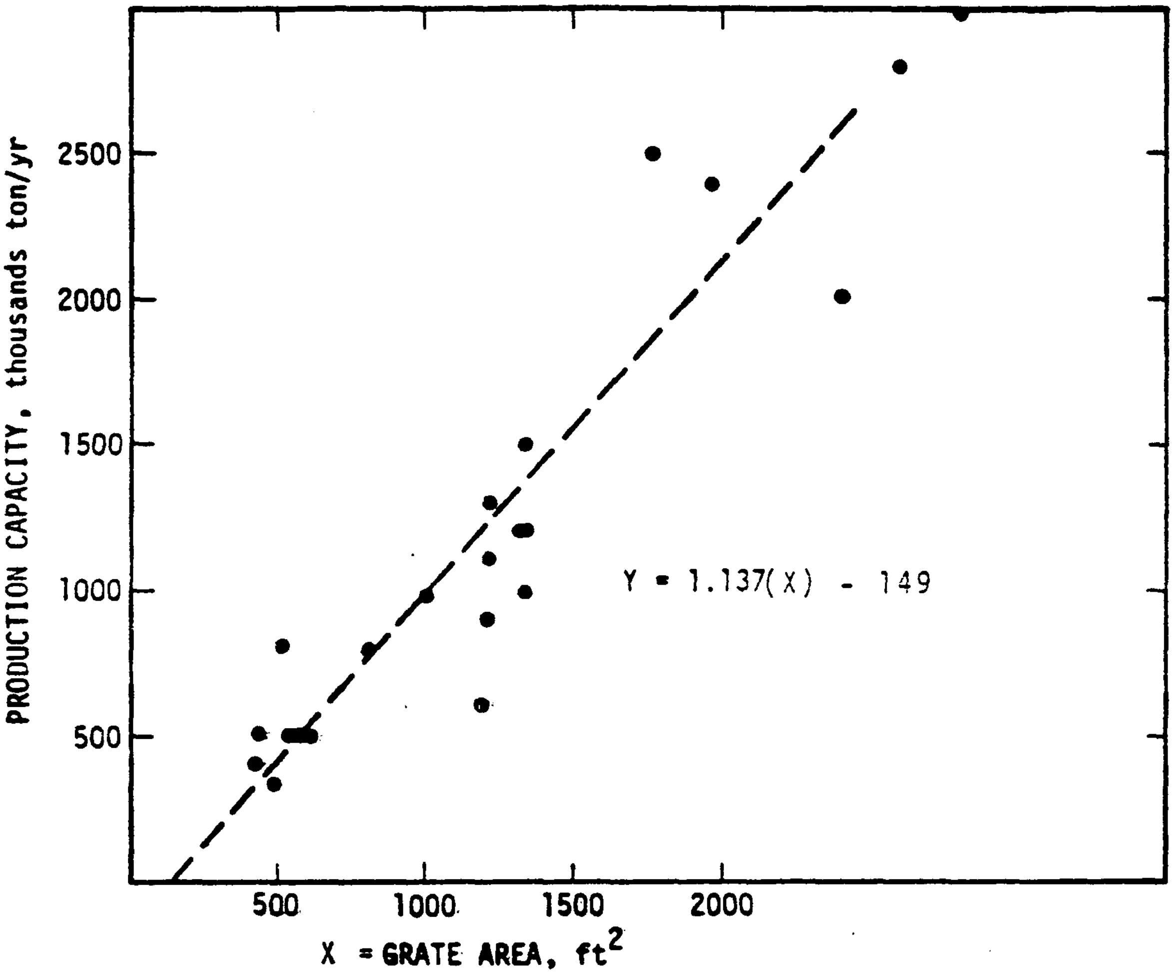


Figure 2-3. Sinter production as a function of grate area.

2-3, we can determine the flow rate as a function of capacity. Flow required for control of sinter discharge emissions is excerpted from Reference 13 and illustrated in Figure 2-4.

Flow rates for enclosed transfer points are based on standard ventilation calculations for enclosed conveyor transfer points and are illustrated in Figure 2-5.

Coking Charging

The census basis for this source is a coke oven battery. The list of coke plants considered is shown in Table B-2.

Larry car sizing is based on oven volume. This means that cost is proportional to oven size rather than capacity per se. Table 2-1 illustrates the relation between various coke oven parameters used to translate physical size into capacity. The control cost includes providing a steam supply to the battery for aspiration during charging and a smoke seal arrangement for the leveling bar and chuck door. It is assumed that existing larry cars can be modified to achieve RACT control but that a new car is required to achieve BACT and LAER control.

Coking Pushing

The census basis is a coke oven battery. One enclosed hot car is used per battery. The basis of sizing is tons per push.

Flow rate for enclosed hot cars is assumed to be a constant of 75,000 acfm. Energy requirement is not calculated in kWh as with other flows, but rather as 0.95 gal No. 2 fuel oil per ton of coke because this mobile equipment carries its own generator and water heater.[14,15] Although a particular design of enclosed hot car is used for costing, the concept is applied in many variations that are equally effective.

Coking Quenching

The census basis is one quench tower per 2500 tons coke/day. No data are available on the actual number of quench towers, but control costs are relatively low with baffles and such an assumption will not introduce significant error into the aggregate

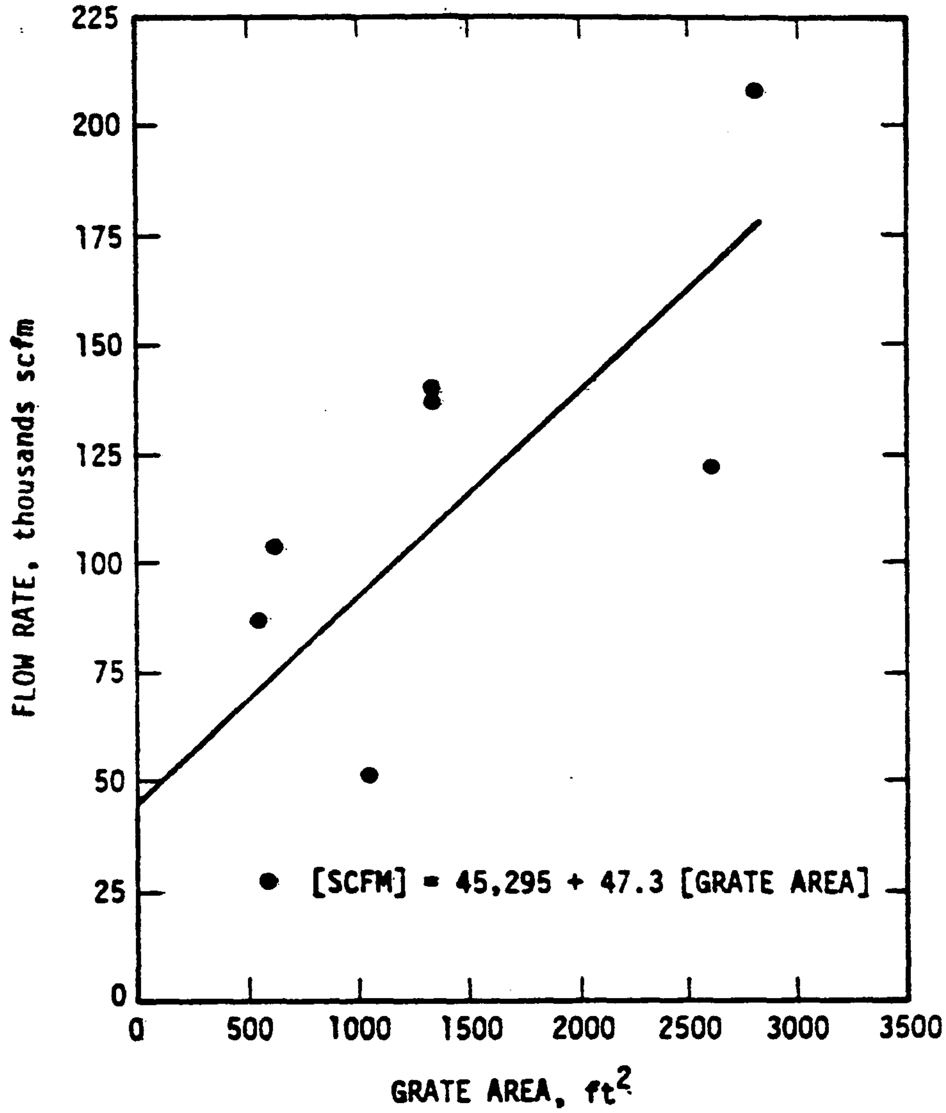


Figure 2-4. Flow required for control of sinter plant discharge.[13]

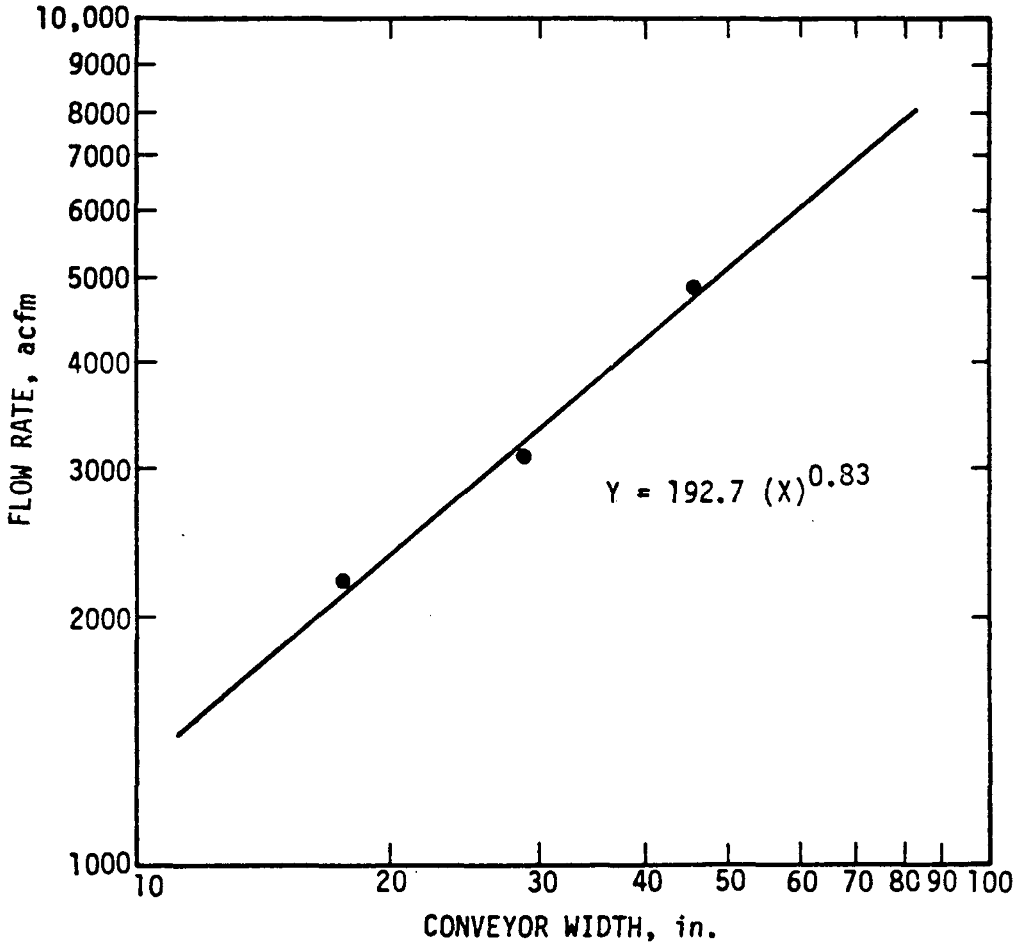


Figure 2-5. Flow rate for exhausting conveyor transfer point hoods.

Table 2-1. RELATIONSHIPS OF SIZE AND OTHER PARAMETERS, COKE OVEN BATTERY

Basis: 50 ovens	Oven height, meters			
	3	4	6[a]	6[b]
Oven volume, ft^3	540	720	1390	1390
Tons coke/push	8.5	12.0	25.0	25.0
Coking time, h	17.5	17.5	17.5	12.5
Pushes/day	68.6	68.6	68.6	96
Tons coke/day	583	823	1715	2401
Tons coke/year	213,000	300,000	626,000	876,000

[a] Conventional battery
[b] Preheated coal battery

cost. Operating cost for clean quench water is based on water usage of 150 gal/ton of coking capacity independent of the number of quench towers. For dry quenching, maximum system size is 6000 tons/day of coke. With dry quenching, an enclosed hot car is not required for pushing emissions control because a similar device is part of the dry quenching system.

Door Emissions

The census basis is the coke oven battery. Control is either by additional manpower or addition of cleaning equipment. It is particularly difficult to assess current compliance status for this emission source and also to generalize as to suitable control requirements. Control costs for RACT are based on addition to the workforce of two maintenance men per shift per battery. For BACT and LAER the cost of door cleaning equipment is added. Some batteries may require additional steps beyond this to achieve control, such as replacement of doors and jambs.

Topside Leaks

The census basis is the coke oven battery. No control equipment is used for topside leaks. Costs of control are strictly operating costs based on one additional man per shift per battery to control topside leaks. This does not include maintenance and supplies such as new lids, new standpipes or standpipe caps, major grouting, or other items required for good maintenance. It covers only manpower for "polishing" duties.

Combustion Stacks

The census basis is one coke oven battery. Flow rate is determined from the coking capacity according to the following calculations:

Assume 11,000 ft^3 coke oven gas/ton coal
Assume 40 percent used to underfire

Products of combustion = 7.9 ft^3/ft^3 gas at 50 percent excess air.[16]

Exhaust flow rate at 50 percent excess air = 11,000 x 0.4 x 7.9
= 34,800 ft^3/ton coal

The control technology specified is electrostatic precipitors. On a new battery, with a suitable maintenance program the emission limitations for BACT and LAER may be met without the need for a control device.

Coke Handling

The census basis is one coke plant facility. No further distinction is made because of the relatively small magnitude of this source. Four transfer points and a hooded screen constitute the control system, and flow rate is calculated from standard ventilation design values.

Coke Oven Gas Desulfurization

The entire cost of coke oven gas desulfurization is included in this source category. Cost for desulfurization is therefore not included with the boiler source or other fuel-burning sources. The control system cost is based on a Sulfiban system with a Claus sulfur recovery plant and HCN destruction.

Coal Preheating

The entire cost of pipeline charging, including coal preheating, is considered as a process cost, because any prorating of costs between process factors (production, replacement) and air pollution control would be arbitrary. Only the scrubber on the coal preheater exhaust is considered as an air pollution control cost. Flow rate for the scrubber on the preheater is determined from the factor 8900 scf/ton coal.

Cast House Emissions

The census basis is the number of blast furnaces, as shown in Table B-3. The number of blast furnaces in the United States is given by various sources as follows:

Source	Number	Comment
AISI Directory[5]	186	Integrated plants only. Complete data on working volume.
Betz Report[3]	151	Not all companies reported.
1976 AISI Statistical Summary[17]	192	114 active as of Jan. 1, 1977.
Deily[2]	189	
308 Survey[9]	152	Accuracy of response unknown.
EPA Compliance Report[8]	169	

Some of the differences are due to inclusion of ferromanganese or foundry furnaces, but most can be attributed to the various degrees of completeness or accuracy of the reports, including interpretations of whether a furnace is "down," "inactive," or "retired." Although the AISI values of 186 or 192 are likely the most accurate regarding existing furnaces, examination of Table B-3 shows 160 active furnaces in integrated mills. Active is understood to denote that the furnace is either operating or is only temporarily down for maintenance or economic reasons.

Three control schemes are considered. The RACT scheme consists of hooding the tap hole area. The BACT scheme includes runner covers in addition to tap hole hooding. The LAER scheme is building evacuation. Reference 3 discusses control of cast house emissions at length and presents suggested designs. Among U.S. blast furnaces the configuration and dimensions of runners, number of spouts, and other cast house features are highly variable and are not necessarily a function of furnace size. Therefore, the sizing of trough hooding and runner cover systems is based on representative dimensions. Furnaces over 60,000 ft^3 working volume are assumed to have two tap holes and therefore two capture systems. Flow rate for the trough area exhaust is based on 420 acfm per square foot of exhaust face area. This results in flow rates on the order of 200,000 acfm at 175°F for a medium size furnace. An additional 200,000 acfm is used for runner cover exhaust. The design of cast house emission controls in this country is still developmental, and flow rate requirements are a major issue. Selection of a design value is important because flow rate influences both capital and operating costs. Also, because the industry operates more cast houses than any other major facility, cost errors in an individual system can become magnified in the aggregate. The problems of cross currents and the impossibility of close hooding in existing cast houses are the main causes of the high flow rate.

The flow rate required for building evacuation is based on cast house volume. Figure 2-6 is a plot of cast house volume versus furnace working volume, based on data from Reference 3. Capacity is related to furnace working volume according to Figure 2-7. The flow rate for total building evacuation is based on 60 air changes per hour. Consequently, flow rate in acfm is equal to building volume times 1.2 to adjust for a temperature of 175°F. References 3 and 18 raise several issues regarding operating and maintenance feasibility of runner covers and tap hole hoods. In the operating cost calculation, we attempt to recognize the severe conditions existing in a cast house by assigning appropriately high maintenance costs.

Blast Furnace Slagging Emissions

The inventory basis is one blast furnace; one control system per furnace is assumed. The basis for calculating emissions is tons of hot metal capacity, slag being a function of hot metal according to the factor 500 lb slag/ton hot metal. The emissions are those occurring at the furnace area from the water quenching or granulation of slag. A hood and stainless steel scrubber comprise the control system with flow rate estimated as 65 acfm/ton of hot metal/day. Specific data on slag processing methods or the emissions and related control devices are sparse.[19] This source does not include emissions from processing of cooled slag, such as crushing and screening.

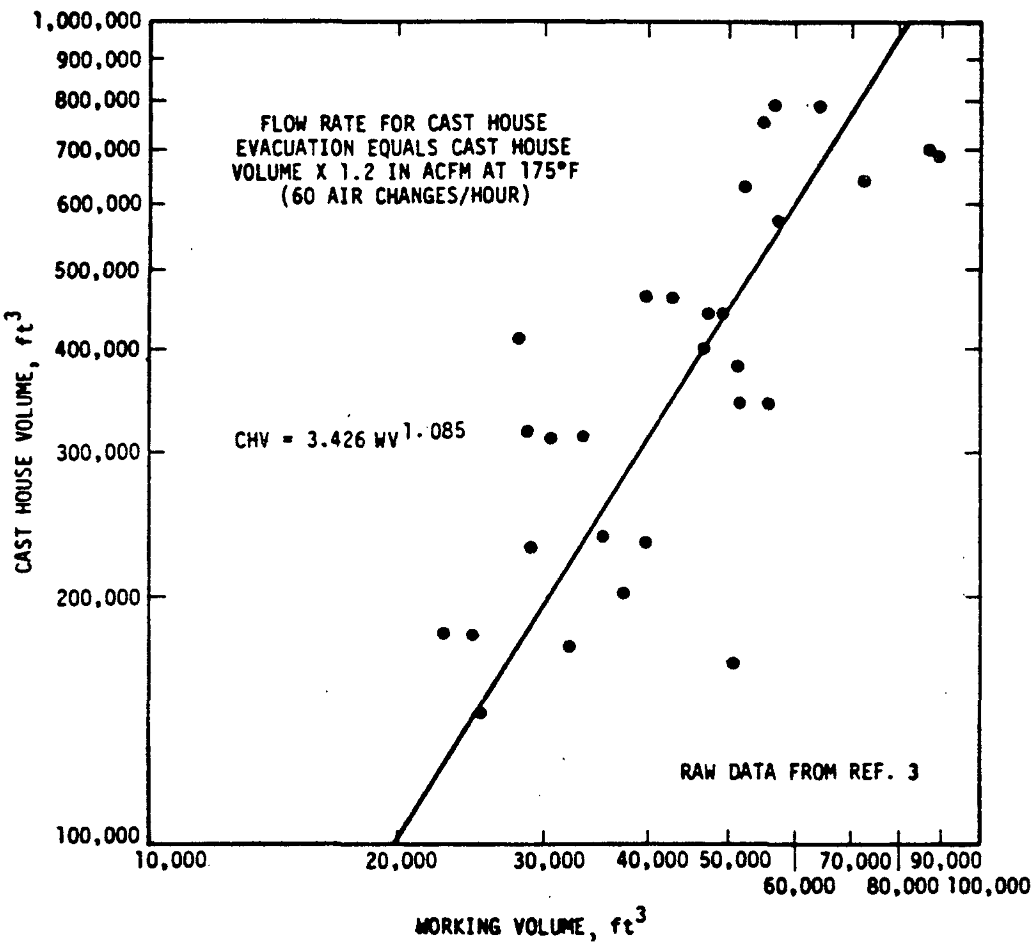


Figure 2-6. Cast house volume as a function of furnace working volume.

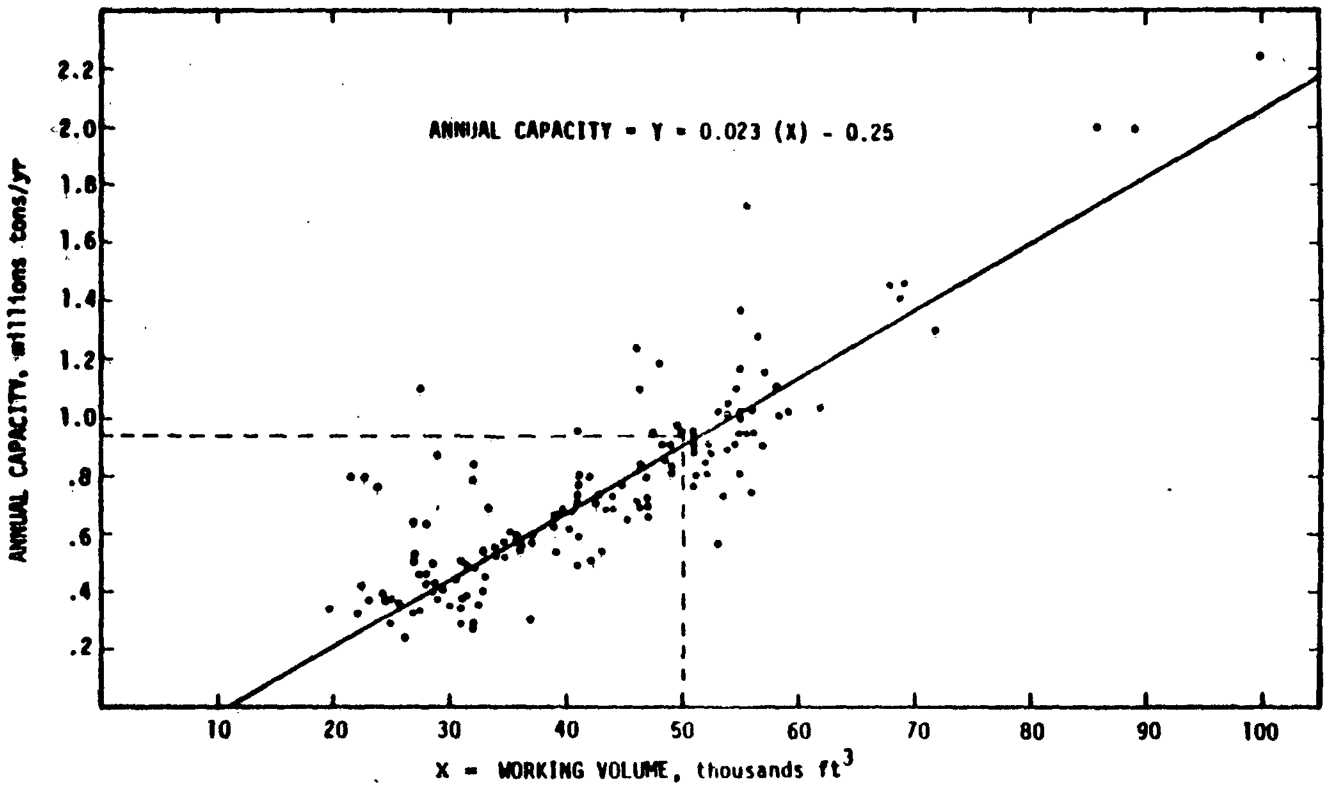


Figure 2-7. Blast furnace capacity vs. working volume.

Blast Furnace Off-gas

All off-gas is assumed to be contained in the gas cleaning system, and top emissions from slips are assumed to be an insignificant source on an industry-wide basis. Because it is assumed that this source is controlled for process and safety reasons, no air pollution control costs are assigned. The outlet loading of cleaned blast furnace gas is assumed to be 0.005 gr/scf. No control therefore is considered for stove stacks.

Blast Furnace Slag Processing

One slag processing facility is assumed per plant site, sized to crush and screen the total slag production. Many plants do not process the slag but dump it as solid waste. Although processing is usually done by an outside firm, costs of control are considered to be steel industry costs. It is assumed that slag is cooled before processing and therefore hooding and exhaust to a baghouse constitute the control scheme.

Steelmaking Furnance Configurations

For all steelmaking categories, the configuration of furnace size and numbers of furnaces for a small, medium, and large shop is shown below:

	Size designation		
Steelmaking method	Small	Medium	Large
BOF: annual production, 10^6 tons/yr	1.61	2.70	3.78
No. furnaces/heat size, tons	2/150	2/250	2/350
OH: annual production, 10^6 tons/yr	1.17	2.28	3.39
No. furnaces/heat size, tons	10/120	10/240	10/360
EAF: annual production, 10^6 tons/yr	0.1	0.47	1.13
No. furnaces/heat size, tons	3/20	3/80	3/200

Steel Slag Processing

For all three steelmaking processes, one slag process facility per plant site is assumed. The control system consists of three hooded transfer points and a hooded screen. The flow rate required is based on standard engineering calculations (see Appendix C). Although slag processing is normally done by an outside contractor, the costs of control are considered herein as steel industry costs.

Open Hearth Hot Metal Transfer, Stack, and Fugitive Emissions

These sources are conveniently discussed together because the census basis for all three is the open hearth "shop" or building. Appendix Table B-4 lists the active shops considered in the study.

For the open hearth sources, only RACT levels of control are considered feasible. It is assumed that no new open hearths will be built.

The basis of control of hot metal transfer emissions is a hood with flow rate sized according to Figure 2-8 (derived from Reference 13). It is assumed that these relationships, although derived for BOF reladling operations, apply also to open hearth reladling. One reladling station per shop is assumed.

For control of stack emissions, it is assumed that all furnaces are vented to a common control device. Although some shops are known to control individual furnaces, this study does not consider site-specific factors. The flow rate basis is that presented in Figure 2-9 (also derived from Reference 13).

No control is considered for fugitive furnace emissions during charging, refining, and tapping. It is assumed that eventual replacement of open hearth facilities with basic oxygen or electric furnaces will be the ultimate control for these fugitive emissions.

BOF Emissions

The census basis for BOF emissions sources is the BOF shop and the number of furnaces. BOF shops considered are shown in

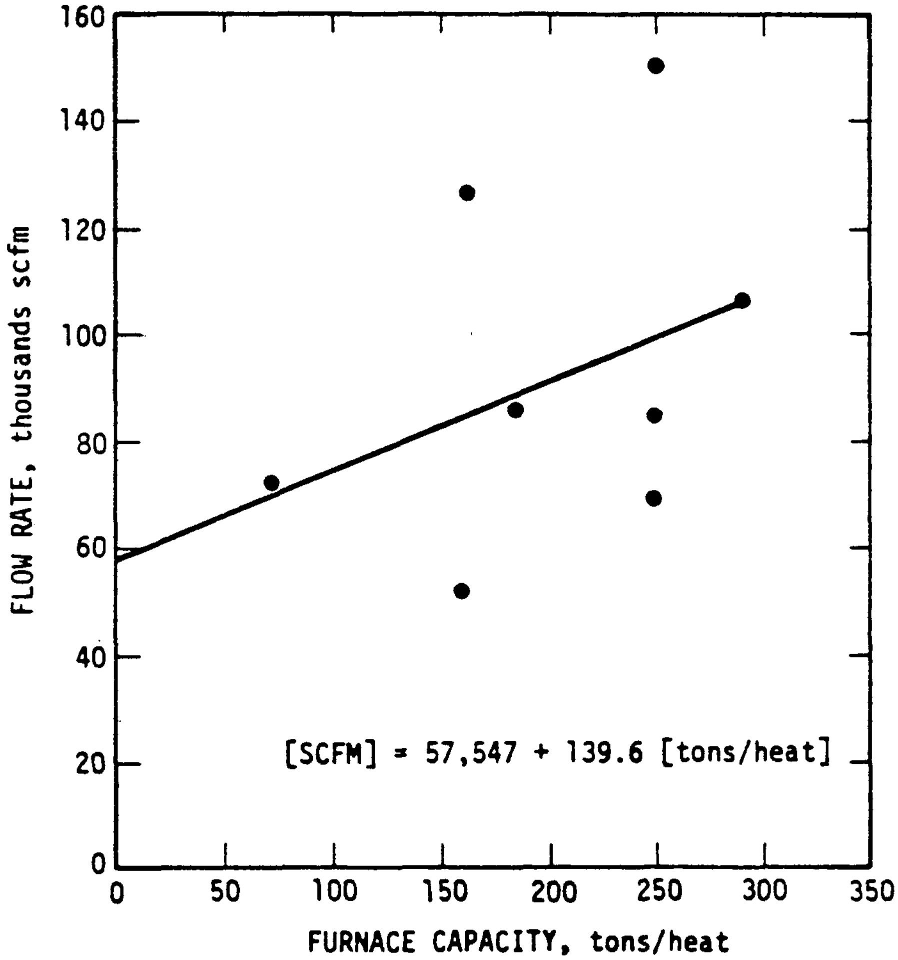


Figure 2-8. Flow required for control of hot metal reladling.[13]

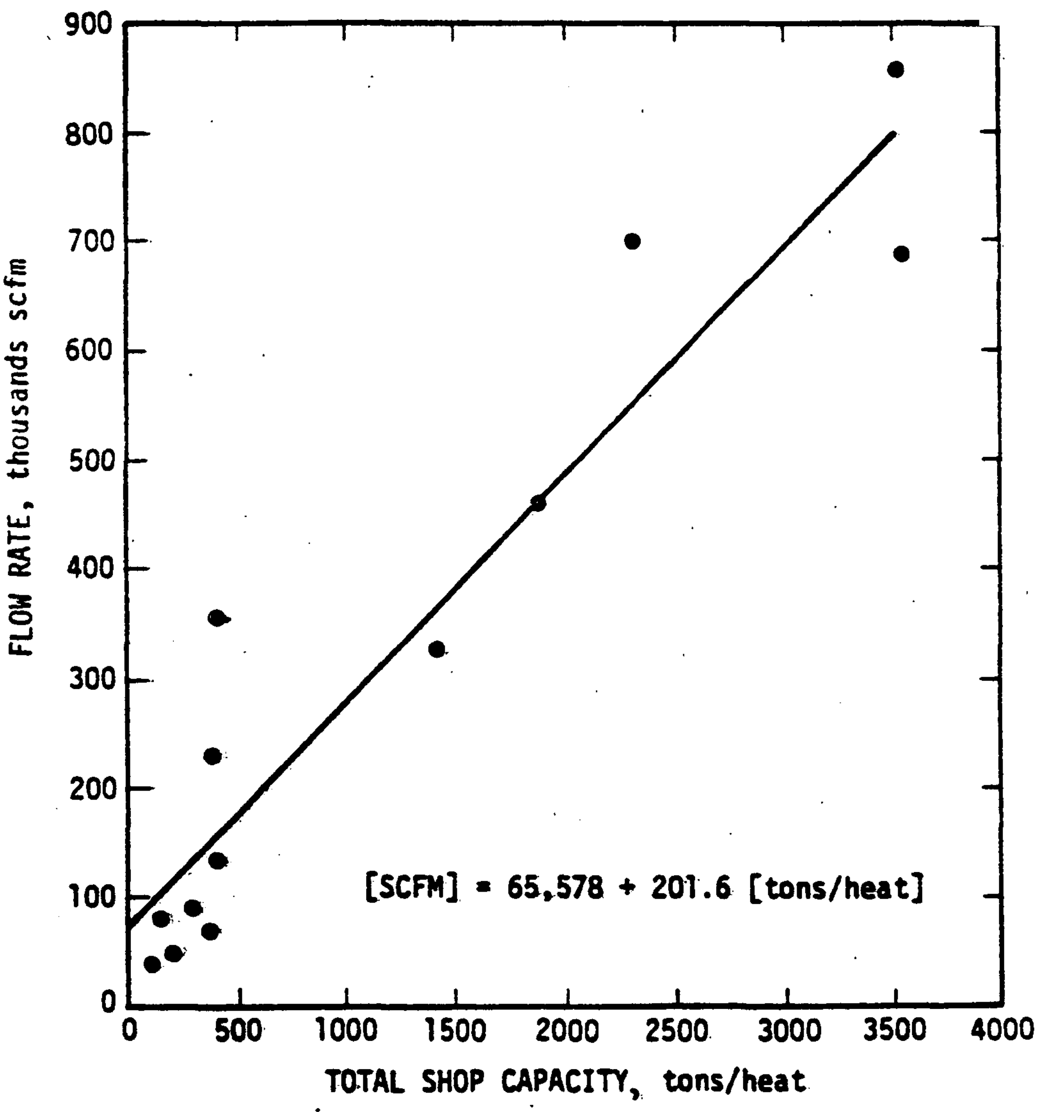


Figure 2-9. Flow required for open hearth fume control.[13]

Appendix Table B-5. For source 09-3 charging and tapping emissions, a hooding or enclosure is included for each furnace, but the control device is common to all furnaces. For source 9-02, refining emissions, some shops have separate control devices for each furnace, but this project assumes one control device per shop for stack (refining) emissions for open-hood control. For closed-hood (suppressed combustion) systems, one control device is assumed for each furnace.

The flow rate basis for hot metal transfer is Figure 2-8. The flow rate basis for stack emissions is shown in Figure 2-10. A higher flow rate is applied to open hood systems, and a distinction is made between scrubbers and ESP's.[20] Open hood systems (RACT) are sized to handle two furnaces operating simultaneously in both two- and three-furnace shops. For BACT control, it is assumed that separate closed hood systems are required for each furnace and, therefore, a distinction is necessary between two- and three-vessel shops. Only the two-vessel shop case is calculated. Flow rate for the closed hood is based on a factor of 488 times the heat size in tons and is derived from data in References 10,23,21,22. For comparative purposes Figure 2-10 includes curves based on the data in Reference 13. The agreement is fairly good considering that Reference 13 is based predominantly on two-vessel shops with open hood systems.

The flow rate basis for 09-3 sources is determined from analysis of literature references and engineering judgment, depending upon the scheme used for capture.[20,24-28] Flow rate for a furnace enclosure is calculated as 1000 acfm times heat size. Flow rates for hooding of source 09-5 slag crushing and screening are based on standard engineering calculations for conveyor transfer points and canopy hoods. One slag processing facility per plant is assumed.

The scheme for BACT and LAER control of slag pouring and cleanup consists of hooding the slag pouring area in the steelmaking shop and venting the emissions to a baghouse. Flow rate is estimated as 200,000 acfm at a temperature of 150°F for a shop

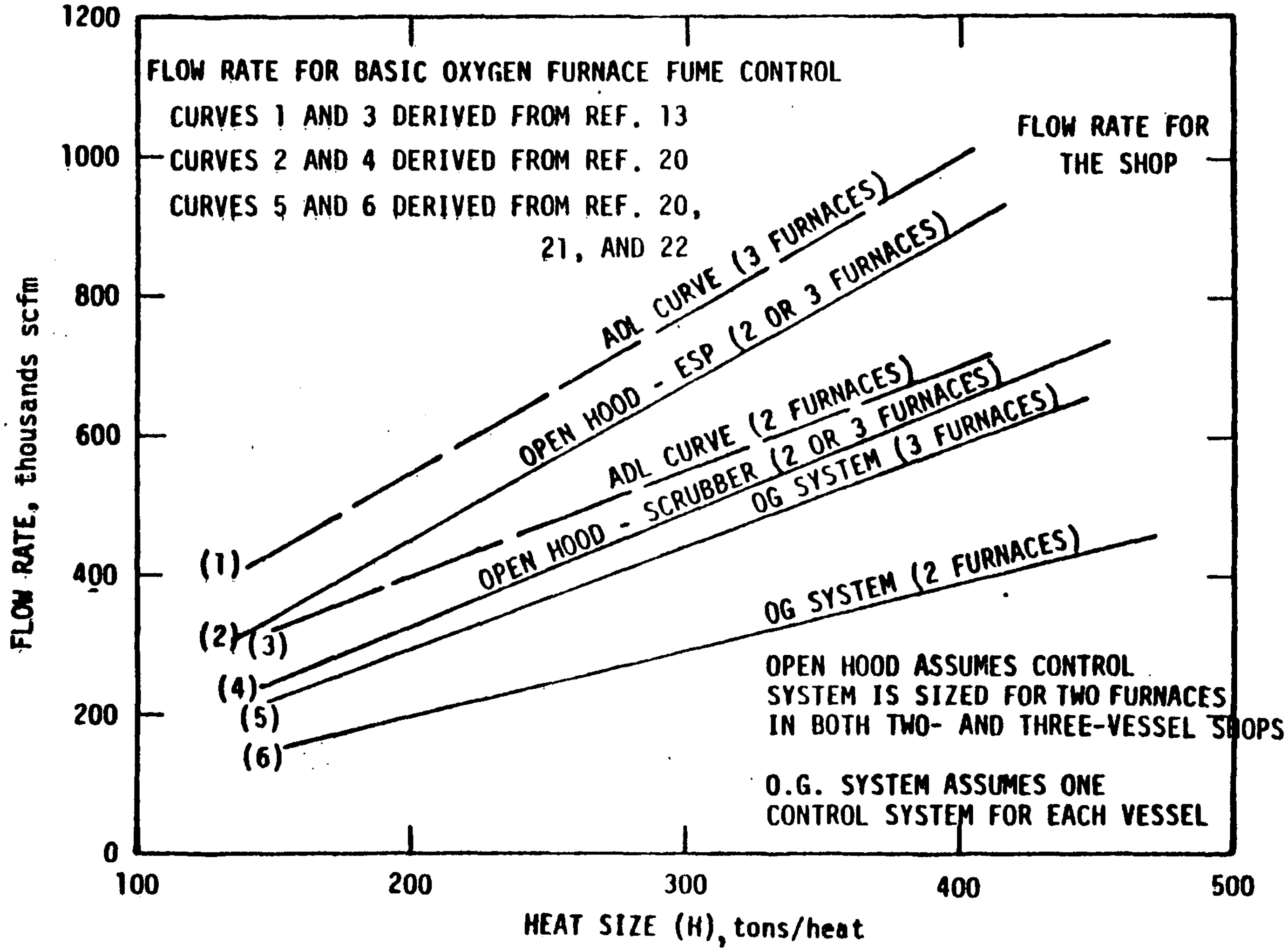


Figure 2-10. Flow rate for BOF fume control.

producing 1,000,000 tons per year. Flow is proportioned for larger shops on this basis, but 200,000 acfm is a minimum flow rate. Cases where molten slag is transported to a slag dump are not considered.

Electric Arc Furnace Stack and Fugitive Emissions

Electric arc furnaces in integrated plants are shown in Appendix Table B-6. When canopy hooding or total building evacuation is used, it is immaterial to consider stack (refining) emissions separately from fugitive emissions. The breakdown in such cases is by type of steel produced rather than by emission source. The control systems evaluated are shown in Figure 2-11. The flow rate basis is the sum of the heat sizes in the shop, but the individual furnaces are considered in estimating the equipment cost for direct shell evacuation ducting and canopy hoods. In all cases, one control device is used per building. Air flow rates are derived from Table II-1 in Reference 29 and are presented in Figure 2-12. As can be seen from Figure 2-12, the flow rates for building evacuation of small (<100 tons) shops cannot be extrapolated. A lower bound, based on engineering judgment, is shown. This bound adjustment is made for building evacuation of small shops and reflects a ventilation rate of 24 air changes/hour and a building volume of 1,125,000 ft^3 (100 by 150 by 75 ft).

Electric Furnace Slag Pouring

Control costs are calculated on the same basis as the BOF slag pouring.

Conventional Casting

No control is considered for this emission source. The census basis is one per steelmaking shop.

Continuous Casting

The census basis is one continuous casting machine, independent of the number of strands. Continuous casters considered are

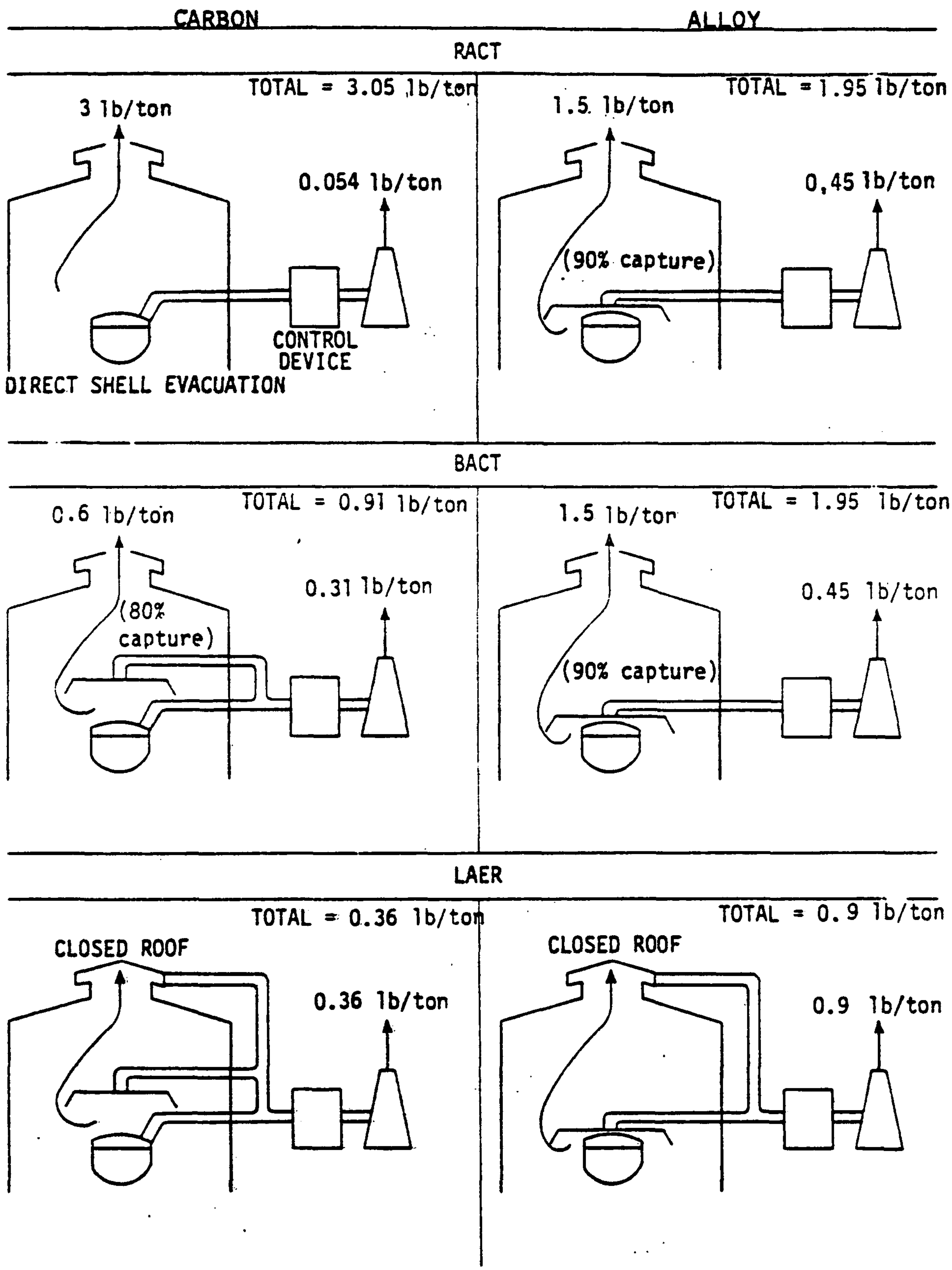


Figure 2-11. Schematic illustration of EAF control technologies.

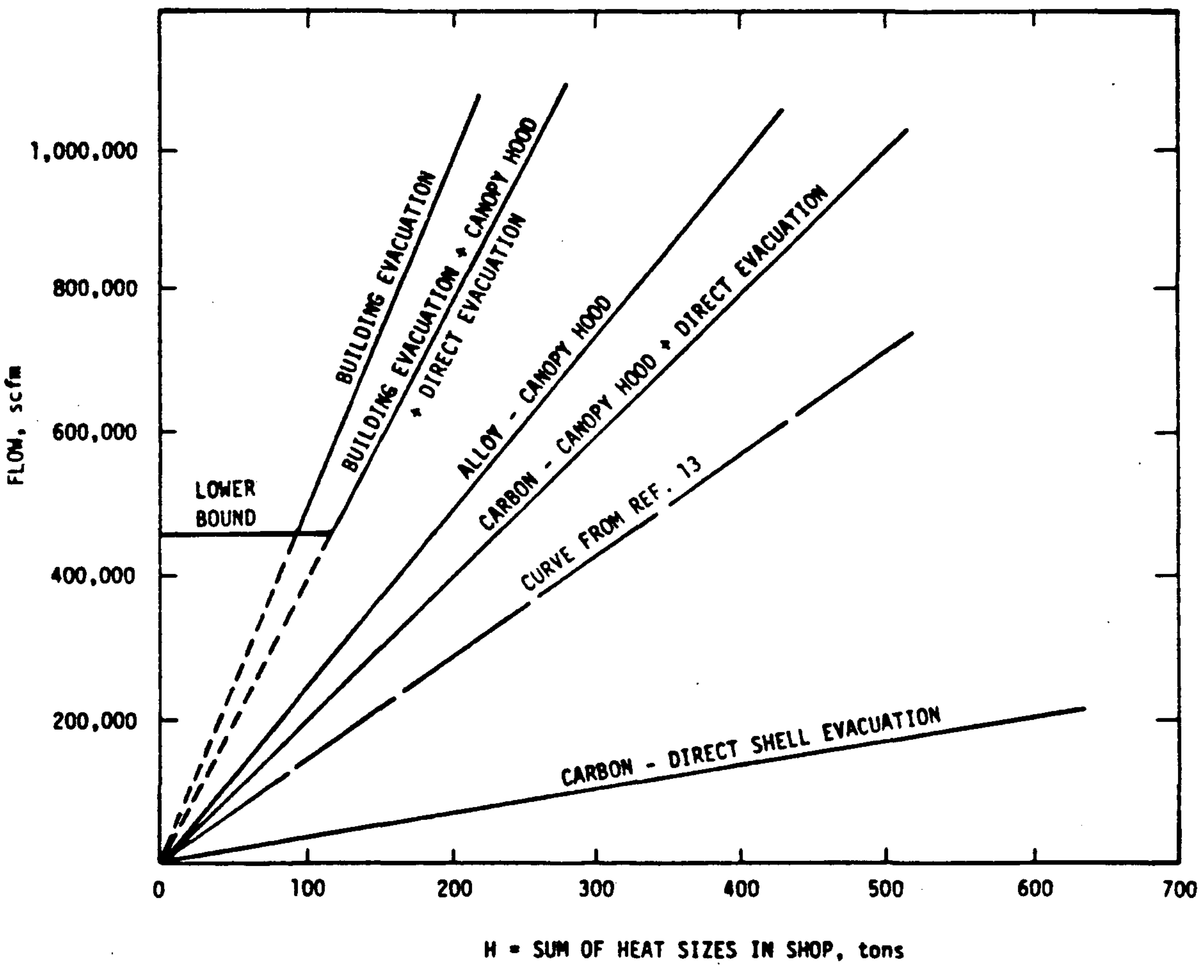


Figure 2-12. Flow rates required for electric arc furnace control.[29]

shown in Appendix Table B-7. Hooding is used, and flow rate is estimated as 175,000 acfm at 150°F based on the assumption that both the ladle and tundish are hooded and the ladle hood must be located above the crane runway. Special close hooding designs with lower flow rates may be possible, but these could only be considered on a site-specific basis. No distinction is made for the type of shape cast.

Soaking Pits

The census basis is the number of soaking pits as shown in Appendix Table B-8. In this case, control requirements are a function of fuel usage and fuel sulfur content. Since these factors are highly variable by plant, no typical cost can be calculated. An analysis of emission rates is presented in Table 2-2. The cost for an ESP installation is calculated for oil-fired pits. Pits fired with gas require no control. Factors relating production (throughput) to heating area and fuel usage to production have been developed as follows:

Assume fuel consumption = 1.35×10^6 Btu/ton[10,22,30,31]
With oil firing at 20 percent excess air:

$$\text{Exhaust rate} = 1.35 \times 10^6 \text{ Btu/ton} \div 150{,}000 \text{ Btu/gal} \times 1871 \text{ ft}^3\text{/gal}$$
$$= 16{,}839 \text{ ft}^3\text{/ton ingots heated.}$$

With coke-oven-gas firing at 10% excess air

$$\text{Exhaust rate} = 1.35 \times 10^6 \text{ Btu/ton} \div 500 \text{ Btu/ft}^3 \times 6 \text{ ft}^3\text{/ft}^3 \text{ gas}$$
$$= 16{,}200 \text{ ft}^3\text{/ton}$$

Since these values are very close, the average value of 16,500 ft^3/ton was used for either fuel.

Soaking pit loading = 0.54 ton/ft^2 heating area

Annual capacity = 304 x heating area

$$\text{where } 304 = 0.54 \times \frac{8760 \text{ h/yr}}{14 \text{ h/load}} \times 0.9 \text{ availability}$$

Automatic Scarfing

The census basis is one scarfing machine. Scarfing machines considered are shown in Appendix Table B-9. Flow rate is based on the relationship shown in Figure 2-13. Emissions are based on tons of steel capacity.

Table 2-2. SOAKING PITS EMISSION ANALYSIS

	Facility size[a]		
	Small	Medium	Large
Heating area, ft^2	2000	4000	10,000
Fuel usage, 10^6 Btu/ton	1.35	1.35	1.35
Throughput, tons/h	76	152	380
Particulate emission with 1% S oil:			
lb/10^6 Btu	0.15	0.15	0.15
lb/h	16	31	77
lb/ton	0.20	0.20	0.20
SO_2 emissions with 1% S oil			
lb/h	114	228	570
lb/ton	1.5	1.5	1.5
lb/10^6 Btu	1.1	1.1	1.1
Particulate emissions with 50 gr H_2S/100 scf coke oven gas			
lb/10^6 Btu (@0.02 gr/scf)	0.006	0.006	0.006
lb/h	0.6	1.2	3.0
lb/ton	0.008	0.008	0.008
SO_2 emissions with 50 gr H_2S/100 scf coke oven gas			
lb/10^6 Btu	0.27	0.27	0.27
lb/h	55	55	137
lb/ton	0.36	0.36	0.36
tons/year produced at 7000 h/year	532,000	1,064,000	2,660,000

[a] These figures are for batteries of soaking pits; individual pits have less than 1000 ft^2 heating area each (generally 500 to 1000).

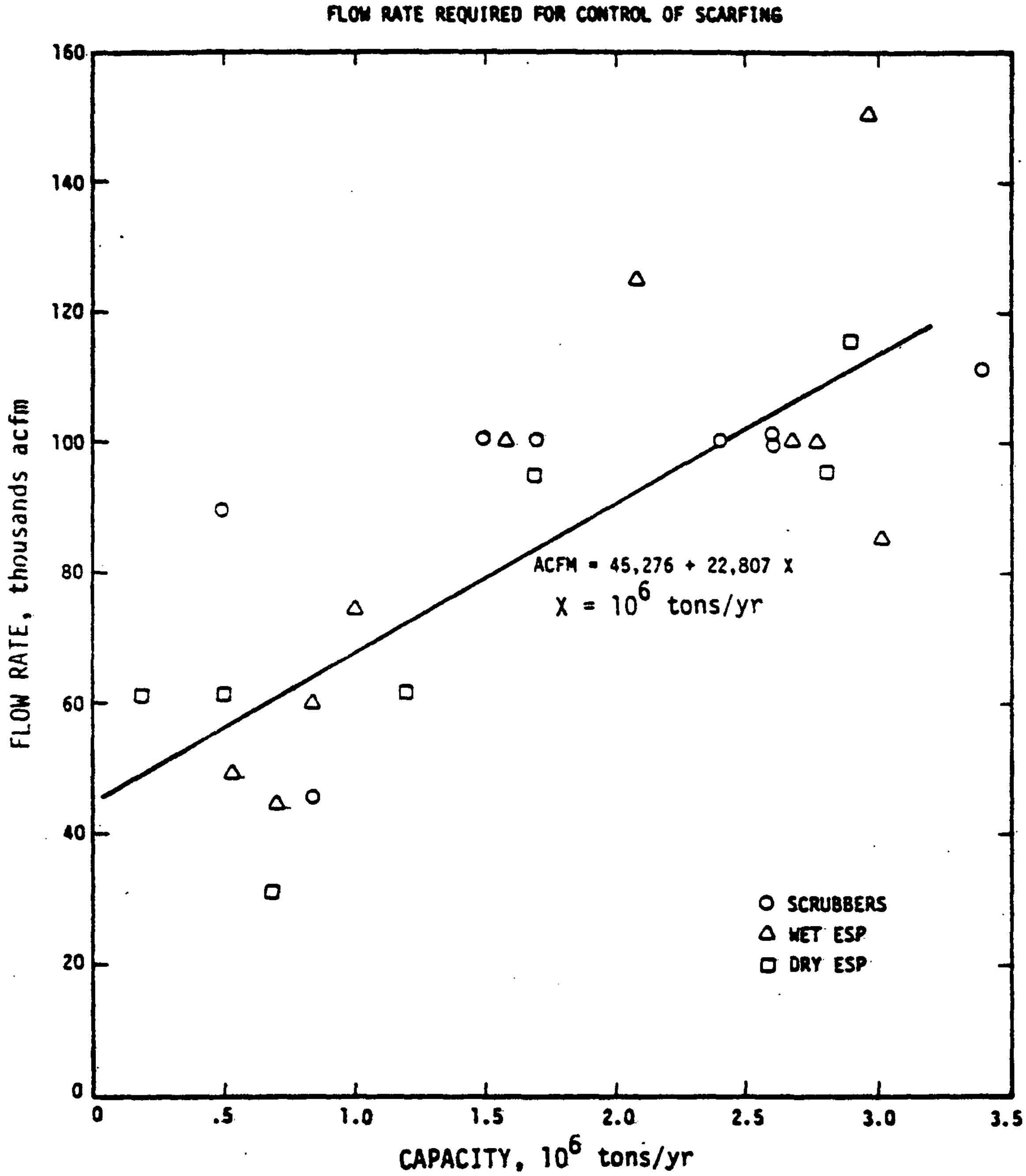


Figure 2-13. Flow required for control of scarfing emissions.[36]

Reheating Furnaces

The census basis is the number of furnaces. Reheat furnaces are listed in Appendix Table B-10. Fuel consumption is calculated from the relationship 2.8×10^6 Btu/ton steel, a value derived from review of the literature.[10,22,32,33,34,35]

Reheat furnace calculations:
Assume fuel consumption = 2.8×10^6 Btu/ton

With oil firing and 20 percent excess air,
exhaust rate = 2.8×10^6 Btu/ton ÷ 150,000 Btu/gal x 1871 ft^3/gal
= 34,925 ft^3/ton slab heated

With coke-oven-gas firing at 10 percent excess air,
exhaust rate = 2.8×10^6 Btu/ton ÷ 500 Btu/ft^3 x 6 ft^3/ft^3 gas
= 33,600 ft^3 ton

Since these values are very close, use the average 34,300 ft^3/ton for either fuel.

For slab reheat furnaces, firing rate in Btu per hour can be related to heating area by the equation:

Throughput = 0.075 ton/h per ft^2.

This equation assumes 85 percent hearth coverage and represents a maximum throughput, i.e., firing rate. This relationship is derived from References 10 and 22.

For soaking pits and reheat furnaces, assume an additional exhaust flow of 20 percent to account for infiltration of tramp air. This increases exhaust rates to 20,000 ft^3/ton and 41,000 ft^3/ton. Analysis of emission rates for reheat furnaces is presented in Table 2-3. The cost of an ESP installation for an oil-fired furnace is calculated. Gas-fired furnaces do not require control. Reheating furnaces for finishing or heat treating furnaces for the finishing and special product categories are not considered a significant source of emissions.

Boilers

Detailed census data on steel mill boilers are very limited. Boilers considered are shown in Appendix Table B-11. The costs

Table 2-3. LARGE REHEAT FURNACE EMISSION ANALYSIS

	Furnace size		
	Small	Medium	Large
Heating area, ft^2	500	1500	3500
Fuel usage, 10^6 Btu/ton	2.8	2.8	2.8
Maximum throughput, tons/h	37	110	260
Particulate emissions with 1% S oil			
lb/10^6 Btu	0.15	0.15	0.15
lb/h	16	48	110
lb/ton	0.4	0.4	0.4
SO_2 emission with 1% S oil			
lb/h	115	347	810
lb/ton	3	3	3
lb/10^6 Btu	1.1	1.1	1.1
Particulate emissions with 50 gr H_2S/100 scf coke oven gas			
lb/10^6 Btu	0.006	0.006	0.006
lb/h	0.7	1.9	4.5
lb/ton	0.017	0.017	0.017
SO_2 emissions with 50 gr H_2S/100 scf coke oven gas			
lb/10^6 Btu	0.27	0.27	0.27
lb/h	28	85	197
lb/ton	0.75	0.75	0.75
Tons/yr produced at 7000 h/yr (avg throughput = 0.045 ton/h)	158,000	470,000	1,103,000

of particulate plus SO_2 control are considered for a coal-fired boiler. The cost of particulate control of oil-fired boilers to comply with a limit of 0.02 gr/scfd is also presented. Boilers fired with blast furnace gas, desulfurized coke oven gas, low-sulfur oil (< 1.2 lb/10^6 Btu), or combinations thereof do not require additional control. Obviously, the need for control equipment on boilers is highly fuel-dependent. Boilers fired with by-product fuel, i.e., coke oven gas or blast furnace gas, may normally need no control. If the boiler is switched to oil for a short period during shortage of by-product fuel or high steam demand, control may be required. The wide variation in emissions is illustrated in Table 2-4. This study does not address the compliance complications arising from short-term fuel switching.

Steel mill boilers have generally low firing rates compared to utility boilers. Flue gas desulfurization systems on such small boilers have a high cost per Btu. If there were only one coal-fired boiler in a mill complex, fuel switching or shutdown would have to be considered as alternatives to control.

Appendix Table C-1 summarizes the flow rates described in this section.

2.3 CONTROL LEVELS AND TECHNOLOGIES CONSIDERED

Table D-1, Appendix D, summarizes the emission rates and control technologies that constitute the general definitions of Reasonably Available Control Technology (RACT), Best Available Control Technology (BACT), and Lowest Achievable Emission Rate (LAER) in this study. Because some detail is lost in condensing so much information into a table, extensive footnotes are presented to provide further information on the emission rates. Note that the emission rates are not necessarily intended to be equivalent to generally accepted emission factors. Although some of the factors are formally recognized in AP-42 or other published sources, many are only estimates or averages of widely

Table 2-4. EXHAUST PARAMETERS FOR VARIOUS BOILER FUELS

(at 50% excess air)

Fuel or Regulation	Particulate lb/10^6 Btu	Particulate gr/scfd	Particulate scf/10^6 Btu	SO_2 lb/10^6 Btu	SO_2 ppm (weight)
Blast furnace gas	0.008	0.002	26,300	0	0
Coke oven gas					
400 gr H_2S/100 scf	0.005	0.002	17,000	2.0	1500
50 gr H_2S/100 scf	0.005	0.002	17,000	0.2	190
10 gr H_2S/100 scf	0.005	0.002	17,000	0.05	40
1% S oil	0.15	0.06	17,000	1.1	840
2.5% S oil	0.15	0.06	17,000	2.7	2100
2.5% S, 10% ash coal	5.4	2.2	17,000	4.0	3100
NSPS[a] boiler <250 x 10^6 Btu/h	0.1	0.04		0.8 oil 1.2 coal	600 920

[a] New Source Performance Standard.

variable data; consequently, there is some controversy as to the correct value. Very few actual data are available for many of the fugitive sources that are not widely controlled.

This study is relatively insensitive to minor differences in emission rates, and such differences do not seriously influence the calculated costs. The costs of quench tower baffles and dry quenching, for example, are independent of the emission rates from coke quenching. The cost of an ESP would be influenced somewhat, in that the efficiency required would change with emission rate and consequently would affect the total plate area. The emission rates are considered reasonable for the purpose intended, i.e., to indicate the relative degrees of control achievable with various control technologies. The factors should not be interpreted as representative of emissions at any specific plant.

Obviously, the technologies listed in Table D-1 are abbreviated descriptions. Specific control equipment is described in detail in Section 3.

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SECTION 3

DETERMINATION OF CAPITAL AND OPERATING COSTS

3.1 GENERAL CONSIDERATIONS IN DEVELOPMENT OF CAPITAL COST FUNCTIONS FOR AIR POLLUTION CONTROL OF STEEL MILL PROCESSES

The approach used in developing capital cost estimates is to define various fundamental elements of control equipment, described herein as modules, and then combine the modules into a control system. The large number of modules considered here results directly from the variety of emission sources covered.

Throughout these estimations we attempt to recognize the severe service conditions of steel plant operation. These are reflected in installed spares for pumps and motors, liberal plate thicknesses in hoods and structurals, painting of exposed members, and adequate instrumentation. The overall procedure is in five steps:

1) Establish individual elements of air pollution control equipment. These elements are referred to as modules. In some cases, the modules are general pieces of equipment such as fans, fabric filters, and ductwork. In other cases, the modules are total systems unique to the steel industry such as enclosed hot cars and coke oven gas desulfurization systems. The modules are shown in Table 3-1 and are described in Appendix E.

2) Using standard engineering methods estimate the total installed costs of the module. These estimates are given for at least three sizes of modules and include separate estimates for equipment, installation, and indirect cost. An example estimate package for the Module 6, water quench-gas cooler, is shown in Appendix F. Some modules that are typically considered as a total system, such as coke oven gas desulfurization, are not estimated in equivalent detail, but costs are based on total system quotation plus engineering and on-site work. Installation costs are based on a 40-hour work week. The cost of interest during construction is a function of estimated installation time.

Table 3-1. EQUIPMENT MODULES

Module and version no.	Module name
01-01	Carbon steel, dry ESP
01-02	Stainless steel, wet ESP
03-01	Carbon steel baghouse $\leq$ 50,000 acfm, uninsulated
03-02	Carbon steel baghouse $\leq$ 50,000 acfm, insulated
03-03	Carbon steel baghouse > 50,000 acfm, uninsulated
03-04	Carbon steel baghouse > 50,000 acfm, insulated
04-01	Carbon steel venturi scrubber
04-02	Stainless steel venturi scrubber
05-01	Lined cyclone
05-02	Unlined cyclone
06-01	Contact gas cooler $\leq$ 250,000 acfm
06-02	Contact gas cooler > 250,000 acfm
06-03	Carbon steel noncontact gas cooler
07-01	Raw material receiving station sprays
09-01	Enclosed hot car
10-01	Pipeline charging
11-01	Modify larry car
11-02	Larry car - stage charge
13-01	Windbox recirculation
14-01	Quench tower baffles
16-01	Dry quenching
17-01	Blast furnace flare
17-02	Coke oven gas flare
17-03	BOF gas flare
18-01	Carbon steel wire-mesh-type mist eliminator
18-02	Stainless steel wire-mesh-type mist eliminator
18-03	Carbon steel blade-type mist eliminator
18-04	Stainless steel blade-type mist eliminator
19-01	Fan and drive (0-800 bhp)
19-02	Fan and drive (801-2000 bhp)
19-03	Fan and drive (> 2000 bhp)
20-01	Carbon steel ductwork, unlined, 100 ft
20-02	Stainless steel ductwork, unlined, 100 ft
20-03	Carbon steel ductwork, lined, 100 ft
20-04	Stainless steel ductwork, lined, 100 ft
21-01	Carbon steel stack, unlined
21-02	Stainless steel stack, unlined
21-03	Carbon steel stack, brick lined
21-04	Stainless steel stack, brick lined
22-01	SO_2 monitor
24-01	EAF canopy hood
24-02	SQ canopy hood $\leq$ 10 ft sides
24-03	SQ canopy hood > 10 ft sides
24-04	SQ canopy hood $\leq$ 10 ft sides with skirt
24-05	SQ canopy hood > 10 ft sides with skirt

(Continued)

Table 3-1 (continued)

Module and version no.	Module name
24-06	SQ canopy hood $\leq$ 10 ft sides with lining
24-07	SQ canopy hood $\geq$ 10 ft sides with lining
24-08	SQ canopy hood $\leq$ 10 ft sides with lining
24-09	SQ canopy hood $\geq$ 10 ft sides with lining
25-01	Wastewater recycle system
27-01	Building louvres
28-01	Cast house runner cover
29-01	BOF enclosure
30-01	Coke oven gas desulfurization (50 grains)
30-02	Coke oven gas desulfurization (35 grains)
30-03	Coke oven gas desulfurization (10 grains)
40-01	Conveyor transfer point hoods
41-01	FGD system, SO_2
41-02	FGD system, particulate and SO_2
41-03	FGD system, particulate, SO_2 and water treatment
41-04	SO_2 scrubber for sinter plant
42-01	Dust handling hoppers and conveyors
43-01	Leveling bar smoke seal
44-01	Steam supply, stage charging
45-01	Carbon steel damper, $\leq$ 7-ft diameter
46-01	Carbon steel damper, $\geq$ 7-ft diameter
47-01	Stainless steel damper
48-01	Spray towers
49-01	Transfer point spray
50-01	Spray truck
51-01	Storage yard dust suppression system
52-01	Opacity monitor
53-01	Combustion control monitor
54-01	Wastewater return system
55-01	Water pumping system (< 1500 gpm)
55-02	Water pumping system (> 1500 gpm)
56-01	Water-cooled plate duct
57-01	Fan and drive electrical (< 150 bhp)
57-02	Fan and drive electrical (> 150 bhp)
58-01	Coke oven door cleaner
59-01	BOF closed hood, one furnace
59-02	BOF open hood, one furnace
60-01	Slag water sprays

3) Determine the mathematical cost function by plotting the estimate in dollars versus the size parameter. The size parameter is often acfm, but it may be a process size. Estimates for some modules require multiple parameters; for example, acfm, pressure drop, and temperature in the case of fans. An example module cost function is shown in Figure 3-1.

4) Design the control system judged to be capable of achieving the level of control desired. The design step therefore consists of two parts. First, assemble the appropriate modules; second, establish broad parameters of design to meet the control level. The parameters include such variables as acfm, air/cloth ratio, and collection area. All of the parameters can be varied, however, in the computer model. For existing sources, an appropriate retrofit multiplier must be chosen since the module cost functions are based on a new installation.

5) Calibrate the control system cost functions by comparing with actual cost data where they are available. Care must be exercised to ensure that the actual cost data represent a control system equivalent to that being estimated and that the data include no extraordinary site-specific costs.

In this procedure three system designs represent each level of control for each emission source; albeit some may be identical. Furthermore, parameters of design must be chosen for three different sizes of each emission source to establish a control system cost function. In some cases, two alternative systems may be capable of achieving the same degree of control. For example, an ESP or scrubber may be equally suitable. In such cases a control system was chosen for this study based on such factors as industry practice, economy, and maintenance and operation.

A concern that arises in such generalized costing procedures as are described herein deals with the validity of the costs in specific cases and the ability to estimate accurately when real-world situations vary markedly. This study does not attempt to estimate costs of a control system for a specific plant. Rather it develops cost for the industry, broken down by type of process, size of process, and degree of control. The aggregate is based

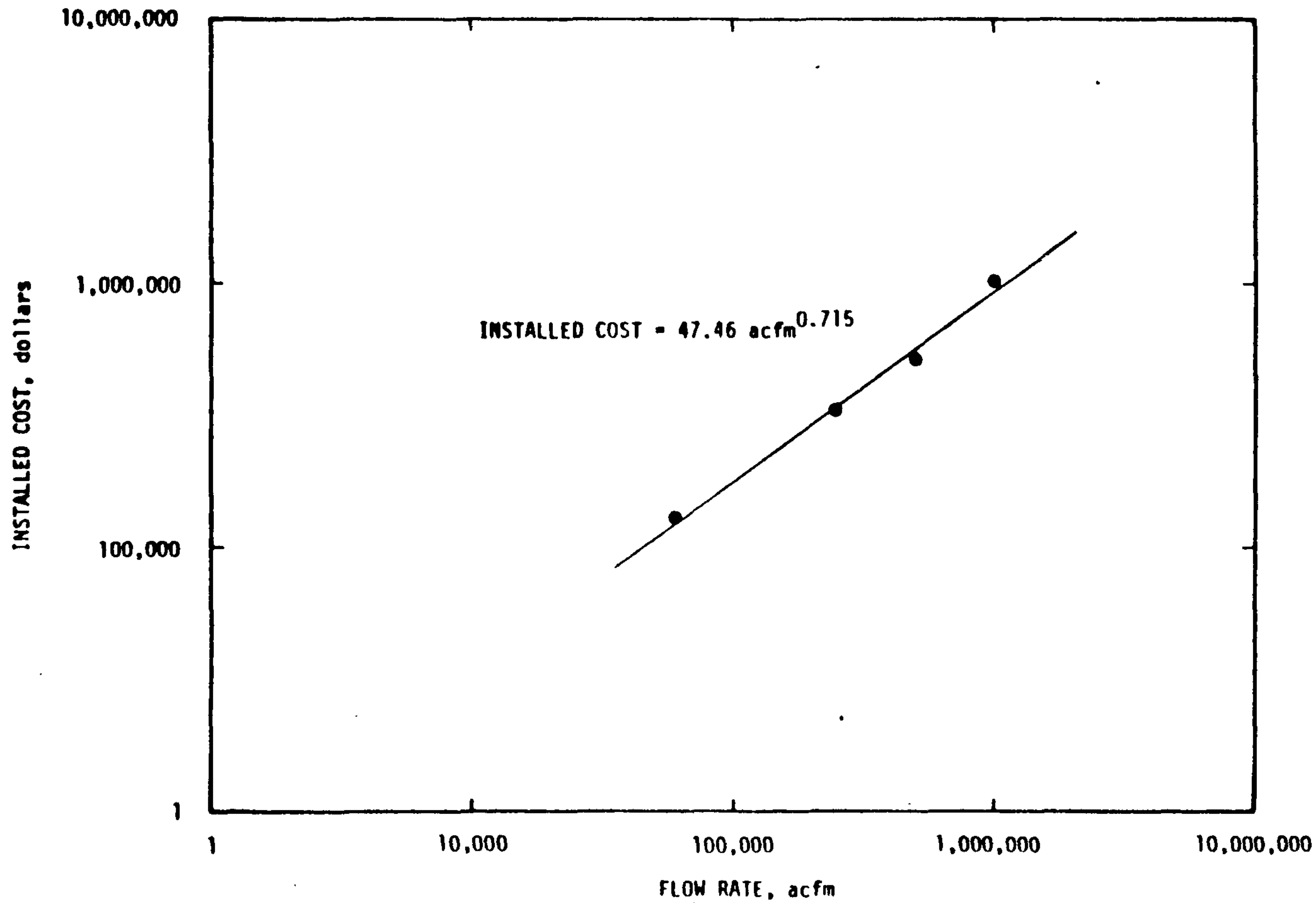

Figure 3-1. Example module cost function, gas cooler-water quench.

on a level of detail that leads to a balancing out of plus and minus errors.

The retrofit situation presents a significant problem in estimating procedures because steel mills vary greatly in size, age, and layout. The use of the module approach, however, permits some degree of distinction to be made. When each type of control system is considered for each emission source, difficulty of the retrofit can be estimated on the basis of typical conditions in many mills. Certainly the estimates cannot be considered site-specific, but at least there is an accounting for retrofit costs. Retrofit multipliers are assigned in the computer cost model in increments of 0.1 (10%). A retrofit multiplier of 20 percent, for example, designates that the retrofit cost is 20 percent higher than the cost of a new installation. The retrofit multipliers are assigned separately and independently for each module.

This study is intended to consider only the costs of air pollution control. Another contractor, Temple, Barker & Sloane, will address costs of water pollution control. Table 3-2 indicates the emission sources that will generate process water requiring treatment and the expected contaminants. Unlike all other air pollution control systems, however, the water treatment portion of flue gas desulfurization (FGD) systems for coal-fired boilers is included as an inherent part of the system.

3.2 EXAMPLE OF DESIGN PROCEDURES FOR AIR POLLUTANT CONTROL SYSTEMS: SINTER PLANT WINDBOX

The technology table discussed (Appendix Table D-1) provides the current EPA estimates of emission rates required under three levels of technology. To avoid any legal implications in interpretations, the terms RACT, BACT, and LAER, are used herein simply as labels for three different situations. Whether they are in fact "reasonable," "best," or "lowest" is not an issue in this application.

Table 3-2. SOURCES REQUIRING WATER TREATMENT AS A RESULT OF AIR POLLUTION CONTROL

Source	Pollutant parameters: SS	pH	F	CN	Phenol	Other (NH_3, $SO_3^=$, etc.)
Sinter windbox[a]	x	x	x			
Coke pushing Enclosed car	x	x		x	x	x
Coke quenching	x	x		x	x	x
Coke comb. stack[a]	x	x				x
BOF stack[a]	x	x	x			
FGD boilers	Water treatment is included with air pollution control system					

[a] These sources could use a dry control system, in which case water treatment would not be required.

Figure 3-2 illustrates the building block concept wherein appropriate control modules are combined to make a control system. The design parameter of flow used in this example is 380,000 acfm. This is for a "medium-sized" sinter plant producing 3767 tons/day. Flow and tonnage are determined as described in Section 2. The uncontrolled emission rates are 4.3 lb TSP/ton sinter, 1.8 lb SO_2/ton sinter, 0.24 lb condensible HC/ton sinter, and 4.7 lb gaseous HC/ton sinter. The level of control achieved by system 1 is for TSP only and is 0.035 gr/scf. At the production rate used, this can be converted to 0.5 lb/ton sinter or 90 percent control of particulate. Note that for a "small" sinter plant (1671 tons/day and 179,000 acfm), the same grain loading results in 0.55 lb/ton sinter or 88 percent control. Such variation occurs in many processes because flow is not always directly proportional to production.

The cyclone is not included as part of the control system because it is considered to be part of the process. One hundred and fifty feet of carbon steel ductwork is the first element of the system. A retrofit factor of 1.6 is used for existing plants to account for elbows, eyes, and general layout complications of the ductwork.

A wet stainless steel scrubber with a pressure drop of 40 in. of water is the second element. A retrofit factor of 1.1 accounts for layout complications. Associated with the scrubber is a wastewater return module and makeup water supply module, both with a 1.1 retrofit factor. A water recirculating module is included, consisting of a clarifier, vacuum filter, and associated pumps and piping. The clarifier is sized to achieve 100 mg/liter suspended solids outlet with a 5 percent blowdown. A stainless steel blade mist eliminator module is added with a retrofit factor of 1.1.

The fan is sized for the flow and temperature required and at a total static pressure capacity of 70 in. The total pressure consists of 40 in. for the scrubber, 25 in. for the process, and 5 in. for duct loss and stack outlet. In calculation of operating

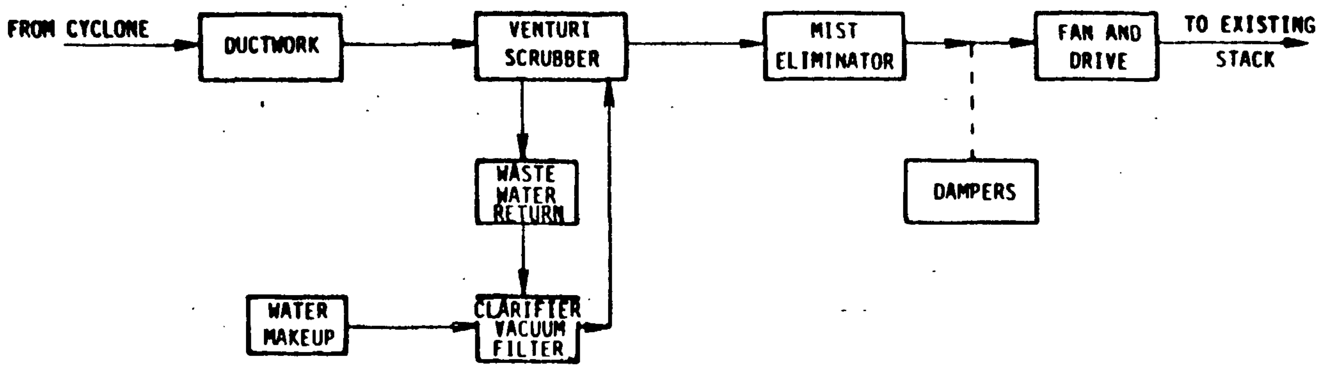

Figure 3-2. Block diagram of sinter plant windbox control (RACT).

cost, only the incremental 40 in. for control is used. The retrofit factor is 1.1. The installed spare fan capacity is 50 percent.

A stack module is not included in this case because it is considered part of the process.

The only change required for system 2 is an increase in scrubber pressure drop. A pressure drop of 60 in. is used to decrease the outlet loading to 0.02 gr/scf F.H.* This translates to 0.3 lb/ton or 94 percent control of particulate. Fan sizing is based on 90 in. water pressure drop.

Figure 3-3 illustrates a significantly more complex system designed to hold total outlet loading to 0.02 gr/scf F.T.** and also provide 90 percent control of SO_2 emissions. A wet ESP is used in conjunction with windbox gas recirculation and SO_2 scrubbing. Flow rate to the scrubber is reduced by 40 percent. Note that continuous monitoring for opacity and SO_2 is added. The retrofit factor for windbox recirculation is 1.6. Even this system provides essentially no control of gaseous hydrocarbons.

This entire procedure is then repeated for a "small" plant and a "large" plant to yield three control system cost functions. Although not within the scope of this project, it is clear that intermediate control levels or other values for design parameters could be examined in the same fashion by use of the computer model. Appendix G contains computer model example printout of the sinter plant windbox control systems.

3.3 OPERATING COST ESTIMATION FOR AIR POLLUTION CONTROL SYSTEMS

The costs of operating pollution control systems fall into three major categories: utilities, operating labor, and maintenance and supplies. Subcategories of each are discussed below.

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* F.H. = Front Half, EPA Method 5.

** F.T. = Full Train, EPA Method 5.

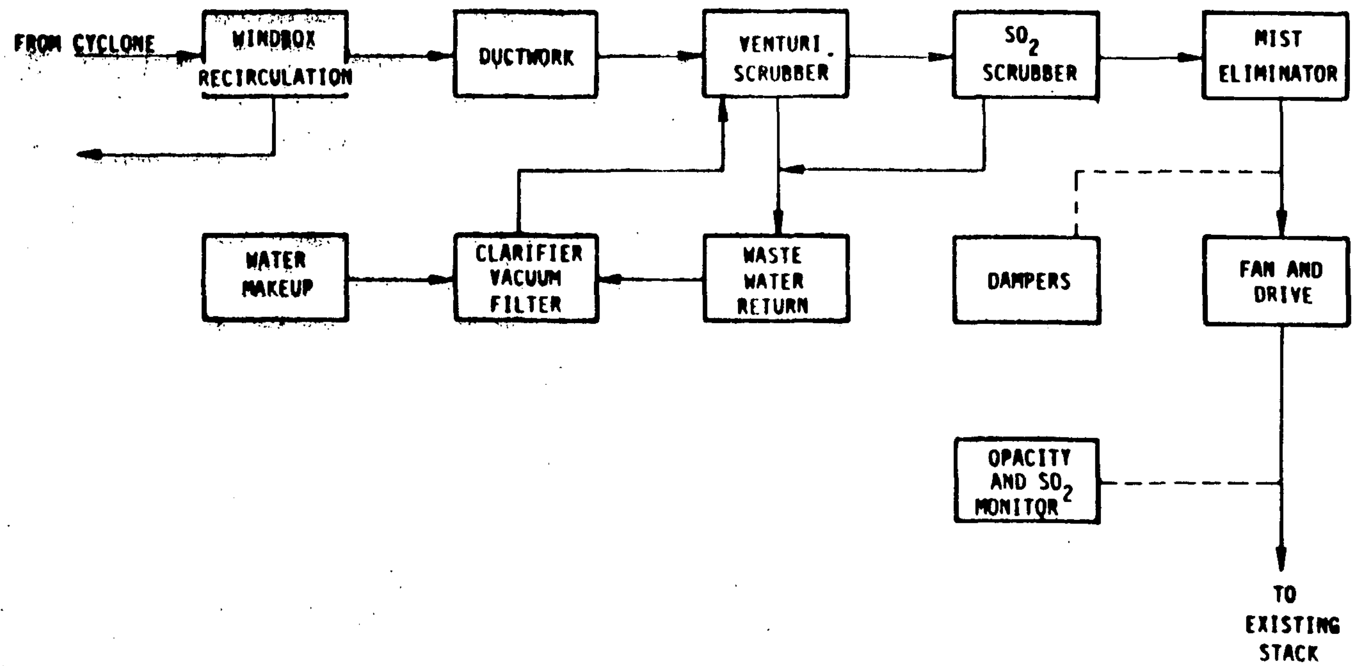

Figure 3-3. Block diagram of sinter plant windbox control (LAER).

Operating costs have been estimated separately for each of the modules in the study. To determine the operating cost of a given control system, the operating costs developed for the modules in that system are added.

Utilities

The category of utilities includes four subcategories: water, electricity, steam, and fuel. The utility rates were taken from Reference 1 and are shown in Table 3-3. The water subcategory includes scrubber and nonscrubber water. A cost of $0.145 per 1000 gallons is used for all supply water. This study does not address costs of water pollution control except to the extent that a clarifier-vacuum filter system is used with wet control devices for water recirculation. The costs associated therewith are included as an inherent cost of air pollution control. Costs of water treatment of dissolved compounds such as fluorides, phenols, or cyanides are not included. Certain air pollution control systems such as those for coke oven pushing or sinter plant windbox might require water treatment beyond suspended solids removal. The value used for cost of clean water for coke quenching is $8.22 per 1000 gallons and is derived from Reference 1. Treatment of coke plant wastes that would otherwise be used for quenching is the basis of this cost. The capital cost of coke plant wastewater treatment is considered to be a water pollution related cost.

Water treatment for a boiler FGD system is integral to the system and consists of a clarifier-vacuum filter system with sludge fixation and sludge pond.

Spray water for dust suppression in ore yards, coal yards, and slag handling is assumed to constitute no runoff problem, and no water collection or treatment costs are considered.

Scrubber water consumption is calculated from the estimated liquid to gas ratio (L/G) of the wet control device and cooler, if required, and the applicable exhaust flow rate. Liquid to gas ratios for venturi scrubbers and wet ESP's range from 6 to 15

Table 3-3. OPERATING COST RATE FACTORS

Item	Cost
Water	$0.145/1000 gal
Electricity	0.0242/kWh
Steam	3.72/1000 lb
No. 2 fuel oil	0.38/gal
Dust surfactant	3.35/gal
Polyelectrolyte	2.25/lb
Operating and maintenance labor	13.04/h[a]
Supervision	15.54/h
Monoethyleneamine (MEA)	0.45/lb
Dacron bags	0.25/ft^2
Glass bags	0.40/ft^2
-200 mesh limestone	20.00/ton

gal/min per 1000 acfm. Review of the literature and EPA Section 308 survey data indicates that values of 6.5 to 10 predominate. Rather than estimate water required for cooling hot exhaust gas separately from the gas scrubbing function, we have developed the relationship described in Appendix E. A minimum L/G of 6.5 is used. The initial cooling of exhaust gases from 3000° to 2000°F is not considered for BOF open hood systems however. This initial cooling (using a spark box, water-cooled hood, or other arrangement) is considered part of the process. In estimating scrubber water consumption, we assume that 95 percent of the water used for scrubbing is recycled.

Among the modules used in this study, three are identified as consuming nonscrubber water. The first is gas cooling water, which is estimated as described previously. The second is water used wetting down ore and coal yards and associated transfer points. This value is difficult to estimate because there is very little experience with this control technology in the steel industry.[2-6] Here, the basis for water usage is that the desired wetting occurs when 2 percent of the material by weight is added as water. We assume that water is applied at this rate when material is delivered and also is applied to the material in inventory 41 times per year (80% of 52 weeks). Natural rainfall is deemed sufficient for wetting during the remaining 20 percent of the time. The material in inventory is one-fourth of the quantity delivered in a year. This results in a total use of 55 gallons per ton of material delivered. Clearly there will be great variation from plant to plant in the natural moisture content of raw materials, the climatic conditions and the subsequent need for dust suppression. The third source of water consumption not determined by L/G ratio is in an enclosed hot car where the estimated usage is 45 gal water/ton of coke produced.[7,8]

Electrical Costs

Electricity is required for elements of five of the equipment modules: pumps, electrostatic precipitators, fans, baghouse shakers, and dust handling conveyors.

Energy to Operate a Fan

In calculating the annual energy requirements for a fan, we assume that the fan is operated at "full power" for h_1 hours per year and at 40 percent of "full power" for h_2 hours per year. By using the Bernoulli equation, assuming that kinetic and potential energy changes are negligible, and accounting for frictional losses by using efficiencies of 0.9 and 0.6 for the motor and fan respectively, we calculate the power or energy required per unit time as follows:

$$P = \frac{Q\Delta P}{D\mu_{fan}\mu_{motor}} + \frac{0.4Q\Delta P}{D\mu_{fan}\mu_{motor}}$$

where D = density of air at standard conditions

μ_{fan} = fan efficiency

μ_{motor} = motor efficiency

After substitutions, conversions, and multiplication by the appropriate number of operating hours, the annual energy requirement is:

$$E = 0.000218\ Q\Delta Ph_1 + 0.000087\ Q\Delta Ph_2$$

where E is in kWh, Q is in acfm, ΔP is in in. H_2O, h_1 is the number of hours at "full load," and h_2 is the number of operating hours at 40 percent of "full load." The estimates used for h_1 and h_2 depend on the process and are shown in Table 3-4. Full-load horsepower rating (0.000218 $Q\Delta P$) is used to size fan motors, but the operating cost calculation corrects for elevated temperature by multiplying the above rating by the ratio of air density at the fan temperature to standard air density.

Energy to Operate a Pump

Calculations of the annual energy required to operate a pump are similar to those for a fan. As above, the Bernoulli equation is used, with the same assumptions regarding kinetic and potential

Table 3-4. ANNUAL OPERATING HOURS AT FULL HORSEPOWER FOR CONTROL DEVICE BY PROCESS

[Operating hours at full hp (h_1) and reduced hp (h_2)]

Process	h_1	h_2	Remarks
Coal handling	7900 per plant	0	
Sintering	7900 per plant	0	
Coke pushing	2700 per battery	0	Enclosed car
Coke combustion stack	8600 per stack	0	
Coke handling	7900 per plant	0	
Blast furnace cast-house	2400 per furnace	6200	
Slag processing	4400 per plant	0	
Open hearth	8600 per shop	0	
Hot metal transfer	3000 per shop	5600	
BOF stack	3100 per furnace	$8600-h_1$	h_1 not to exceed 6200
BOF Chg and tap	1500 per furnace	$8600-h_1$	h_1 not to exceed 3000
Electric arc furnace	7900 per shop	700	
Scarfing	4400 per machine	3500	

energy and the same efficiency values to account for friction. The pump is assumed to be operating at "full power" 90 percent of the time. The power needed is:

$$P = \frac{Q\Delta P}{D_{water}\mu_{fan}\mu_{motor}}$$

With making the appropriate substitutions and conversions and an assumed ΔP of 125 ft H_2O, the annual energy requirement is:

$$E = 344Q$$

Where E is in kWh and Q is in gal/min.

Energy to Operate a Baghouse Shaker

In calculating the annual energy requirements for a baghouse shaker, we assume that a 1-hp motor can shake 2000 ft^2 of bags and that the motor operates 1 min during an hour, 8600 h/yr. The annual energy requirements are:

$$E = 0.053\ A$$

where E is in kWh and A is the total cloth area in ft^2.

Energy to Operate an ESP

The annual energy requirements for an ESP are based on a power density of 3 w/ft^2 plate area. If precipitator operation is assumed to be 8600 h/yr, the annual energy requirements are:

$$P = 25.8\ A$$

where P is in kWh and A is total plate area in ft^2.

Energy for Dust Handling Conveyors

Energy requirements for screw conveyors are based on conveyor size and motor horsepower required, expressed as

$$kW = 6.2(X)^{0.18}$$

where X is tons of dust per day.

A given module that is an integral part of a control system may contain any or all of these sources of electrical energy consumption. The total energy requirements for that system are merely a summation of the individual consumption values. To get the annualized electrical costs, the number of kilowatthours is multiplied by $0.0242, the cost per kilowatthour.

Steam Costs

The third subcategory of utilities is steam, which is used for stage charging, dry electrostatic precipitators, and coke oven gas desulfurization. The cost of $3.72 per 1000 lb steam is based on 70 percent boiler efficiency and $2.27 per 10^6 Btu for fuel.[1]

In stage charging, steam consumption is estimated to be 24 pounds per ton of coal charged, based on 9/16-in. steam nozzles activated for 6 min per charge. Steam consumption by dry electrostatic precipitators is estimated from data in Reference 9. Data for steam consumption in coke oven gas desulfurization were obtained from Reference 10.

Cost of distillate fuel oil is estimated as $0.38 per gallon. This oil is used in only one module, the enclosed hot car, at a rate of 0.95 gal oil/ton coke produced.[7,8]

Operating Labor

The category of operating labor includes two subcategories, direct and supervision. In each case, and for each module that requires an operator, the number of hours is estimated through engineering judgment. The number of working hours for supervision is estimated to be 20 percent of the direct labor hours. The wages for direct labor and supervisory labor, including fringe benefits, are estimated at $13.04 and $15.64 per hour, respectively.[1] The operating labor hours for the blast furnace runner cover module are estimated from information given in Section 2, Reference 18.

Maintenance and Supplies

Maintenance labor hours are based on engineering judgment. The wage for the labor including fringe benefits is $13.04 per hour. The material portion of these costs is estimated as a fraction of the labor cost and varies by module.

Supplies includes the cost of fabric filter bags, dust control surfactants, flocculants, and extraction chemicals. The cost of bags is based on an average bag life of 2 years for the sintering process and 4 years for other processes.[11] The cost of dust suppressant chemicals is $3.35 per gallon, the chemicals being mixed at a ratio of 1 gal/1000 gal water. The cost of flocculating chemicals is $2.25 per pound, these chemicals being mixed at 1 ppm for makeup scrubber water. Monoethanolamine is used in coke oven gas desulfurization at a rate of 15 lb/1,000,000 scf gas treated.[10] The cost of monoethanolamine is $0.45 per pound. A miscellaneous supplies category is included as 15 percent of maintenance cost.

Costs Not Considered

The cost of land, although not regarded as insignificant, is not considered because a uniform method of costing cannot be developed. The impact of land requirement may appear in the form of a much higher cost of installation because of the need for long duct or pipe runs to available space; the cost of extra grading, excavation, or piling (i.e., land preparation); or the cost of structural work for elevated or building-mounted equipment. Land costs also may be reflected indirectly in the need to demolish existing structures or the increased cost of other facilities in the future as available space is used for environmental control facilities. Any attempt to allocate land costs on the basis of dollar per acre or dollar per square foot would not be meaningful. Land costs are too site-specific, and the impacts may range from insignificant to catastrophic.

The costs of lost production or increased cost of production during construction and start-up are not considered. Here again, the impact can vary considerably depending both upon the specific installation and the company's supply-demand status at the time.

The costs of research and development or pilot testing are not included. These too can be significant. Some companies have spent millions of dollars on control systems in a developmental mode and eventually abandoned them because of unanticipated poor performance or high maintenance costs.

Credit for by-product recovery is not considered except for steam credits in coke oven gas desulfurization and coke dry quenching. The theoretical value of iron-bearing dusts captured in the various control systems could be calculated based on present rates for iron units, lime units, and carbon units (the three primary constituents of value), but some cost would have to be added for processing to make the material suitable for use. In many cases, the material is recovered by sintering, but a significant amount is dumped or stockpiled.[12] The value of the dust depends of course on how it is recycled. It may be converted to blast furnace feed, treated for recovery of some individual component such as zinc, or sold for some other use. Simple economics suggests that where dust is being discarded, not an uncommon practice, it must be valueless. The cost of disposal of collected dusts or sludges is not considered. These costs may be minor at facilities that can recycle the dusts and sludges. Where materials must be transported to a dump area or storage area, the costs can be significant.

3.4 CAPITAL CHARGES

Capital charges include overhead, insurance, taxes, depreciation, and similar costs. This study does not consider capital charges. These are to be determined by Temple, Barker & Sloane under another U.S. EPA contract.

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SECTION 4

RESULTS

4.1 CONTROL COSTS FOR INDIVIDUAL EMISSION SOURCES

Using the procedures described earlier, we have designed control systems (groups of specific modules) for each emission source, each technology level, and in three sizes. For a specific emission source and technology level, the cost is regressed against process size and a system cost function of the form: cost = A $(\text{size})^B$ is determined. The values for the coefficients A and B and the units of the size variable are tabulated for capital cost and operating cost in Tables 4-1 to 4-3. The computer cost model can calculate the cost for any size system, but the sizes used here are those defined by Temple, Barker & Sloane. Sizes for some process categories, such as soaking pits, reheat furnaces, and boilers were not provided by Temple, Barker & Sloane. Representative sizes were selected in such cases by examining industry data. Where the control equipment is a function of some physical size parameter rather than tons of capacity, the appropriate physical sizes are used in the model, but the final cost equation is expressed in tons.

In determining the control system required to meet SIP requirements, the typical SIP control level is determined from the SIP regulations (Appendix H) and compared with the RACT, BACT, and LAER levels of Appendix D. The next highest level is used to represent SIP. For example, if the efficiency required under a typical SIP process weight rate formula is less than RACT, then RACT is used; if it is greater than RACT but less than BACT, then BACT is used. If a SIP does not address an emission source or if it is in terms of some general restrictions on

Table 4-1. CAPITAL COST COEFFICIENTS, NEW INSTALLATION

(Values of A and B for the equation $y = Ax^B$)

Emission source	Technology level						Typical SIP	Units of X
	RACT		BACT		LAER			
	A	B	A	B	A	B		
Ore yard	77,675.6	0.086	234,030.0	0.054	34.7	0.762	RACT	Total plant, annual tons of hot metal capacity
Coal yard	100,103.0	0.067	219,765.5	0.047	46.5	0.767	RACT	Total plant, annual tons of coke capacity
Coal preparation	2,679.0	0.335	3,284.3	0.326	3,284.3	0.326	RACT	Total plant, annual tons of coal capacity
Sinter windbox	12,484.6	0.431	17,172.7	0.413	19,187.4	0.453	BACT	Sinter plant, annual tons of sinter capacity
Sinter discharge	7,278.7	0.387	23,262.5	0.321	23,262.5	0.321	BACT	Sinter plant, annual tons of sinter capacity
Sinter fugitive - building	0.0	0.0	17,460.9	0.199	17,460.9	0.199	BACT	Sinter plant, annual tons of sinter capacity
Coke oven charging	282,721.1	0.020	8,620.6	0.396	8,620.6	0.396	RACT	One battery, annual tons of coke capacity
Coke oven pushing	385,888.2	0.194	385.888.2	0.194	385,888.2	0.194	RACT	One battery, annual tons of coke capacity
Coke quenching	6.8	0.737	17.5	0.684	702.1	0.706	RACT	Total plant, annual tons of coke capacity
Coke oven doors	0.0	0.0	376,483.8	0.0	376,483.0	0.0	RACT	One battery, annual tons of coke capacity

(continued)

Table 4-1 (continued)

Emission source	Technology level: RACT A	RACT B	BACT A	BACT B	LAER A	LAER B	Typical SIP	Units of X
Coke oven topside	0.0	0.000	0.0	0.000	0.0	0.000	RACT	One battery, annual tons of coke capacity
Coke underfire stack	2,934.2	0.465	4,392.3	0.439	2,330.1	0.500	UNC[a]	One battery, annual tons of coke capacity
Coke handling	864.5	0.464	864.5	0.464	864.5	0.464	RACT	Total plant, annual tons of coke capacity
Coke oven gas	9,548.2	0.481	9,888.6	0.481	10,248.7	0.481	RACT	Total plant, annual tons of coke capacity
Coal preheater	568.9	0.509	568.9	0.504	568.9	0.504	RACT	One battery, annual tons of coal capacity
Cast house emission	101,254.6	0.250	158,839.9	0.250	1,455.5	0.583	RACT	One blast furnace, annual tons of hot metal capacity
Blast furnace slag pouring	0.0	0.000	4,884.4	0.495	4,884.4	0.495	BACT	Total plant, annual tons of hot metal capacity
Blast furnace slag processing	25,316.9	0.000	10,181.1	0.224	10,181.1	0.224	RACT	One blast furnace, annual tons of hot metal capacity
Open hearth (OH) hot metal transfer	35,925.1	0.243	35,925.1	0.243	35,925.1	0.243	RACT	One OH shop, annual tons of steel capacity
Open hearth refining	995.6	0.632	995.6	0.632	995.6	0.632	RACT	One OH shop, annual tons of steel capacity

(continued)

Table 4-1 (continued)

Emission source	Technology level: RACT A	RACT B	BACT A	BACT B	LAER A	LAER B	Typical SIP	Units of X
Open hearth fugitive	0.0	0.000	0.0	0.000	0.0	0.000	N.A.	One OH shop, annual tons of steel capacity
Open hearth slag processing	25,338.9	0.000	25,338.9	0.000	25,338.9	0.000	RACT	Total plant, annual tons of steel capacity
BOF hot metal transfer	33,307.1	0.246	33,307.1	0.246	33,307.1	0.246	RACT	One BOF shop, annual tons of steel capacity
BOF refining	3,337.2	0.544	6,812.5	0.489	6,812.5	0.489	RACT	One BOF shop, annual tons of steel capacity
BOF charging tapping	164.1	0.597	6,585.6	0.450	6,585.6	0.450	RACT	One BOF shop, annual tons of steel capacity
BOF slag pouring	25,238.5	0.000	1,199,378.0	0.025	1,199,378.0	0.025	RACT	One BOF shop, annual tons of steel capacity
BOF slag processing	25,238.5	0.000	2,341.0	0.320	2,341.0	0.320	RACT	Total plant, annual tons of steel capacity
EAF Emissions - carbon	94.2	0.774	1,308.2	0.642	10,683.3	0.514	BACT	One EAF shop, annual tons of steel capacity
EAF emissions - alloy	1,023.8	0.658	1,022.2	0.663	1,459.0	0.640	BACT	One EAF shop, annual tons of steel capacity
EAF slag pouring	25,293.4	0.000	1,287.4	0.516	1,287.4	0.516	RACT	One EAF shop, annual tons of steel capacity

N.A. - Not applicable.

(continued)

Table 4-1 (continued)

Emission source	Technology level						Typical SIP	Units of X
	RACT		BACT		LAER			
	A	B	A	B	A	B		
EAF slag processing	25,293.4	0.000	86,711.7	0.079	86,711.7	0.079	RACT	Total plant, annual tons of steel capacity
Continuous casting	0.0	0.000	1,261,960.0	0.024	1,261,960.0	0.024	BACT	One casting machine, annual tons of steel capacity
Soaking pit stack stack	0.0	0.000	574.7	0.581	574.7	0.581	UNC[b]	Group of pits, annual tons of steel capacity
Auto scarfing	529,826.1	0.128	529,826.1	0.128	529,826.1	0.128	RACT	One scarfing machine, annual tons of steel capacity
Reheat furnace stack	0.0	0.000	1,541.0	0.558	1,541.0	0.558	UNC[c]	Group of furnaces, annual tons of steel capacity
Boiler stack - coal fired	173,759.8	0.685	173,759.8	0.685	173,759.8	0.685	RACT	Total plant,[d] MM Btu/hr capacity
Boiler stack - oil fired	84,056.8	0.568	84,056.8	0.568	84,056.8	0.568	UNC	Total plant,[d] MM Btu/hr

UNC - uncontrolled.

[a] Typical SIP does not require control on a process weight or combustion source basis, but does require an opacity limitation which might in turn require a control device depending upon age and condition of battery.

[b] Typical SIP does not require control, cost coefficients shown are for an ESP on soaking pits firing 100% oil.

[c] Typical SIP does not require control, cost coefficients shown are for an ESP on reheat furnaces firing 100% oil.

[d] Cost function can be used for combined or individual boilers in the range of 100 MM Btu/hr to 750 MM Btu/hr.

Table 4-2. CAPITAL COST COEFFICIENTS, RETROFIT INSTALLATION[a]

Emission source	Technology level						Typical SIP	Units of X
	RACT		BACT		LAER			
	A	B	A	B	A	B		
Ore yard	88,580.0	0.085	294,225.2	0.050	43.0	0.755	RACT	Total plant, annual tons of hot metal capacity
Coal yard	113,734.5	0.065	262,700.5	0.045	58.4	0.758	RACT	Total plant, annual tons of coke capacity
Coal preparation	2,722.2	0.340	3,358.9	0.331	3,358.9	0.331	RACT	Total plant, annual tons of coal capacity
Sinter windbox	12,815.1	0.437	17,692.2	0.419	20,404.6	0.456	BACT	Sinter plant, annual tons of sinter capacity
Sinter discharge	7,706.1	0.390	24,923.1	0.323	24,923.1	0.323	BACT	Sinter plant, annual tons of sinter capacity
Sinter fugitive	0.0	0.000	17,010.2	0.207	17,010.2	0.207	BACT	Sinter plant, annual tons of sinter capacity
Coke oven charging	310,236.2	0.020	9,461.1	0.396	9,461.1	0.396	RACT	One battery, annual tons of coke capacity
Coke oven pushing	423,541.2	0.194	423,541.2	0.194	423,541.2	0.194	RACT	One battery, annual tons of coke capacity
Coke quenching	8.8	0.738	19.3	0.684	773.0	0.706	RACT	Total plant, annual tons of coke capacity
Coke oven doors	0.0	0.000	451,801.0	0.000	451,801.0	0.000	RACT	One battery, annual tons of coke capacity

(continued)

Table 4-2 (continued)

Emission source	Technology level RACT A	RACT B	BACT A	BACT B	LAER A	LAER B	Typical SIP	Units of X
Open hearth fugitive	0.0	0.000	0.0	0.000	0.00	0.000	NA	One OH shop, annual tons of steel capacity
Open hearth slag processing	25,338.9	0.000	25,338.9	0.000	25,338.9	0.000	RACT	Total plant, annual tons of steel capacity
BOF hot metal transfer	35,835.6	0.247	35,835.6	0.247	35,835.6	0.247	RACT	One BOF shop, annual tons of steel capacity
BOF refining	3,728.6	0.543	15,887.1	0.464	15,887.1	0.464	RACT	One BOF shop, annual tons of steel capacity
BOF charging, tapping	163.8	0.606	8,578.4	0.443	8,578.4	0.443	RACT	One BOF shop, annual tons of steel capacity
BOF slag pouring	25,238.5	0.000	1,232,843.8	0.031	1,232,843.8	0.031	RACT	One BOF shop, annual tons of steel capacity
BOF slag processing	25,238.5	0.000	2,158.5	0.332	2,158.5	0.332	RACT	Total plant, annual tons of steel capacity
EAF emissions - carbon	95.5	0.783	1,438.9	0.643	11,932.0	0.514	BACT	One EAF shop, annual tons of steel capacity
EAF emissions - alloy	1,172.6	0.660	1,172.5	0.665	1,689.0	0.641	BACT	One EAF shop, annual tons of steel capacity
EAF slag pouring	25,293.4	0.000	1,493.5	0.513	1,493.5	0.513	RACT	One EAF shop, annual tons of steel capacity

(continued)

Table 4-2 (continued)

Emission source	Technology level RACT A	RACT B	BACT A	BACT B	LAER A	LAER B	Typical SIP	Units of X
Coke oven topside	0.0	0.000	0.0	0.000	0.0	0.000	RACT	One battery, annual tons of coke capacity
Coke underfire stack	3,348.2	0.470	4,833.1	0.446	2,608.2	0.505	UNC[b]	One battery, annual tons of coke capacity
Coke handling	931.4	0.466	931.4	0.466	931.4	0.466	RACT	Total plant, annual tons of coke capacity
Coke oven gas	12,354.6	0.481	12,802.9	0.481	13,264.6	0.481	RACT	Total plant, annual tons of coke capacity
Coal preheater	623.0	0.504	623.0	0.504	623.0	0.504	RACT	One battery, annual tons of coke capacity
Cast house emissions	127,706.0	0.250	156,588.9	0.269	1,646.4	0.588	RACT	One blast furnace, annual tons of hot metal capacity
Blast furnace slag pouring	0.0	0.000	5,287.8	0.496	5,287.8	0.496	BACT	One blast furnace, annual tons of hot metal capacity
Blast furnace slag processing	25,316.9	0.000	10,829.9	0.226	10,829.9	0.226	RACT	Total plant, annual tons of hot metal capacity
Open hearth hot metal transfer	39,837.9	0.246	39,837.9	0.246	39,837.9	0.246	RACT	One OH shop, annual tons of steel capacity
Open hearth refining	916.7	0.657	916.7	0.657	916.7	0.657	RACT	One OH shop, annual tons of steel capacity

UNC - uncontrolled.

(continued)

Table 4-2 (continued)

Emission source	Technology level: RACT A	RACT B	BACT A	BACT B	LAER A	LAER B	Typical SIP	Units of X
EAF slag processing	25,293.4	0.000	93,357.3	0.080	93,357.3	0.080	RACT	Total plant, annual tons of steel capacity
Continuous casting	0.0	0.000	1,457,337.0	0.025	1,457,337.0	0.025	BACT	One casting machine, annual tons of steel capacity
Soaking pit stack	0.0	0.000	632.5	0.586	632.5	0.586	UNC[c]	Group of pits, annual tons of steel capacity
Auto scarfing	573,959.3	0.129	573,959.3	0.129	573,959.3	0.129	RACT	One scarfing machine, annual tons of steel capacity
Reheat furnace stack	0.0	0.000	1,740.9	0.561	1,740.9	0.561	UNC[d]	Group of furnaces, annual tons of steel capacity
Boiler stack - coal fired	190,750.2	0.686	190,750.2	0.686	190,750.2	0.686	RACT	Total plant, MM Btu/hr capacity
Boiler stack -	96,459.0	0.572	96,459.0	0.572	96,459.0	0.572	UNC	Total plant, MM Btu/hr capacity[e]

N.A. - not applicable.

UNC - uncontrolled.

[a] Based on engineering judgement of retrofit difficulty in typical situation for existing plants. Specific plants could require higher costs due to unique site-specific factors.

[b] Typical SIP does not require control on a process weight or combustion source basis, but does require an opacity limitation which might in turn require a control device depending upon age and condition of battery.

[c] Typical SIP does not require control, cost coefficients shown are for an ESP on soaking pits firing 100% oil.

[d] Typical SIP does not require control, cost coefficients shown are for an ESP on reheat furnaces firing 100% oil.

[e] Cost function can be used for combined as individual boilers in the range of 100 MM Btu/hr to 750 MM Btu/hr.

Table 4-3. ANNUAL DIRECT OPERATING COSTS COEFFICIENTS FOR AIR POLLUTION CONTROL SYSTEMS ON BOTH NEW AND EXISTING FACILITIES

(Values of A and B for the equation $y = Ax^B$)

Emission source	Technology level						Typical SIP	Units of X
	RACT		BACT		LAER			
	A	B	A	B	A	B		
Ore yard	9,177.6	0.130	13,219.0	0.131	2.6	0.831	RACT	Total plant, annual tons of hot metal capacity
Coal yard	20,234.1	0.072	20,223.6	0.087	4.3	0.821	RACT	Total plant, annual tons of coke capacity
Coal preparation	6,986.3	0.159	6,947.5	0.160	6,947.5	0.160	RACT	Total plant, annual tons of coal capacity
Sinter windbox	2,886.8	0.436	1,570.0	0.491	71,117.6	0.217	BACT	Sinter plant, annual tons of sinter capacity
Sinter discharge	3,441.0	0.297	7,648.0	0.253	7,648.0	0.253	BACT	Sinter plant, annual tons of sinter capacity
Sinter fugitive - building	0.0	0.000	14,986.0	0.107	14,986.0	0.107	BACT	Sinter plant, annual tons of sinter capacity
Coke oven charging	62,910.5	0.125	76,894.8	0.116	76,894.8	0.116	RACT	One battery, annual tons of coke capacity
Coke oven pushing	3,691.7	0.368	3,691.9	0.368	3,691.9	0.368	RACT	One battery, annual tons of coke capacity
Coke quenching	0.5	0.739	1.4	0.991	-0.7	1.071	RACT	Total plant, annual tons of coke capacity
Coke oven doors	405,047.5	0.000	571,501.4	0.000	571,501.4	0.000	RACT	One battery, annual tons of coke capacity

(continued)

Table 4-3 (continued)

Emission source	Technology level RACT A	RACT B	BACT A	BACT B	LAER A	LAER B	Typical SIP	Units of X
Coke oven topside	195,916.1	0.000	195,916.1	0.000	195,916.1	0.000	RACT	One battery, annual tons of coke capacity
Coke underfire stack	49,092.1	0.126	55,252.3	0.121	48,944.3	0.131	UNC	One battery, annual tons of coke capacity
Coke handling	166.0	0.462	166.2	0.462	166.2	0.462	RACT	Total plant, annual tons of coke capacity
Coke oven gas	981.5	0.495	406.5	0.571	218.8	0.625	RACT	Total plant, annual tons of coke capacity
Coal preheater	1,619.2	0.304	1,619.2	0.304	1,619.2	0.304	RACT	One battery, annual tons of coke capacity
Cast house emissions	75,076.6	0.135	291.321.4	0.096	158.2	0.599	RACT	One blast furnace, annual tons of hot metal capacity
Blast furnace slag pouring	0.0	0.000	12,259.9	0.316	12,259.9	0.316	BACT	One blast furnace, annual tons of hot metal capacity
Blast furnace slag processing	10,006.7	0.000	26,494.3	0.057	26,494.3	0.057	RACT	Total plant, annual tons of coke capacity
Open hearth hot metal transfer	15,910.3	0.162	15,910.3	0.162	15,910.3	0.162	RACT	One OH shop, annual tons of steel capacity
Open hearth refining	1,078.8	0.480	1,078.8	0.480	1,078.8	0.480	RACT	One OH shop, annual tons of steel capacity

(continued)

Table 4-3 (continued)

Emission source	Technology level: RACT A	RACT B	BACT A	BACT B	LAER A	LAER B	Typical SIP	Units of X
Open hearth fugitive	0.0	0.000	0.0	0.000	0.0	0.000	NA	One OH shop, annual tons of steel capacity
Open hearth slag processing	10,015.4	0.000	10,015.4	0.000	10,015.4	0.000	RACT	Total plant, annual tons of steel capacity
BOF hot metal transfer	14,951.5	0.164	14,951.5	0.164	14,951.5	0.164	RACT	One BOF shop, annual tons of steel capacity
BOF refining	410.5	0.539	2,050.4[a]	0.440[a]	2,050.4[a]	0.440[a]	RACT	One BOF shop, annual tons of steel capacity
BOF charging, tapping	1,559.4	0.283	536.9	0.467	536.9	0.467	RACT	One BOF shop, annual tons of steel capacity
BOF slag pouring	10,000.0	0.000	265,868.9	0.000	265,868.9	0.000	RACT	One BOF shop, annual tons of steel capacity
BOF slag processing	10,000.0	0.000	15,972.1	0.090	15,972.1	0.090	RACT	Total plant, annual tons of steel capacity
EAF emissions - carbon	22.7	0.773	106.3	0.709	905.7	0.581	BACT	One EAF shop, annual tons of steel capacity
EAF emissions - alloy	110.6	0.699	110.1	0.700	157.2	0.676	BACT	One EAF shop, annual tons of steel capacity
EAF slag pouring	9,997.4	0.000	293.1	0.486	293.1	0.486	RACT	One EAF shop, annual tons of steel capacity

(continued)

Table 4-3 (continued)

Emission source	Technology level RACT A	RACT B	BACT A	BACT B	LAER A	LAER B	Typical SIP	Units of X
EAF slag processing	9,997.4	0.000	41,185.2	0.030	41,185.2	0.030	RACT	Total plant, annual tons of steel capacity
Continuous casting	0.0	0.000	226,810.3	0.013	226,810.3	0.013	BACT	One casting machine, annual tons of steel capacity
Soaking pit stack	0.0	0.000	6,687.0	0.289	6,687.0	0.289	UNC	Total plant, annual tons of steel capacity
Auto scarfing	468,121.4	0.037	486,121.4	0.037	486,121.4	0.037	RACT	One scarfing machine, annual tons of steel capacity
Reheat furnace stack	0.0	0.000	3,391.3	0.372	3,391.3	0.372	UNC	Total plant, annual tons of steel capacity
Boiler stack - coal fired	643,417.1	0.158	643,417.1	0.158	643,417.1	0.158	RACT	Total plant, MM Btu/hr capacity
Boiler stack - oil fired	36,321.1	0.412	36,321.1	0.142	36,321.1	0.412	UNC	Total plant, MM Btu/hr capacity

N.A. - not applicable.

UNC - uncontrolled.

[a] A = 11,386.4 and B = 0.3395 for retrofit case.

fugitive emissions, then an assignment of RACT, BACT, LAER, or uncontrolled is made based on engineering judgment.

All costs in Tables 4-1 to 4-3 are in terms of mid-1977 dollars. The costs are considered study estimates with an accuracy of ± 35 percent. In Table 4-3, a negative operating cost is shown for dry quenching.

This value arises from the inclusion of a steam credit in total operating cost. The steam credit is based on 800 pounds of steam produced per ton of coke quenched at a value of $3.72 per 1000 pounds. The resultant credit is very significant and must be used with the caveat that it is only applicable to the extent that the steam produced can, in fact, be utilized and effectively replace steam which would otherwise be generated by the plant in a boiler.

The adjustment to the LAER operating cost function to delete the credit is $2.98/ton coke. For example, the operating cost for a 1,000,000 ton per year plant without the steam credit would be:

$$\begin{aligned}\text{Cost} &= -0.7\ (1{,}000{,}000)^{1.071} - (-2.98 \times 1{,}000{,}000)\\ &= -1{,}866{,}800 + 2{,}980{,}000\\ &= \$1{,}113{,}200\end{aligned}$$

The credit should be separated from the operating cost in this manner and shown as a potential offset. The BACT technology for blast furnace cast house emissions consists of a hooded trough area and runner covers and LAER consists of cast house evacuation. The resultant cost functions in Tables 4-1 and 4-2 describe a higher cost for BACT than for LAER except for very large furnances. The emission rate is the same in both cases. This can give rise to an anomalous interpretation of BACT vs. LAER. The proper interpretation is that BACT and LAER systems are essentially alternatives for reaching the lowest achievable emission rate and one cannot make a generalized definition as to the appropriate system for a given blast furnace. The flow rate data available are not sufficiently definitive to justify a clear distinction.

The retrofit costs in Table 4-2 are based on engineering judgment as to the additional cost associated with longer duct runs, clearance problems, etc. Certain retrofit situations, however, raise issues of feasibility. The retrofit of an ESP to coke oven underfire stacks, for example, may not be feasible for some batteries because of space limitations and the difficulty of tie-in to existing flues. Whether the gas can be shut off to an existing battery for a sufficient time to accomplish tie-in is a site-specific problem that is not addressed in this study.

In general, it should be noted that the control schemes estimated are relatively independent of the emission rates achieved. The emission rates are nominal values only and consequently the cost-effectiveness of a given BACT system may be superior to the corresponding RACT system.

It should also be noted that each source is treated independently. In actual practice, some sources may be controlled by a common control device. Such comingling of sources would result in a lower total cost. For example, control of sinter feed transfer points (04-3) would most likely be accomplished by venting to the control device on the discharge end.

COMPLIANCE STATUS OF EMISSION SOURCES

The compliance status of emission sources is rated according to the following definitions:

0 No data available.

1 Suitable equipment installed, no additional expenditures required.

2 On a compliance schedule, necessary funds committed and considered spent.

3 Not on a compliance schedule, additional expenditures required.

These definitions are used to determine the capital expenditures required by the industry to meet present SIP regulations as interpreted in a strict engineering sense. The definitions do not, and are not intended to, address the question of compliance in the legal sense.

Each emission source in the inventory was assigned a code from 0 to 3 representing the above definitions based on discussions with EPA regional office personnel in Regions III and V. Other available sources of data on control equipment installed were used to make the compliance status interpretation for the plants not included in Regions III and V.

Table 4-4 summarizes the results on a numerical and tonnage basis by emission source. Table 4-5 is a statistical summary of the capacity rating of the emission sources.

Table 4-4. SUMMARY OF COMPLIANCE STATUS[a] BY SOURCE

Emission source	Percent of capacity in category				Number of facilities requiring expenditures
	Status unknown	In compliance	On a schedule	Expenditures required	
Ore yard	0	58	0	42	22 ore yards
Coal yard	0	49	0	51	18 coal yards
Coal preparation	54	42	0	4	3 plants
Sinter windbox	0	35	16	49	13 sinter plants
Sinter discharge	0	63	11	26	7 sinter plants
Sinter fugitive	0	56	2	42	12 sinter plants
Coke charging	7	20	15	58	87 batteries
Coke pushing	8	14	23	55	86 batteries
Coke quenching	0	81	7	12	6 coke plants
Coke doors	18	13	13	56	85 batteries
Coke topside	22	27	13	39	61 batteries
Coke stack	9	31	16	44	73 batteries
Coke screening	39	58	0	3	2 coke plants
Coke gas	5	63	2	30	16 coke plants
Coal preheat	0	76	24	0	0 coke plants
Cast house	0	21	0	79	133 blast furnaces
B.F. slag pouring	0	84	0	16	24 blast furnaces
B.F. slag processing	7	92	0	1	1 plant
OH metal transfer	44	10	13	33	4 OH shops
OH refining	0	46	16	38	4 OH shops
OH fugitive	0	45	13	42	5 OH shops
OH slag processing	21	66	13	0	0 plants
BOF metal transfer	24	36	27	13	6 BOF shops

[a] See Section .2.

(continued)

Table 4-4 (continued)

Emission source	Percent of capacity in category: Status unknown	In compliance	On a schedule	Expenditures required	Number of facilities requiring expenditures
BOF refining	0	80	5	15	5 BOF shops
BOF charging, tapping	4	18	42	36	16 BOF shops
BOF slag pouring	0	75	0	25	11 BOF shops
BOF slag processing	3	96	0	1	1 plant
EAF refining	3	82	6	9	1 EAF shop
EAF fugitives	5	75	12	8	2 EAF shops
EAF slag pouring	0	100	0	0	0 EAF shops
EAF slag processing	21	79	0	0	0 plants
Conventional teeming	0	100	0	0	0 plants
Continuous casters	0	97	0	3	2 casters
Soaking pits	0	100	0	0	0 plants
Scarfing machines	14	68	10	8	3 machines
Reheat furnaces	0	100	0	0	0 furnaces
Boilers	24	62	5	9	9 boilers

Table 4-5. STATISTICAL SUMMARY OF CAPACITY RATINGS OF EMISSION SOURCES

Emission source	Capacity values in millions of tons per year (boilers in millions Btu per hour)											
	Mean	Maximum	Minimum	Standard deviation	Number $\le S_1$	S_1 < Number $\le S_2$	S_2 < Number $\le S_3$	Number > S_3	S_1	S_2	S_3	Units of tons
Ore yard	1.215	4.48	0.19	0.91	34	13	3	0	1.40	3.17	6.74	Ore in storage
Coal yard	0.56	2.68	0.075	0.49	27	10	2	0	0.66	1.54	4.29	Coal in storage
Coal preparation	2.24	10.74	0.30	1.96	8	8	19	4	0.66	1.54	4.29	Coal
Sinter windbox	1.51	4.93	0.18	1.15	8	17	2	7	0.61	1.68	2.14	Sinter
Sinter discharge	1.51	4.93	0.18	1.15	8	17	2	7	0.61	1.68	2.14	Sinter
Sinter fugitive	1.51	4.93	0.18	1.15	8	17	2	7	0.61	1.68	2.14	Sinter
Coke charging	0.38	1.35	0.08	0.20	24	64	55	8	0.23	0.36	0.75	Coke
Coke pushing	0.40	1.35	0.08	0.22	24	64	55	12	0.23	0.36	0.75	Coke
Coke quenching[a]	1.56	7.52	0.21	1.34	8	8	20	4	0.46	1.08	3.00	Coke
Coke doors	0.40	1.35	0.08	0.22	24	64	55	12	0.23	0.36	0.75	Coke
Coke topside	0.40	1.35	0.08	0.22	24	64	55	12	0.23	0.36	0.75	Coke
Coke stack	0.40	1.35	0.08	0.22	24	64	55	12	0.23	0.36	0.75	Coke
Coke screening	1.56	7.52	0.21	1.34	8	8	20	4	0.46	1.08	3.00	Coke
Coke gas	1.56	7.52	0.21	1.34	8	8	20	4	0.46	1.08	3.00	Coke
Coal preheat	0.95	1.04	0.91	0.05	0	4	0	0	0.88	1.05	1.23	Coke
Cast house	0.74	2.24	0.25	0.34	28	43	63	26	0.40	0.66	1.01	Hot metal
BF slag pouring	0.74	2.24	0.25	0.34	28	43	63	26	0.40	0.66	1.01	Hot metal
BF slag processing	2.58	8.96	0.38	1.87	6	14	20	5	0.80	1.98	4.04	Hot metal
OH metal transfer	2.49	4.34	0.97	1.01	1	6	3	3	1.17	2.28	3.39	Steel
OH refining	2.49	4.34	0.97	1.01	1	6	3	3	1.17	2.28	3.39	Steel
OH fugitive	2.49	4.34	0.97	1.01	1	6	3	3	1.17	2.28	3.39	Steel
OH slag processing	2.49	4.34	0.97	1.01	1	6	3	3	1.17	2.28	3.39	Steel

(continued)

Table 4-5 (continued)

Emission source	Capacity values in millions of tons per year (boilers in millions Btu per hour)											
	Mean	Maximum	Minimum	Standard deviation	Number $\leq S_1$	S_1 < Number $\leq S_2$	S_2 < Number $\leq S_3$	Number > S_3	S_1	S_2	S_3	Units of tons
BOF metal transfer	2.86	8.10	0.88	1.40	9	9	12	8	1.61	2.70	3.78	Steel
BOF refining	2.86	8.10	0.88	1.40	9	9	12	8	1.61	2.70	3.78	Steel
BOF charging, tapping	2.86	8.10	0.88	1.40	9	9	12	8	1.61	2.70	3.78	Steel
BOF slag pouring	2.86	8.10	0.88	1.40	9	9	12	8	1.61	2.70	3.78	Steel
BOF slag processing	3.20	10.0	0.88	1.99	7	8	11	8	1.61	2.70	3.78	Steel
EAF refining	0.70	2.05	0.20	0.47	0	9	6	3	0.10	0.47	1.13	Steel
EAF fugitive	0.70	2.05	0.20	0.47	0	9	6	3	0.10	0.47	1.13	Steel
EAF slag pouring	0.70	2.05	0.20	0.47	0	9	6	3	0.10	0.47	1.13	Steel
EAF slag processing	0.70	2.05	0.20	0.47	0	9	6	3	0.10	0.47	1.13	Steel
Conventional teeming	2.31	8.1	0.22	1.48	17	17	17	20	1.00	2.00	3.00	Steel
Continuous casters	0.95	2.40	0.28	0.67	6	4	5	1	0.43	1.00	1.58	Steel
Soaking pits[b]	1.76	5.44	0.26	0.93	0	45	26	1	0.10	1.94	3.78	Steel
Scarfing machines	1.80	4.00	0.31	0.90	0	33	20	1	0.10	1.94	3.78	Steel
Reheat furnaces[c]	1.35	7.50	0.06	1.53	2	74	21	4	0.10	1.94	3.78	Steel
Boilers	214	4800	1	334	128	109	74	10	100	250	750	MM Btu/h

[a] The basis is all coke quenching in a plant, not individual quench towers.

[b] The basis is a battery of soaking pits, not individual pits.

[c] The basis is a group of reheat furnaces, not individual reheat furnaces.

APPENDIX A

INTEGRATED STEEL MILLS IN THE UNITED STATES

APPENDIX A

Table A-1. INTEGRATED STEEL MILLS IN THE UNITED STATES

PEDCo Plant I.D.	Company	Plant	City	County	State
045-01	Alan Wood Steel Co.	Ivy Rock & Swedeland Plants[a]	Ivy Rock & Swedeland	Montgomery	PA
079-02	Armco Steel Corporation	Middletown Works[b] (Hamilton)	Middletown	Butler	OH
103-03	Armco Steel Corporation	Ashland Works	Ashland	Boyd	KY
216-04	Armco Steel Corporation	Houston Works	Houston	Harris	TX
151-05	Bethlehem Steel Corporation	Bethlehem Plant	Bethlehem	Northampton	PA
115-06	Bethlehem Steel Corporation	Sparrows Point Plant	Sparrows Point	Baltimore	MD
162-07	Bethlehem Steel Corporation	Lackawanna Plant	Lackawanna	Erie	NY
195-08	Bethlehem Steel Corporation	Johnstown Plant	Johnstown	Cambria	PA
067-09	Bethlehem Steel Corporation	Burns Harbor Plant	Burns Harbor	Porter	IN
038-10	CF & I Steel Corporation	Pueblo Plant	Pueblo	Pueblo	CO
197-11	Crucible Inc.	Midland Plant	Midland	Beaver	PA
103-12	Empire-Detroit Steel	Portsmouth Plant	Portsmouth	Scioto	OH
123-13	Ford Motor Co.	Rouge Works	Dearborn	Wayne	MI
070-14	Granite City Steel	Granite City Works	Granite City	Madison	IL
123-15	Great Lakes Steel	River Rouge & Ecorse Works[c]	River Rouge & Ecorse	Wayne	MI

(continued)

Table A-1. (continued)

PEDCo Plant I.D.	Company	Plant	City	County	State
067-16	Inland Steel Company	Indiana Harbor Works	East Chicago	Lake	IN
067-17	Interlake Inc.	Chicago Plant & Riverdale Station Works[d]	South Chicago & Chicago	Cook	IL
197-18	Jones & Laughlin Steel Corp.	Pittsburgh Works	Pittsburgh	Allegheny	PA
197-19	Jones & Laughlin Steel Corp.	Aliquippa Works	Aliquippa	Beaver	PA
174-20	Jones & Laughlin Steel Corp.	Cleveland Works	Cleveland	Cuyahoga	OH
024-21	Kaiser Steel	Fontana Works	Fontana	San Bernardino	CA
222-22	Lone Star Steel Company	Lone Star Works	Lonestar	Morris	TX
123-23	McLouth Steel Corporation	Trenton Works[e]	Trenton	Wayne	MI
178-24	Republic Steel Corporation	Mahoning Valley[f] Dist. Warren Works Youngstown Works	Warren & Niles & Youngstown	Trumbull & Mahoning	OH
174-25	Republic Steel Corporation	Cleveland Works	Cleveland	Cuyahoga	OH
162-26	Republic Steel Corporation	Buffalo Works	Buffalo	Erie	NY
174-27	Republic Steel Corporation	Central Alloy[g] Dist. Canton Works Massillon Works	Canton Massillon	Stark	OH
067-28	Republic Steel Corporation	South Chicago Works	South Chicago	Cook	IL

(continued)

Table A-1. (continued)

PEDCo Plant I.D.	Company	Plant	City	County	State
003-29	Republic Steel	Gulfsteel Works	Gadsden	Etowah	AL
178-30	Sharon Steel Corporation	Sharon Works	Sharon	Mercer	PA
045-31	United States Steel Corporation	Fairless Works	Fairless Hills	Bucks	PA
197-32	United States Steel Corporation	Homestead Works[h] (includes Clairton)	Homestead	Allegheny	PA
174-33	United States Steel Corporation	Lorain Cuyahoga[i] Works (incl. Cleveland Works)	Lorain	Lorain & Cuyahoga	OH
197-34	United States Steel Corporation	National Duquesne Works[j] (Incl. McKeesport Plant)	Duquesne	Allegheny	PA
178-35	United States Steel Corporation	Youngstown Works	Youngstown	Mahoning & Trumbull	OH
067-36	United States Steel Corporation	Gary Works	Gary	Lake	IN
197-37	United States Steel Corporation	Edgar Thomson[k] Irvin Works	Braddock	Allegheny	PA
067-38	United States Steel Corporation	South Works	S. Chicago	Cook	IL
004-39	United States Steel Corporation	Fairfield District Works	Fairfield	Jefferson	AL
220-40	United States Steel Corporation	Geneva Works	Geneva	Utah	UT

(continued)

Table A-1. (continued)

PEDCo Plant I.D.	Company	Plant	City	County	State
181-41	Weirton Steel	Weirton Plant[l]	Weirton	Hancock	WV
181-42	Wheeling Pittsburgh Steel Corporation	Steubenville[m] Plant	Steubenville	Jefferson	OH
197-43	Wheeling Pittsburgh Steel Corporation	Monessen Works	Monessen	Westmoreland	PA
067-44	Wisconsin Steel	South Chicago Works	South Chicago	Cook	IL
178-45	Youngstown Sheet & Tube Co.	Campbell Works[n]	Campbell	Mahoning	OH
067-46	Youngstown Sheet & Tube Co.	Indiana Harbor Works	East Chicago	Lake	IN
178-47	Youngstown Sheet & Tube Co.	Brier Hill Works	Youngstown	Mahoning	OH

[a] All facilities are shut down except the coke plant which is now operated by Keystone Coke Co.

[b] Armco Middletown includes the plant at Hamilton.

[c] Great Lakes Steel includes the plants at both River Rouge and Ecorse.

[d] Interlake South Chicago also includes the works at Riverdale Station.

[e] McLouth Steel includes the works at Trenton, Detroit, and Gibraltar.

[f] Republic Steel Mahoning Valley District Works include both the Warren Works and the Youngstown Works.

[g] Republic Steel Central Alloy District includes both the Canton Works and the Massillon Works.

[h] U.S.S. Homestead includes Rankin, Saxonburg, McKeesport, and the Clairton Works.

[i] U.S.S. Lorain - Cuyahoga Works includes the Lorain Works and the Cleveland Works which has two locations within Cleveland.

[j] U.S.S. National Duquesne Works also includes the McKeesport Plant.

[k] U.S.S. E.T. Irvin Works includes the locations of Braddock, Dravosburg, and Vandergrift.

[l] Weirton Steel includes the facilities at Steubenville.

[m] Wheeling-Pittsburgh's Steubenville Plant includes the Coke Plant at Follansbee, West Virginia.

[n] Only operating facilities are included in the census, the majority of the plant is shut down.

APPENDIX B

LISTING OF IRON AND STEEL FACILITIES IN THE UNITED STATES

APPENDIX B

Table B-1. SINTER PLANTS IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	Strands	Ft² G.A.	Width	Capacity (10^6 TPY)
Alabama						
Etowah/Gadsden	Republic	003-29	1	569	6'	0.5*
Jefferson/Fairfield	USS	004-39	4	1760 1344	3-6' 1-8'	2.90
California						
San Bernardino/ Fontana	Kaiser	024-21	2	1224	6'	1.4
Colorado						
Pueblo/Pueblo	CF&I	038-10	2	1224	6'	0.9*
Illinois						
Cook/S. Chicago	Interlake	067-17	1	1022	8'3"	1.2
Cook/S. Chicago	USS	067-38	1	1344	8'	1.4*
Madison/Granite City	Granite City	070-14	1	1024	8'	1.08
Cook/S. Chicago	Wisconsin	067-44	1	432	6'	.2
Indiana						
Lake/E. Chicago	Inland	067-16	1	1344	8'	1.2*
Lake/Gary	USS	067-36	5	3879 1224	3-8'3" 2-6'	4.9 1.1
Lake/E. Chicago	YS&T	067-46	1	1344	8'	1.46
Porter/Burns Harbor	Bethlehem	067-09	1	2020	13'	2.20

(continued)

Table B-1 (continued)

State County/City	Company	Plant ID#	Strands	Ft^2 G.A.	Width	Capacity (10^6 TPY)
Kentucky						
Boyd/Ashland	Armco	103-03	1	807	8'3"	0.88
Maryland						
Baltimore/Sparrows Point	Bethlehem	115-06	6 1	3072 3800	6' 19'5"	3.98 4.45
Michigan						
Wayne/River Rouge	Great Lakes	123-15	1	2400	12'	2.0
New York						
Erie/Buffalo	Bethlehem (Lackawanna)	162-07	2	1224	2-6'	1.46
Ohio						
Cuyahoga/Cleveland	J&L	174-20	1	NA	8'	0.9*
Mahoning/Youngstown	USS	178-35	1	1344	8'	1.5*
Trumbull/Warren	Republic (MVD)	178-24	1	432	6'	0.4*
Butler/Middletown	Armco	079-02	1	768	NA	0.96
Lorain/Lorain	USS	174-33	1	459	6'	0.41
Cuyahoga/Cleveland	Republic	174-25	1	419	6'	.4(est)

(continued)

Table B-1 (continued)

State County/City	Company	Plant ID#	Strands	Ft^2 G.A.	Width	Capacity (10^6 TPY)
Pennsylvania						
Bucks/Fairless Hills	USS	045-31	2	2787	2-8'	2.63
Butler/Saxonburg	USS (Homestead)	197-32	3	3879	8'3"	4.5*
Beaver/Aliquippa	J&L	197-19	1	NA	13'2"	2.37
Cambria/Johnstown	Bethlehem	195-08	2	1192	2-6'	0.98
Allegheny/McKeesport	USS (Nat-Duq)	197-34	1	NA	6'	0.18
Northampton/ Bethlehem	Bethlehem	151-05	4	1984	4-6'	2.4*
Westmoreland/Monessen	Wheeling-Pittsburgh	197-43	1	612	6'	0.55
Texas						
Harris/Houston	Armco	216-04	1	536	6'	0.50
Morris/Lone Star	Lone Star	022-22	1	550	5'	.70
Utah						
Utah/Geneva	USS	220-40	2	1224	2-6'	1.1
West Virginia						
Hancock/Follansbee	Wheeling-Pittsburgh	181-42	1	1018	6'	0.55
Hancock/Weirton	Weirton	181-41	1 1	832 1764	1-8' 1-12'	0.94 2.05

* Capacity from EPA 600/2-76-002 (January, 1976) Sintering Plant Emissions Using ESP, Varga, Battelle
Remaining Capacity data from 308 survey data.

Table B-2. COKE BATTERIES IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	#Batteries/ Ovens	Oven Height (m)	Capacity (10^6 TPY)
Alabama					
1. Jefferson/ Fairfield	USS	004-39	2-73 3-63 2-77	4.0 4.3 3.4	2.8
2. Etowah/Gadsden Jefferson/Birming-ham	Republic	003-29	2-65 1-65	4.0 4.0	0.87 0.39
California					
3. San Bernardino/ Fontana	Kaiser	024-21	7-45	4.0	1.5
Colorado					
4. Pueblo/Pueblo	CF&I	038-10	1-65 1-47 1-31	4.0 4.0 4.0	0.96
Illinois					
5. Madison/Granite City	Granite City	070-14	2-76 1-61	4.0 4.0 4.0	0.96
6. Cook/S. Chicago	Wisconsin	067-44	1-45	5.0	0.37
7. Cook/S. Chicago	Interlake	067-17	2-50	3.9	0.64
8. Cook/S. Chicago	Republic	067-28	1-75	4.0	0.50

(continued)

Table B-2 (continued)

State County/City	Company	Plant ID#	#Batteries/ Ovens	Oven Height (m)	Capacity (10^6 TPY)
Indiana					
9. Lake/E. Chicago	Inland	067-16	1-56 (pipeline)	6.2	3.17
			1-65	3.7	
			3-87	3.7	
			1-51	6.1	
10. Porter/Burns Harbor	Bethlehem	067-09	2-82	6.2	2.43
11. Lake/Gary	USS	067-36	1-85	6.2	4.37
			2-57	6.2	
			5-77	3.1	
12. Lake/E. Chicago	YS&T	067-46	1-81	4.0	0.97
			1-75	4.0	
Maryland					
13. Baltimore/ Sparrows Point	Bethlehem	115-06	1-60	3.1	3.58
			5-63	3.1	
			2-61	3.7	
			4-65	3.7	
Michigan					
14. Wayne/Dearborn	Ford Motor	123-13	1-45	4.0	1.58
			2-61	4.0	
			1-25	4.0	
			1-13	4.0	
15. Wayne/River Rouge	Great Lakes	123-15	1-70	4.0	1.97
			1-78	4.0	
			1-85	6.0	

(continued)

Table B-2 (continued)

State County/City	Company	Plant ID#	#Batteries/ Ovens	Oven Height (m)	Capacity (10^6 TPY)
New York					
16. Erie/Lackawanna	Bethlehem	162-07	1-76 1-76	3.6 6.0	1.3
Ohio					
17. Scioto/Portsmouth	Empire-Detroit	103-12	1-70	4.0	0.42
18. Butler/Hamilton	Armco	079-02	1-45 1-15 2-25	3.8 3.8 3.8	0.59
19. Butler/Middletown	Armco	079-02	2-57	6.0	1.35
			1-76	4.0	0.54
20. Lorain/Lorain	USS	174-33	7-59	3.1	1.63
21. Mahoning/Youngstown	Republic	178-24	1-38 1-65 1-59	3.9 3.9 3.9	1.10
22. Trumbull/Warren & Niles	Republic	178-24	2-40	3.9	0.68
23. Cuyahoga/Cleveland	Republic	174-25	4-51 2-63	3.8 4.0	2.3
24. Stark/Massillon	Republic	174-27	1-31	3.9	0.21
25. Mahoning/Campbell	YS&T	178-45	3-76	4.0	1.39
Pennsylvania					
26. Westmoreland/ Monessen	Wheeling-Pitts.	197-43	1-74 1-19	4.0 4.0	0.67

(continued)

APPENDIX B

LISTING OF IRON AND STEEL FACILITIES IN THE UNITED STATES

APPENDIX B

Table B-1. SINTER PLANTS IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	Strands	Ft^2 G.A.	Width	Capacity (10^6 TPY)
Alabama						
Etowah/Gadsden	Republic	003-29	1	569	6'	0.5*
Jefferson/Fairfield	USS	004-39	4	1760 1344	3-6' 1-8'	2.90
California						
San Bernardino/ Fontana	Kaiser	024-21	2	1224	6'	1.4
Colorado						
Pueblo/Pueblo	CF&I	038-10	2	1224	6'	0.9*
Illinois						
Cook/S. Chicago	Interlake	067-17	1	1022	8'3"	1.2
Cook/S. Chicago	USS	067-38	1	1344	8'	1.4*
Madison/Granite City	Granite City	070-14	1	1024	8'	1.08
Cook/S. Chicago	Wisconsin	067-44	1	432	6'	.2
Indiana						
Lake/E. Chicago	Inland	067-16	1	1344	8'	1.2*
Lake/Gary	USS	067-36	5	3879 1224	3-8'3" 2-6'	4.9 1.1
Lake/E. Chicago	YS&T	067-46	1	1344	8'	1.46
Porter/Burns Harbor	Bethlehem	067-09	1	2020	13'	2.20

(continued)

Table B-1 (continued)

State County/City	Company	Plant ID#	Strands	Ft² G.A.	Width	Capacity (10^6 TPY)
Kentucky						
Boyd/Ashland	Armco	103-03	1	807	8'3"	0.88
Maryland						
Baltimore/Sparrows Point	Bethlehem	115-06	6 1	3072 3800	6' 19'5"	3.94 4.45
Michigan						
Wayne/River Rouge	Great Lakes	123-15	1	2400	12'	2.0
New York						
Erie/Buffalo	Bethlehem (Lackawanna)	162-07	2	1224	2-6'	1.46
Ohio						
Cuyahoga/Cleveland	J&L	174-20	1	NA	8'	0.9*
Mahoning/Youngstown	USS	178-35	1	1344	8'	1.5*
Trumbull/Warren	Republic (MVD)	178-24	1	432	6'	0.4*
Butler/Middletown	Armco	079-02	1	768	NA	0.96
Lorain/Lorain	USS	174-33	1	459	6'	0.41
Cuyahoga/Cleveland	Republic	174-25	1	419	6'	.4(est)

(continued)

Table B-1 (continued)

State County/City	Company	Plant ID#	Strands	Ft^2 G.A.	Width	Capacity (10^6 TPY)
Pennsylvania						
Bucks/Fairless Hills	USS	045-31	2	2787	2-8'	2.63
Butler/Saxonburg	USS (Homestead)	197-32	3	3879	8'3"	4.5*
Beaver/Aliquippa	J&L	197-19	1	NA	13'2"	2.37
Cambria/Johnstown	Bethlehem	195-08	2	1192	2-6'	0.98
Allegheny/McKeesport	USS (Nat-Duq)	197-34	1	NA	6'	0.18
Northampton/ Bethlehem	Bethlehem	151-05	4	1984	4-6'	2.4*
Westmoreland/Monessen	Wheeling-Pittsburgh	197-43	1	612	6'	0.55
Texas						
Harris/Houston	Armco	216-04	1	536	6'	0.50
Morris/Lone Star	Lone Star	022-22	1	550	5'	.70
Utah						
Utah/Geneva	USS	220-40	2	1224	2-6'	1.1
West Virginia						
Hancock/Follansbee	Wheeling-Pittsburgh	181-42	1	1018	6'	0.55
Hancock/Weirton	Weirton	181-41	1 1	832 1764	1-8' 1-12'	0.94 2.05

* Capacity from EPA 600/2-76-002 (January, 1976) Sintering Plant Emissions Using ESP, Varga, Battelle
Remaining Capacity data from 308 survey data.

Table B-2. COKE BATTERIES IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	#Batteries/ Ovens	Oven Height (m)	Capacity (10^6 TPY)
Alabama					
1. Jefferson/ Fairfield	USS	004-39	2-73 3-63 2-77	4.0 4.3 3.4	2.8
2. Etowah/Gadsden Jefferson/Birming-ham	Republic	003-29	2-65 1-65	4.0 4.0	0.87 0.39
California					
3. San Bernardino/ Fontana	Kaiser	024-21	7-45	4.0	1.5
Colorado					
4. Pueblo/Pueblo	CF&I	038-10	1-65 1-47 1-31	4.0 4.0 4.0	0.96
Illinois					
5. Madison/Granite City	Granite City	070-14	2-76 1-61	4.0 4.0 4.0	0.96
6. Cook/S. Chicago	Wisconsin	067-44	1-45	5.0	0.37
7. Cook/S. Chicago	Interlake	067-17	2-50	3.9	0.64
8. Cook/S. Chicago	Republic	067-28	1-75	4.0	0.50

(continued)

Table B-2 (continued)

State County/City	Company	Plant ID#	#Batteries/ Ovens	Oven Height (m)	Capacity (10^6 TPY)
Indiana					
9. Lake/E. Chicago	Inland	067-16	1-56 (pipeline)	6.2	3.17
			1-65	3.7	
			3-87	3.7	
			1-51	6.1	
10. Porter/Burns Harbor	Bethlehem	067-09	2-82	6.2	2.43
11. Lake/Gary	USS	067-36	1-85	6.2	4.37
			2-57	6.2	
			5-77	3.1	
12. Lake/E. Chicago	YS&T	067-46	1-81	4.0	0.97
			1-75	4.0	
Maryland					
13. Baltimore/ Sparrows Point	Bethlehem	115-06	1-60	3.1	3.58
			5-63	3.1	
			2-61	3.7	
			4-65	3.7	
Michigan					
14. Wayne/Dearborn	Ford Motor	123-13	1-45	4.0	1.58
			2-61	4.0	
			1-25	4.0	
			1-13	4.0	
15. Wayne/River Rouge	Great Lakes	123-15	1-70	4.0	1.97
			1-78	4.0	
			1-85	6.0	

(continued)

Table B-2 (continued)

State County/City	Company	Plant ID#	#Batteries/ Ovens	Oven Height (m)	Capacity (10^6 TPY)
New York					
16. Erie/Lackawanna	Bethlehem	162-07	1-76 1-76	3.6 6.0	1.3
Ohio					
17. Scioto/Portsmouth	Empire-Detroit	103-12	1-70	4.0	0.42
18. Butler/Hamilton	Armco	079-02	1-45 1-15 2-25	3.8 3.8 3.8	0.59
19. Butler/Middletown	Armco	079-02	2-57	6.0	1.35
			1-76	4.0	0.54
20. Lorain/Lorain	USS	174-33	7-59	3.1	1.63
21. Mahoning/Youngstown	Republic	178-24	1-38 1-65 1-59	3.9 3.9 3.9	1.10
22. Trumbull/Warren & Niles	Republic	178-24	2-40	3.9	0.68
23. Cuyahoga/Cleveland	Republic	174-25	4-51 2-63	3.8 4.0	2.3
24. Stark/Massillon	Republic	174-27	1-31	3.9	0.21
25. Mahoning/Campbell	YS&T	178-45	3-76	4.0	1.39
Pennsylvania					
26. Westmoreland/ Monessen	Wheeling-Pitts.	197-43	1-74 1-19	4.0 4.0	0.67

(continued)

Table B-2 (continued)

State County/City	Company	Plant ID#	#Batteries/ Ovens	Oven Height (m)	Capacity (10^6 TPY)
27. Beaver/Aliquippa	J.&L.	197-19	2-106 1-59 1-56	4.0 4.0 6.2 (pipe-line charg-ing)	2.54
28. Allegheny/ Pittsburgh	J.&L.	197-18	1-79 4-59	4.0 4.0	1.93
29. Beaver/Midland	Crucible	197-11	1-21 1-63 1-29	3.0 3.0 3.0	0.46*
30. Montgomery/ Swedeland	Alan Wood	045-01	2-55	3.0	0.45
31. Northampton/ Bethlehem	Bethlehem	151-05	2-51 1-80 1-80	3.0 3.8 6.4	2.1
32. Cambria/Johnstown	Bethlehem	195-08	1-74	3.8	0.42
33. Bucks/Fairless	USS	045-31	2-87	3.7	1.1
34. Allegheny/Clairton	USS	197-32	9-64 1-85 6-61 4-87	3.6 3.1 3.6 4.2	7.6

(continued)

Table B-2 (continued)

State County/City	Company	Plant ID#	#Batteries/ Ovens	Oven Height (m)	Capacity (10^6 TPY)
Texas					
35. Morris/Lone Star	Lone Star	022-22	2-39	3.7	0.44
36. Harris/Houston	Armco	216-04	1-47	4.0	0.38
			1-15	4.0	
Utah					
37. Utah/Geneva	USS	220-40	4-63	4.0	1.3
West Virginia					
38. Brooke/Follansbee	Wheeling-Pittsburgh	181-42	2-47	3.0	2.1
			1-51	3.0	
			1-63	4.0	
			1-79	6.0	
39. Hancock/Weirton	Weirton	181-41	1-87	6.0	3.0
			2-53	4.0	
			1-61	4.0	
			2-41	4.0	

* Estimated by PEDCo, remaining capacity data from 308 survey data.

Table B-3. BLAST FURNACES IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	No. of furnaces	Hearth Diameter	Working Volume	Capacity (10^6 TPY)
Alabama						
Jefferson/ Fairfield	USS	004-39	6	22' 0" 22' 6" 21' 6" 25' 0" 25' 0" 28' 9"	30,393 33,235 31,865 40,829 40,995 52,070	2.94
Etowah/Gadsden	Republic	003-29	2	17' 0" 26' 0"	19,700 45,600	0.99
California						
San Bernardino/ Fontana	Kaiser	024-21	4	27' 0" 27' 0" 27' 0" 29' 6"	40,433 40,433 40,433 51,212	2.63
Colorado						
Pueblo/Pueblo	CF&I	038-10	4 (2)*	22' 9" 21' 0" 21' 6" 21' 9"	32,000 30,600 24,656 31,310	1.16
Illinois						
Cook/S. Chicago	Wisconsin	067-44	2	18' 9" 25' 0"	23,117 35,700	0.91
Cook/S. Chicago	USS	067-38	8	23' 0" 25' 9" 21' 6" 22' 3" 32' 0" 25' 3" 29' 0" 29' 0"	31,702 37,058 25,700 25,758 66,538 36,232 51,004 51,004	4.45 (for 7 active)

(continued)

Table B-3 (continued)

State County/City	Company	Plant ID#	No. of Furnaces	Hearth Diameter	Working Volume	Capacity (10^6 TPY)
Illinois (Continued)						
Cook/S. Chicago	Republic	067-28	1	28' 0"	54,400	0.91
Madison/Granite City	Granite City	070-14	2	27' 3" 28' 0"	50,428 51,172	1.90
Cook/S. Chicago	Interlake	067-17	2	25' 3" 19' 8"	41,448 27,027	1.24
Indiana						
Lake/Gary	USS	067-36	13	20' 6" 20' 6" 20' 6" 28' 3" 20' 6" 28' 0" 28' 0" 26' 6" 23' 10" 27' 10" 27' 10" 25' 0" 40' 0"	24,194 24,194 24,929 47,563 27,326 47,550 42,106 41,017 28,827 42,680 39,256 39,256 100,100	8.96
Porter/Burns Harbor	Bethlehem	067-09	2	38' 3" 35' 0"	89,204 86,477	4.00
Lake/E. Chicago	YS&T	067-46	4	27' 6" 22' 0" 29' 6" 32' 0"	48,191 28,532 55,900 69,775	3.90
Lake/E. Chicago	Inland	067-16	8	21' 6" 19' 10" 21' 6" 20' 10" 26' 6" 26' 6" 26' 6" 26' 6"	32,179 24,265 31,946 29,585 48,218 46,290 46,294 46,595	8.1

(continued)

Table B-3 (continued)

State County/City	Company	Plant ID#	No. of furnaces	Hearth Diameter	Working Volume	Capacity (10^6 TPY)
Kentucky						
Boyd/Ashland	Armco	103-03	2	33' 5" 28' 9"	72,000 52,538	2.2
Maryland						
Baltimore/ Sparrows Point	Bethlehem	115-06	8	25' 6" 25' 6" 28' 0" 28' 0" 19' 9" 28' 0" 30' 0" 30' 0" 30' 0"	38,895 38,895 42,245 42,858 24,892 47,101 54,515 54,830 54,799	6.95
Michigan						
Wayne/Dearborn	Ford Motor	123-13	3	20' 0" 20' 0" 29' 0"	28,000 27,400 54,907	2.43
Wayne/River Rouge	Great Lake	123-15	4	30' 6" 29' 0" 28' 3" 28' 0"	62,434 55,468 50,605 53,252	4.0
Wayne/Trenton	McLouth	123-23	2	30' 0" 30' 0"	57,238 57,238	1.83
New York						
Erie/Lackawanna	Bethlehem	162-07	6	21' 3" 29' 6" 26' 0" 27' 0" 29' 0" 29' 11"	28,423 51,037 39,614 39,991 51,897 55,112	4.56

(continued)

Table B-3 (continued)

State County/City	Company	Plant ID#	No. of furnaces	Hearth Diameter	Working Volume	Capacity (10^6 TPY)
New York (Continued)						
Erie/Buffalo	Republic	162-26	2	21' 6" 22' 9"	27,700 33,500	1.16
Ohio						
Mahoning & Trumbull/ Youngstown	USS	178-35	4	25' 0" 23' 6" 23' 0" 25' 0"	37,055 34,724 33,986 37,356	1.72 (for 3 active)
Lorain/Lorain	USS	174-33	5	23' 0" 23' 3" 28' 6" 29' 0" 23' 5	28,628 28,973 48,505 49,196 28,689	2.90
Cuyahoga/ Cleveland	USS	174-33	1	26' 0"	42,140	0.31
Butler/Hamilton	Armco	079-02	2	18' 6" 19' 5"	22,653 27,467	0.93
Butler/Middletown	Armco	079-02	1	29' 6"	55,324	1.73
Cuyahoga/Cleveland	J.&L.	174-20	2	27' 6" 30' 6"	46,600 57,200	1.96
Scioto/Portsmouth	Empire- Detroit	103-12	1	29' 3"	53,763	0.73
Mahoning/ Youngstown	Republic	178-24	2	26' 3" 26' 3"	42,700 46,500	1.40
Trumbull/Warren & Niles	Republic	178-24	1	28' 0"	53,200	1.02

(continued)

Table B-3 (continued)

State County/City	Company	Plant ID#	No. of furnaces	Hearth Diameter	Working Volume	Capacity (10^6 TPY)
Ohio (Continued)						
Cuyahoga/ Cleveland	Republic	174-25	4	27' 0" 27' 0" 29' 6" 28' 0"	44,900 43,270 56,100 55,300	3.36
Stark/Canton	Republic	174-27	1 (0)*	18' 4"	21,600	
Mahoning/ Campbell	YS&T	178-45	4	22' 5" 22' 5" 24' 6" 23' 9"	30,457 30,561 43,188 40,965	1.97
Jefferson/ Steubenville	Wheeling-Pittsburgh	181-42	5	25' 0" 23' 0" 24' 0" 21' 1/2" 24' 9"	37,161 35,415 33,661 27,639 40,536	2.66
Pennsylvania						
Allegheny/ McKeesport	USS	197-34	3	24' 0" 25' 0" 22' 5"	30,613 34,825 28,329	1.4
Allegheny/ Duquesne	USS	197-34	4	20' 0" 23' 0" 24' 6" 28' 0"	25,909 32,713 35,215 58,045	2.53
Cambria/Johnstown	Bethlehem	195-08	2 (1)*	26' 0" 28' 0"	47,578 48,578	1.9 (for 2)
Bucks/Fairless Hills	USS	045-31	3	29' 6" 30' 10" 30' 10"	55,651 58,940 58,940	3.0

(continued)

Table B-3 (continued)

State County/City	Company	Plant ID#	No. of furnaces	Hearth Diameter	Working Volume	Capacity (10^6 TPY)
<u>Pennsylvania</u> (Continued)						
Allegheny/ Clairton	USS	197-32	1 (0)*	23' 0"	30,120	
Allegheny/ Rankin	USS	197-32	4 (2)*	29' 6" 29' 6" 23' 6" 23' 6"	51,281 51,281 31,558 31,558	2.3 (for 4)
Northampton/ Bethlehem	Bethlehem	151-05	4	30' 0" 27' 11" 30' 0" 24' 0"	54,431 49,748 54,519 41,068	3.87
Allegheny/ Pittsburgh	J.&L.	197-18	3 (1)*	22' 0" 29' 0" 26' 6"	28,600 54,400 35,400	1.93 (for 3)
Beaver/Midland	Crucible	197-11	2	26' 6" 19' 0"	46,655 27,580	1.1
Mercer/Sharon	Sharon	178-30	2	23' 1" 23' 1"	30,850 31,550	1.02
Allegheny/ Braddock	USS	197-37	5 (3)*	28' 10" 28' 10" 26' 0" 25' 0" 23' 6"	48,986 48,986 38,837 31,980 32,510	3.25
Westmoreland/ Monessen	Wheeling-Pittsburgh	197-43	3	19' 0" 19' 0" 28' 0"	24,661 25,025 51,000	1.6

(continued)

Table B-3 (continued)

State County/City	Company	Plant ID*	No. of furnaces	Hearth Diameter	Working Volume	Capacity (10^6 TPY)
Pennsylvania (Continued)						
Beaver/Aliquippa	J.&L.	197-19	5	28' 6"	43,900	4.0
				29' 0"	56,600	
				28' 6"	34,100	
				29' 0"	54,400	
				27' 3"	31,500	
Texas						
Harris/Houston	Armco	216-04	1	27' 3"	54,890	0.8
Morris/Lone Star	Lone Star	022-22	1	27' 0"	52,810	0.57
Utah						
Utah/Geneva	USS	220-40	3	26' 6"	43,666	2.1
				26' 6"	43,666	
				26' 6"	43,855	
West Virginia						
Hancock/Weirton	Weirton	181-41	4	27' 0"	56,197	2.89
				27' 0"	45,960	
				25' 6"	47,135	
				25' 6"	47,135	

* Number of furnaces listed in Air and Water Compliance Summary of the Steel Industry EPA Office of Enforcement, October 20, 1977 Capacities are from 308 survey data. Where typical production was reported greater than capacity, capacity was set equal to typical production.

Table B-4. OPEN HEARTH SHOPS IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	No. of furnaces	Heat size	Control device	Annual capacity (10^6 tons)
California						
San Bernardino/Fontana	Kaiser	024-21	8 (5 down)	8-225	ESP	1.80
Illinois						
Cook/S. Chicago	Republic	067-28	2-operating part-time	2-250	ESP	0.22
Indiana						
Lake/E. Chicago	Inland	067-16	7	7-350	ESP	2.40
Lake/E. Chicago	YS&T	067-46	8	8-315	Venturi Scrubber	2.77
Maryland						
Baltimore/Sparrows Point	Bethlehem	115-06	7	7-420	ESP and Scrubber	3.95
Ohio						
Butler/Middletown	Armco	079-02	6	6-310	Venturi Scrubber	2.0
Scioto/Portsmouth	Empire-Detroit	103-12	5	5-320	No control device	0.97
Cuyahoga/Cleveland	Republic	174-25	4	4-400	ESP	1.18
Mahoning & Trumbull/Youngstown	USS	178-35	14	14-163	ESP	1.72

(continued)

Table B-4 (continued)

State County/City	Company	Plant ID#	No. of furnaces	Heat size	Control device
Ohio (Continued)					
Mahoning/ Youngstown	YS&T	178-47	11	11-175	No control device
Pennsylvania					
Cambria/ Johnstown	Bethlehem	195-08	6	6-180	ESP
Allegheny/ Pittsburgh	Jones & Laughlin	197-18	6	6-340	ESP
Bucks/Fairless Hills	USS	045-31	9	9-395	ESP
Allegheny/ Homestead	USS	197-32	11	11-320	ESP
Texas					
Morris/ Lone Star	Lone Star	022-22	5	5-250	Steam-hydro
Utah					
Utah/Geneva	USS	220-40	10	10-340	ESP

Table B-5. BASIC OXYGEN FURNACES IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	No. of furnaces	Heat size	Capacity (10^6 TPY)
Alabama					
Etowah/Gadsden	Republic	003-29	2	2-150	1.61
Jefferson/ Fairfield	USS	004-39	2	2-200 (Q-BOP)	2.72
California					
San Bernardino/ Fontana	Kaiser	024-21	3	3-120	1.40
Colorado					
Pueblo/Pueblo	CF&I	038-10	2	2-120	1.10
Illionis					
Cook/Chicago	Interlake	067-17	2	2-75	0.88
Madison/Granite City	Granite City	070-14	2	2-235	2.52
Cook/S. Chicago	USS	067-38	3	3-200	4.1*
Cook/S. Chicago	Republic	067-28	2	2-200(Q-BOP)	2.70(est)
Cook/S. Chicago	Wisconsin	067-44	2	2-140	1.27
Indiana					
Lake/E. Chicago	Inland	067-16	4	2-255 2-210	4.0 3.65
Porter/Burns Harbor	Bethlehem	067-09	2	2-300	4.4
Lake/Gary	USS	067-36	6	3-220 (Q-BOP) 3-220	4.5 5.5

(continued)

Table B-5 (continued)

State County/City	Company	Plant ID#	No. of furnaces	Heat size	Capacity (10^6 TPY)
Indiana (Continued)					
Lake/E. Chicago	YS&T	067-46	2	2-285	3.8
Kentucky					
Boyd/Ashland	Armco	103-03	2	2-180	2.4
Maryland					
Baltimore/ Sparrows Point	Bethlehem	115-06	2	2-220	3.35
Michigan					
Wayne/Dearborn	Ford Motor	123-13	2	2-250	2.85
Wayne/Trenton	McLouth	123-23	5	5-110	2.65
Wayne/River Rouge and Ecorse	Great Lakes	123-15	4	2-300 2-200	3.6 2.0
New York					
Erie/Lackawanna	Bethlehem	162-07	3	3-300	8.10
Erie/Buffalo	Republic	162-26	2	2-125	1.66
Ohio					
Butler/Middletown	Armco	079-02	2	2-200	2.77
Cuyahoga/Cleveland	J.&L.	174-20	2	2-205	2.40
Trumbull & Mahoning/Warren, Niles and Youngstown	Republic	178-24	2	2-150	2.60

(continued)

Table B-5 (continued)

State County/City	Company	Plant ID*	No. of furnaces	Heat size	Capacity (10^6 TPY)
Ohio (Continued)					
Cuyahoga/ Cleveland	Republic	174-25	2	2-245	3.58
Lorain and Cuyahoga/Lorain	USS	174-33	2	2-225	2.80
Jefferson/ Steubenville	Wheeling-Pittsburgh	181-42	2	2-285	3.12
Pennsylvania					
Northampton/ Bethlehem	Bethlehem	151-05	2	2-270	3.16
Beaver/Midland	Crucible Inc.	197-11	2	2-100	0.9*
Beaver/Aliquippa	J.&L.	197-19	3	3-200	3.5
Mercer/Sharon	Sharon	178-30	3	3-150	1.28
Allegheny/Duquesne	USS	197-34	2	2-215	2.74
Allegheny/Braddock	USS	197-37	2	2-230	2.83
Westmoreland/ Monessen	Wheeling-Pittsburgh	197-43	2	2-200	1.75
West Virginia					
Hancock/Weirton	Weirton	181-41	2	2-390	4.27

* Capacity data marked * was taken from Iron and Steel Engineer, August, 1977, p. 54. Remaining capacity data from 308 survey data.

Table B-6. ELECTRIC ARC FURNACES IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	No. of furnaces	Heat size	Type steel	Capacity (10^6 TPY)
Alabama						
Etowah/Gadsden	Republic	003-29	2	2-185	Carbon, alloy	0.4 (est)
Colorado						
Pueblo/Pueblo	CF&I	038-10	2	2-120	Carbon, alloy	0.33
Illinois						
Cook/S. Chicago	USS	067-38	3	2-200 1-100	Carbon alloy Stainless	0.72 0.17
Cook/S. Chicago	Republic	067-28	3	3-200	Carbon, alloy	0.90
Indiana						
Lake/E. Chicago	Inland	067-16	2	2-120	Carbon, alloy	0.5
Michigan						
Wayne/Ecorse	Great Lakes	123-15	2	2-150	Carbon, alloy	0.73
Wayne/Trenton	McLouth	123-23	2	2-200	Carbon, stainless	0.42
Wayne/Dearborn	Ford Motor	123-13	4	4-200	Carbon, alloy	0.91
Ohio						
Cuyahoga/Cleveland	J.&L.	174-20	2	2-190	Carbon, high strength	1.1
Stark/Canton	Republic	174-27	7	3-85 4-200	Carbon, alloy, stainless Carbon, alloy, stainless	1.54

(continued)

Table B-6 (continued)

State County/City	Company	Plant ID#	No. of furnaces	Heat size	Type steel	Capacity (10^6 TPY)
Pennsylvania						
Beaver/Midland	Crucible	197-11	5	4-75	Carbon, alloy, stainless	0.4 (est)
				1-25	Carbon, alloy stainless	
Mercer/Sharon	Sharon	178-30	2	2-110	Alloy, stainless	0.33
Northampton/ Bethlehem	Bethlehem	151-05	6	1-7	Alloy	0.33
				1-28	Alloy	
				4-50	Alloy	
Bucks/Fairless Hills	USS	045-31	2	2-200	Carbon, alloy	0.58
Allegheny/ Duquesne	USS	197-34	5	1-20	Alloy, stainless	0.38
				1-50	Alloy, stainless	
				3-65	Alloy, stainless	
Texas						
Harris/Houston	Armco	216-04	6	2-117	Carbon, alloy	2.42
				4-175	Carbon, alloy	

Table B-7. CONTINUOUS CASTING MACHINES IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	#Machines	Product Cast	Annual Capacity (TPY)
Colorado					
Pueblo/Pueblo	C F & I	038-10	1-6 STRAND	Billets	315,000
Illinois					
Cook/S. Chicago	U.S.S.	067-38	1-4 STRAND	Billets	928,000
Cook/S. Chicago	Wisconsin	067-44	1-8 STRAND	Billets	318,000
Indiana					
Lake/Gary	U.S.S.	067-36	1-1 STRAND	Slabs	1,517,000
Lake/E. Chicago	Inland	067-16	1-2 STRAND	Slabs	1,500,000
			1-4 STRAND	Billets	500,000
Porter/Burns Harbor	Bethlehem	067-09	1-2 STRAND	Slabs	1,497,000
Michigan					
Wayne/Trenton	McLouth	123-23	1-4 STRAND	Slabs	2,400,000
Wayne/Ecorse	Great Lakes	123-15	2-4 STRAND	Slabs	1,500,000*
Ohio					
Stark/Canton	Republic	174-27	1-4 STRAND	Billets	275,000
			1-2 STRAND	Slabs	384,000
Butler/Middletown	Armco	079-02	2-2 STRAND	Slabs	1,387,000
Pennsylvania					
Bucks/Fairless Hills	U.S.S.	045-31	1-2 STRAND	Blooms	548,000
Beaver/Aliquippa	J & L	197-19	1-6 STRAND	Billets	548,000
Beaver/Midland	Crucible	197-11	1-1 STRAND	Slabs	330,000*
Texas					
Morris/Lone Star	Lone Star	022-22	1-2 STRAND	Billets	N/A
West Virginia					
Hancock/Weirton	Weirton	181-41	1-4 STRAND	Billets	1,503,000

*Capacities marked (*) are taken from Steel Industry in Brief: Databook USA 1977, R.L. Deily. Remaining capacities from 308 Survey Data.

Table B-8. SOAKING PITS IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	# of Pits	Sq. Ft. Heating Area
Alabama				
Etowah/Gadsden	Republic	003-29	6	6-3978
Jefferson/Fairfield	U.S.S.	004-39	26	11-1800 15-5896
California				
San Bernardino/ Fontana	Kaiser	024-21	20	20-8200
Colorado				
Pueblo/Pueblo	CF&I	038-10	59	35-1350 24-3000
Illinois				
Cook/S. Chicago	Republic	067-28	8	8-6533
Cook/S. Chicago	U.S.S.	067-38	29	6-2583 4-1960 7-1280 1-441 2-862 9-4523
Madison/Granite City	Granite City	070-14	8	8-4235
Cook/S. Chicago	Wisconsin	067-44	9	9-2885
Cook/Chicago	Interlake	067-17	4	4-640
Indiana				
Lake/E. Chicago	Youngstown Sheet & Tube	067-46	21	1-484 11-3989 9-7695

(continued)

Table B-8 (continued)

State County/City	Company	Plant ID#	# of Pits	Sq. Ft. Heating Area
Indiana (Continued)				
Porter/Burns Harbor	Bethlehem	067-09	32	32-9728
Lake/Gary	U.S.S.	067-36	58	10-3776 15-5709 2-1071 2-1539 3-4928 12-12,300 14-14,350
Lake/E. Chicago	Inland	067-16	49	8-5634 26-4682 15-8413
Kentucky				
Boyd/Ashland	Armco	103-03	50	
Maryland				
Baltimore/Sparrows Point	Bethlehem	115-06	79	22-7040 22-4488 5-770 30-8076
Michigan				
Wayne/Ecorse	Great Lakes	123-15	22	8-4000 4-2300 10-8500
Wayne/Dearborn	Ford Motor	123-13	13	6-4800 7-8400
Wayne/Trenton	McLouth	123-23	5	5-2200

(continued)

Table B-8 (continued)

State County/City	Company	Plant ID#	# of Pits	Sq. Ft. Heating Area
<u>New York</u>				
Erie/Buffalo	Republic	162-26	4	4-3190
Erie/Lackawanna	Bethlehem	162-07	131	32-4288 36-5088 15-2250 12-1696 26-11,340
<u>Ohio</u>				
Mahoning/Youngstown	Youngstown Sheet & Tube	178-47	9	2-946 6-2304 1-314
Mahoning/Campbell	Youngstown Sheet & Tube	178-45	10	10-4162
Jefferson/Steubenville	W.P. Steel	181-42	13	8-4182 5-2635
Mahoning/Youngstown	Republic	178-24	8	8-2520
Trumbull/Warren & Niles	Republic	178-24	10	10-3780
Cleveland/Cuyahoga	Republic	174-25	14	9-5429 5-5720
Stark/Massillon	Republic	174-27	7	7-1601
Stark/Canton	Republic	174-27	9	9-4032
Lorain/Lorain	U.S.S.	174-33	15	15-8400
Mahoning & Trumbull/ Youngstown	U.S.S.	178-35	18	10-2230 8-1940
Cuyahoga/Cleveland	J&L Steel	174-20	11	11-8085
Scioto/Portsmouth	Empire-Detroit	103-12	14	12-2904 1-748 1-792
Butler/Middletown	Armco	079-02	32	

(continued)

Table B-8 (continued)

State County/City	Company	Plant ID#	# of Pits	Sq. Ft. Heating Area
Pennsylvania				
Westmoreland/Monessen	W.P. Steel	197-43	8	8-3818
Allegheny/Braddock	U.S.S.	197-37	26	26-5268
Cambria/Johnstown	Bethlehem	195-08	47	12-624 35-5390
Bucks/Fairless Hills	U.S.S.	045-31	14	10-2700 4-950
Allegheny/Homestead	U.S.S.	197-32	27	10-5670 17-7912
Allegheny/McKeesport	U.S.S.	197-34	10	10-2400
Allegheny/Duquesne	U.S.S.	197-34	8	8-6336
Northampton/ Bethlehem	Bethlehem	151-05	68	16-960 4-1024 16-3600 16-960 10-1084 6-1650
Beaver/Aliquippa	J&L Steel	197-19	11	11-6540
Allegheny/Pittsburgh	J&L Steel	197-18	12	12-8901
Beaver/Midland	Crucible	197-11	10	10-3600
Mercer/Sharon	Sharon	178-30	7	3-1296 4-3470
Texas				
Harris/Houston	Armco	216-04	34	10-3140 24-8064
Morris/Lone Star	Lone Star	022-22	12	12-2592
Utah				
Utah/Geneva	U.S.S.	220-40	10	10-4020
West Virginia				
Hancock/Weirton	Weirton	181-41	14	14-24,000

(continued)

Table B-9. SCARFING MACHINES IN INTEGRATED STEEL MILLS

State/county/city	Company	Plant number	No. auto scarfers	Product scarfed S=slabs B=blooms	Control device
California					
San Bernardino/Fontana	Kaiser	024-21	1	S	ESP
Colorado					
Pueblo/Pueblo	CF&I	038-10	1	B	
Illinois					
Cook/S. Chicago	Wisconsin	067-44	1	B	
Cook/S. Chicago	Republic	067-28	1	B	
Cook/S. Chicago	USS	067-38	1	-	Scrubber
Indiana					
Porter/Burns Harbor	Bethlehem	067-09	1	S&B	Wet scrubber
Lake/E. Chicago	Inland	067-16	3	S&B	Water plume & sprays
Lake/Gary	U.S.S.	067-36	5	S&B	ESP
Lake/E. Chicago	YS&T	067-46	1	S&B	Wet scrubber
Kentucky					
Boyd/Ashland	Armco	103-03	2	S&B	
Maryland					
Baltimore/Sparrows Pt.	Bethlehem	115-06	2	S&B	ESP
Michigan					
Wayne/Dearborn	Ford Motor	123-13	1	S&B	Water plume & sprays
Wayne/Ecorse	Great Lakes	123-15	2	S&B	
Wayne/Trenton	McLouth	123-23	1	S&B	
New York					
Erie/Lackawanna	Bethlehem	162-07	3	S&B	
Erie/Buffalo	Republic	162-26	1	B	ESP

(continued)

Table B-9 (continued)

State/county/city	Company	Plant number	No. auto scarfers	Product scarfed S=slabs B=blooms	Control device
Ohio					
Butler/Middletown	Armco	079-02	1	S	Wet scrubber
Scioto/Portsmouth	Empire-Detroit	103-12	1	S&B	
Cuyahoga/Cleveland	J&L	174-20	1	S	ESP
Cuyahoga/Cleveland	Republic	174-25	3	S&B	ESP
Trumbull & Mahoning/Youngstown	Republic	178-24	1	B	Baghouse
Lorain/Lorain	U.S.S.	174-33	2	B	Wet scrubber
Jefferson/Steubenville	Wheeling-Pitt.	181-42	2	S&B	Wet scrubber on one
23. Mahoning/Youngstown	YS&T	178-47	1	S&B	Wet scrubber
Pennsylvania					
Northampton/Bethlehem	Bethlehem	151-05	1	B	ESP
Cambria/Johnstown	Bethlehem	195-08	2	B	Wet scrubber on one
Beaver/Midland	Crucible	197-11	1	S&B	ESP
Beaver/Aliquippa	J&L	197-19	2	S&B	ESP
Allegheny/Pittsburgh	J&L	197-18	1	S&B	ESP
Mercer/Sharon	Sharon	178-30	1	S&B	
Allegheny/Braddock	U.S.S.	197-37	1	S&B	Wet scrubber
Allegheny/Duquesne	U.S.S.	197-34	1	S&B	ESP
Bucks/Fairless Hills	U.S.S.	045-31	2	S&B	ESP
Allegheny/Homestead	U.S.S.	197-32	1	S&B	Cyclone
Texas					
Harris/Houston	Armco	216-04	2	S&B	Wet scrubber
West Virginia					
Hancock/Weirton	Weirton	181-41	1	S&B	

Reference: "Electrostatic Precipitation of Scarfer Fume" by Ronald L. Hill, 1977 Spring Convention of the Assoc. of Iron & Steel Engineers.

(continued)

Table B-10. REHEAT FURNACES IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID#	# of Furnaces	Sq. Ft. Heating Area	Mill
Alabama					
Etowah/Gadsden	Republic	003-29	3	1-1778	plate
				2-2669	hot strip
Jefferson/Fairfield	U.S.S.	004-39	17	5-2583	structural
				2-952	plate
				3-5571	plate
				4-6400	hot strip
				3-2525	finishing
California					
San Bernardino/ Fontana	Kaiser	024-21	9	1-1828	structural
				3-5724	plate
				3-7200	hot strip
				1-1600	finishing
				1-440	finishing
Colorado					
Pueblo/Pueblo	CF&I	038-10	10	2-2400	structural
				1-750	finishing
				3-1300	finishing
				1-1860	finishing
				1-3000	finishing
				1-700	finishing
				1-2226	finishing
Illinois					
Madison/Granite City	Granite City	070-14	3	3-	walking beam
Cook/S. Chicago	U.S.S.	067-38	14	4-1246	plate
				2-1144	plate
				2-6424	structural
				1-775	structural
				2-1599	structural
				2-1600	finishing
				1-4095	finishing

(continued)

Table B-10 (continued)

State County/City	Company	Plant ID#	# of Furnaces	Sq. Ft. Heating Area	Mill
Illinois (Continued)					
Cook/S. Chicago	Republic	067-28	6	2-2940	finishing
				1-1680	finishing
				1-2250	finishing
				1-1620	finishing
				1-1200	finishing
Cook/S. Chicago	Wisconsin	067-44	5	1-1120	finishing
				2-1470	finishing
				2-1700	finishing
Cook/Chicago	Interlake	067-17	2	2-4250	hot strip
Indiana					
Lake/E. Chicago	Youngstown Sheet & Tube	067-46	14	5-12,600	hot strip
				1-1024	finishing
				1-1458	finishing
				2-750	finishing
				1-3750	finishing
				1-730	finishing
				3-	finishing
Lake/Gary	U.S.S.	067-36	19	4-220	tie plate
				4-1686	plate
				2-1290	plate
				5-1600	hot strip
				4-4410	hot strip

(continued)

Table B-10 (continued)

State County/City	Company	Plant ID#	# of Furnaces	Sq. Ft. Heating Area	Mill
Indiana (Continued)					
Lake/Gary (Continued)	U.S.S.	067-36	17	2-1590	finishing
				2-1340	finishing
				2-1340	finishing
				1-820	finishing
				1-805	finishing
				1-1070	finishing
				1-1200	finishing
				2-not available	finishing
				1-3000	finishing
				1-470	finishing
				1-88	finishing
				1-212	finishing
				1-105	finishing
Porter/Burns Harbor	Bethlehem	067-09	18	2-4180	plate
				4-3100	plate
				1-739	plate
				6-1498	plate
				1-3475	plate
				1-2500	plate
				3-10,710	hot strip
Lake/E. Chicago	Inland	067-16	21	2-3456	structural
				1-1770	billet
				1-936	plate
				3-4860	hot strip
				4-5420	hot strip
				4-14,280	hot strip
				2-990	finishing
				2-1100	finishing
				1-2520	finishing
				1-1522	finishing
Kentucky					
Boyd/Ashland	Armco	103-03	3	3-1020	strip & sheet

(continued)

Table B-10 (continued)

State County/City	Company	Plant ID#	# of Furnaces	Sq. Ft. Heating Area	Mill
Maryland					
Baltimore/Sparrows Point	Bethlehem	115-06	30	8-2240	plate
				4-1600	plate
				2-3680	plate
				2-750	pipe
				4-9360	strip
				3-8190	strip
				5-760	flange
				1-1350	rod
				1-3480	rod
Michigan					
Wayne/Ecorse	Great Lakes	123-15	9	5-16,000	hot strip
				4-5928	hot strip
Wayne/Dearborn	Ford Motor	123-13	3	2-8750	hot strip
				1-921	finishing
Wayne/Trenton	McLouth	123-23	2	2-4320	sheet
New York					
Erie/Buffalo	Republic	162-26	3	1-2190	finishing
				1-1203	finishing
				1-945	finishing
Erie/Lackawanna	Bethlehem	162-07	17	2-1330	rail & billet
				5-3610	structural
				2-2137	structural
				5-7806	strip
				2-1700	finishing
				1-1843	finishing

(continued)

Table B-10 (continued)

State County/City	Company	Plant ID#	# of Furnaces	Sq. Ft. Heating Area	Mill
Ohio					
Mahoning/Youngstown	Republic	178-24	4	1-2109	finishing
				2-930	finishing
				1-576	finishing
Cuyahoga/Cleveland	Republic	174-25	5	3-10,710	strip
				1-2113	finishing
				1-1440	finishing
Stark/Massillon	Republic	174-27	7	1-1414	billets
				3-1849	finishing
				3-519	finishing
Stark/Canton	Republic	174-27	3	2-1650	finishing
				1-1080	finishing
Mahoning/Campbell	Youngstown Sheet & Tube	178-45	20	3-7800	hot strip
				1-282	finishing
				4-4078	finishing
				2-1650	finishing
				2-154	finishing
				3-2577	finishing
				1-4078	finishing
				4-	finishing
Mahoning/Youngstown	Youngstown Sheet & Tube	178-47	1	1-385	blooming
Jefferson/Steubenville	W.P. Steel	181-42	3	3-9690	hot strip
Cuyahoga/Cleveland	U.S.S.	174-33	3	1-755	strip
				1-2660	finishing
				1-750	finishing
Mahoning & Trumbull/ Youngstown	U.S.S.	178-35	13	3-5350	strip
				1-1020	strip
				1-1240	strip
				1-375	finishing
				1-1020	finishing
				1-1020	finishing
				2-1900	finishing
				1-1020	finishing
				1-1170	finishing
				1-515	finishing

(continued)

Table B-10 (continued)

State County/City	Company	Plant ID#	# of Furnaces	Sq. Ft. Heating Area	Mill
Trumbull/Warren & Niles	Republic	178-24	3	3-6840	strip
Cuyahoga/Cleveland	J&L Steel	174-20	3	3-10,404	slabbing
Scioto/Portsmouth	Empire-Detroit	103-12	3	3-[illegible]200	hot strip & sheet
Butler/Middleton	Armco	079-02	4		
Pennsylvania					
35. Allegheny/Braddock	U.S.S.	197-37	5	5-6300	hot strip sheet
Northampton/ Bethlehem	Bethlehem	151-05	20	2-4134	strip
				2-1654	structural
				2-1873	structural
				2-1772	structural
				2-432	structural
				1-189	structural
				1-500	structural
				2-1700	structural
				2-4134	finishing
				2-1654	finishing
				2-1873	finishing

(continued)

Table B-10 (continued)

State County/City	Company	Plant ID#	# of Furnaces	Sq. Ft. Heating Area	Mill
Pennsylvania (Continued)					
Cambria/Johnstown	Bethlehem	195-08	9	7-2872	plate
				2-890	plate
			11	1-458	finishing
				1-1315	finishing
				1-1728	finishing
				1-1728	finishing
				1-632	finishing
				1-2500	finishing
				1-493	finishing
				1-220	finishing
				1-1932	finishing
				1-200	finishing
				3-2537	finishing
Bucks/Fairless Hills	U.S.S.	045-31	8	4-2125	hot strip
				2-2380	blooming
				1-2580	finishing
				1-4095	finishing
Allegheny/Clairton	U.S.S.	197-32	11	2-864	structural
				2-802	structural
				4-1404	structural
				3-2164	structural
Allegheny/Homestead	U.S.S.	197-32	24	2-1250	structural
				1-825	structural
				1-675	structural
				2-3680	plate
				6-2708	plate
				4-4320	plate
				8-2208	plate
Beaver/Aliquippa	J&L Steel	197-19	7	2-4472	hot strip
				1-1600	finishing
				2-3083	finishing
				1-1913	finishing
				1-2100	finishing

(continued)

Table B-10 (continued)

State County/City	Company	Plant ID#	# of Furnaces	Sq. Ft. Heating Area	Mill
Pennsylvania (Continued)					
Allegheny/Pittsburgh	J&L Steel	197-18	7	3-4686	strip
				2-2812	finishing
				1-2079	finishing
				1-	finishing
Beaver/Midland	Crucible	197-11	13	9-5220	hot strip
				1-2436	hot strip
				3-1000	forging press
			15	1-1140	finishing
				5-3072	finishing
				2-1270	finishing
				7-1830	finishing
Mercer/Sharon	Sharon	178-30	4	2-4800	hot strip
				2-2970	strip & sheet
				8-2492	finishing
Allegheny/McKeesport	U.S.S.	197-34	8	8-11,650	finishing
Allegheny/Duquesne	U.S.S.	197-34	6	6-3728	finishing
Texas					
Morris/Lone Star	Lone Star	022-22	2	1-2100	slabbing
				1-1200	finishing
Harris/Houston	Armco	216-04	7	3-1100	finishing
				2-1025	finishing
				1-1900	finishing
				1-2300	finishing
Utah					
Utah/Geneva	U.S.S.	220-40	7	3-6180	structural
				4-11,113	plate & strip
West Virginia					
Hancock/Weirton	Weirton	181-41	5	4-10,350	strip
				1-980	structural

(continued)

Table B-11. BOILERS IN INTEGRATED STEEL MILLS

State County/City	Company	Plant ID	No. of Boilers	Capacity	Fuel
Alabama					
Etowah/Gadsden	Republic	003-29	12	2-135 5-90 1-165 1-133 1-331 1-221 1-193	coke oven gas blast furnace gas distillate oil residual oil natural gas
Jefferson/Fairfield	U.S.S.	004-39	28	2-105 2-150 1-300 1-75 7-73 1-175 4-160 1-67 3-457 5-305 1-45	coal coke oven gas blast furnace gas natural gas creosote
California					
San Bernardino/ Fontana	Kaiser	024-21	7	7-157	coke oven gas blast furnace gas natural gas
Colorado					
Pueblo/Pueblo	CF&I	038-10	2	1-220 1-110	coke oven gas blast furnace gas natural gas
Indiana					
Lake/E. Chicago	YS&T	067-46	8	2-190 2-230 3-390 1-930	oil natural gas blast furnace gas coke oven gas coal
Porter/Burns Harbor	Bethlehem	067-09	5	1-783 2-718 1-713 1-624	coke oven gas blast furnace gas residual oil
Lake/E. Chicago	Inland	067-16	9	4-455 4-262 1-300	coke oven gas blast furnace gas natural gas residual oil bituminous coal

(continued)

Table B-11 (continued)

State County/City	Company	Plant ID	No. of Boilers	Capacity	Fuel
Indiana (Continued)					
Lake/Gary	U.S.S.	067-36	11	1-2250	natural gas
				1-870	blast furnace gas
				1-850	coke oven gas
				1-150	oil
				3-400	coal
				1-76	
				1-105	
				1-140	
				1-455	
Illinois					
Madison/Granite City	Granite City	070-14	1	1-4800	oil
Kentucky					
Boyd/Ashland	Armco	103-03	7	4-44	residual oil
				3-155	blast furnace gas
Michigan					
Wayne/Trenton	McLouth	123-23	6	5-170	natural gas
				1-312	residual oil
New York					
Erie/Buffalo	Republic	162-26	4	1-304	natural gas
				1-174	
				1-79	
				1-87	
Erie/Lackawanna	Bethlehem	162-07	19	4-241	natural gas
				1-40	
				1-9	
				1-112	
				1-404	
				1-300	
				2-32	
				2-139	

(continued)

Table B-11 (continued)

State County/City	Company	Plant ID	No. of Boilers	Capacity	Fuel
New York (Continued)					
Erie/Lackawanna	Bethlehem	162-07	19	1-525 1-62 1-150 1-191 1-18 1-377	
Ohio					
Cuyahoga/Cleveland	Jones & Laughlin	174-20	11	6-53 1-243 1-130 1-138 1-113 1-122	blast furnace gas natural gas
Mahoning/Campbell	YS&T	178-45	10	6-282 3-25 1-585	oil coke oven gas blast furnace gas natural gas coal
Mahoning/Youngstown	Republic	178-24	7	2-225 3-90 2-408	residual oil coke oven gas blast furnace gas bituminous coal
Scioto/Portsmouth	Empire-Detroit	103-12	7	2-100 2-7 1-3 1-34 1-1	distillate oil natural gas coke oven gas
Mahoning/Youngstown	YS&T	178-47	10	10-22	coal blast furnace gas
Mahoning & Trumbull/ Youngstown	U.S.S.	178-35	6	4-310 2-457	blast furnace gas natural gas coal oil

(continued)

Table B-11 (continued)

State County/City	Company	Plant ID	No. of Boilers	Capacity	Fuel
Ohio (Continued)					
Jefferson/Steubenville	W.P.	181-42	12	4-80 2-165 3-116 3-132	coal coke oven gas blast furnace gas oil
Lorain & Cuyahoga/ Lorain	U.S.S.	174-33	6	6-67	oil blast furnace gas natural gas
Pennsylvania					
Allegheny/Duquesne	U.S.S.	197-34	2	2-62	coal
Westmoreland/Monessen	W.P.	197-43	6	4-50 2-146	coal natural gas coke
Montgomery/Swedeland	Alan Wood	045-01	2	2-276	residual oil blast furnace gas coke oven gas
Bucks/Fairless Hills	U.S.S.	045-31	5	4-47 1-14 1-14	

(continued)

Table B-11 (continued)

State County/City	Company	Plant ID	No. of Boilers	Capacity	Fuel
Pennsylvania (Continued)					
Beaver/Midland	Crucible	197-11	12	2-50 5-100 3-41 2-94	residual oil bituminous coal blast furnace gas natural gas
Allegheny/Pittsburgh	Jones & Laughlin	197-18	8	5-230 3-170	bituminous coal natural gas
Northampton/Bethlehem	Bethlehem	151-05	34	19-60 3-100 3-36 2-120 1-150 1-19 1-390 1-300 2-18 1-100	blast furnace gas anthracite coal bituminous coal coke oven gas residual
Mercer/Sharon	Sharon	178-30	6	4-40 2-14	coal
Allegheny/Braddock	U.S.S.	197-37	7	3-143 4-52	coal blast furnace gas

(continued)

Table B-11 (continued)

State County/City	Company	Plant ID	No. of Boilers	Capacity	Fuel
Texas					
Harris/Houston	Armco	216-04	4	2-275 1-93 1-64	blast furnace gas
Morris/Lone Star	Lone Star	022-22	5	2-200 3-90	natural gas residual oil
Utah					
Utah/Geneva	U.S.S.	220-40	5	3-412 2-206	coal coke oven gas blast furnace gas natural gas
West Virginia					
Hancock/Weirton	Weirton	181-41	4	4-47	coal

(continued)

APPENDIX C

SUMMARY OF EXHAUST GAS FLOW RATE EQUATIONS

APPENDIX C

PPS-ES	FLOW RATE EQUATION	REMARKS
1-1 Ore yard	Not applicable	
2-1 Coal yard	Not applicable	
2-3 Coal crushing	$acfm = 192.7\ W^{.8343} \times 4$	W = belt width; 4 = No. of transfer points. Belt width is determined from the following table: 10^6 TPY — Belt width, in. 0 - 0.2 — 18 0.2 - 0.59 — 30 0.59 - 1.20 — 42 1.20 - 2.57 — 60 >2.57 integral multiple of 60-in. belt e.g., 2.78 — 2 60-in. belts 5.15 — 3 60-in. belts
4-1 Sinter windbox	$scfm = 12{,}897 + 205.6 \times \left(\frac{1000\ Prod + 149}{1.137}\right)$	Production is in 10^6 tons/year (TPY) Reduced by 40% for windbox recirculation
4-2 Sinter discharge	$scfm = 42{,}295 + 47.3 \times \left(\frac{1000\ Prod + 149}{1.137}\right)$	Production is in 10^6 (TPY)
4-3 Sinter plant	$acfm = 192.7W^{.8342} \times 5$	W = belt width 5 = No. of transfer points. Belt width is determined from the following table: 10^6 TPY — Belt width, in. 0 - 0.46 — 18 0.46 - 1.3 — 30 1.3 - 2.66 — 42 2.66 - 5.69 — 60 >5.69 integral multiple of 60-in. belt e.g., 5.94 — 2 60-in. belts 11.76 — 3 60-in. belts

(continued)

Table C-1 (continued)

PPS-ES	FLOW RATE EQUATION	REMARKS
5-1 Coke charging	Not applicable	
5-2 Coke pushing	For enclosed car: acfm = 75,000 For shed: acfm = 1.67 (volume)	 Volume = 35.6 (length) (tons/push) Length = 4 (No. of ovens) + 20
5-3 Quenching	scfm = 24,000 (ton coke/push) acfm = 88 (TPD Coke)	Conventional quenching Dry quenching
5-4 Door leaks	Not applicable	
5-5 Topside leaks	Not applicable	
5-6 Combustion stack	scfm = 66,120 (10^6 TPY of coal)	
5-7 Coke handling	scfm = acfm = (1.4 PDV) + ($192.7\ W^{.8343}$ x 5)	P = Perimeter of hood, V = 200 fpm D = distance from source to hood W = belt width, 5 = No. of transfer points. Belt width is shown in the following table: 10^6 TPY — Belt width, in. 0 - 0.13 — 18 0.13 - 0.35 — 30 0.35 - 0.65 — 42 0.65 - 1.54 — 60 >1.54 integral multiples of 60-in. belt e.g., 1.77 — 2 60-in. belts 3.24 — 3 60-in. belts
5-8 Coke oven gas	scfm = 11,000 x (tons coal per day) divided by 1440	
5-9 Coal preheater	scfm = 16,910 (10^6 TPY coal)	

(continued)

Table C-1 (continued)

PPS-ES	FLOW RATE EQUATION	REMARKS
7-2 Cast house evacuation	acfm = 1.2 (cast house volume)	C.H. volume = 3.426 (working volume)$^{1.085}$ Annual cap (in 10^6 TPY) = 0.023 (working volume) $^{-0.25}$, where working volume is in 10^3 ft^3
7-2 Tap hole hood	acfm = 1.4 (300) PD @ 175°F	P = Perimeter of hood D = Vertical distance
7-2 Runner covers	acfm = 200,000 @ 175°F	
7-3 Slag pouring	acfm = 65 x TPD Hot metal	Slag granulator hooding
7,8, 9,10 -5 Slag processing (open hearth, BOF, EAF, and blast furnace)	scfm = acfm = (1.4 PDV) + (192.7W$^{.8343}$ x 3)	P = perimeter of hood, V = 200 fpm A = area covered by hood, D = vertical distance W = belt width, 3 = No. of transfer points. Belt width is determined in the same way as coal crushing and transfer.
8,9-1 Hot metal transfer	scfm = 57,547 + 139.6H	H = heat size
8-2 Open hearth stack	scfm = 65,578 + 201.6H (No. of furnaces)	H = heat size
8-3 Open hearth fugitive	Not applicable	
9-2 BOF stack	scfm = 2242H scfm = 1634H scfm = 976H scfm = 1464H	ESP = open hood Scrub-open hood Closed hood, 2 furnaces Closed hood, 3 furnaces H = heat size
9-3 BOF enclosure	acfm = 1000 H for enclosure	H = heat size
9-4 BOF slag pouring	scfm = 200,000 scfm = 400,000	For shop producing, 1,000,000 TPY For shop producing, 2,000,000 and over

(continued)

Table C-1 (continued)

PPSES	FLOW RATE EQUATION	REMARKS
10-1 Electric furnace 10-2 control	scfm = 5000 H (No. of furnaces in shop)	Building evacuation
	scfm = 2500 H (No. of furnaces in shop)	Alloy canopy hood
	scfm = 4000 H (No. of furnaces in shop)	Carbon building evacuation + CH + DSE
	scfm = 2000 H (No. of furnaces in shop)	Carbon canopy hood + DSE
	scfm = 350 H (No. of furnaces in shop) H = heat size	Carbon direct shell evacuation
12-1 Continuous casting	acfm = 175,000 @ 150°F	
14-1 Soaking pits	scfm = 20,000 x (0.038 tons/hr/ft^2) ft^2 heating area)/60	
14-3 Scarfing machine	acfm = 22,807 x (10^6 TPY) + 45276	
17-1 22-1 Reheat furnace	scfm = 41,000 (0.075 tons/hr/ft^2) (ft^2 heating area)/60	
29-1 Boiler	scfm = 17,000 X MM Btu/hr/60	

APPENDIX D

CONTROL TECHNOLOGY SUMMARY AND EMISSION RATES FOR RACT, BACT, AND LAER

The technologies defining RACT, BACT, and LAER in this report were selected, in part, to examine a wide range of alternatives. As such, they should not be interpreted as representing Agency policy because appropriate technology definitions are continually evolving. Furthermore, it should be noted that various steel plants have site-specific control requirements which are not intended to be addressed by this study.

Table D-1 presents a summary of control technology and emission rates for RACT, BACT, and LAER. These data are based on information received from various EPA personnel. In some cases, the uncontrolled RACT columns are based on information received from Mr. Gary McCutchen of Office Air Quality Planning and Standards (OAQPS). The BACT and LAER columns are based on information received from Mr. Bernie Bloom of Division of Stationary Source Enforcement (DSSE). Mr. Bloom also had input to the uncontrolled and RACT columns. Where estimates had to be made by PEDCo to complete the table, the exception is noted.

The uncontrolled factors for ore yards and coal yards are derived from application of formulas developed by Midwest Research Institute (MRI) to a hypothetical ore yard and coal yard believed to be representative in the Chicago-Gary AQCR. The RACT, BACT, and LAER emission values for ore yards and coal yards are based upon 40 percent, 75 percent, and 90 percent efficiency, respectively, as assumed by PEDCo. The distinction between control levels is the sophistication and extent of control equipment used. These emission rates are very dependent on site-specific conditions, and the values in this table should only be used as a guide to relative magnitude.

APPENDIX D

Table D-1. SUMMARY OF EMISSION FACTORS AND CONTROL TECHNOLOGIES

(lb/ton except noted)

PPS-ES	Process or operation	Basis for emission measurement	Uncontrolled emission rate, TSP unless otherwise noted	RACT Control	RACT Emission rate	BACT Control	BACT Emission rate	LAER Control	LAER Emission rate
	Raw materials:								
1-1	Ore handling and storage	Hot metal produced	0.47	Water spray dust suppression	0.19	Water spray dust suppression	0.12	Water spray dust suppression	0.05
2-1	Coal handling and storage	Coal used	0.12	Water spray dust suppression	0.05	Water spray dust suppression	0.03	Water spray dust suppression	0.01
2-3	Coal crushing and transfer	Coal used	0.40[a]	Baghouse	0.04	Baghouse	0.004 or 0.005 gr/acf[b]	Baghouse	0.004 or 0.005 gr/acf
	Sintering:								
4-1	Sinter windbox	Sinter produced	4.3[c] SO_x 1.8 HC 0.24	Scrubber None None	0.5 or 0.035 gr/acf	Scrubber None None	0.29 or 0.02 gr/acf	Wet ESP Scrubber None	0.07[d] or 0.01 gr/acf SO_x - 0.18
4-2	Sinter discharge	Sinter produced	7.0	Baghouse	1.1	Baghouse	0.1 or 0.01 gr/acf	Baghouse	0.1 or 0.01 gr/acf
4-3	Sinter building fugitives	Sinter produced	0.7	None	0.7	Baghouse	0.007 or 0.01 gr/acf	Baghouse	0.007 or 0.01 gr/acf
	Coking:								
5-1	Wet coal[e] charging	Coke produced	1.14[f] SO_x 0.03 HC 3.6	Stage charging-modified larry car	0.16	Stage charging-new larry car	0.021	Stage charging-new larry car	0.021
5-2	Coke pushing	Coke produced	5.7	Enclosed hot car	0.043	Enclosed hot car	0.043	Enclosed hot car	0.043

(continued)

Table D-1 (continued)

PPS-ES	Process or operation	Basis for emission measurement	Uncontrolled emission rate, TSP unless otherwise noted	RACT		BACT		LAER	
				Control	Emission rate	Control	Emission rate	Control	Emission rate
5-3	Coke quenching	Coke produced	8.6	Baffles	2.1	Baffles and clean water	1.0	Dry quenching	0.36
5-4	Door emissions	Coke produced	0.71	Door maintenance	0.14	Door maintenance and auto cleaning	0.07	Door maintenance and auto cleaning	0.07
5-5	Topside leaks	Coke produced	0.49	Good maintenance	0.043	Good maintenance	0.043	Good maintenance	0.043
5-6	Underfire stack	Coke produced	1.0	Dry ESP	0.15 or 0.03 gr/scf	Dry ESP	0.15 or 0.03 gr/scf	Dry ESP	0.08 or 0.015 gr/scf
5-7	Coke handling	Coke produced	0.03	Baghouse	0.002	Baghouse	0.002	Baghouse	0.002
5-8	Coke oven gas[g]	Coal used	SO_x 13.3	Desulfurization	1.9	Desulfurization	1.0	Desulfurization	0.3
5-9	Coal preheater	Coal used	0.13	Scrubber	0.025	Scrubber	0.025	Scrubber	0.025
	Ironmaking:								
7-2	Cast house emissions	Hot metal produced	0.69	Taphole and bag house	0.07	RACT and runner covers	0.042	Cast house evacuation	0.042
7-3	Slag pouring	Hot metal produced	0.28[h]	None	0.28	Hood and scrubber	0.014	Hood and scrubber	0.014
7-5	Slag crushing and screening	Hot metal produced	0.24	Water sprays	0.12	Baghouse	0.025 or 0.005 gr/scf	Baghouse	0.025 or 0.005 gr/scf
	Steelmaking:								
8-1	Open hearth hot metal transfer	Hot metal used[i]	0.35	Baghouse	0.007 or 0.01 gr/scf	Same as RACT[j]	Same as RACT	Same as RACT	Same as RACT
8-2	Open hearth stack	Steel produced	17.4	ESP	0.35	Same as RACT	Same as RACT	Same as RACT	Same as RACT

(continued)

Table D-1 (continued)

PPS-ES	Process or operation	Basis for emission measurement	Uncontrolled emission rate, TSP unless otherwise noted	RACT		BACT		LAER	
				Control	Emission rate	Control	Emission rate	Control	Emission rate
8-3	Open hearth building fugitives	Steel produced	0.29	None	0.29	Same as RACT	Same as RACT	Same as RACT	Same as RACT
8-5	Open hearth slag crushing and screening	Steel produced	0.21	Water sprays	0.11	Same as RACT	Same as RACT	Same as RACT	Same as RACT
9-1	BOF hot metal transfer	Hot metal used[i]	0.35	Baghouse	0.007 or 0.01 gr/scf	Baghouse	0.007 or 0.01 gr/scf	Baghouse	0.007 or 0.01 gr/scf
9-2	BOF stack	Steel produced	51.0	Open hood-ESP	0.34	Closed hood-scrubber	0.04 or 0.015 gr/scf	Closed hood-scrubber	0.04 or 0.015 gr/scf
9-3	BOF charging, tapping, and sampling	Steel produced	1.0[k]	Hood to existing furnace control	0.40	Furnace enclosure	0.08	Furance enclosure	0.08
9-4	BOF slag pouring	Steel produced	0.12[l]	Water sprays	0.06	Baghouse	0.01	Baghouse	0.01
9-5	BOF slag crushing and screening	Steel produced	0.17	Water sprays	0.08	Baghouse	0.01	Baghouse	0.01
10-1 10-2	Electric furnace emissions including fugitives[m]	Steel produced							
	Carbon steel		30.0	Direct evacuation	3.05	Direct evacuation and canopy hood	0.91	BACT and building evacuation	0.36

(continued)

Table D-1 (continued)

PPS-ES	Process or operation	Basis for emission measurement	Uncontrolled emission rate, TSP unless otherwise noted	RACT		BACT		LAER	
				Control	Emission rate	Control	Emission rate	Control	Emission rate
	Alloy steel		15.0	Canopy hood	1.95	Canopy hood	1.95	BACT and building evacuation	0.90
10-3	Electric furnace slag	Steel produced	0.07[n]	Water sprays	0.035	Baghouse	0.01	Baghouse	0.01
10-5	Electric furnace slag crushing and screening	Steel produced	0.10	Water sprays	0.05	Baghouse	0.01	Baghouse	0.01
11-1	Conventional casting	Steel produced	0.06[p]	None	0.06	None	0.06	None	0.06
13-1	Continuous[q] casting	Steel produced	0.12	None	0.12	Baghouse	0.01	Baghouse	0.01
14-1,16-1	Soaking pits[r] using 100% oil at 1.0% sulfur	Steel produced	0.2	None	0.2	ESP	0.03	ESP	0.03
14-3, 16-3 17-3, 18-3	Automatic scarfing	Steel scarfed	0.24	Wet ESP	0.03	Wet ESP	0.03	Wet ESP	0.03
17-1,18-1, 22-1,28-1	Reheat furnaces[r] using 100% oil at 1.0% sulfur		0.42	None	0.42	ESP	0.06	ESP	0.06
29-1	Boiler stack[s]	10^6 Btu/hr firing capacity							
	Coal fired		5.4	FGD	0.1	FGD	0.1	FGD	0.1
	Oil fired		0.15	ESP	0.05	ESP	0.05	ESP	0.05

FOOTNOTES TO TABLE D-1

a. Emission factors shown as pounds per ton of coal can be converted to pounds per ton of coke by dividing by 0.7 and vice versa.

b. Where emission rates are given as gr/scf, this value was used in conjunction with model plant flow rate. The value lb/ton is based on a typical flow rate.

c. The uncontrolled emission factors are from the SSEIS for Sinter Plants, Preliminary Draft, May 1977. Cyclone control is considered to be an inherent part of the process for protecting exhaust fans and therefore the emission rate after the cyclone is used as the base.

d. The LAER limitation is given by U.S. EPA's DSSE as 0.02 gr/scf, full train, thus including particulate and condensible hydrocarbon. It is assumed the particulate and condensible hydrocarbon are equally divided.

e. SO_x and HC factors are per U.S. EPA Publication No. AP-42. The implied efficiency for particulate matter is used to derive control values for these pollutants. HC as listed in gaseous hydrocarbons. Condensible hydrocarbons are included in particulate matter.

f. The uncontrolled rate assumes a rudimentary form of control as the base, i.e., charging on the main as a typical "uncontrolled" state.

g. Based on 450 gr H_2S/100 scf of coke oven gas, 11,000 ft^3 of gas per ton of coal. Emission rates are for all coke oven gas produced, regardless of where used. Controlled rates based on 65, 35 and 10 gr H_2S/100 scf, respectively, where H_2S represents all sulfur compounds in gas.

h. Estimate by PEDCo based on 40% of cast house emission factor. Controlled rate based on 95% efficiency. No data are available for this source.

i. The factors used to relate hot metal to steel are:

Charge to steel yield = 86%
% hot metal in open hearth charge = 50%
% hot metal in BOF charge = 75%

j. All open hearth BACT and LAER controls are equal to RACT on assumption that no new open hearth shops will be built.

k. Charging = 0.5 lb/ton, tapping and slagging = 0.25, sampling = 0.25 for total of 1 lb/ton. RACT = sampling + 80% capture and 99% removal for charging and tapping. BACT = 90% capture + 99% removal and sampling in upright position or through wicket hole in enclosure.

l. Estimated by PEDCo as 50% of value for BOF tapping and slagging. This source includes dumping slag ladles and cleanup using bulldozer.

m. The definition of primary emissions and fugitive emissions in the electric furnace category changes as the control technology changes. Figure D-1 is a schematic illustration of the definitions of RACT, BACT, and LAER.

n. Based on value for BOF factored for lower slag volume.

p. The emissions from conventional casting are estimated by PEDCo as 20% of total open hearth fugitive building emissions.

q. The emissions from continuous casting are estimated by DSSE.

r. Soaking pit and reheat furnace emission values are based on the following:

	Soaking pit	Reheat furnace
Fuel consumption	1,350,000 Btu/ton	2,800,000 Btu/ton
Exhaust rate	20,000 scf/ton	41,000 scf/ton
Throughput	38 tons/h	225 tons/h

Coke oven gas is desulfurized to 65, 35 and 10 gr H_2S/100 scf for RACT. BACT and LAER, respectively, (including organic sulfur). A maximum oil sulfur content of 1% is used. The particulate emission factor used for oil is 23 lb/1000 gal (AP-42). A control device is required for particulate only if oil is used. When coke oven gas is used, all the emissions have been accounted for under the "coke oven gas" source.

s. Values shown for coal are based on coal of 2.5% S and 10% ash using AP-42 formulas. Values shown for oil are based on 1.05% S and AP-42 factors for particulate. Coke oven gas is accounted for under "coke oven gas" regardless of where used. Natural gas and blast furnace gas are considered clean fuels with no significant emissions.

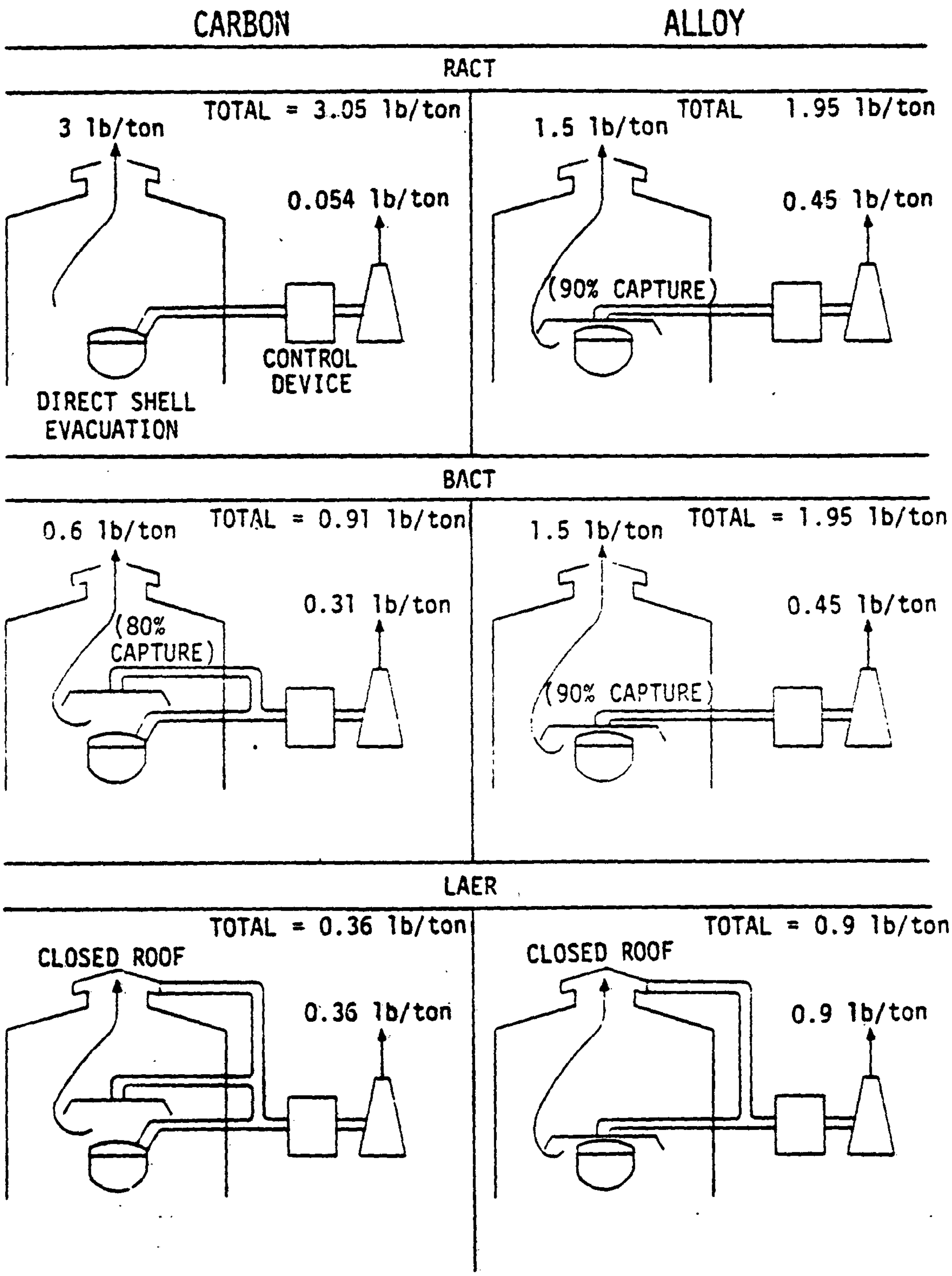


Figure D-1. Schematic illustration of EAF control technologies.

DERIVATION OF STORAGE PILE EMISSION FACTORS AS A FUNCTION OF HOT METAL PRODUCTION

The fugitive emission factors for storage piles are derived as follows using equations from reference 1:

$$\text{EF load-in stacker (or load-out)} = 0.0018 \times \frac{\left(\frac{S}{5}\right)\left(\frac{U}{5}\right)}{\left(\frac{M}{2}\right)^2} \text{ lb/ton moved}$$

$$\text{EF load-out loader (or load-in)} = 0.0018 \times \frac{\left(\frac{S}{5}\right)\left(\frac{U}{5}\right)}{\left(\frac{M}{2}\right)^2\left(\frac{Y}{6}\right)} \text{ lb/ton moved}$$

$$\text{EF traffic} = 0.10 \times \frac{S}{1.5} \times \frac{d}{235} \text{ lb/ton moved}$$

$$\text{EF wind erosion} = 0.05 \quad \frac{D}{90} \times \frac{S}{1.5} \times \frac{d}{235} \times \frac{f}{15} \text{ lb/ton put through storage cycle}$$

s = silt content (%-75μ)

M = skin moisture (%)

U = mean wind speed

D = duration of storage (days)

y = loader capacity (yd^3)

d = dry days per year

f = % pf time wind speed exceeds 12 mph

EF = emission factor

Representative values for the above factors are assumed because information is not available on a plant-by-plant basis. On an AQCR basis, from weather bureau data, we have the following representative values:

AQCR	Dry days	Mean wind speed	Max wind	f
067	239	9.3	58	13
045	249	9.6	73	16
197	212	9.4	58	13
178	202	10.0	58	13
216	257	7.6	46	10

In AQCR 067, wind speed exceeds 12 mph on 17.2% of the days. Assume it exceeds 12 mph 75% of the time during those days. The composite period of time the wind speed exceeds 12 mph is therefore 0.75 x 17.2%, or 13%.

For values of S, we use the values given in Reference 1.

coal - 4% slag 2%
pellets - 11% ore fines (ore bedding) 9%
lump ore - 12%
coke - 1%

For sinter, assume a value of 12% (not given in Reference 1)

Assume an ore yard content of material as follows:

sinter = 10%	moisture = 0%
pellets = 60%	" = 3%
ore fines = 20%	" = 3%
lump ore = 5%	" = 2%
slag like materials = 5%	" = 5%

The weighted moisture is therefore 2.75%
The weighted S factor is 10.3
Assume Y = 10 yd^3 representing an ore bridge bucket or large loader

We can now calculate a representative value for AQCR 067, Chicago Gary. In the absence of plant-specific data, our interest is to examine the sensitivity of the MRI equations.

$$\text{EF load-in stacker} = (0.0018)\frac{\left(\frac{10.3}{5}\right)\left(\frac{9.3}{5}\right)}{\left(\frac{2.75}{2}\right)^2} = 0.0036$$

Reclaim = 25% of stacker = 0.0009

The parameters of interest here are S and M since mean wind speed (9.3) is a relatively constant value. The most conservative values we might choose are S = 15 and M = 1.5, whereby EF = 0.018. For the lowest EF, we would choose S = 6, M = 3, whereby EF = 0.002

EF for batch load-out and load-in $= 0.0018 \times \dfrac{\left(\frac{S}{5}\right)\left(\frac{U}{5}\right)}{\left(\frac{M}{2}\right)^2\left(\frac{Y}{6}\right)} = 0.0018\dfrac{\left(\frac{10.3}{5}\right)\left(\frac{9.3}{5}\right)}{\left(\frac{2.75}{2}\right)^2\left(\frac{10}{6}\right)} = 0.0022$

Similarly, for the range of S and M used above, EF max = 0.012 and EF min = 0.0012.

For load-in with a railcar dumper, Y = 40 and EF = 0.0005

For traffic induced dust from loaders and trucks in storage area, we have the following calculations:

$$EF = (0.1)\left(\frac{S}{1.5}\right)\left(\frac{d}{235}\right) = (0.1)\left(\frac{10.3}{1.5}\right)\left(\frac{239}{235}\right) = 0.69$$

EF max = 1.10 EF min = 0.44 for S = 15 and 6, respectively

For storage pile wind erosion, $EF = (0.05)\left(\frac{S}{1.5}\right)\left(\frac{d}{235}\right)\left(\frac{f}{15}\right)\left(\frac{D}{90}\right)$

$= (0.05)\left(\frac{10.3}{1.5}\right)\left(\frac{239}{235}\right)\left(\frac{13}{15}\right)\left(\frac{60}{90}\right) = 0.20$ lb/ton put through storage cycle

For EF max, S = 15, f = 20 EF max = 0.49

For EF min S = 6 f = 5 EF min = 0.05

For a typical ore yard operation, assume an average between load in with a railcar dumper and load out with a 10 yd^3 bucket (i.e., 0.0022 + 0.0005; and stacker-reclaim (1.25 x 0.0036). This equals 0.004 lb/ton transferred. For these operations, we assume no mobile equipment in yard, i.e., no traffic component.

For a coal yard, we duplicate this entire procedure, using S = 4 and M = 5 with Y = 6. The typical values are:

$$\text{EF load in stacker} = \frac{(0.0018)\left(\frac{4}{5}\right)\left(\frac{9.3}{5}\right)}{\left(\frac{5}{2}\right)^2} = 0.0005$$

$$\text{EF load out loader} = \frac{(0.0018)\left(\frac{4}{5}\right)\left(\frac{9.3}{5}\right)}{\left(\frac{5}{2}\right)^2\left(\frac{6}{6}\right)} = 0.0004$$

$$\text{EF traffic} = (0.1)\left(\frac{4}{1.5}\right)\left(\frac{239}{235}\right) = 0.27$$

$$\text{EF wind erosion} = (0.05)\left(\frac{4}{1.5}\right)\left(\frac{239}{235}\right)\left(\frac{13}{15}\right)\left(\frac{90}{90}\right) = 0.12$$

TRANSFER (COAL) = 0.0005 lb/ton transferred

STORAGE (COAL) = 0.12 lb/ton put through storage cycle

Further assumptions are necessary to estimate material quantities and obtain theoretical total emissions.

It will be convenient to derive raw material quantities from hot metal production as follows:

Assume 3400 lb (1.7 tons) of burden for 1 ton hot metal

Assume a burden of 70% pellets and 30% sinter

Assume 70% of sinter feed is ore fines and 85% feed to sinter yield (not counting recirculating feed)

Assume a 1200 lb coke rate and 70% coke/coal yield

These assumptions give the following material rates:

pellets 1.2 tons/ton hot metal
sinter 0.50 tons/ton hot metal
sinter ore 0.40 tons/ton hot metal
other sinter feed 0.2 tons/ton hot metal
coke 0.60 tons/ton hot metal
coal 0.86 tons/ton hot metal

Assume the following inventory rates:

pellets 2 months = 0.17 annual usage
sinter 1 month = 0.08 annual usage
sinter ore 2 months = 0.17 annual usage
other feed 1 month = 0.08 annual usage
coke 1 month = 0.08 annual usage
coal 3 months = 0.25 annual usage

We can now "weight" the emission factors for transfer and storage and convert to a hot metal basis.

For 1 ton hot metal, there are 2.3 tons of ore material and 0.86 tons of coal transferred in and out of storage.

$$\text{EF transfer} = 0.004 \text{ lb/ton transferred} \times \frac{2.3 \text{ tons transferred}}{\text{ton hot metal}}$$

= 0.009 lb/ton hot metal (for ore)

and = 0.0004 lb/ton hot metal (for coal)

EF wind erosion = 0.20 lb/ton put through storage cycle x 2.3

= 0.46 lb/ton hot metal annually from ore

and = 0.10 lb/ton hot metal annually from coal

Finally, for storage and transfer, we have:

EF ore = 0.009 + 0.46 = 0.47 lb/ton hot metal

EF coal = 0.0004 + 0.10 = 0.10 lb/ton hot metal

For a plant producing 1,000,000 tons hot metal per year,

Ore yard emissions = 0.47 x 1,000,000 = 235 tpy

Coal yard emissions = 0.1 x 1,000,000 = 50 tpy

If actual values for each variable were available, then the reliability of the final emission factor would become equal to the reliability of the MRI equations which are the starting point. It is beyond the scope of this project to examine the variables involved in these calculations on a site-specific basis.

DERIVATION OF EMISSIONS FACTORS FOR STEELMAKING SLAG PROCESSING

The uncontrolled emissions from slag processing operations are calculated based on removal of slag from the steelmaking shop or blast furnace using trucks and front-end loaders and delivered to an open crushing and screening operation. The calculations are as follows:

Slag processing emissions emanate from five areas of activity:

1. Load-in (front-end loader)
2. Crushing and screening
3. Load-out (front-end loader)
4. Traffic
5. Windblown fugitive dust

Emission factors, based on 1.0 net ton slag, for each of these activities are derived as follows:

Area of Activity	Derivation	
Load-in (front-end loader)	$EF = (0.0018) \dfrac{\left(\frac{S}{5}\right)\left(\frac{U}{5}\right)}{\left(\frac{M}{2}\right)^2\left(\frac{Y}{6}\right)}$	S = 1.5 (assumed silt content) U = 9.3 (mean wind speed for AQCR 067) M = 1.0 (assumed moisture content) Y = 6 (bucket capacity, CY)
	= 0.004 lb.	

Crushing and screening	Using factors for limestone crushing obtained from EPA Publication No. 450/3-77-010 Tech. Guidance for Control of Industrial Process Fugitive Particulate Emissions.[2] Secondary crushing - 1.5 lb/ton, 60% falls out in plant leaving 40% of 1.5 or 0.6 lb/ton
Load-out (front-end loader)	Same as load-in (front-end loader) = 0.004 lb.
Windblown fugitive dust	$EF = (0.05)\left(\frac{s}{1.5}\right)\left(\frac{d}{235}\right)\left(\frac{f}{15}\right)\left(\frac{D}{90}\right)$ s = 1.5 (assumed silt content) d = 239 (number of dry days per year for AQCR 067) f = 13 (Percentage of time wind speed is more than 12 mph for AQCR 067) D = 30 (days storage duration) = 0.015 lb/ton put through storage cycle
Traffic	$EF = (0.10)\left(\frac{s}{1.5}\right)\left(\frac{d}{235}\right) K$ lb/ton carried s = 1.5 (assumed silt content) d = 239 (number of dry days per year for AQCR 067) K = 3.5 for vehicles in the 4-to-30 ton range = 0.35 lb/ton carried

Thus, the total particulate emissions attributable to steelmaking slag processing operations are:

Pounds per ton of slag transferred = 0.004 + 0.004 + 0.35 + 0.6 + 0.015 = 0.97

The following examples indicate how these emission factors are applied to the various types of steelmaking processes.

For BOF Operation:

$$\text{Total emissions} = \left(\frac{350}{2000}\right)(0.97) = 0.17 \text{ lb/ton steel}$$

<u>For Open Hearth Operation</u>:

Same as above except slag volume = 440 lb/ton steel.

Total emissions $= \left(\frac{440}{2000}\right)(0.97) = 0.21$ lb/ton steel

<u>For Electric Furnace Operation</u>:

Same as above except slag volume = 200 lb/ton steel.

Total emissions $= \left(\frac{200}{2000}\right)(0.97) = 0.10$ lb/ton steel

<u>For Blast Furnace Operation</u>:

Same as above except slag volume = 500 lb/ton hot metal.

Total emissions $= \left(\frac{500}{2000}\right)(0.97) = 0.24$ lb/ton hot metal

REFERENCES FOR APPENDIX D

1. Fugitive Emissions From Integrated Iron and Steel Plants. Prepared for IERL, Research Triangle Park, North Carolina by Midwest Research Institute, 425 Volker Boulevard, Kansas City, Missouri 64110, March 1978. EPA-600/2-78-050.

2. Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions. EPA-450/3-77-010.

APPENDIX E

DESCRIPTION OF CONTROL EQUIPMENT MODULES

APPENDIX E

DESCRIPTION OF CONTROL EQUIPMENT MODULES

Electrostatic Precipitators

The efficiency of an ESP is a function of the collecting surface and the electrical and physical properties of the particles being collected. Because many texts deal with the theoretical and practical aspects of ESP design, there is no need to review these here. The basis of ESP cost in this project is specific collecting area (SCA) expressed as square feet of collecting area per 1000 acfm of flow. Table E-1 lists the SCA values used for the various processes.

Other sources provide values for migration velocity, which can be used in the Deutsch Anderson equation to calculate SCA at a given efficiency.

$$SCA = \frac{-1000 \ \ell n \ (1\text{-eff.})}{\text{migration velocity} \times 60}$$

These values are shown in Table E-2 only to illustrate how site-specific factors can cause variation in migration velocity and consequently in SCA required. Data that give SCA directly are given preference herein because these values represent manufacturers' experience with the specific steel processes and avoid the oversimplification inherent in the Deutsch Anderson equation.

Given an SCA value, total plate area is obtained by multiplying by the flow rate in acfm. Maximum ESP inlet temperature is 600°F. An installed spare capacity of 20 percent is assumed to permit efficient operation during periodic inspections and repair. The ESP as installed is insulated and covered for rain protection.

Table E-1. SPECIFIC COLLECTION AREA FOR ESP

(ft^2/1000 acfm)

Efficiency, %	Emission source								
	Open hearth furnace[a]	Basic oxygen furnace[a]	Electric furnace[a]	Sintering[a]	Scarfing[a]	Coke pushing[b]	Coke oven underfire[c]	Oil-fired boiler, soaking pits and reheat furnace	Coal-fired boiler[d]
99.9	412	520	310	450	540	385	860	200	410
99.8	412	420	310	450	540	385	860	200	410
99.0	290	220	310	450	304	240	538	200	230
98.0	244	160	190	325	225	188	450	170	170
95.0	189	160	190	198	225	188	324	150	170
90.0	189	160	190	198	225	188	232	150	170
85.0	189	160	190	198	225	188	178	150	170

[a] Copyright 1974, Research Cottrell, Inc., (Ref. 1).
[b] Derived from Ref. 2.
[c] Derived from Ref. 3.
[d] Derived from Ref. 4.

Table E-2. MIGRATION VELOCITY (W) FOR VARIOUS STEEL PROCESSES

Process	W (fps)
Open hearth	0.16
Blast furnace	0.2-0.46
Sinter	0.07-0.38
BOF	0.15-0.25
Electric arc	0.12-0.16
Sinter	0.2-0.35
Open hearth	0.19
Electric arc	0.28 (wet ESP)
Blast furnace	0.31-0.38 (wet ESP)

Wet ESP's are considered to be equal in cost to dry units except for the addition of the water supply system. Water use is a function of pollutant removal and gas cooling requirements. The minimum liquid-to-gas ratio (L/G) for pollutant removal purposes used in this study is 6.5. Where exhaust gas temperatures exceed 215°F additional water is needed to cool the gases. The amount of water required was determined empirically based on data shown in Figure E-1. If for example, the exhaust temperature is 300°F (sinter windbox), the water requirement is 7.9 gpm/1000 acfm.

For corrosive gas streams such as sintering, corrosion resistant materials are specified.[5,6]

The precipitator basic module cost includes the box and internals, power supply, rapping equipment, transformer-rectifiers, insultation, electrical instrumentation transition duct, hoppers and roof. See Figure E-2 and E-3.

Fabric Filter

Fabric filters are employed for particulate control in many of the processes in this study. Baghouses of two types were estimated: prefabricated units, for less than 50,000 acfm flow and custom units for over 50,000 acfm. The small baghouses include a mechanical shaker system, screw conveyor, dumpster box with guard, access ladder, and walkway. The custom baghouse cost is flange to flange and includes supports, inlet and outlet headers, pressure and temperature instruments, an annunicator, area lighting, piping for instrumentation, foundations, painting, and a control building. Bags, either dacron or fiberglass, are added as a separate module. Dacron is used for inlet temperatures up to 250° and fiberglass used for over 250°F. Dust handling conveyors and hoppers are added as a separate module. Cost is determined as a function of total cloth area and 20 percent spare capacity is assumed. See Figure E-4.

Venturi Scrubber

Venturi scrubbers are employed in this study for particulate control for several different processes. The variations are

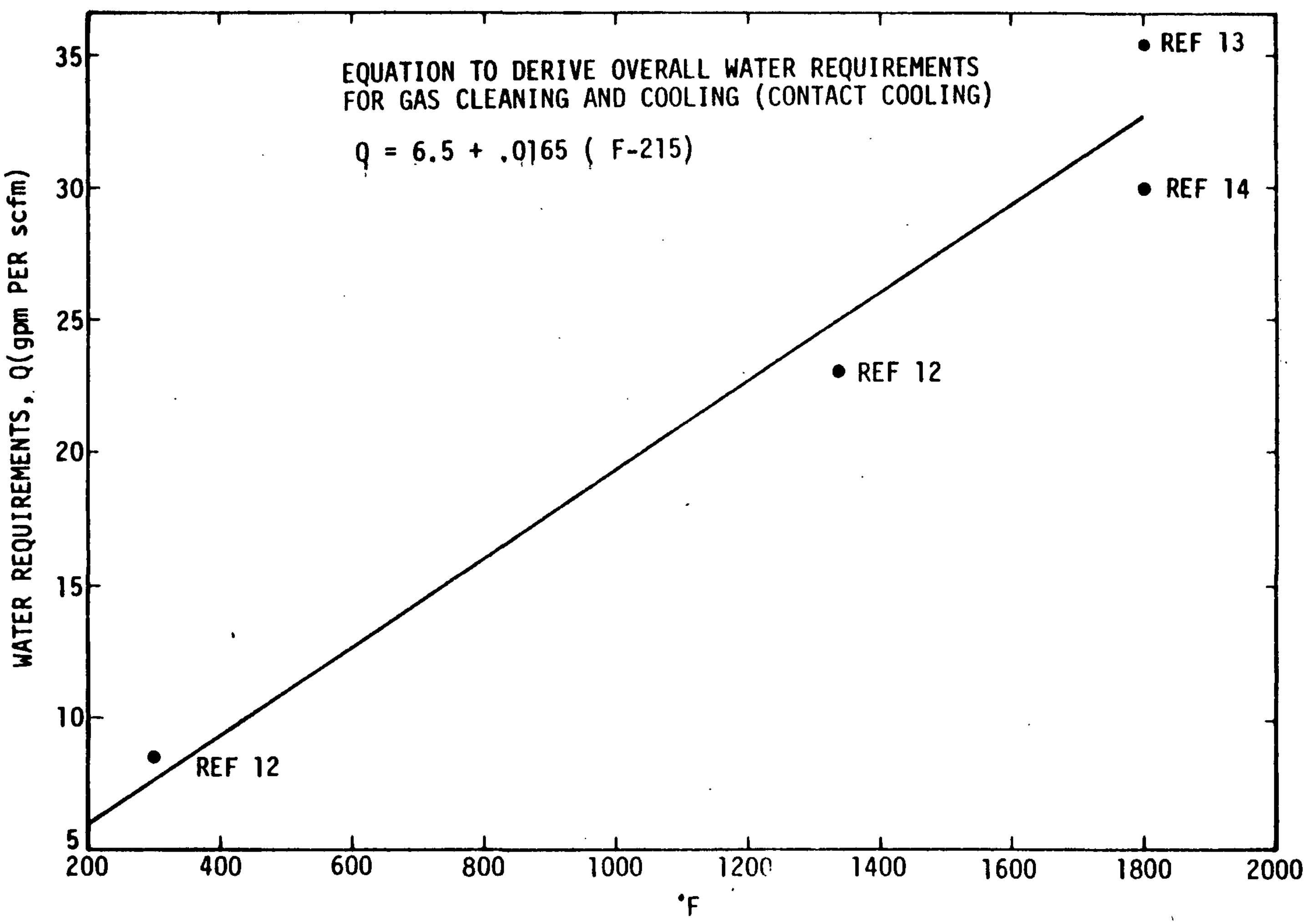
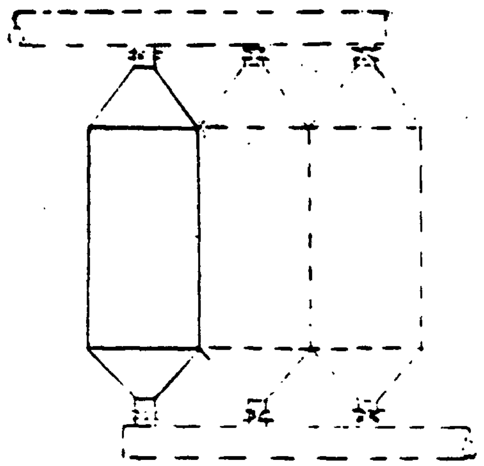


Figure E-1. Water requirements for gas cooling and cleaning as a function of process outlet temperature.

		Module No. 1A Sheet 10 of 23
	DESIGN DATA	
PEDCo ENVIRONMENTAL	DESCRIPTION DRY ESP	DATE 1-24-78
PROJECT NO. 3315		BY TRAUB

DESIGN CRITERIA:



INCLUDED IN COST ESTIMATED

PRECIPITATOR(S) WITH ROOF, INTERNALS, ELECTRICAL EQUIP, INSULATION, INSTRUMENTATION

SUPPORTS & FOUNDATIONS

ACCESS STAIRWAY AND WALKWAYS

TRANSITIONS TO HEADERS

INLET AND OUTLET HEADER WHERE APPLICABLE

DAMPERS FOR MULTIPLE UNITS

ELECTRIC POWER SUPPLY CABLES INTERCONNECTING WIRING

CONTROL ROOM

Figure E-2. Dry ESP module.

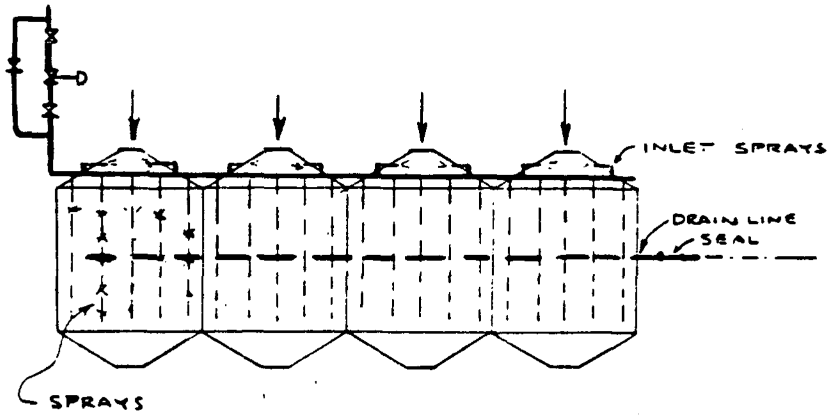
Module No. 2 Sheet 10 of 28

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION DATE 2-5-78

PROJECT NO. 3315 ADDITIONS FOR WESP BY TRAUB

DESIGN CRITERIA:



ESTIMATE PROVIDES FOR WATER PIPING TO ESP TO MAKE IT A WET TYPE AND INCLUDES:

- PIPING (SPRAY & DRAIN)
- VALVES
- CONTROL VALVE
- FLOW RECORDER / CONTROLLER
- ELECTRICAL FOR CONTROL & INSTRUMENTATION

Figure E-3. Wet ESP module.

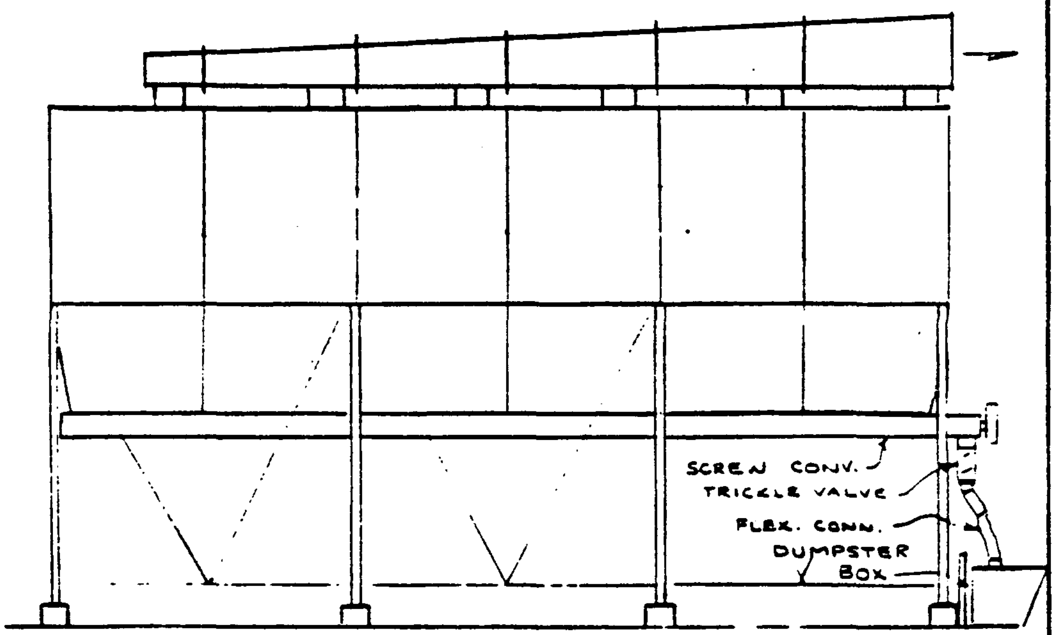
Module No. 3A Sheet 7 of 15

DESIGN DATA

PEDCo ENVIRONMENTAL | DESCRIPTION FABRIC FILTERS (MODULAR TYPE) | DATE 11-18-77

PROJECT NO. 3315 | BY TRAUB

DESIGN CRITERIA:



TYPICAL ARRGT WITH SIX COMPARTMENTS

1. CAPACITY (EACH COMPARTMENT HAS 1500 S.F. CLOTH AREA)

A/C RATIO	CFM/COMP.	No. OF COMP.	TOTAL VOL	HORSEPOWER SHAKERS	HORSEPOWER SCREW
1.5	2250	5	11250 CFM	5 @ 3/4	1/2
1.5	2250	9	20250 "	9 @ 3/4	1/2
3.0	3000	3	13500 "	3 @ 3/4	1/2
3.0	3000	9	40500 "	9 @ 3/4	3/4

INSTALLATION INCLUDES:-

1. MECH SHAKER SYSTEM
2. SCREW CONVEYOR, TRICKLE VALVE, FLEX. CONNECTION, DUST BOX
3. GUARD FOR DUST BOX
4. ACCESS LADDERS & WALKWAY
5. PRESS. GAUGE ON INLET
6. ZERO SPEED SWITCH & ALARM

SHAKE TIME = 1/30

SUCTION TYPE

Figure E-4. Fabric filter module.

carbon steel or stainless steel. Both variations include piping at the scrubber, an access platform, automatic pressure drop control, an electrical system, instrumentation, and lighting. Pumping and water clarification are handled as separate modules. See Figure E-5. Water usage is determined from the equation shown in Figure E-1. The rationale for water usage is discussed above in the section relating to electrostatic precipitation.

Contact Gas Cooler

The contact gas cooler is utilized in pollution control systems to cool gases prior to their entering control devices such as ESP's, fabric filters, or scrubbers. Water is sprayed through nozzles at the top of the tower with the hot gas flowing up through the sprays. The water is drained by gravity through the bottom of the tower. The temperatures assumed for the gas in the design of this device are 2500°F in and 275°F out. The design gas velocity through the tower is 600 feet per minute, and the cooling water temperature is assumed to be 90°F. Construction is of 1/4 in. plate. See Figure E-6.

Radiation-convection Gas Cooler

The gas cooler is utilized to cool gases without wetting them prior to their entering a control device. Estimates were made for both carbon steel and stainless steel. Hairpin construction is used to maximize total duct surface area in the minimum space. Three-foot diameter duct is used. The gases transfer their heat to the air by convection and radiation. See Figure E-7.

Dust Suppression for Car Dumper

This device is utilized in the prevention of fugitive dust where railroad cars are dumped mechanically. The system consists of a wetting agent storage tank, a mixing tank, a filter for the water supply, and pumps. The wetting solution is pumped into four headers, one on the dumper, and three around the hopper. See Figure E-8.

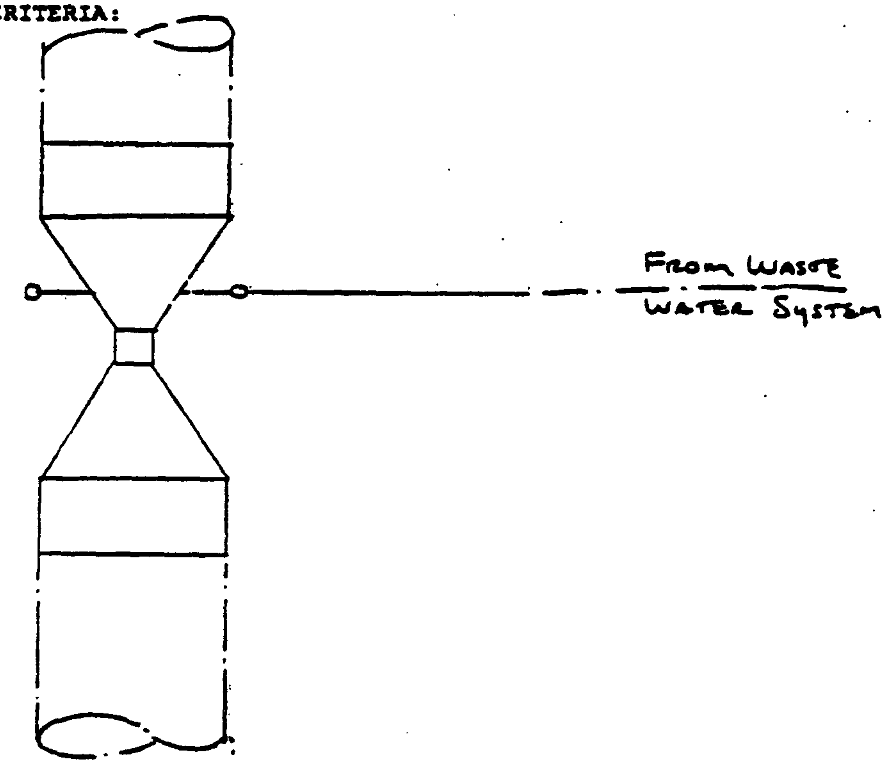
Module No. 4 Sheet 4 of 11

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION ______________ DATE 1-11-78

PROJECT NO. 3315 VENTURI SCRUBBER BY TRAUB

DESIGN CRITERIA:



INSTALLATION TO INCLUDE

SCRUBBER

PIPING AT SCRUBBER

ACCESS PLATFORM

AUTO. ΔP CONTROL

ELECTRICAL

INSTRUMENTATION

LIGHTING

Figure E-5. Scrubber module.

Module No. 6 Sheet 5 of 16

DESIGN DATA

PEDCo ENVIRONMENTAL | DESCRIPTION Gas Cooling (Water Quench) | DATE 10-24-77

PROJECT NO. 3315 | BY TRAUB

DESIGN CRITERIA: Following assumption used to develop general design parameters for estimating:

Flow - ACFM @ 2500°F in - 275°F out (based on air)

Velocity in ducts - 4000 FPM

Velocity thru cooler - 600 FPM

Cooling water temp - 90°F

Gases are not corrosive

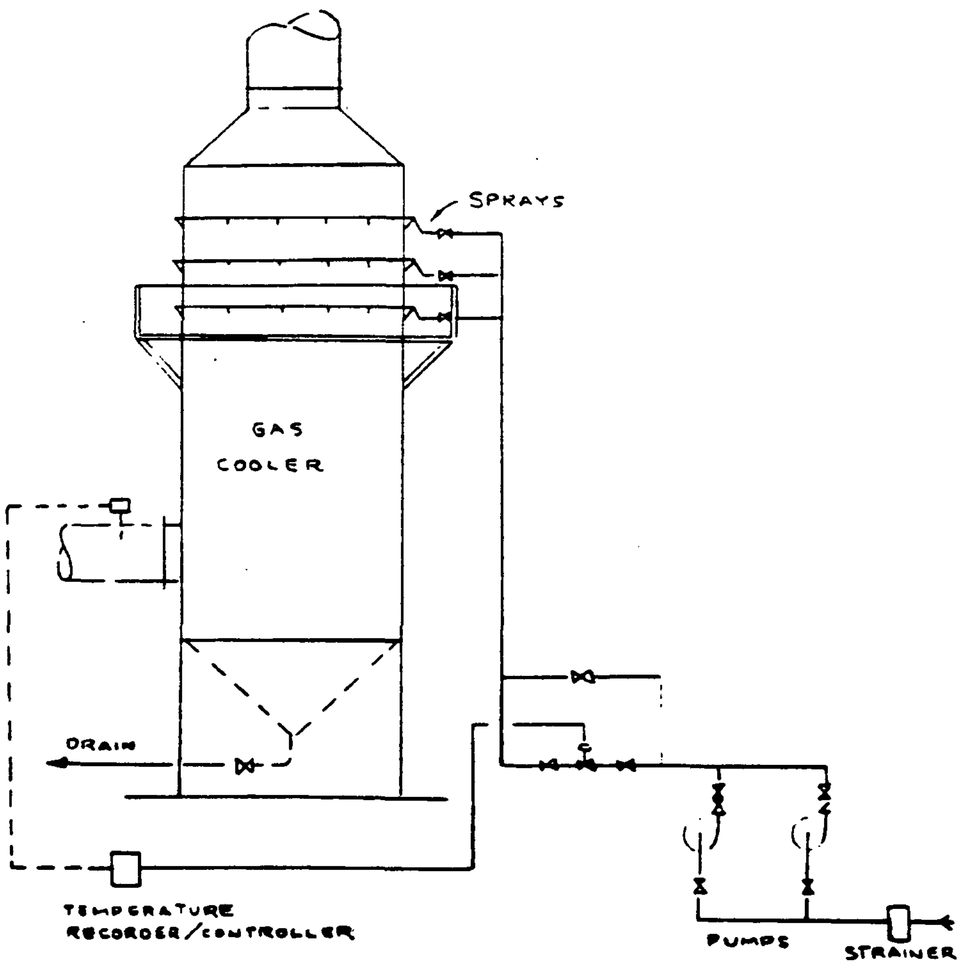


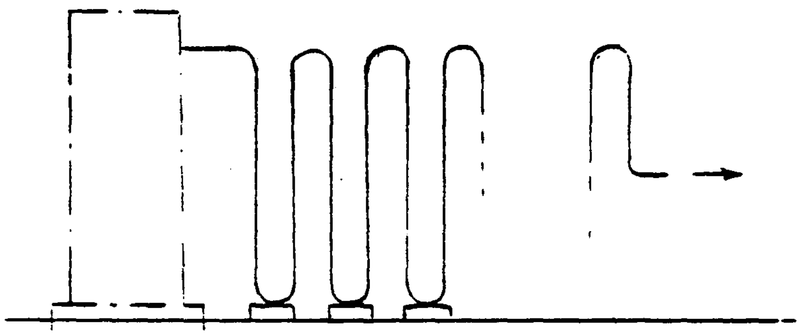
Figure E-6. Spray type gas cooler module.

Module No. 6B Sheet 4 of 6

DESIGN DATA

PEDCo ENVIRONMENTAL	DESCRIPTION Gas Cooling	DATE 1-8-78
PROJECT NO. 3315	(Convection & Radiation)	BY Traub

DESIGN CRITERIA:



FLOW			Duct Dia	Velocity @ 800°F (FPM)	Total Length (FT)	Surface Area (SQ FT)
@ 2000°F ACFM	@ 500°F ACFM	LB/MIN				
60,000	23,400	800	3'-0"	3612	1000	9400
350,000	137,000	4670	7'-0"	3871	1800	—
750,000	292,200	10000	10'-0"	4064	2600	—

COST DETERMINED ON SQ FT BASIS FOR 3' DIA. DUCT

SQ. FT. = .2 × SCFM

COST = SQ. FT. REQ'D. × COST/SQ. FT.

Figure E-7. Noncontact gas cooler module.

Module No. 7A Sheet 2 of 5

DESIGN DATA

PEDCo ENVIRONMENTAL — DESCRIPTION Dust Suppression — DATE 11-22-77

PROJECT NO. 3315 — Rotary Car Dumper — BY TRAJB

DESIGN CRITERIA:

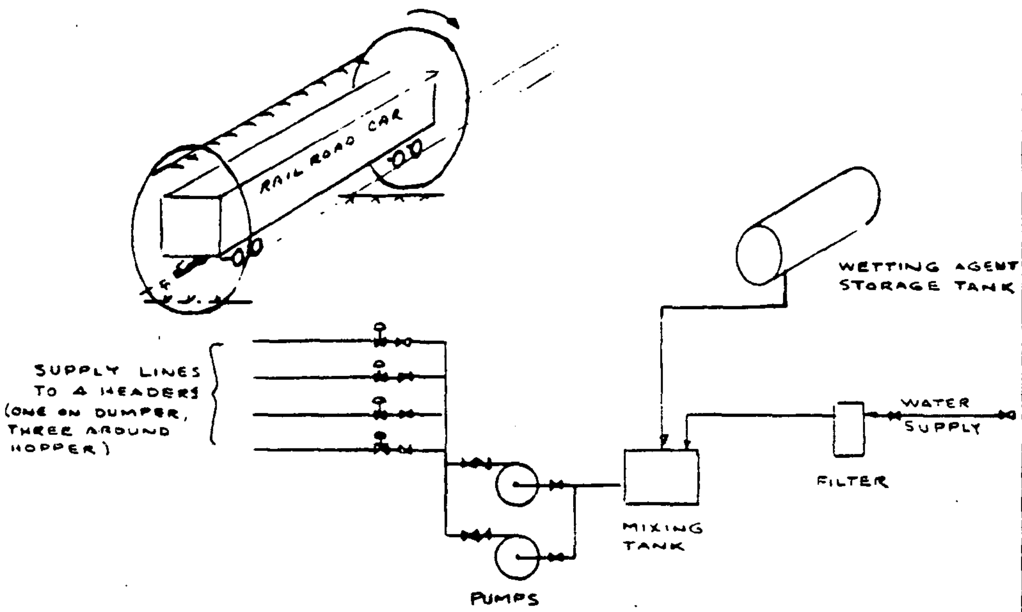


Figure E-8. Car dumper spray module.

Module No. 7B Sheet 2 of 3

DESIGN DATA

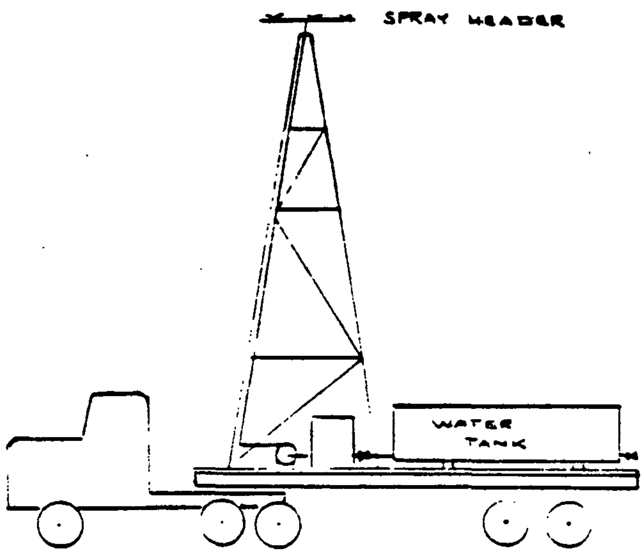
PEDCo ENVIRONMENTAL

DESCRIPTION Dust Suppression DATE 11-22-77

PROJECT NO. 3315

TRUCK MOUNTED SYSTEM BY TRAUB

DESIGN CRITERIA:



TRUCK MOUNTED SYSTEM

- SPRAY TOWER
- WATER STORAGE TANK
- WETTING AGENT STORAGE TANK
- MIXING TANK
- GAS DRIVEN PUMP
- NO INSULATION PROVIDED
- TRAILER INCLUDED IN EST., ALSO TRACTOR

Figure E-9. Spray truck module.

Dust Suppression Spray Truck

This module is utilized in the prevention of fugitive dust from storage areas and roadways that are situated such that permanent sprays would not be feasible. These would also be used for sealing dormant piles. See Figure E-9.

Dust Suppression Spray Tower

These are suitable for dust suppression from relatively inactive storage piles of iron ore and coal or waste materials in generally open areas. The module consists of a spray tower, a filter for the water supply, and a pump. See Figure E-10.

Dust Suppression at Transfer Points

This module is utilized to control fugitive dust at transfer points in the movement of raw materials by conveyor, and at screens and crushers. It consists of a pump, 1000 ft of pipe, and proportioning equipment for controlling the amount of chemical dust retardant mixed with the water. See Figure E-11.

Dust Suppression at Perimeter of Storage Yards

This module is utilized in the prevention of fugitive dust around the perimeter of well defined storage yards. It consists of a pump, piping, and spray nozzles every 30 feet. Cost of one system is based on a coverage of 240,000 ft^2. See Figure E-12.

All of the five preceding dust suppression schemes are estimated based on similar concepts applied in other industries. There are no known systems in the U.S. steel industry which can be evaluated as to their effectiveness or operating problems.

Hooded Quench Car

The hooded quench car is utilized for the control of emissions during quenching. An enclosed hooded coke guide directs the fumes into the hood around the quench car. Further enclosure is provided by side wing plates on the existing door machine and coke guide. Allowance is included for bench modifications to hold the additional weight via the retrofit factor. Before

Module No. 7C Sheet 2 of 4

DESIGN DATA

PEDCo ENVIRONMENTAL	DESCRIPTION DUST SUPPRESSION	DATE 11-22-77
PROJECT NO. 3315	TOWER FOR STORAGE PILE	BY TRAUB

DESIGN CRITERIA:

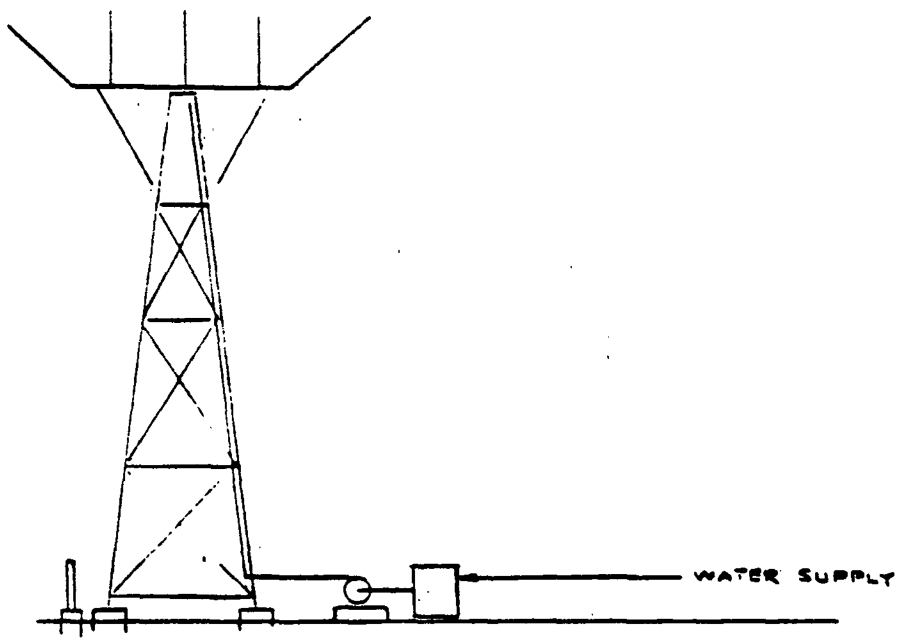


Figure E-10. Spray tower module.

Module No. 7D Sheet 2 of 4

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION Dust Suppression DATE 11-22-77

PROJECT NO. 3315 Transfer Points, etc. BY Traub

DESIGN CRITERIA:

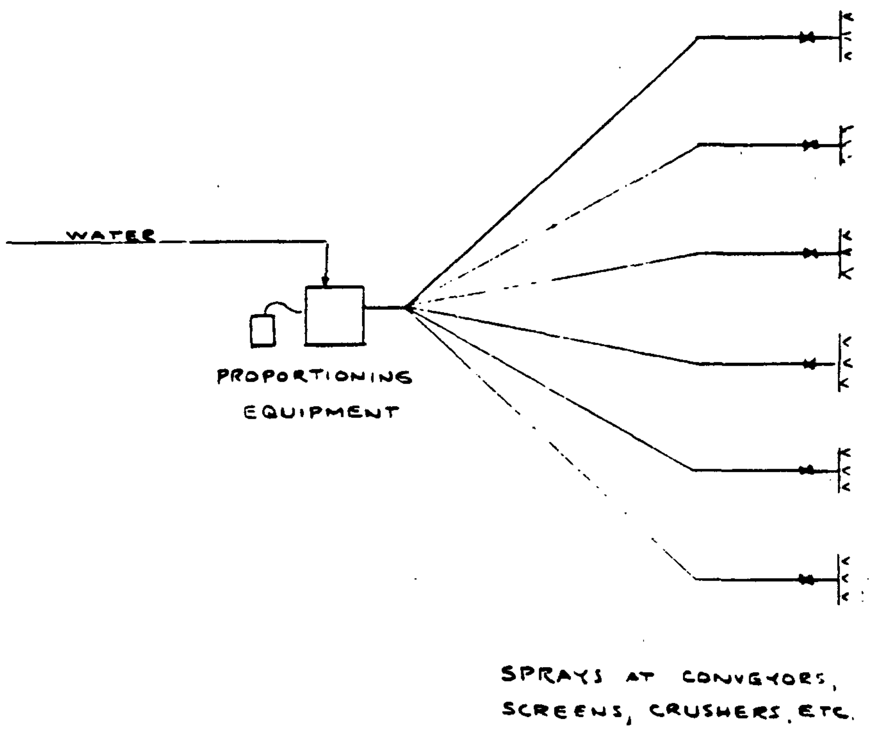


Figure E-11. Transfer point spray module.

Module No. 7E Sheet 2 of 5

DESIGN DATA

PEDCo ENVIRONMENTAL — DESCRIPTION Dust Suppression — DATE 12-26-77

PROJECT NO. 3315 — Storage Yard 200' x 1200' — BY TRAUB

DESIGN CRITERIA:

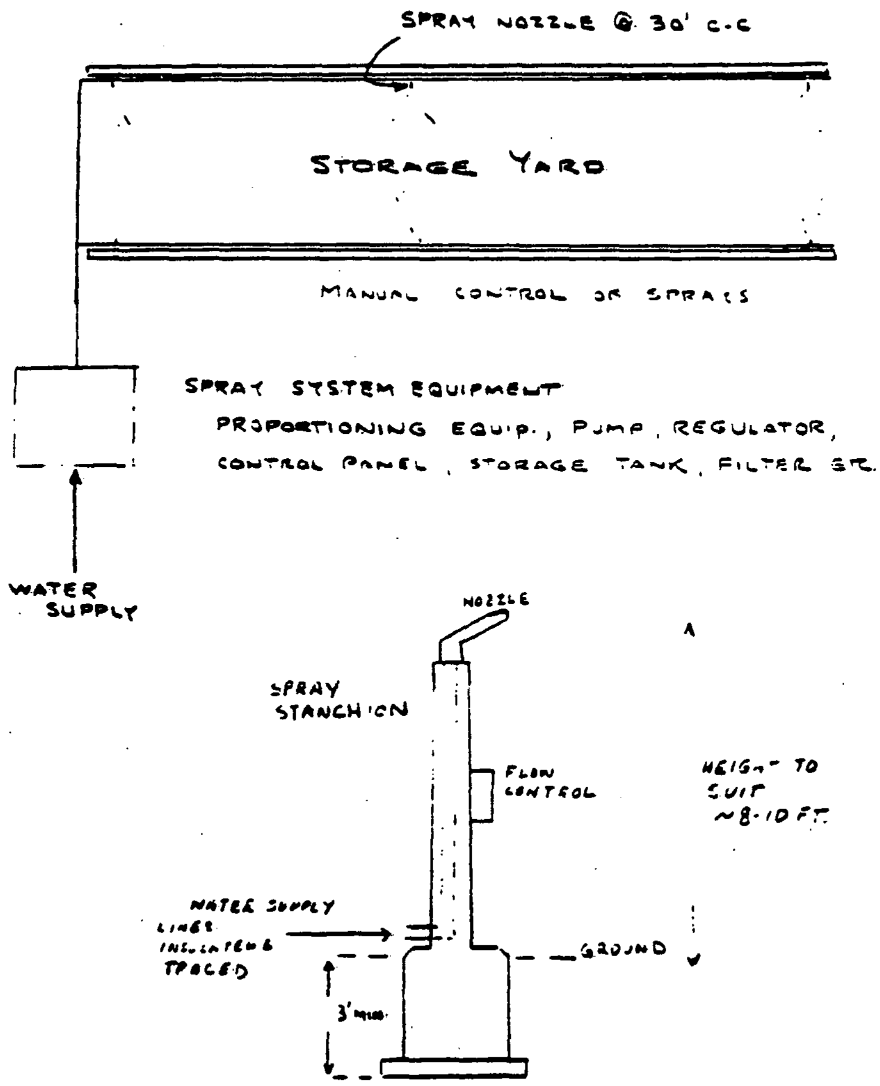


Figure E-12. Storage yard perimeter sprays.

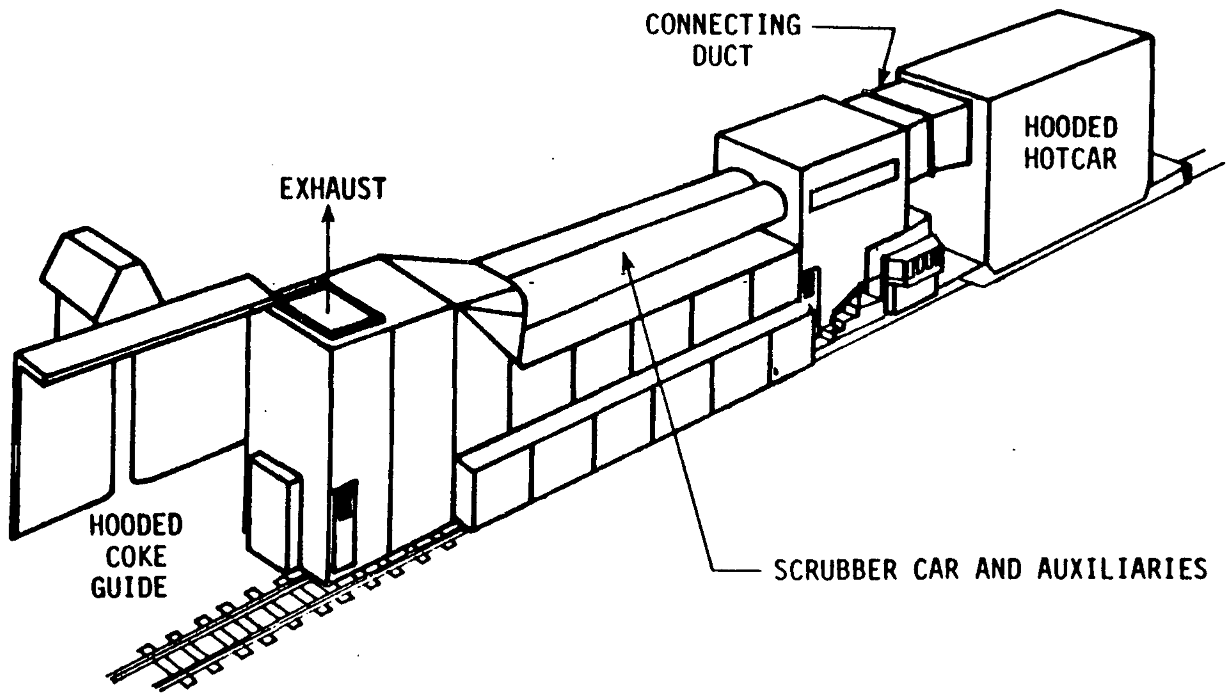


Figure E-13. Hooded quench car module.

release to the atmosphere, the fumes are cleaned by a hot water scrubbing system, which is included in the package. See Figure E-13.

Stage Charging

Stage charging is utilized in the control of charging emissions in coking. Both a retrofit option and a new car option are provided in the cost model. In the retrofit option, the existing car is modified by equipping it with fume piping, new hopper gate assemblies, stainless steel cones for the hoppers, a hydraulic system, an electrical control system, and a gooseneck cutter. A steam supply and a pushing machine leveler bar smoke seal are also provided in this option. The new car is designed with four hoppers utilizing gravity feed and a butterfly flow control plate. The fume pipe connects the No. 1 and No. 4 hoppers and the No. 4 charging hole two ovens away. A hydraulic system operates the slide gates, the drop sleeves and the flow control valves. A gooseneck cleaner and an air conditioned cab with filtered air are included. Lid lifters are not included. See Figure E-14.

Sinter Plant Windbox Recirculation

Sinter plant windbox recirculation is utilized in the control of windbox emissions by filtration of the air through the bed of hot sinter. The module includes a recycle main with supports, off takes with dampers, a hood over the sintering machine with supports, and refractory lining for the hood. See Figure E-15.

Quench Tower Baffles

Quench tower baffles are utilized in the control of quenching emissions in coking. This module includes a spraying system for backflushing with supports, a pump, and a strainer as well as the baffles themselves. See Figure E-16.

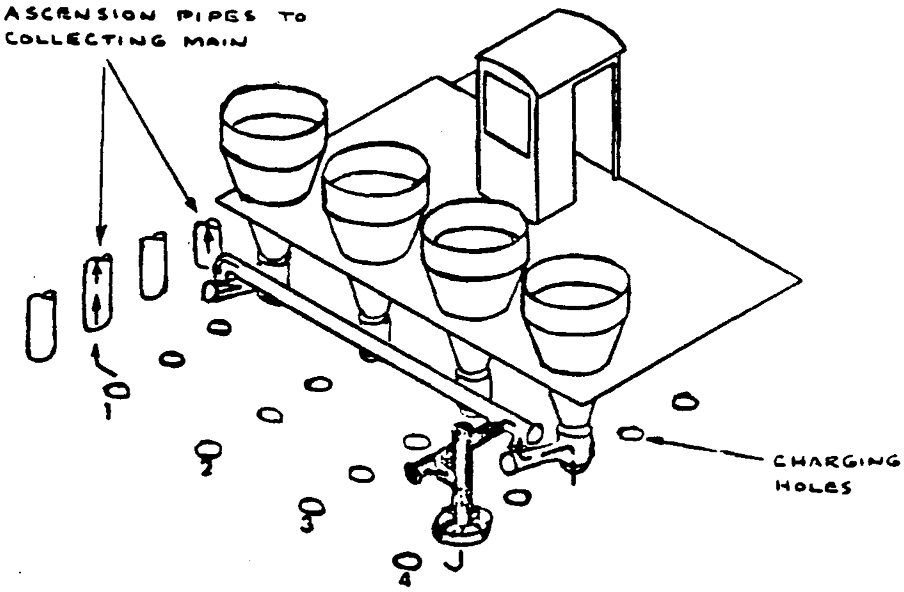
Module No. 11B Sheet 2 of 6

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION Coke Oven Charging DATE 10-20-77

PROJECT NO. 3315 Car Modifications BY Traub

DESIGN CRITERIA: For Staged Charging



Fume pipe between No. 1 & 4 hoppers and second oven away

Scope of work

- Fume Piping
- New Hopper Gate Assemblies
- St. Steel Cones for Hoppers
- Hydraulic System
- Electrical Control System
- Gooseneck Cutter

Figure E-14. Stage charging larry car module.

(continued)

Module No. 11C Sheet 4 of 9

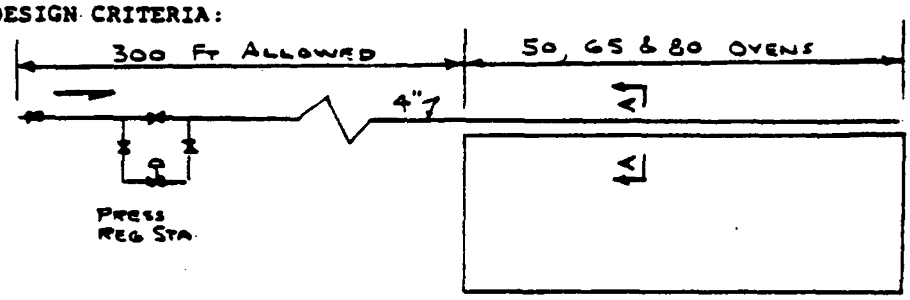
DESIGN DATA

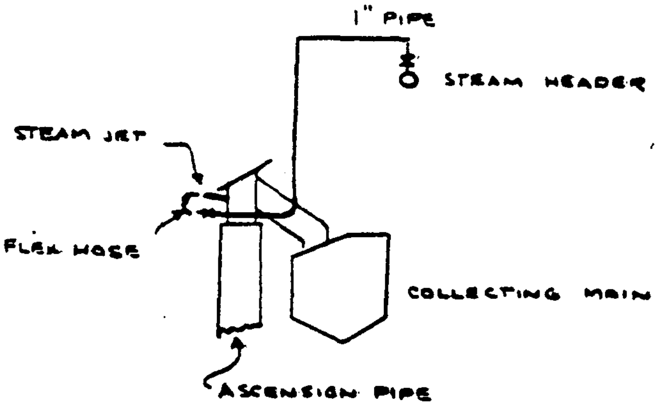
PEDCo ENVIRONMENTAL

DESCRIPTION Coke Oven Steam Sup. DATE 10-15-77

PROJECT NO. 3315 (Charging Emission Control) BY Traub

DESIGN CRITERIA:





SECTION A-A

Figure E-14 (continued). Steam supply for stage charging.

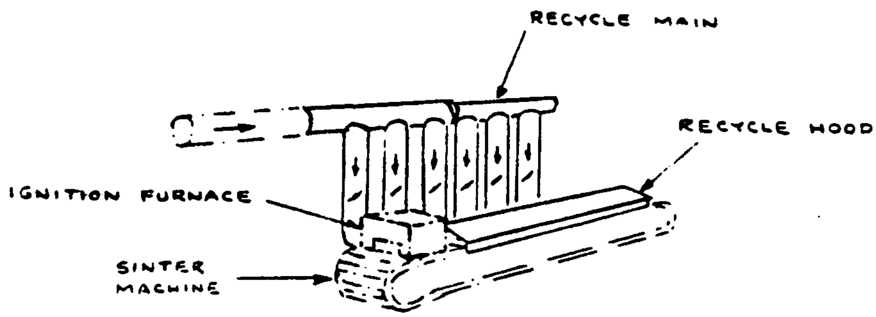
Module No. 13 Sheet 4 of 6

DESIGN DATA

PEDCo ENVIRONMENTAL — DESCRIPTION Sinter Plant — DATE 10-21-77

PROJECT NO. 3315 — Windbox Recirculation — BY Traub

DESIGN CRITERIA:



Tons per day	Machine Width	Machine Length	SCFM @ 80 cfm/T/day	ACFM @ 90° - 10" WC	Main duct dia	Off-takes
1671	42" 3 (req)	67'	134,000	156,400	7'-1"	(7) 2'-8" dia
3767	96"	140'	300,000	350,000	10'-7"	(14) 2'-10" dia
5863	120"	170	470,000	550,000	13'-3"	(14) 3'-7 dia

Scope of cost estimate
- Recycle main with supports
- Off-takes with dampers
- Hood over sinter machine w/supports
- Refractory lining of hood

Figure E-15. Sinter plant windbox recirculation module.

		Module No. 14 Sheet 2 of 4
	DESIGN DATA	
PEDCo ENVIRONMENTAL	DESCRIPTION	DATE 10-19-77
PROJECT NO. 3315	Quench Tower Baffles	BY TRAUB

DESIGN CRITERIA:

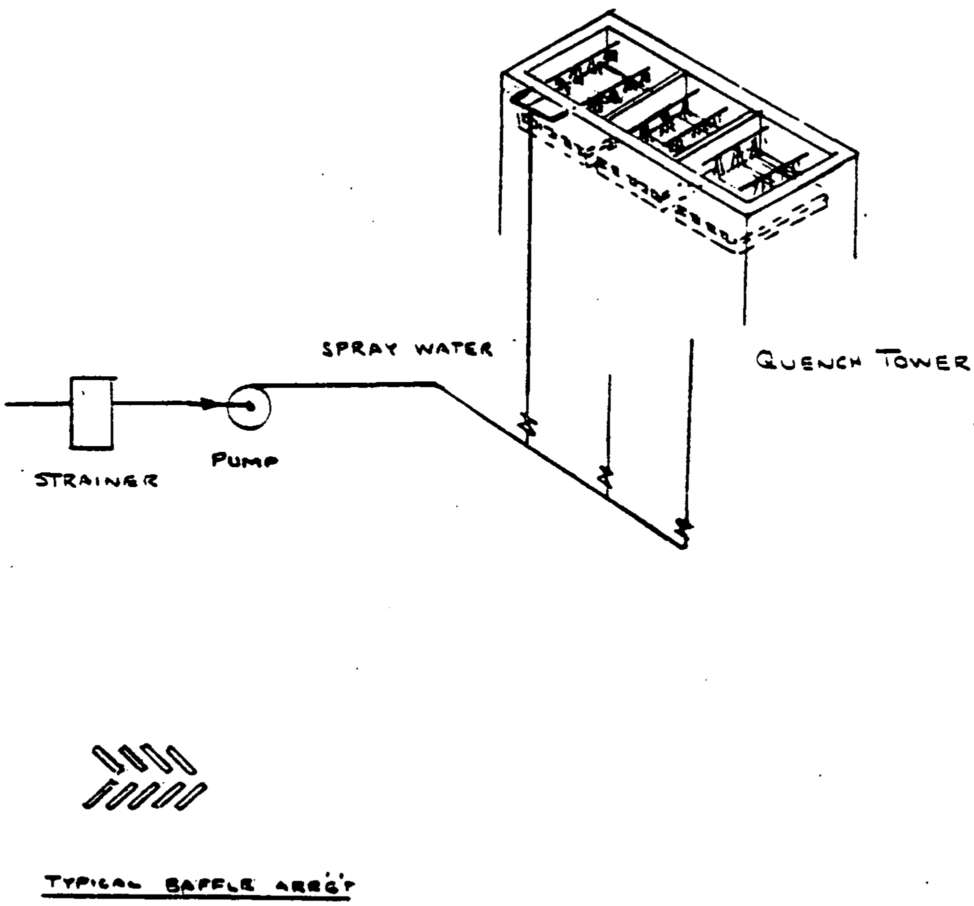


Figure E-16. Quench tower baffles.

		Module No. 15 Sheet 2 of 3
	DESIGN DATA	
PEDCo ENVIRONMENTAL	DESCRIPTION	DATE 1-8-78
PROJECT NO. 3315	COKE OVEN DOOR CLEANING	BY TRAUB

DESIGN CRITERIA:

ESTIMATE BASED ON HYDRAULIC SYSTEM DESIGNED BY INDUSTRIAL HIGH PRESSURES SYSTEMS, INC.

UNIT TO BE INSTALLED ON EXISTING PUSHER, DOOR MACHINE OR ON SEPARATE CAR.

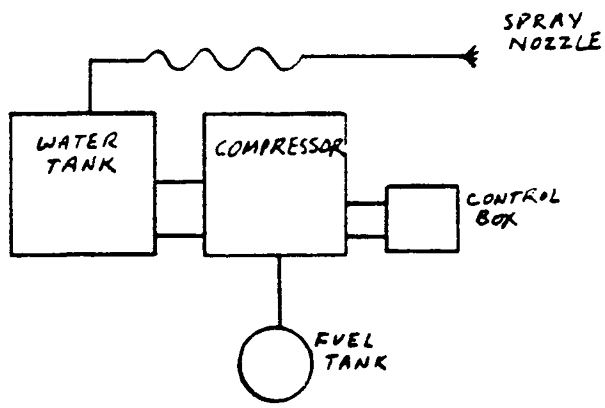


Figure E-17. Coke oven door cleaning module.

Coke Oven Door Cleaner

This module is utilized in the cleaning of coke oven doors. It consists of a high pressure hydraulic system, and is installed on the existing pushing machine and door machine. See Figure E-17.

Dry Quenching

Dry quenching is utilized in the control of quenching emissions in coking and eliminates the emission of particulate which occurs in wet quenching. This module was estimated as a package which includes all the equipment necessary for the process. Basically, the coke is released into a water jacketed cooling bunker where its temperature is decreased to less than 200°C by recirculating inert gas. There is byproduct steam created in the cooling bunker which can be used elsewhere in the plant. See Figure E-18.

Bleeder Flares

Bleeder flares are utilized in the control of emissions of excess fuel gas. Modules are provided for the flaring of coke oven gas, blast furnace gas and BOF off gas. For the blast furnace and BOF gas bleeder flare, two burners are provided. One burner is operating while the other is on standby. Natural gas is used for the burner system. Ignition is started manually from the base of the stack. A new platform and ladder for the existing bleeder stack are provided. The coke oven gas flare does not require an enlarged stack because of the higher Btu content of coke oven gas. Thermocouples are provided to monitor the pilots. See Figures E-19 and E-20.

Mist Eliminator

The mist eliminator is utilized in controlling water mist present in exhaust gases that have been passed through wet control devices such as wet scrubbers. Two basic types have been estimated: the wire mesh type and the blade type. Each can be either carbon steel or stainless steel. The stainless and

Module No. 16 Sheet 1A of 3

DESIGN DATA

PEDCo ENVIRONMENTAL | DESCRIPTION DRY QUENCHING | DATE 12-18-77

PROJECT NO. 3315 | BY HEINZ

DESIGN CRITERIA:

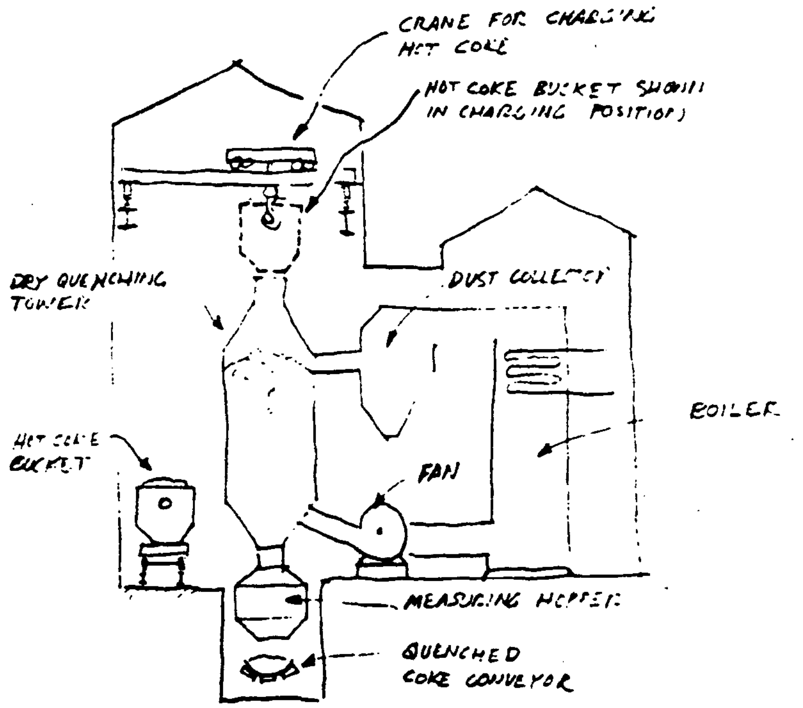


Figure E-18. Dry quenching module.

Module No. 17A Sheet 4 of 9

DESIGN DATA

FEDCo ENVIRONMENTAL DESCRIPTION ______________ DATE 10-26-77

PROJECT NO. 3315 GAS BLEEDER FLARE BY TRAUB

DESIGN CRITERIA:

1. TWO BURNERS TO BE PROVIDED FOR ALL SIZES OF FLARE STACKS.
2. AUTOMATIC BLEEDER CONTROL IS EXISTING.
3. NAT. GAS USED FOR BURNER SYSTEM
4. NEW PLATFORM & LADDER TO BE INCLUDED
5. MANUAL START OF IGNITION FROM BASE OF STACK
6. ONE BURNER OPERATING WITH SECOND AS STAND-BY

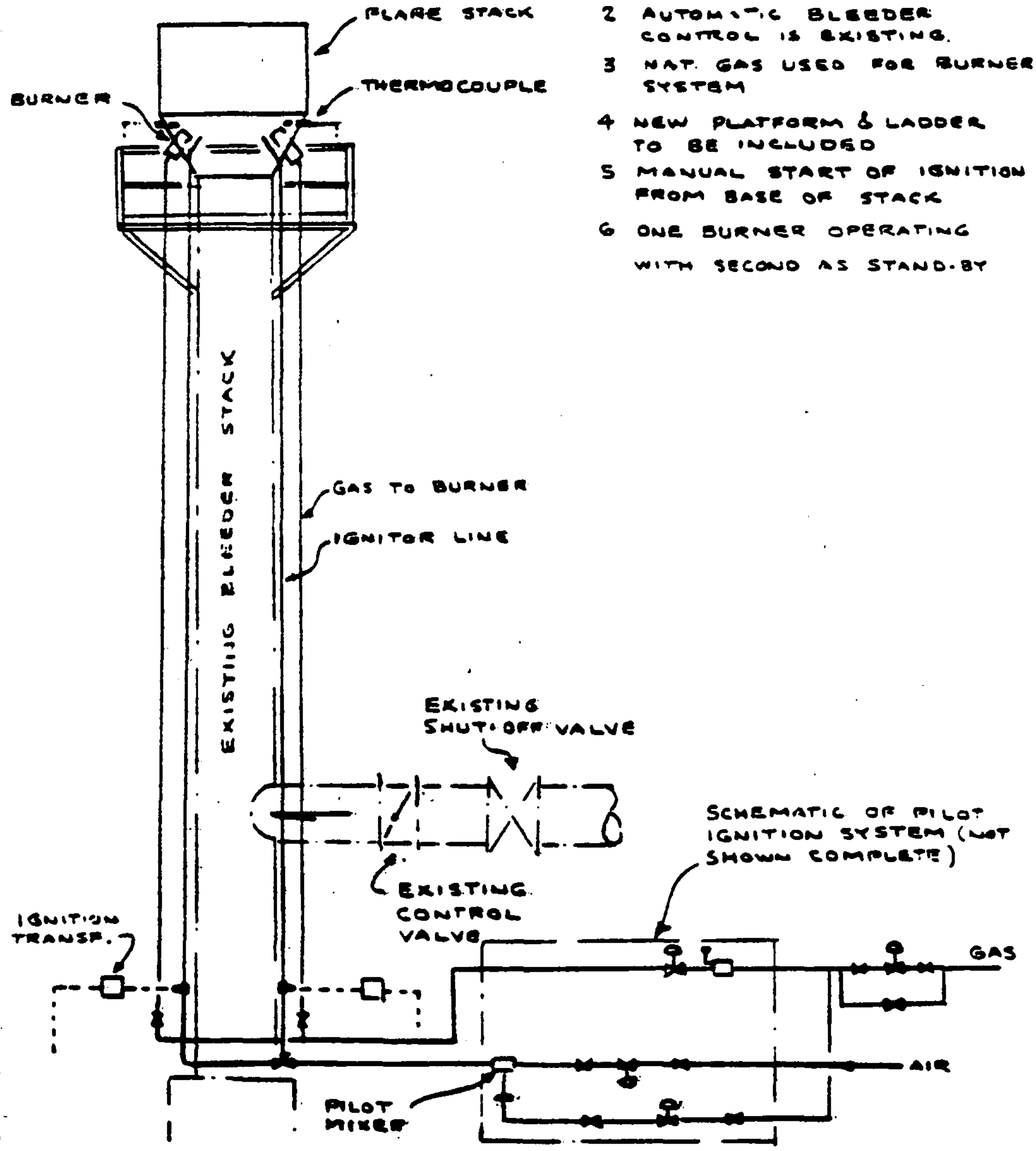


Figure E-19. Blast furnace gas flare.

Module No. 17B Sheet 3 of 6

DESIGN DATA

PEDCo ENVIRONMENTAL

PROJECT NO. 3315

DESCRIPTION BLEEDER FLARE FOR COKE OVEN GAS

DATE 11-3-77

BY TRAUB

DESIGN CRITERIA:

1. ESTIMATE BASED ON JOHN ZINK FLARE WITH TWO PILOTS AND ONE IGNITION SYS.
2. MANUAL START OF IGNITION FROM BASE OF STACK
3. PROVIDE THERMOCOUPLES TO MONITOR PILOTS.
4. ONE PILOT OPERATING, ONE ON STAND-BY
5. NEW ACCESS LADDER AND PLATFORM TO BE PROVIDED

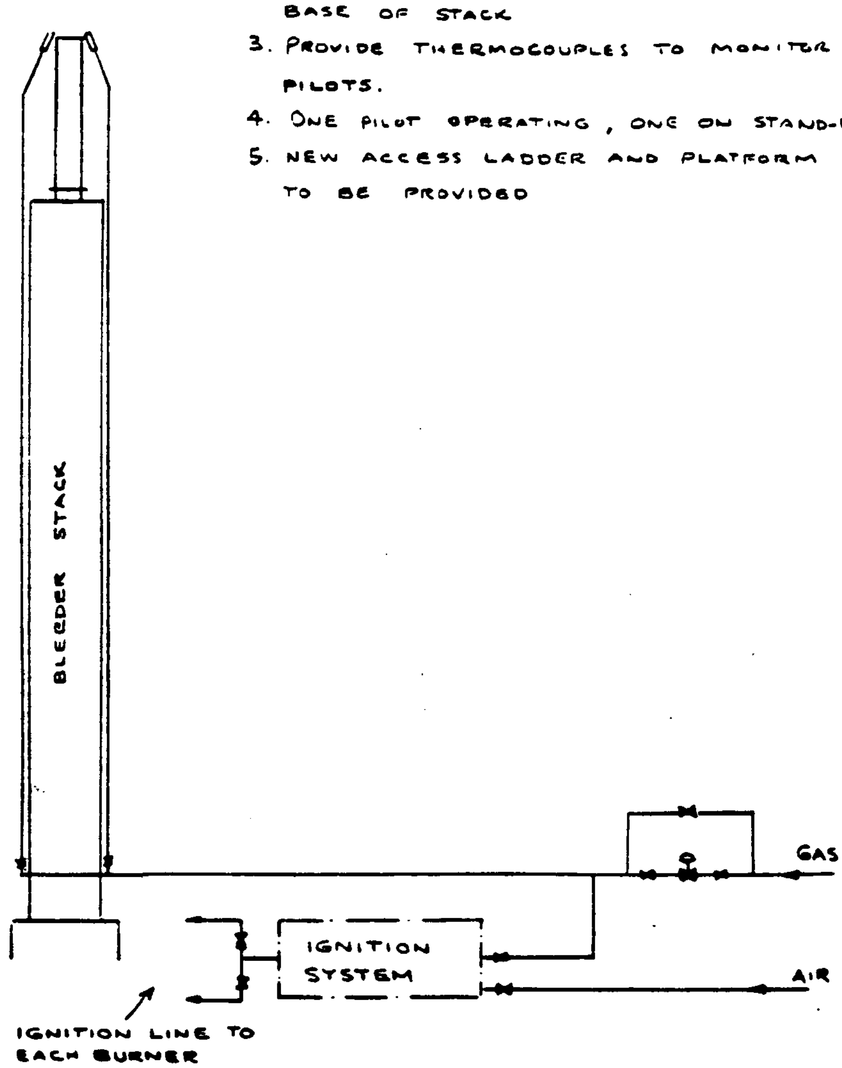


Figure E-20. Coke oven gas flare.

Module No. 18 8 Sheet 7 of 15

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION MIST ELIMINATOR (BLADE TYPE) DATE 10-19-77

PROJECT NO. 3315 BY TRAUS

DESIGN CRITERIA: VELOCITY THROUGH BLADES = 1000 FPM

DUCT VELOCITY ≈ 4000 FPM

FLOW (ACFM)	BLADE TYPE DEMISTER			DUCTWORK		
	DIA (FT)	AREA-(S.F)	VEL (FPM)	DIA. (FT)	AREA (S.F)	VEL (FPM)
50,000	8	50.27	995	4	12.56	3979
250,000	18	254.5	982	9	63.6	3930
500,000	26	530.9	942	12'-8"	126	3968

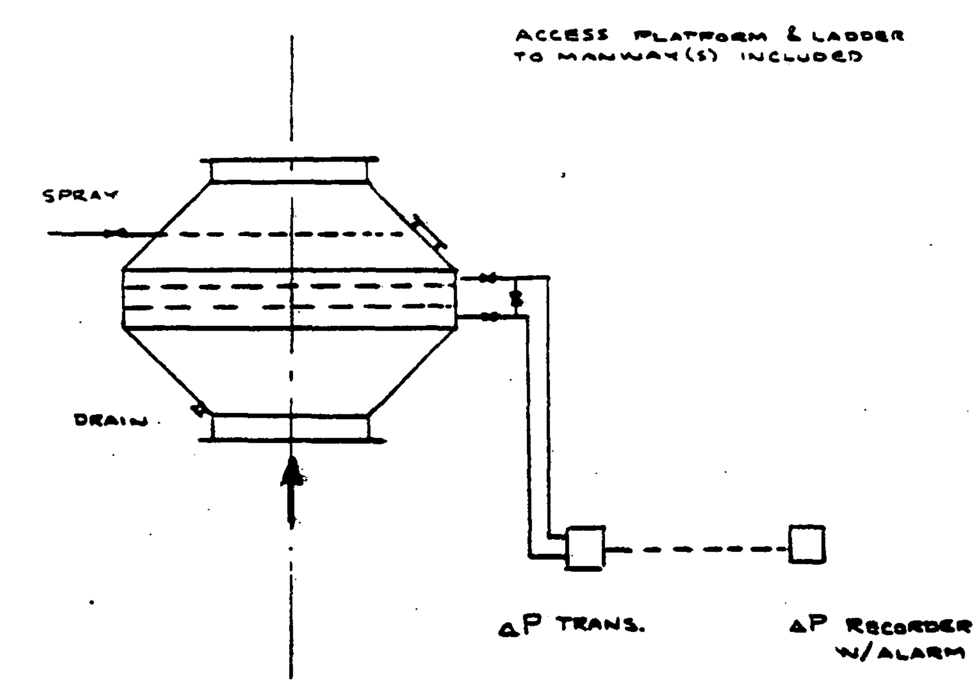


Figure E-21. Mist eliminator module - blade type.

Module No. 18A Sheet 7 of 20

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION Mist Eliminator (Wire mesh type) DATE 10-17-77

PROJECT NO. 3315 BY Traub

DESIGN CRITERIA: Velocity through pad = 7 to 8 fps
Velocity in duct = 4000 ± fpm

Flow (ACFM)	Wire mesh demister			Ductwork		
	Dia. (ft)	Area (S.F.)	Vel. (fps)	Dia. (ft.)	Area (S.F.)	Vel. (fpm)
50,000	12	113.1	7.4	4	12.56	3979
250,000	27	572	7.3	9	63.6	3930
500,000	36	1018	8.1	12'-8"	126	3968
1,000,000	53	2206	7.6	18	254.47	3929

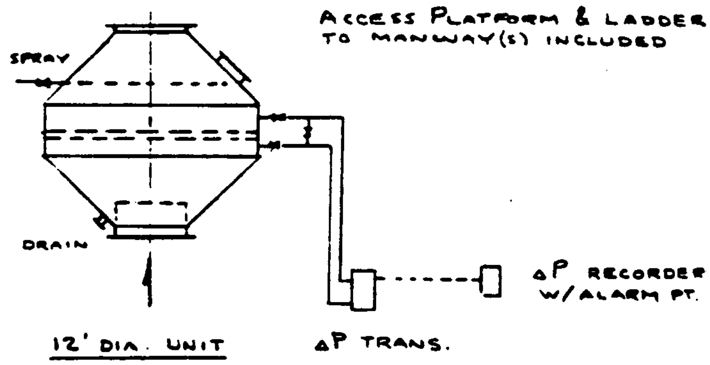


Figure E-22. Mist eliminator module - wire mesh type.

carbon steel varieties of both types are of similar construction. All consist of a vessel containing the blades or stainless steel wire mesh, along with a spraying system and drain at the bottom for back washing. Also included in the estimate is a pressure drop recorder with alarm, and an access platform and ladder to the manways. See Figure E-21 and 22.

Fans

The fan module consists of the fan, motor and coupling along with the electrical control system. Foundations, structurals, and supports are included as required depending on fan size. The control parameter for cost is horsepower which is a function of acfm and fan static pressure. Fans are sized for cold startup, i.e., acfm at the temperature of the exhaust stream at the fan. In calculating operating cost, fan horsepower is reduced at elevated temperature to account for lower air density. Below 500 hp, 100 percent installed spares are used and above 500 hp, 50 percent installed spares are used. Individual fan size is limited to 1,000,000 acfm and motor size is limited to 5000 hp. See Figure E-23.

Ductwork

Ductwork is utilized as a portion of many control systems. It can be either carbon steel or stainless steel and can be either refractory brick lined or unlined. The estimate has a basis of 100 ft of duct. Flanges are placed at 40 ft intervals. For the 100 ft of duct, there are four supports, two to the ground with foundations and two to existing structural steel. There is one expansion joint per 100 ft of length. The basis for sizing the diameter of a given duct is a velocity of 4000 ft per minute. Insulation is calculated separately as required at a cost of $6 per square foot. See Figure E-24.

Ductwork Dampers

Dampers are utilized along with ductwork for isolating control devices. There are two different materials of construction,

Module No. 19A Sheet 15 of 20

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION FANS DATE 2-23-78

PROJECT NO. 3315 BY TRAUB

DESIGN CRITERIA:

ESTIMATE INCLUDES –
- FAN WITH MOTOR AND COUPLING
- FOUNDATION
- PAINTING
- PLATFORM & LADDER FOR LARGE MOTORS

HORSEPOWER BASED ON:

$$BHP = \frac{CFM \times S.P}{3812}$$

FAN ELECTRICAL:

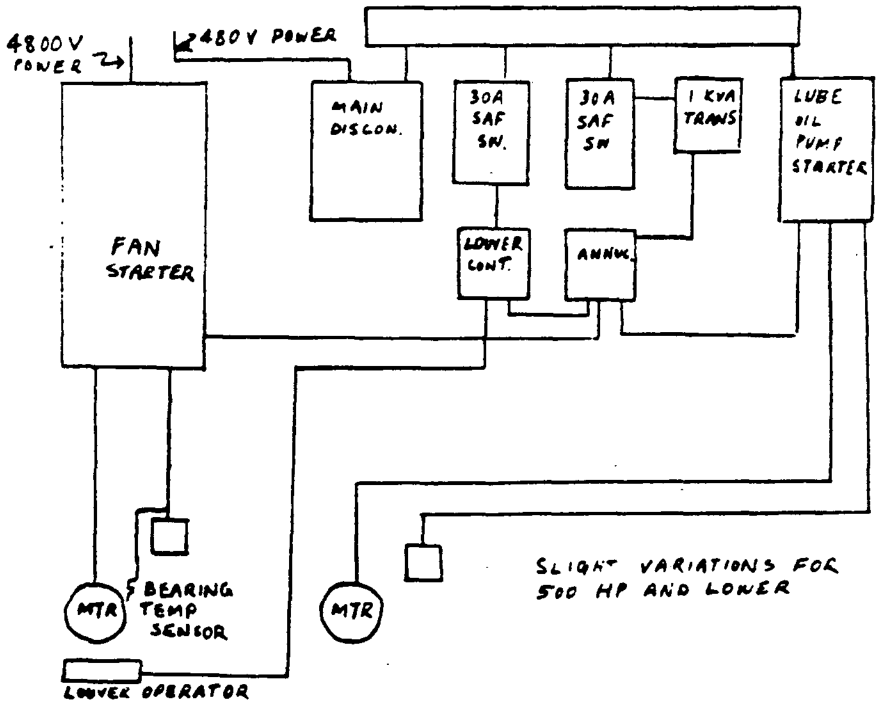


Figure E-23. Fans.

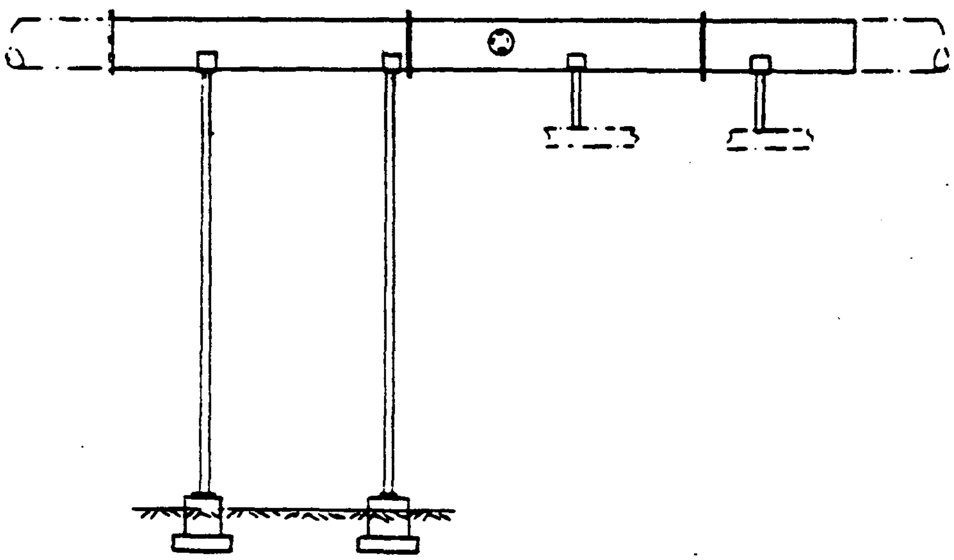
Module No. 20A Sheet 16 of 22

DESIGN DATA

PEDCo ENVIRONMENTAL | DESCRIPTION Ductwork | DATE 11-17-77

PROJECT NO. 3315 | BY TRAUB

DESIGN CRITERIA:



BASIS FOR DEVELOPING COST ESTIMATES

1 ESTIMATE FOR 100 FT LONG WITH FLANGES EVERY 40 FT

2 FOUR SUPPORTS - TWO TO GROUND WITH FOUNDATIONS AND TWO TO EXISTING STRUCTURAL STEEL.

3 MANWAY INCLUDED EVERY 100 FT LENGTH

4 VELOCITY = 4000 FPM

5 MATERIAL CABON STEEL
STAINLESS STEE
REFRACTORY LINED ABOVE 600°F

6 ONE EXPANSION JOINT PER 100 FT

Figure E-24. Ductwork module.

Module No. 20B Sheet 6 of 8

DESIGN DATA

PEDCo ENVIRONMENTAL — DESCRIPTION ____ — DATE 1-8-78

PROJECT NO. 3315 — DUCTWORK DAMPERS — BY JWT

DESIGN CRITERIA:

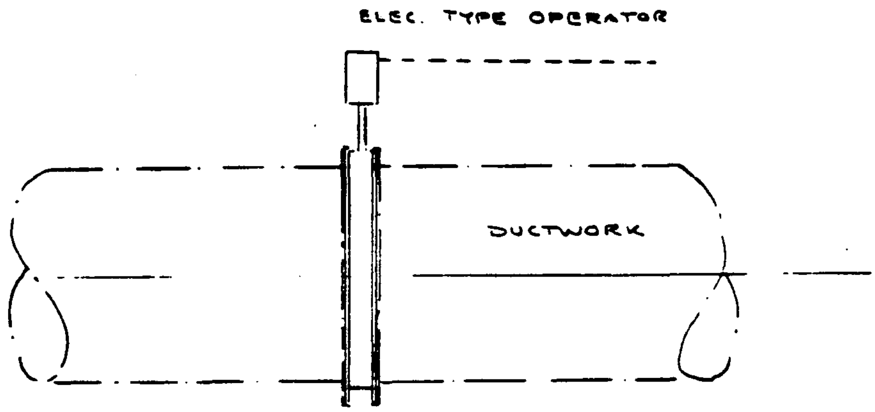


Figure E-25. Ductwork damper module.

carbon steel, and stainless steel. Included with the damper is an electric operator which controls the opening and closing of the damper. See Figure E-25.

Exhaust Stack

The cross sectional area for stacks is determined based on a velocity of 3000 ft/min. The variables for stacks are the material of construction which can be either carbon steel or stainless steel and whether the stack is lined with 4-1/2 in. of brick or unlined. The stack module cost is based on a stack 100 ft. high provided with an access ladder and platform, test ports, foundations, and grounding. The stack is designed for a wind load of 40 pounds per square foot. See Figure E-26.

Opacity Monitor

The opacity monitor is utilized on some stacks, when specified by NSPS or at the LAER control level. The module includes an optical head assembly, a retroreflector assembly, connecting flanges, two blower units with filters, mounting plates, weather hoods, a remote control panel, and an access platform and ladder. It is assumed that the stack is 100 ft high and that it is 100 ft from the control room. See Figure E-27.

SO_2 Monitor

The SO_2 monitor is utilized on stacks where the SO_2 concentration in the exhaust gas is controlled. The module consists of a filter probe assembly, a temperature controller, a heated sample line, an analyzer system, and a recorder. See Figure E-28.

Combustion Control Monitor

The combustion control monitor is utilized on fuel burning sources at the LAER control level to help control opacity excursions. This module may be divided into two parts, actual sampling and control of the fuel to air ratio of the combustion source. The sampling portion consists of a sample probe, an

Module No. 21 Sheet 20 of 30

DESIGN DATA

PEDCo ENVIRONMENTAL

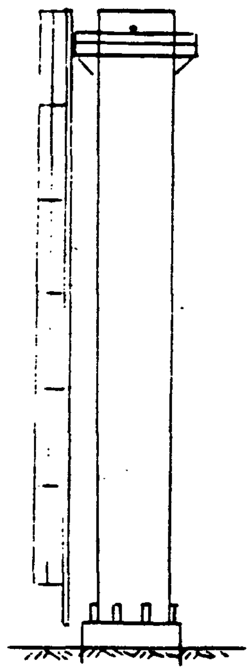
DESCRIPTION EXHAUST STACKS

DATE 11-16-77

PROJECT NO. 3315

BY TRAUB

DESIGN CRITERIA:



1 STACKS TO BE 100 ft HIGH
2 PROVIDE:
   ACCESS LADDER AND PLATFORM
   TEST PORTS
   FOUNDATION
   GROUNDING
3. DESIGNED FOR WIND LOAD OF 40 PSF
4 CORROSION ALLOWANCE FOR
   CARBON STEEL 1/8"
   STAINLESS STEEL - NONE
5 BRICK LINING ESTIMATED FOR 4½" & 9", ACID BRICK AND HIGH DUTY FIREBRICK. ACID BRICK RECOMMENDED BELOW 365°F

* CFM @ 4000 FPM

STEEL		BRICK LINED									
UNLINED		4½"		6"		9"		13½"		18"	
DIA	CFM*	I.D	CFM*	I D	CFM*	I.D.	CFM*	I.D	CFM*	I.D	CFM*
3'	28280	2'-3"	15920								
5'	78560	4'-3"	56760	4'	50,280	3'-6"	38480	2-9	23760		
8'	201,000	7'-3"	165,100	7'	153960	6'-6"	132,720	5'-9"	103880		
12'-8'	504,000	11'-11"	446,000	11'-8'	427,600	11'-2"	391,760	10'-6"	340,880		
15'-6"	754,800	14'-9"	683,600	14'-6"	660,400	14'-0"	615,600	13'-3	551,600		

Figure E-26. Exhaust stack module.

Module No. 22A Sheet 2 of 4

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION DATE 10-17-77

PROJECT NO. 3315 MONITORING OPACITY BY TRAUB

DESIGN CRITERIA:

BASED ON RESEARCH APPLIANCE CO.

RAC TRANSMISSOMETER OPTICAL SYSTEM

INCLUDES - OPTICAL HEAD ASSEMBLY

RETROREFLECTOR ASSEMBLY

CONNECTING FLANGES

TWO BLOWER UNITS WITH FILTERS

MOUNTING PLATES

WEATHER HOODS

REMOTE CONTROL PANEL

PROVIDE ACCESS PLATFORM & LADDER

ASSUME 100 FT HIGH, 100 FT TO CONT ROOM

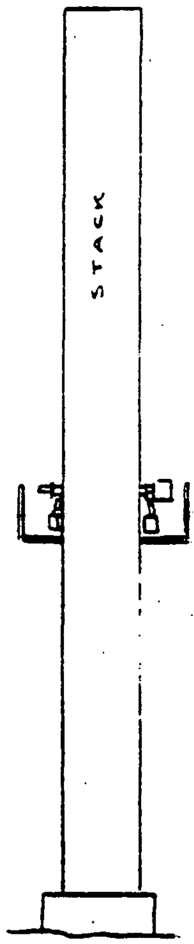


Figure E-27. Opacity monitor module.

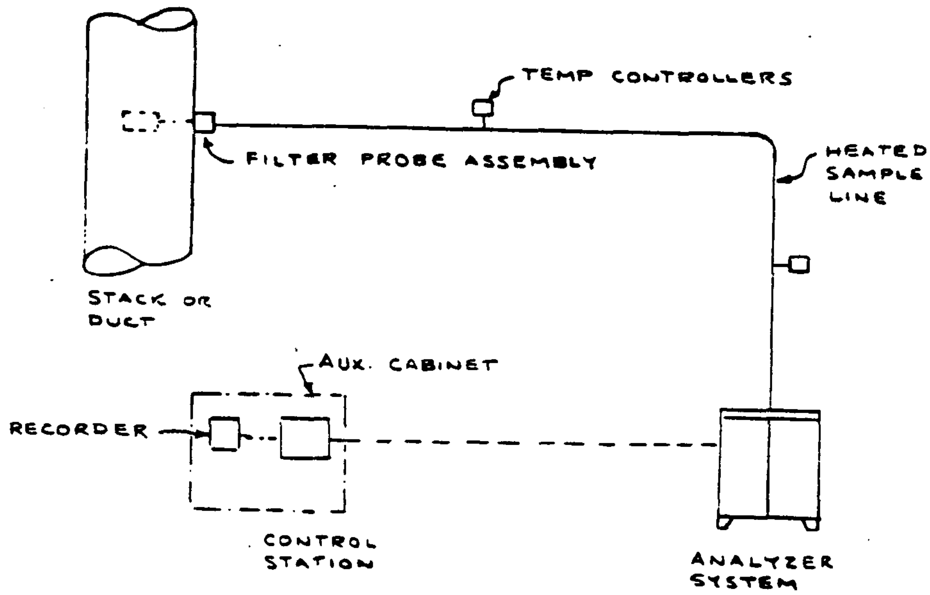
Module No. 22B Sheet 2 of 4

DESIGN DATA

PEDCo ENVIRONMENTAL | DESCRIPTION | DATE 10-23-77

PROJECT NO. 3315 | MONITORING SO_2 | BY TRAUB

DESIGN CRITERIA:



NOTE - NO ACCESS LADDER OR PLATFORM INCLUDED

Figure E-28. SO_2 monitoring module.

Module No. 22C Sheet 2 of 4

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION ________ DATE 10-27-77

PROJECT NO. 3315 COMBUSTION CONTROL LOOP BY TRAUB

DESIGN CRITERIA: SCOPE IS FOR ADDITION OF EQUIPMENT TO MONITOR STACK GAS FOR CO AND PROVIDE A SIGNAL TO OVER-RIDE EXISTING FUEL/AIR RATIO CONTROL TO CONTROL EMISSIONS

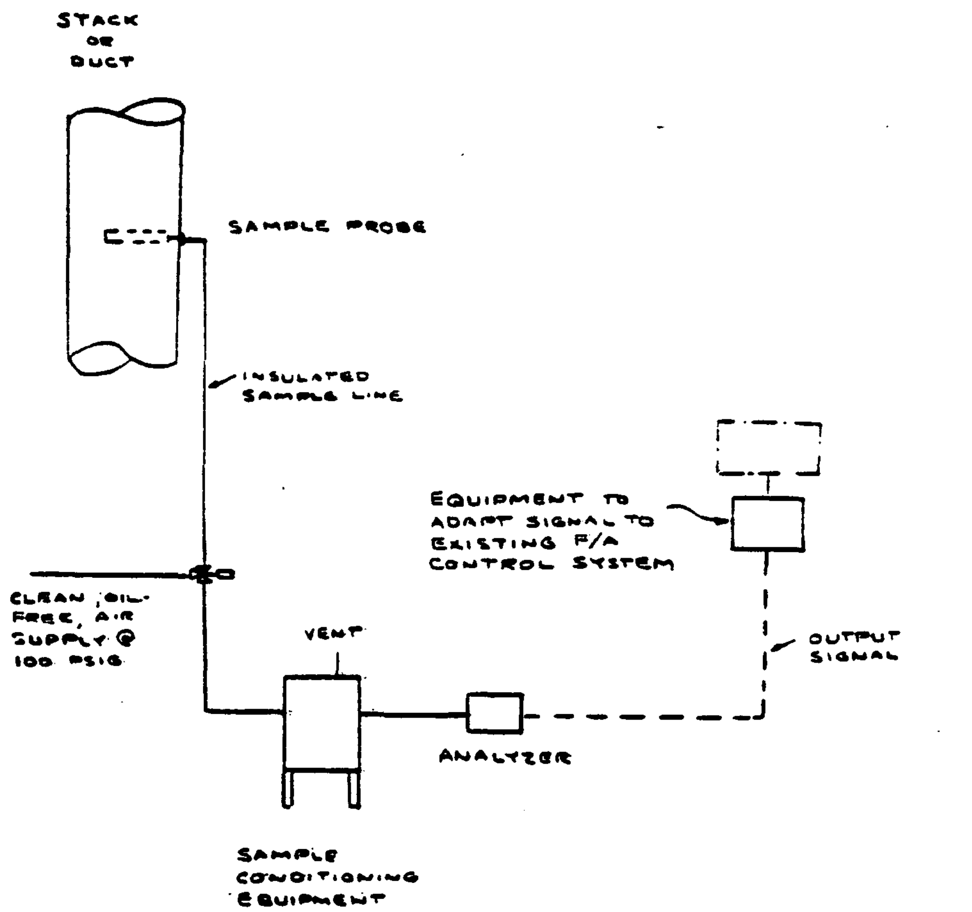


Figure E-29. Combustion control module.

insulated sample line, a clean air supply at 100 psig, a sample conditioner, and an analyzer. The control portion of this module begins in the analyzer where an output signal originates. This signal is adapted to override the existing fuel to air ratio control system. See Figure E-29.

Canopy Hoods

Canopy hoods are utilized to capture emissions from a vessel or a process. They are placed above the emission source and capture the gases escaping from it. The canopy hoods for this study are square in cross section and made from carbon steel. The estimate includes fabrication and carbon steel plate in the range of 1/8-in. to 1/4-in. depending on the size of the hood. There are two available options in the cost model: refractory brick lining and skirting. See Figure E-30.

Canopy Hoods for Electric Arc Furances

Canopy hoods are utilized in the control of fugitive emissions from electric arc furnace steelmaking. They are placed in the roofing structure of the building which encloses the furnace and are located directly above the furnace. This estimate is based on construction of 20 gauge galvanized carbon steel sheeting and carbon steel supporting members. The estimate includes fabrication. See Figure E-31.

Wastewater Treatment

The wastewater treatment module is utilized for removal of suspended solids from the discharge water of wet control devices such as a scrubber. It consists of a degritter, a flash tank, primary clarifier rated at 2.5 gpm/ft^2 overflow rate, a pump well, pH control, and vacuum filters for sludge dewatering. See Figure E-32.

Water Pumping System Module

This module consists of pumps, valves, and piping to supply clean water (river water) to wet control systems such as makeup

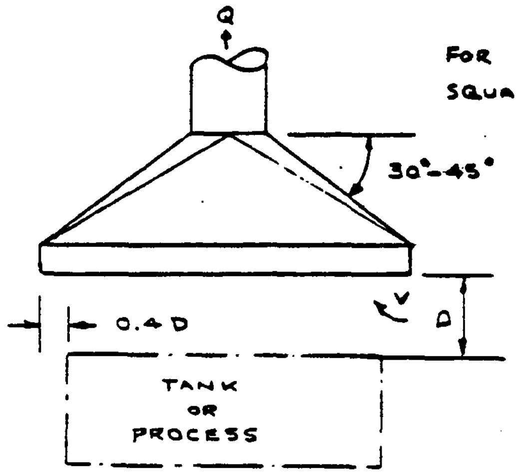
Module No. 24A Sheet 9 of 13

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION ________ DATE 10 28 77

PROJECT NO. 3315 CANOPY HOOD DESIGN BY TRAUE

DESIGN CRITERIA: FACTORS FOR CANOPY HOODS



FOR ROUND OR ESSENTIALLY SQUARE HOODS

$Q = 1.4\,PDV$ = RATE EXHAUSTED (CFM)

P = PERIMETER OF SOURCE (FT.)

D = VERTICAL DISTANCE (FT.)

V = REQUIRED AVERAGE VELOCITY BETWEEN SOURCE AND CANOPY (FPM)

(V = 50 TO 500 FPM DEPENDING ON SOURCE)

IN PRESENCE OF THERMAL CURRENTS RATE IS:

$Q = Q_Z + A_H V_H$ = HOOD EXHAUST RATE (CFM)

Q_Z = THERMAL AIR CURRENT AT HOOD FACE (FPM)

A_H = CROSS SECTION OF HOOD FACE (SQ. FT.)

V_H = CONTROL VELOCITY AT HOOD FACE (FPM)

(V_H VALUE OF 100 TO 150 FPM USUALLY ADEQUATE)

$Q_Z = 1.9\,Z^{1.5}(q)^{\frac{1}{3}}$ = AIR RATE AT EFFECTIVE HEIGHT Z (CFM)

q = CONVECTION HEAT LOSS FROM HOT BODY (BTU/HR)

$Z = Y + 2B$ Y = ACTUAL HT ABOVE BODY (FT)

B = LARGEST HORIZONTAL DIM. OF BODY (FT)

REF - STEEL MILL VENTILATION, MAY, 1965. AISI

Figure E-30. Canopy hood module.

Module No. 24B Sheet 5 of 8

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION CANOPY HOOD DATE 11-16-77

PROJECT NO. 3315 FOR ELECTRIC FURNACE BY TRAUB

DESIGN CRITERIA: TYPICAL BUILDINGS FOR DEVELOPING ESTIMATES

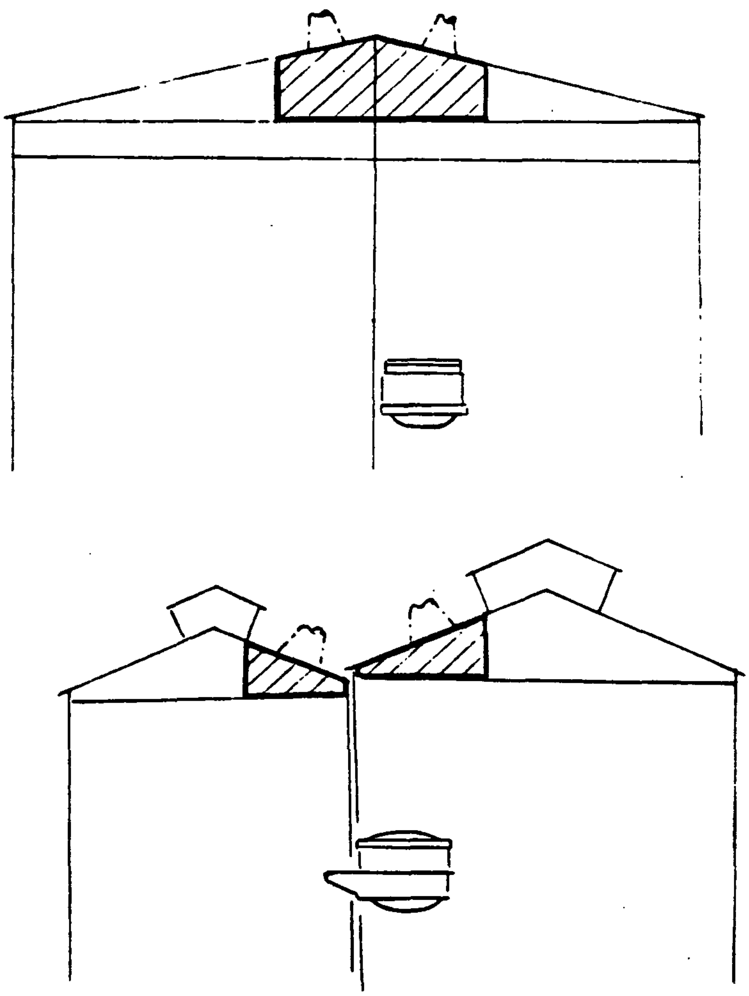


Figure E-31. Electric furnace canopy hood module.

Module No. 25 Sheet 4 of 21

DESIGN DATA

PEDCo ENVIRONMENTAL — DESCRIPTION ________ — DATE 1-3-77

PROJECT NO. 3315 — WASTE WATER TREATMENT — BY TRAUB

DESIGN CRITERIA: EST. FOR FLOWS OF 500, 1500 & 3000 GPM

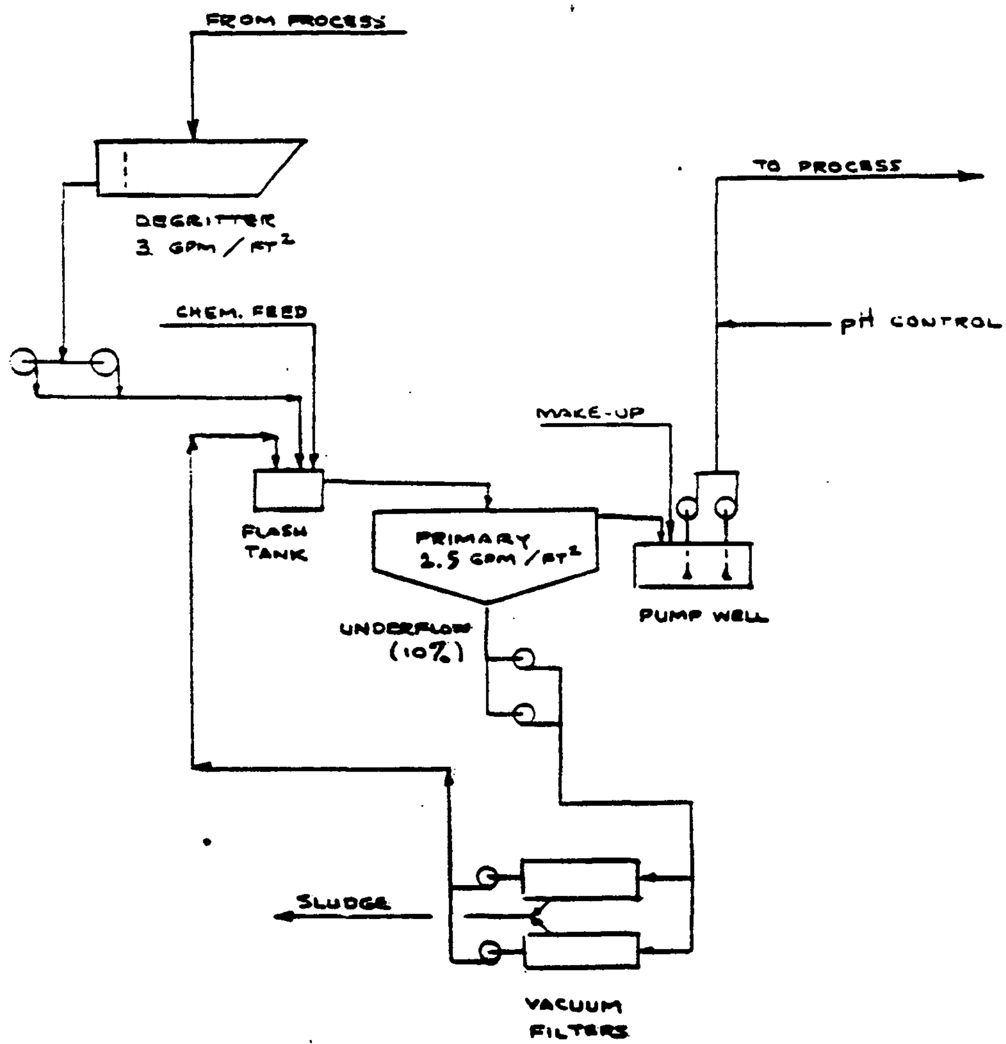
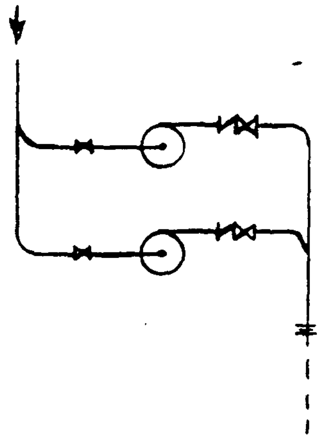


Figure E-32. Wastewater treatment module.

		Module No. ____	Sheet 6 of 13
	DESIGN DATA		
PEDCo ENVIRONMENTAL	DESCRIPTION		DATE 2.20.78
PROJECT NO. 3315	WATER PUMPING SYSTEM		BY TRAUB

DESIGN CRITERIA: 500, 1500, 3000, 6000, 10000 GPM



SCOPE INCLUDES -

TWO FULL SIZE PUMPS

SUCTION & DISCHARGE PIPE (TOTAL 800 FT.)

FOUNDATIONS

FLOW METER

ELECTRIC POWER SUPPLY, CONTROL & WIRING

480 VOLT UP TO 3000 GPM

2200 " FOR 6000 & 10,000 GPM

Figure E-33. Water supply module.

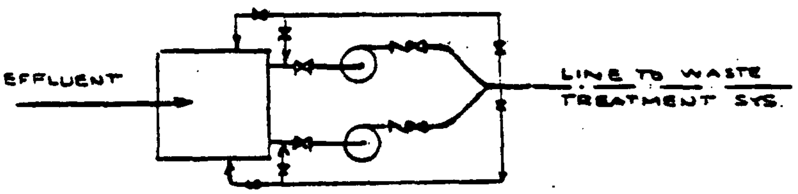
Module No. ____ Sheet 4 of 10

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION ______________ DATE 2-8-78

PROJECT NO. 3315 WASTE WATER RETURN SYSTEM BY TRAUB

DESIGN CRITERIA: FLOWS OF 500, 1500 & 3000 GPM



SYSTEM TO INCLUDE
- EFFLUENT LINE
- SURGE TANK
- LEVEL CONTROL
- TWO 100% PUMPS
- CONNECTING PIPING & VALVES
- FLUSHING LINES (RECIRCULATING)

Figure E-34. Wastewater return module.

water to a recirculating system or supply water to a dust suppression system. See Figure E-33.

Waste Water Return System

This module consists of a sump, slurry pumps, and necessary piping and valving to return wastewater from a wet control device to the wastewater treatment system. See Figure E-34.

Building Louvres

Building evacuation is utilized where a building encloses one or more fugitive emission sources. This module consists of louvers for 100 ft of building length, and a louver operator every 50 ft on either side of the building. This module is only a small portion of a building evacuation system, the majority of cost being in fans, ductwork and control device. See Figure E-35.

Blast Furnace Runner Covers

Blast furnace runner covers are utilized in the control of cast house emissions in the iron making process. They cover the iron runners from the skimmer plate to the pouring spouts, and channel the air flow to a collection outlet, where telescoping duct extensions are connected to capture the emissions. The design length and width of the runner covers are 20 ft and 5 ft, respectively, and they are constructed of carbon steel, with refractory lining. Eyebolts are included for lifting the covers into position. See Figure E-36.

Basic Oxygen Furnace Enclosure

BOF enclosures are utilized in the control of fugitive emissions which occur in the basic oxygen process during charging, slagging, and tapping. The enclosure completely surrounds the furnace and channels the emissions toward its top where a duct connection is made. The enclosure is equipped with sliding doors which are opened when the furnace is charged. The enclosure is constructed of carbon steel. See Figure E-37.

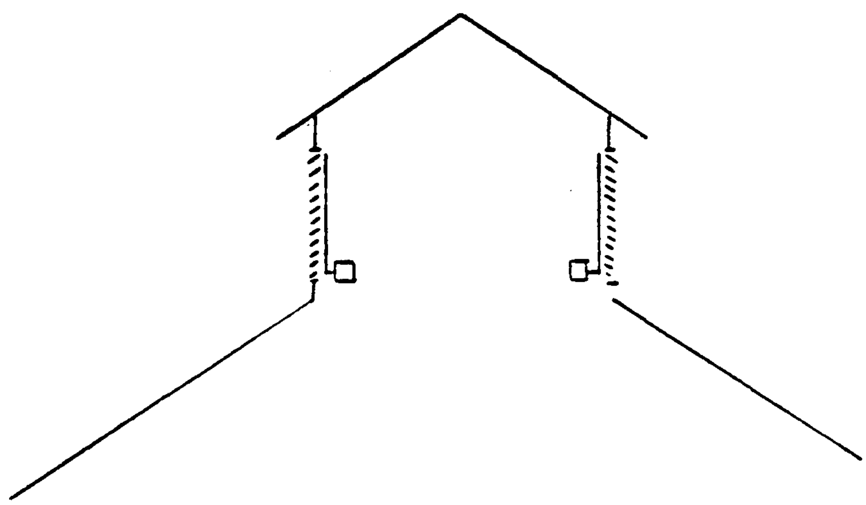
Module No. 27 Sheet 2 of 3

DESIGN DATA

PEDCo ENVIRONMENTAL — DESCRIPTION BUILDING EVACUATION — DATE 1-11-78

PROJECT NO. 3315 — LOUVER OPERATORS FOR 100 FT. — BY TRAUB

DESIGN CRITERIA:

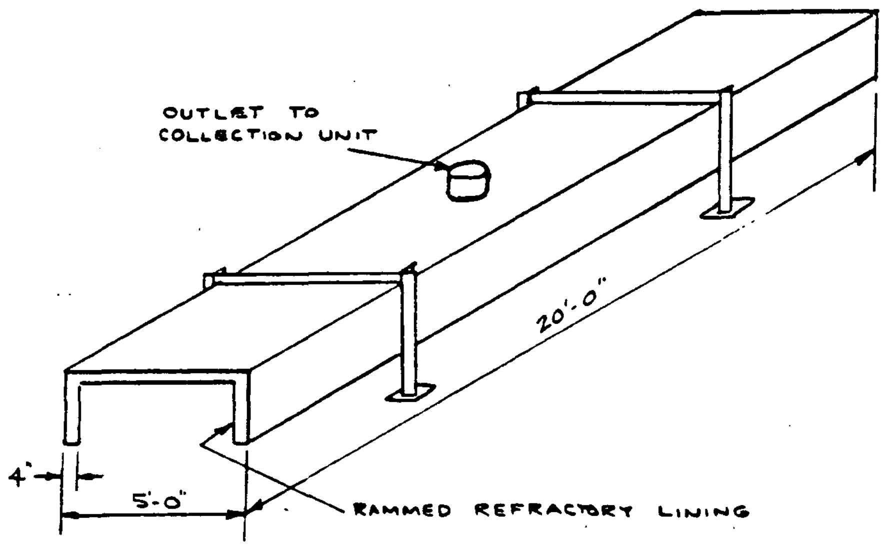


PROVIDE LOUVER OPERATOR EVERY 50 FT EACH SIDE - 4 OPERATORS / 100 FT OF BUILDING.

Figure E-35. Building louver module.

		Module No. 28 Sheet 2 of 3
	DESIGN DATA	
PEDCo ENVIRONMENTAL	DESCRIPTION Blast Furnace	DATE 10-13-77
PROJECT NO. 3315	Iron Runner Covers (20')	BY TRAUB

DESIGN CRITERIA:



TYPICAL RUNNER ARRG'T

NOTE - COMPLETE RIBBING NOT SHOWN
- LIFTING EYES NOT SHOWN
- BASED ON 1/2" PLATE

Figure E-36. Blast furnace runner cover module.

		Module No. 29 Sheet 2 of 2
	DESIGN DATA	
PEDCo ENVIRONMENTAL	DESCRIPTION BOF ENCLOSURE	DATE 10-20-77
PROJECT NO. 3315		BY HENZ

DESIGN CRITERIA:

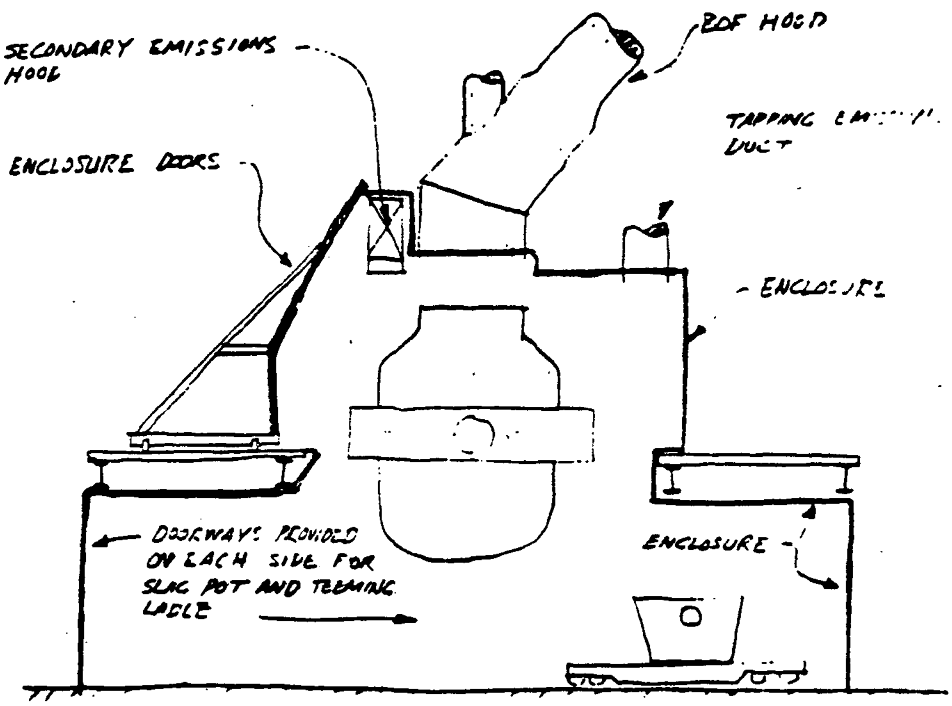


Figure E-37. BOF enclosure module.

Coke Oven Gas Desulfurization

Coke oven gas desulfurization is utilized in the removal of hydrogen sulfide and organic sulfur compounds from coke oven gas so that it can be used as a fuel. There are three basic parts to the representative system used in this study. The first is a Sulfiban* plant where H_2S as well as organic sulfur compounds and HCN are removed from coke oven gas by passing it countercurrent to a monoethanolamine (MEA) solution. The second is HCN pretreatment where after removal from the MEA solution, the acidic gas is passed over a catalyst, and the HCN is decomposed. The third part is the Claus plant where the partially oxidized acidic gas is again passed over a catalyst and is converted into elemental sulfur. There are a number of viable processes[7-10] for desulfurizing coke oven gas. The Sulfiban process is used herein as representative of the class of processes available and in addition will remove organic sulfur. The efficiency of the process is apparently adequate to achieve the limit of 10 grs H_2S/100 scf used as the LAER definition herein. The scope of this project does not permit detailed examination of operating or capital cost variations which result from fine tuning the efficiency of the process to achieve 50, 35 or 10 grains total sulfur content. A distinction is made based on Dunlap's work[9] and is primarily a matter of increased steam consumption at higher efficiencies. The vacuum carbonate process requires additional reactor vessels to achieve higher efficiencies, but the Sulfiban process is reported[7,8] to be capable of the 10 grain level with only an increase in MEA recirculating rate, consumption and contact time. See Figure E-38.

Conveyor Belt Hoods

Conveyor belt hoods are utilized in the prevention of fugitive dust where materials are moved by conveyor belt. They fit over the belt, and a suction is provided to capture the air-

*Mention of product or trade names does not constitute or imply an endorsement of the product by PEDCo or EPA.

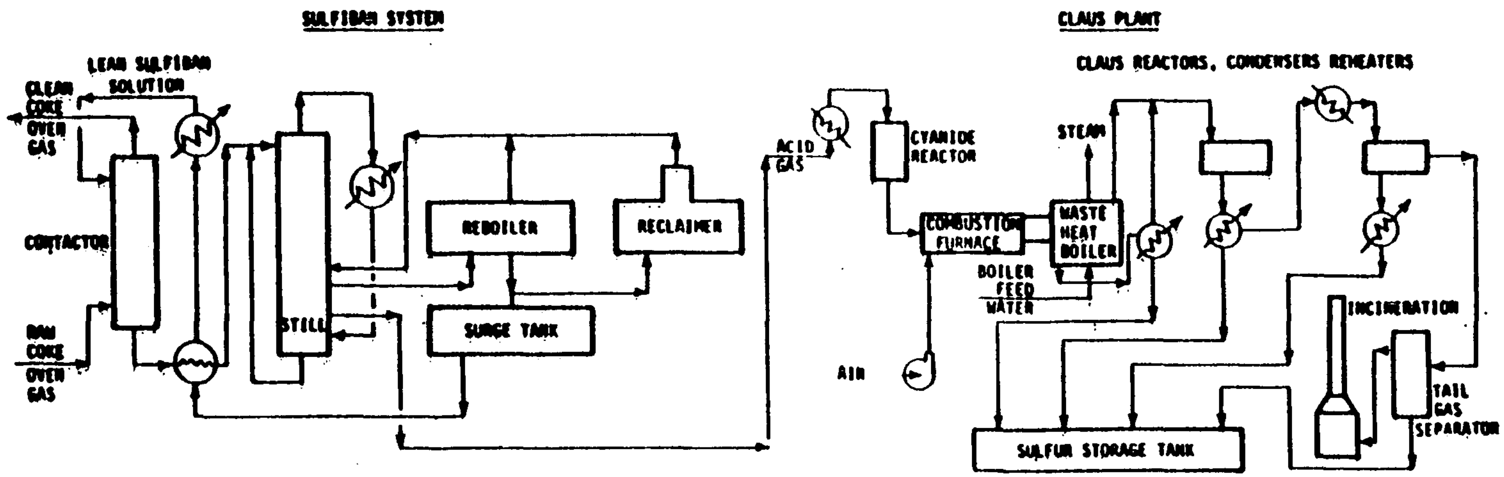


Figure E-38. Coke oven gas desulfurization.

		Module No. 40 Sheet 7 of 10
	DESIGN DATA	
PEDCo ENVIRONMENTAL	DESCRIPTION Hoods For	DATE 10-31-77
PROJECT NO. 3315	Conveyor Belts	BY TRAUB

DESIGN CRITERIA:

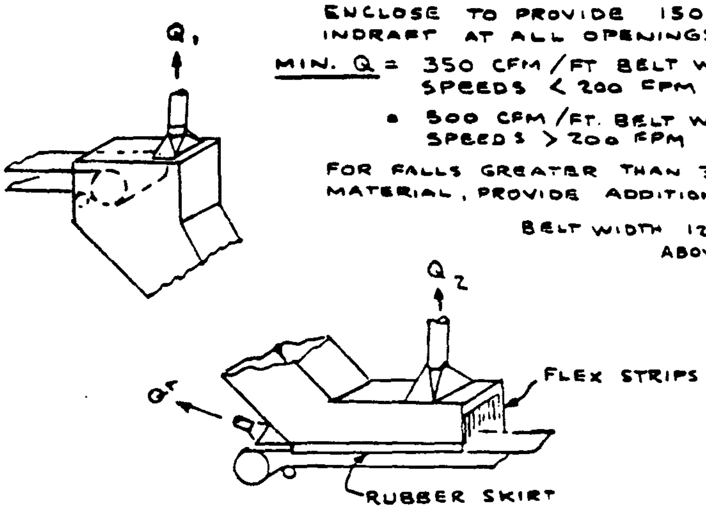
ENCLOSE TO PROVIDE 150-200 fpm INDRAFT AT ALL OPENINGS

MIN. Q = 350 CFM/FT BELT WIDTH FOR BELT SPEEDS < 200 FPM

- 500 CFM/FT. BELT WIDTH FOR BELT SPEEDS > 200 FPM

FOR FALLS GREATER THAN 3 FT WITH DUSTY MATERIAL, PROVIDE ADDITIONAL EXHAUST Q_A

BELT WIDTH 12" TO 36" Q_A = 700 CFM
ABOVE 36" Q_A = 1000 CFM



BELT SIZE	Q_1 (CFM)		Q_2 (CFM)		Q_A (CFM)
	< 200 FPM	> 200 FPM	< 200 FPM	> 200 FPM	-
18"	600 (5½" DIA)	750 (6" DIA)	525 (5" DIA)	750 (6" DIA)	700 (5½" DIA)
30"	1200 (7½" DIA)	1250 (8" DIA)	875 (6½" DIA)	1250 (8" DIA)	700 (5½" DIA)
48"	1700 (9" DIA)	2000 (10" DIA)	1400 (8" DIA)	2000 (10" DIA)	1000 (7" DIA)

REF. IND. VENTILATION MANUAL

Figure E-39. Conveyor transfer point hooding module.

borne particulate. The module includes both head end and tail end hoods. They are only used in the conveyor belt system where the material being moved must undergo transfer. See Figure E-39.

FGD System

The FGD system utilized in this study is for boilers. It is a package estimate and includes everything that is needed except for a new stack. There are three options available. The first is a limestone SO_2 absorber only. The second adds a venturi scrubber for particulate control. The third includes a waste-water treatment plant in addition to the absorber and the scrubber. The type of system required depends on the fuel used by the boiler. A modified version of the system without the venturi scrubber is used for SO_2 scrubbing of sinter plant windbox exhaust gas. See Figure E-40.

BOF Hood Modules

Two types of hoods are included in the cost model; the conventional open hood mounted in a fixed position above the furnace, and the closed hood for suppressed combustion systems with a telescoping lower section for mating to the furnace mouth. The cost for a conventional hood was derived from Reference 19. The closed hood was based on cost 30 percent higher than a conventional hood. The cost of the conventional hood is considered part of the process and is not included in the control system cost. In the BACT and LAER control systems, however, the cost of the closed hood arrangement is included for the retrofit situation. See Figure E-41.

Water Cooled Duct

Water cooled duct is used for the initial cooling of electric furnace exhaust gas in direct shell evacuation control systems. As with many of the modules, a broad range of design variations are possible depending upon site specific factors and the designer's preference.

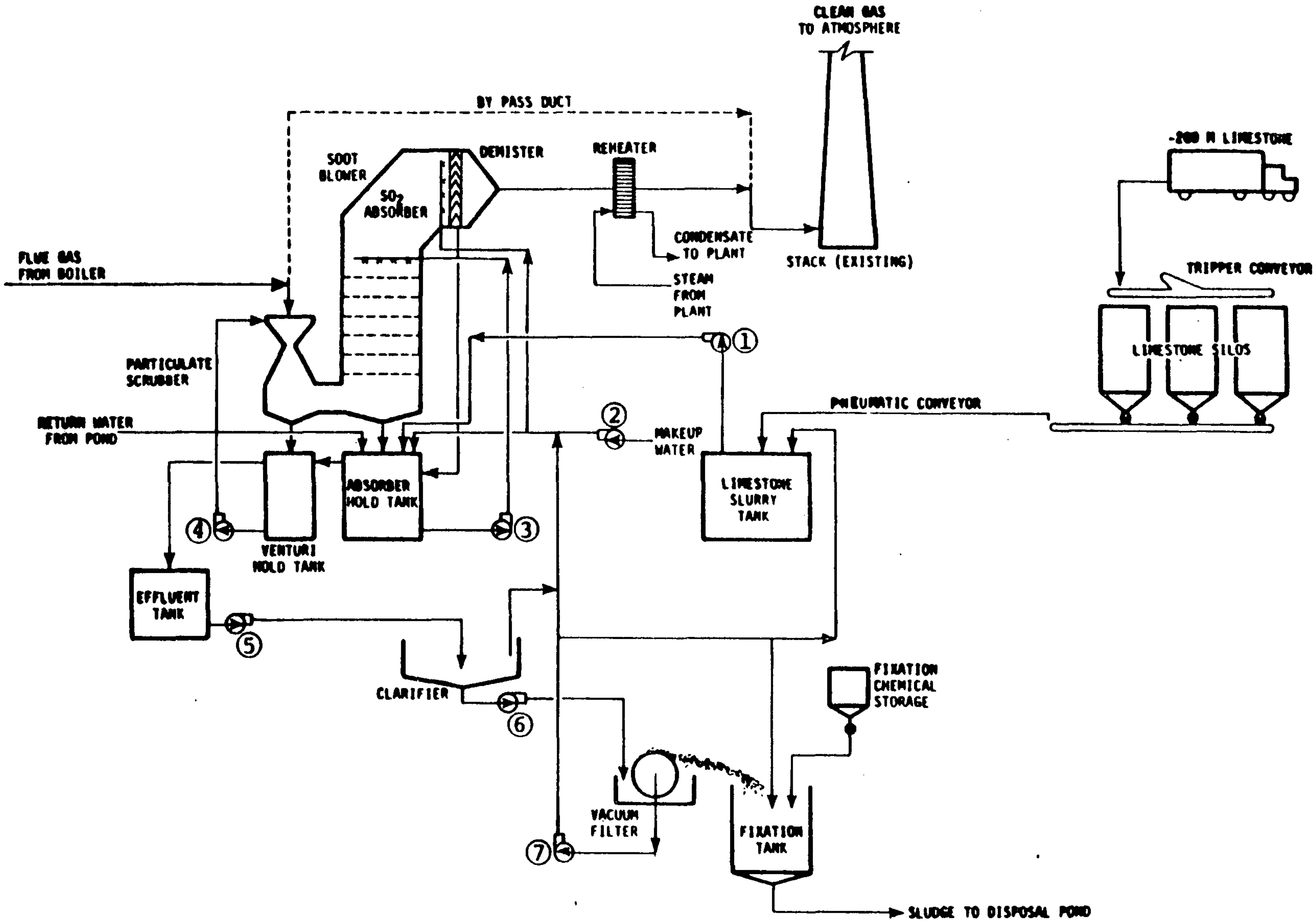


Figure E-40. FGD module - limestone system.

Module No. 59 Sheet ___ of ___

DESIGN DATA

PEDCo ENVIRONMENTAL   DESCRIPTION BOF HOOD + PRIMARY COOLING   DATE 2-17-78

PROJECT NO. 3315   BY WFK

DESIGN CRITERIA:

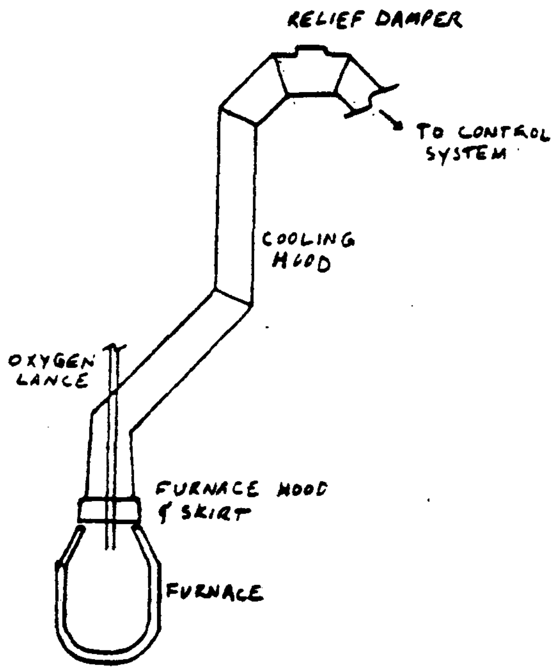


Figure E-41. BOF closed hood module.

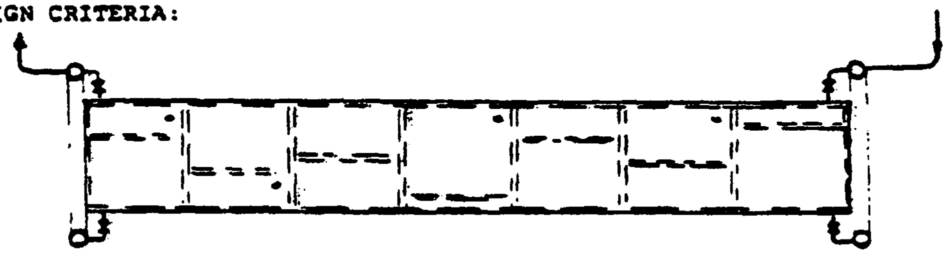
Direct spray cooling is an alternative to noncontact cooling in electric furnace systems, but it has not been used in this study because of the potential of water carryover and bag fouling. See Figure E-42.

Dust Handling Equipment

The dust handling module is included with dry ESP's and fabric filters. It is sized on the basis of tons of dust collected per day with a minimum capacity of one ton per day. The module includes screw conveyors, bucket elevators, storage bin and ancillary equipment. No wetting or pelletizing equipment is included. See Figure E-43.

		Module No. 6C Sheet 4 of 7
	DESIGN DATA	
PEDCo ENVIRONMENTAL	DESCRIPTION	DATE 2-14-78
PROJECT NO. 3315	WATER COOLED PLATE DUCT	BY TRAUB

DESIGN CRITERIA:



DUCT MADE OF CONCENTRIC DUCTS WITH INTERNAL BAFFLING WITH INLET AND OUTLET HEADERS AND FLUSHING CONNECTIONS.

BASED ON HEAT TRANSFER OF 8 BTU/SQ.FT/°F/HR

GAS TEMP. 3000° IN 2000°F OUT

GAS VEL. = 4000 FPM MIN. WATER VEL. = 5 FPS

ΔT OF WATER 60°F MAX

LENGTHS -

60,000 ACFM	4'-6" DIA. DUCT	44 FT. LG
350000 "	10'-6" " "	92 " "
750000 "	15'-6" " "	160 " "

GPM COOLING WATER REQUIRED = .0362 (SCFM)

Figure E-42. Water cooled duct.

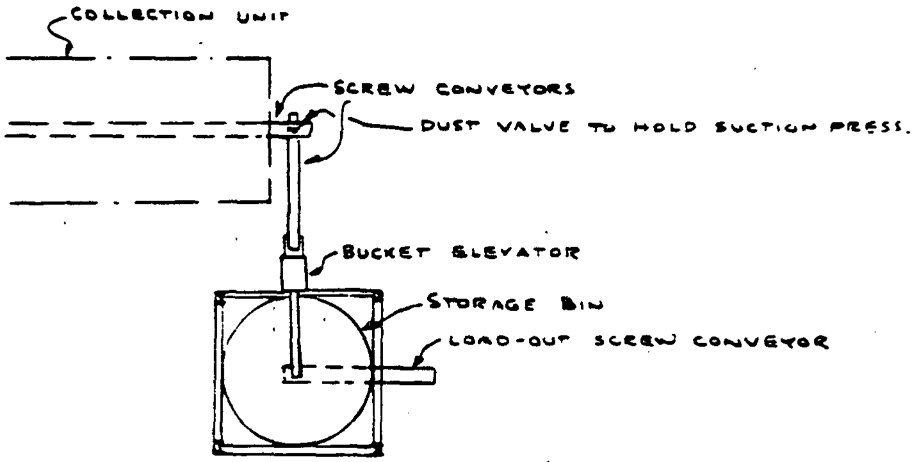
Module No. ____	Sheet 4 of 9

DESIGN DATA

PEDCo ENVIRONMENTAL DESCRIPTION Dust Handling DATE 1-28-78

PROJECT NO. 3315 BY TRAUB

DESIGN CRITERIA: For 3,72,125 Tons Per Day



COST ESTIMATE INCLUDES-

Screw Conveyors
Motor Operated Dust Valve(s)
Bucket Elevators
Chutes
Foundations
Electric Supply, Control & Wiring
Painting

Figure E-43. Dust handling module.

REFERENCES

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2. Standards Support and Environmental Impact Statement - An Investigation of the Best Systems of Emission Reduction for Pushing Operation on By-product Coke Ovens (Draft) U.S. Environmental Protection Agency OAQPS Research Triangle Park, North Carolina.

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12. Steiner, B.A., and R.J. Thompson, Metallurgical Applications of Wet Scrubbers. Journal of the Air Pollution Control Assoc. November 1977.

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APPENDIX F

SAMPLE COST ESTIMATE WORKSHEETS

SUMMARY

PEDCo ENVIRONMENTAL DESCRIPTION GAS COOLING DATE 10-26-77

PROJECT NO. 3315 60,000 ACFM (WATER QUENCH) BY TRAUB

DESCRIPTION	DETAIL SHEET	MATERIAL	LABOR	TOTAL
DIRECT COSTS				
1. Equipment	14	12600	11200	23800
2. Instrumentation	12	2500	840	3340
3. Piping	7	6700	3640	10340
4. Electrical	11	1500	1120	2620
5. Foundations	13	780	1560	2340
6. Structural	13	5640	994	6634
7. Sitework	14	—	240	240
8. Insulation	—	—	—	—
9. Painting	7	—	2200	2200
10. Buildings				
11.				
12.				
15. DIRECT SUB-TOTAL		29720	21794	51514
INDIRECT COSTS				
21. Field Overhead	15			10340
22. Contractor's Fee (10%)	—			6185
23. Engineering	16			34000
24. Freight	16			3000
25. Offsite	—			—
26. Taxes (5% x material)	—			1486
27. Allowance For Shake-down	16			1200
28. Spares	—			1800
29.				
30.				
31. INDIRECT SUB-TOTAL				58011
35. SUB-TOTAL				109525
41. Contingency (20% line 35)				20475
42.* Interest During Construction				
45. (Mid-1977 Costs) TOTAL				130,000

* Interest will be calculated on total system after assembling modules.

SUMMARY

PEDCo ENVIRONMENTAL	DESCRIPTION Gas Cooling	DATE 10-26-77	
PROJECT NO. 3315	250,000 ACFM (Water Quench)	BY Traub	

DESCRIPTION	DETAIL SHEET	MATERIAL	LABOR	TOTAL
DIRECT COSTS				
1. Equipment	14	54000	44800	98800
2. Instrumentation	12	2500	840	3340
3. Piping	8	17200	9100	26300
4. Electrical	11	3100	1680	4780
5. Foundations	13	2160	4320	6480
6. Structural	13	18680	3276	21956
7. Sitework	14	–	360	360
8. Insulation	–	–	–	–
9. Painting	7	–	9900	9900
10. Buildings				
11.				
12.				
15. DIRECT SUB-TOTAL		97640	74276	171916
INDIRECT COSTS				
21. Field Overhead	15			34112
22. Contractor's Fee (10%)	–			20603
23. Engineering	16			38000
24. Freight	16			5000
25. Offsite	–			–
26. Taxes (5% x material)	–			4882
27. Allowance For Shake-down	16			1200
28. Spares	–			1400
29.				
30.				
31. INDIRECT SUB-TOTAL				102598
35. SUB-TOTAL				274514
41. Contingency (20% line 35)				54486
42. Interest During Construction				
45. (Mid-1977 Costs) TOTAL				329,000

SUMMARY

PEDCo ENVIRONMENTAL DESCRIPTION Gas Cooling DATE 10-26-77

PROJECT NO. 3315 500,000 ACFM (Water Quench) BY Traub

DESCRIPTION	DETAIL SHEET	MATERIAL	LABOR	TOTAL
DIRECT COSTS				
1. Equipment	14	91500	78400	169900
2. Instrumentation	12	2500	840	3340
3. Piping	9	20000	11900	31900
4. Electrical	11	8600	3360	11960
5. Foundations	13	3720	7440	11160
6. Structural	13	25440	4452	29892
7. Sitework	14	—	600	600
8. Insulation	—	—	—	—
9. Painting	7	—	16500	16500
10. Buildings				
11. ______				
12. ______				
15. DIRECT SUB-TOTAL		151760	123492	275252
INDIRECT COSTS				
21. Field Overhead	15			56581
22. Contractor's Fee (10%)	—			33183
23. Engineering	16			40 000
24. Freight	16			8000
25. Offsite	—			—
26. Taxes (5% x material)				7588
27. Allowance For Shake-down	16			1200
28. Spares	—			1000
29. ______				
30. ______				
31. INDIRECT SUB-TOTAL				147552
35. SUB-TOTAL				422804
41. Contingency (20% line 35)				84096
42. Interest During Construction				
45. (Mid-1977 Costs) TOTAL				506,900

SUMMARY

PEDCo ENVIRONMENTAL DESCRIPTION Gas Cooling DATE 10-26-77

PROJECT NO. 3315 1,000,000 ACFM (Water Quench) BY Traub

DESCRIPTION	DETAIL SHEET	MATERIAL	LABOR	TOTAL
DIRECT COSTS				
1. Equipment	14	222000	168000	390 000
2. Instrumentation	12	2500	840	3340
3. Piping	10	42000	18200	60200
4. Electrical	12	14500	3780	18280
5. Foundations	13	6060	12120	18180
6. Structural	13	50160	8778	58928
7. Sitework	14	—	1200	1200
8. Insulation	—	—	-	—
9. Painting	7	—	41800	41800
10. Buildings				
11.				
12.				
15. DIRECT SUB-TOTAL		337200	254718	591918
INDIRECT COSTS				
21. Field Overhead	16			112857
22. Contractor's Fee	-			70478
23. Engineering	16			44000
24. Freight	16			17000
25. Offsite	—			—
26. Taxes (5% x material)	16			16860
27. Allowance For Shake-down				1200
28. Spares	—			2000
29.				
30.				
31. INDIRECT SUB-TOTAL				264395
35. SUB-TOTAL				856,313
41. Contingency (20% line 35)				173687
42. Interest During Construction				
45. (Mid-1977 Costs) TOTAL				1,030,000

Module No. 6 Sheet 5 of 16

DESIGN DATA

PEDCo ENVIRONMENTAL

PROJECT NO. 3315

DESCRIPTION Gas Cooling (Water Quench)

DATE 10-24-77

BY TRAUB

DESIGN CRITERIA: Following assumption used to develop general design parameters for estimating:

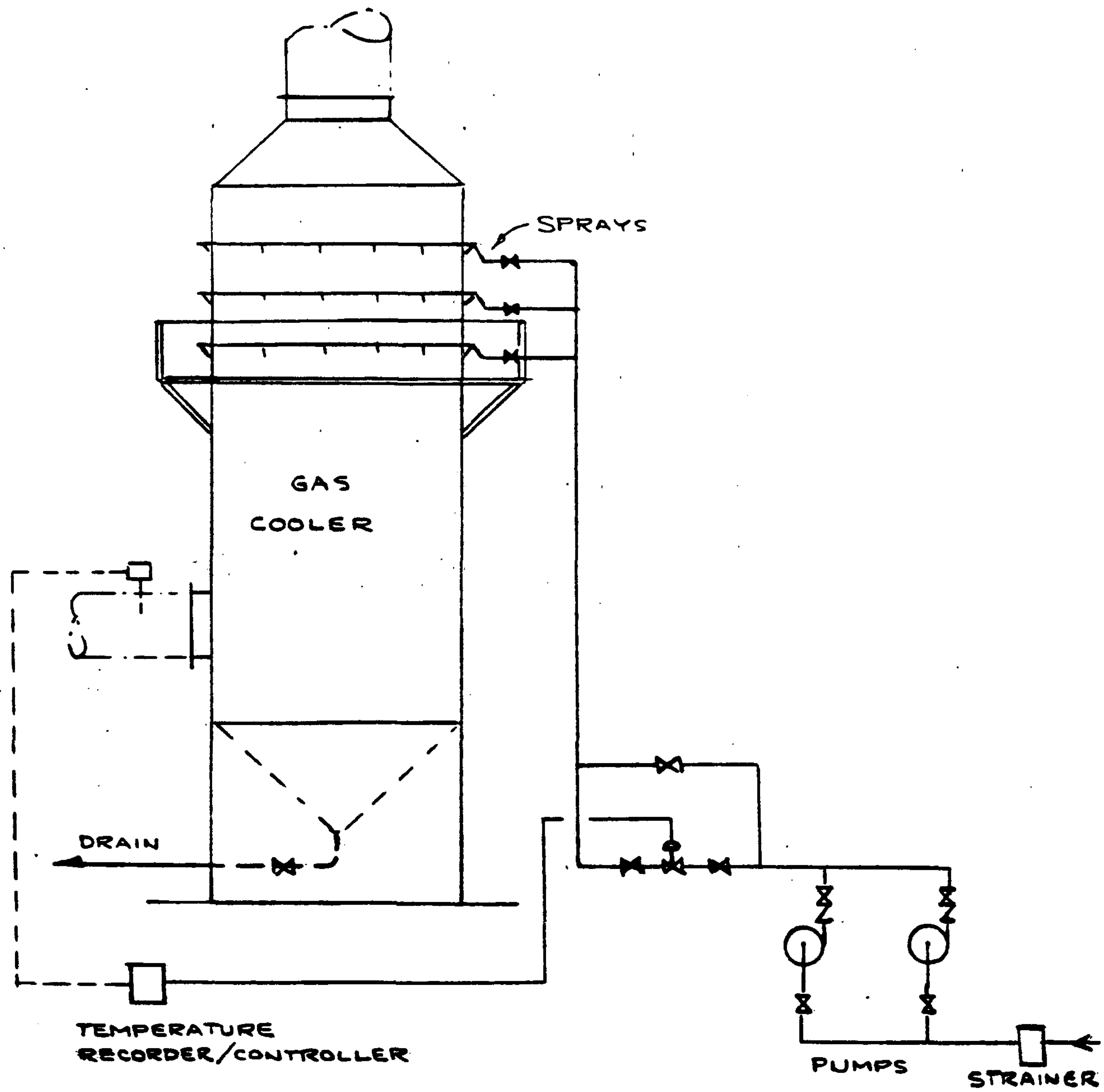
Flow - ACFM @ 2500°F in - 275°F out (based on air)

Velocity in ducts - 4000 FPM

Velocity thru cooler - 600 FPM

Cooling Water Temp - 90°F

Gases are not corrosive



DESIGN DATA

PEDCo ENVIRONMENTAL

PROJECT NO. 3315

DESCRIPTION GAS COOLING (WATER QUENCHING)

DATE 10-24-77

BY TRAUB

DESIGN CRITERIA:

	ACFM IN	DIA INLET	DIA OF COOLER	GAS ACFM OUT	VOLUME OF VAPOR	TOTAL VOLUME OUT	DIA. OUTLET
1	60,000	4'-5"	11'-4"	14900	13200	28,100	3'-0"
2	250,000	9'-0"	23'-0"	62100	55000	117,100	6'-2"
3	500,000	12'-8"	32'-8"	124,200	110,000	234,200	8'-8"
4	1,000,000	18'-0"	46'-0"	248,400	220,000	468,400	12'-3"

	WATER VAPOR LB/MIN	PUMP SIZE AT 200% VAPOR
1	436	105 GPM
2	1815	435 GPM
3	3630	870 GPM
4	7260	1740 GPM

DETAIL ESTIMATE Module No. 6 Sheet 7 of 16

PEDCo ENVIRONMENTAL
PROJECT NO. 3315

DESCRIPTION GAS COOLING (WATER QUENCHING)

DATE 10-25-77
BY TRAUB

DESCRIPTION	QUANTITY	UNITS	MATERIAL		LABOR			TOTAL
			UNIT PRICE	AMOUNT	MAN-HOURS	RATE	AMOUNT	
3 PIPING - (FOR 60,000 ACFM)								
PIPING INCL. HEADER (2")	200	FT	1.40	280	34			
GATE VALVES	8	—	32	256	12.			
CHECK "	2	—	45	90	3			
GLOBE "	1	—	60	60	1			
SPRAY NOZZLES	10	—	20	200	10			
DRAIN PIPING (6")	100	FT	5.93	593	35			
GATE VALVE 6"	1	—	261	261	3			
FLANGES 6"	3	—	21	63	9			
FITTINGS 2"	15	—	10	150	16			
FITTINGS 6"	4	-	30.	120	24			
PUMPS	2	—	1100	2200	16			
SUPPORTS	20	—	30	600	50			
STRAINER	1	—	200	200	2			
FLOW CONT VALVE	1	—	1150	1150	3			
MISC	ALLOWANCE			377	28			
CONTROL AIR PIPING	100	FT	100/100	100	14			
TOTAL				6700	260	14	3640	10340
9 PAINTING								
60,000 ACFM UNIT	2000	S.F	1.10 (M+L)	—	—	—	2200	2200
250,000 " "	9000	S.F	1.10	—	—	—	9900	9900
500,000 " "	15000	SF	1.10	—	—	-	16500	16500
1,000,000 " "	38000	SF	1.10	—	—	—	41800	41800

DETAIL ESTIMATE Module No. 6 Sheet 8 of 16

PEDCo ENVIRONMENTAL DESCRIPTION Gas Cooling (Water Quenching) DATE 10-25-77

PROJECT NO. 3315 BY Traub

DESCRIPTION	QUANTITY	UNITS	MATERIAL UNIT PRICE	MATERIAL AMOUNT	LABOR MAN-HOURS	LABOR RATE	LABOR AMOUNT	TOTAL
3 Piping (250,000 ACFM unit)								
Piping Incl. Header 6"	320	Ft	593	1900	112			
Gate Valves 6"	8	—	261	2088	18			
Glove Valve 6"	1	—	337	337	3			
Check Valves 6"	2	—	198	396	3			
Spray Nozzles	45	—	20	900	45			
Spray Piping 2"	100	Ft	1.40	140	20			
Flanges 6"	24	—	21	504	72			
Fittings 6"	15	—	30	450	90			
Supports	20	—	30	600	60			
Drain Piping 10"	100	Ft	12.25	1225	15			
Valve 10"	1	—	730	730	3			
Flanges 10"	3	—	63	189	13			
Fittings 10"	4	—	70	280	36			
Supports	6	—	40	240	24			
Strainer	1	—	1200	1200	20			
Flow Cont. Valve	—	1	2100	2100	5			
Control Air Piping	100	Ft	100/100 Ft	100	14			
Misc	Allowance			621	47			
Pumps	2	—	1600	3200	50			
				17200	650	14	9100	26300

DETAIL ESTIMATE Module No. 6 Sheet 9 of 16

PEDCo ENVIRONMENTAL DESCRIPTION Gas Cooling DATE 10-25-77
PROJECT NO. 3315 (Water Quench) BY Traub

DESCRIPTION	QUANTITY	UNITS	MATERIAL		LABOR			TOTAL
			UNIT PRICE	AMOUNT	MAN-HOURS	RATE	AMOUNT	
3. Piping (For 500 000 ACFM)								
Piping To Header 6"	200	Ft	5 93	1200	70			
Header Piping 2"	450	Ft	1.40	630	76			
Spray Piping 2"	150	–	1.40	210	26			
Sprays	90	–	20	1800	90			
Gate Valves 6"	6	–	261	1566	13			
Globe " 6"	1	–	337	337	3			
Check " 6"	2	–	198	396	3			
Fittings 6"	12	–	30	360	72			
Pumps	2	–	2000	4000	66			
Strainer	1	–	1200	1200	20			
Flanges	18	–	21	378	54			
Drain Piping 12"	100	Ft	13	1300	15			
Valve 12"	1	–	1100	1100	4			
Flanges 12"	3	–	90	270	16			
Fittings 12"	4	–	90	360	42			
Flow Cont. Valve 12"	1	–	2500	2500	5			
Control Air Piping	100	Ft	100/100	100	14			
Supports	50	–	30	1500	200			
Misc	Allowance			793	61			
				20,000	850	14	11900	31900

PEDCo ENVIRONMENTAL
PROJECT NO. 3315

DESCRIPTION: Gas Cooling (Water Quench)

DATE 10-25-77
BY Traub

DESCRIPTION		QUANTITY	UNITS	MATERIAL		LABOR			TOTAL
				UNIT PRICE	AMOUNT	MAN-HOURS	RATE	AMOUNT	
3 Piping (For 1,000,000 ACFM)									
Piping to Headers	10"	240	Ft	12.25	2940	40			
Spray Headers	4"	600	Ft	3.53	2118	150			
Spray Piping	2"	300	Ft	1.40	420	60			
Fittings	2"	180	–	10	1800	180			
Sprays		180	–	20	3600	120			
Gate Valves	10"	6	–	730	4380	18			
Globe "	10"	1	–	900	900	4			
Check "	10"	2	–	680	1360	5			
Flanges	10"	22	–	63	1386	66			
Strainer		1	–	1800	1800	24			
Pumps		2	–	3000	6000	14			
Control Valve		1	–	5000	5000	6			
Supports		60	–	40	2400	240			
Drain Piping	14"	100	–	17	1700	16			
Gate Valve	14"	1	–	1608	1608	4			
Fittings	14"	4	–	130	520	50			
Flanges	14"	3	–	124	372	19			
Supports		6	–	60	360	30			
Control Air Piping		100	Ft	100/100	100	14			
Spray Header Valves	4"	5	–	165	825	9			
" " Flanges		10		11	110	15			
Misc		Allowance			2301	156			
					42000	1300	14	18200	60200

DETAIL ESTIMATE Module No. 6 Sheet 11 of 16

PEDCo ENVIRONMENTAL DESCRIPTION Gas Cooling (Water Quench) DATE 10-26-77
PROJECT NO. 3315 BY Traub

DESCRIPTION	QUANTITY	UNITS	MATERIAL UNIT PRICE	MATERIAL AMOUNT	LABOR MAN-HOURS	LABOR RATE	LABOR AMOUNT	TOTAL
4 Electrical (60,000 ACFM)								
Motor 2-10HP	2		400	800	8			
Starter	2	–	60	120	6			
Switch	2	–	40	80	2			
Conduit Run & Wiring	200	Ft	1.10	220	32			
Supports & Misc	Allow.			280	32			
Total				1500	80	14	1120	2620
4 Electrical (250,000 ACFM)								
Motor 2-30-HP	2	–	900	1800	16			
Starter	2	–	197	394	14			
Switch	2	–	90	180	4			
Conduit & Wiring	200	Ft	1.90	380	46			
Supports & Misc	Allow.			346	40			
Total				3100	120	14	1680	4780
4 Electrical (500,000 ACFM)								
Motor 2-75HP	2	–	3000	6000	32			
Starter	2	–	445	890	20			
Switch	2		127	254	10			
Conduit & Wiring	200	Ft	3.80	760	90			
Supports & Misc	Allow			696	88			
Total				8600	240	14	3360	11960

DETAIL ESTIMATE Module No. 6 Sheet 12 of 16

PEDCo ENVIRONMENTAL DESCRIPTION GAS COOLING (WATER QUENCH) DATE 10-26-77

PROJECT NO. 3315 BY TRAUB

DESCRIPTION	QUANTITY	UNITS	MATERIAL UNIT PRICE	MATERIAL AMOUNT	LABOR MAN-HOURS	LABOR RATE	LABOR AMOUNT	TOTAL
1 ELECTRICAL (1,000,000 ACFM)								
MOTOR 2-125HP	2	-	5000	10000	48			
STARTER	2	2	700	1400	24			
SWITCH	2	2	400	800	20			
CONDUIT & WIRING	200	FT	6.70	1340	92			
SUPPORTS & MISC	ALLOWANCE			960	86			
				14500	270	14	3780	18280
2 INSTRUMENTATION								
THERMOCOUPLE INSTALL.	1	—	40	40	2			
TEMP. TRANSMITTER	1	—	800	800	11			
RECORDER / CONTROLLER	1	—	1300	1300	15			
CONDUIT & CABLE	100	FT	50/100	50	8			
110 V SUPPLY	100	FT	160/100	70	10			
SUPPORT & MISC.	ALLOWANCE			240	14			
				2500	60	14	840	3340

DETAIL ESTIMATE Module No. 6 Sheet 13 of 16

PEDCo ENVIRONMENTAL DESCRIPTION GAS COOLING (WATER QUENCH) DATE 10.26.77
PROJECT NO. 3315 BY TRAUB

DESCRIPTION	QUANTITY	UNITS	MATERIAL		LABOR			TOTAL
			UNIT PRICE	AMOUNT	MAN-HOURS	RATE	AMOUNT	
6 STRUCTURAL (60,000 ACFM)								
PLATFORM 51 x 100 #/	5100	LBS	1.00	5100	64			
LADDER 30' x 18 #/	540	"	1.00	540	7			
TOTAL				5640	71	14	994	6634
6 STRUCTURAL (250,000 ACFM)								
PLATFORM (2) x 100#/ x 88	17600	LBS	1.00	17600	220			
LADDER 60 x 18 #/	1080	LBS	1.00	1080	14			
TOTAL				18680	234	14	3276	21956
6 STRUCTURAL (500,000 ACFM)								
PLATFORM (2) x 100#/ x 120	24000	LBS	1.00	24000	300			
LADDER 80 x 18 #/	1440	LBS	1.00	1440	18			
TOTAL				25440	318	14	4452	29892
6 STRUCTURAL (1,000,000 ACFM)								
PLATFORM (3) x 100#/ x 160	48000	LBS	1.00	48000	600			
LADDER 120 x 18 #/	2160	LBS	1.00	2160	27			
TOTAL				50160	627	14	8778	58938
5 FOUNDATIONS FOR COOLER, PUMPS, STRAINER								
60,000 ACFM UNIT	13	C.Y.	60	780	130	12	1560	2340
250,000 " "	36	C.Y.	60	2160	360	12	4320	6480
500,000 " "	62	CY	60	3720	620	12	7440	11160
1,000,000 " "	101	CY	60	6060	1010	12	12120	18180

DETAIL ESTIMATE Module No. 6 Sheet 14 of 16

PEDCo ENVIRONMENTAL DESCRIPTION Gas Cooling (Water Quench) DATE 10-26-77

PROJECT NO. 3315 BY TRAUB

DESCRIPTION	QUANTITY	UNITS	MATERIAL		LABOR			TOTAL
			UNIT PRICE	AMOUNT	MAN-HOURS	RATE	AMOUNT	
1. Equipment – Cooler								
60,000 ACFM Unit	21000	LBS	.60	12600	800	14	11200	23800
250 000 " "	90,000	LBS	.60	54000	3200	14	44800	98800
500,000 " "	152,500	LBS	.60	91500	5600	14	78400	169900
1,000,000 " "	370000	LBS	.60	222000	12000	14	168000	390,000
7 Sitework								
60,000 ACFM Unit	Allowance				20	12	240	240
250,000 " "	"				30	12	360	360
500,000 " "	"				50	12	600	600
1,000,000 " "	"				100	12	1200	1200

DETAIL ESTIMATE Module No. 6 Sheet 15 of 16

PEDCo ENVIRONMENTAL DESCRIPTION Gas Cooling (Water Quench) DATE 10-26-77
PROJECT NO. 3315 BY Traub

DESCRIPTION	QUANTITY	UNITS	MATERIAL UNIT PRICE	MATERIAL AMOUNT	LABOR MAN-HOURS	LABOR RATE	LABOR AMOUNT	TOTAL
21 Overhead (60,000 ACFM)								
Inst. & Piping					320	7.80		2496
Electrical					80	6.88		550
Foundations					130	5.23		680
Structural					871	7.50		6533
Sitework					20	4.06		81
Total								10340
21 Overhead (250,000 ACFM)								
					710	7.80		5538
Ditto Above					120	6.88		826
					360	5.23		1872
					3434	7.50		25755
					30	4.06		122
Total								34113
21 Overhead (500,000 ACFM)								
					910	7.80		7098
Ditto Above					240	6.82		1652
					620	5.23		3243
					5918	7.50		44385
					50	4.06		203
Total								56581

DETAIL ESTIMATE Module No. 6 Sheet 16 of 16

PEDCo ENVIRONMENTAL PROJECT NO. 3315

DESCRIPTION Gas Cooling (Water Quench)

DATE 10.26.77

BY Traub

DESCRIPTION	QUANTITY	UNITS	MATERIAL		LABOR			TOTAL
			UNIT PRICE	AMOUNT	MAN-HOURS	RATE	AMOUNT	
21 Overhead (1,000,000 ACFM)								
Inst. & Piping					1360	7.80	10608	
Electrical					270	6.88	1858	
Foundations					1010	5.23	5282	
Structural					12627	7.50	94703	
Sitework					100	4.06	406	
Total							112857	
23 Engineering								
60,000 ACFM Unit	12	DWGS			1200	20	+ 10,000	34000
250,000 " "	14	"			1400	20	For	38000
500,000 " "	15	"			1500	20	Engrs	40000
1,000,000 " "	17	"			1700	20		44000
24 Freight								
60,000 ACFM Unit	3	Trucks	@ 720	+ 840 Misc				3000
250,000 " "	5	"	" "	+ 1400 "				5000
500,000 " "	9	"	" "	+ 1620 "				8000
1,000,000 " "	20	"	" "	+ 2600 "				17000
27 Shake-down	Allowance				60	20		1200

APPENDIX G

EXAMPLE COMPUTER COST PRINTOUT

SINTER PLANT WINDBOX CONTROL

BACT TECHNOLOGY LEVEL

THREE PLANT SIZES

GENERAL INFORMATION:

		UNITS	
PPSES: 401.	SINTER WINDBOX	SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

PARTICULATE

LOAD IN:	4.300 LBS/TON	.256 GRS/SCF	
ALLOWABLE:	.333 LBS/TON	.020 GRS/SCF	EFFICIENCY: 92.3%
	25.71 LBS/HR		

SULFUR DIOXIDE

LOAD IN:	1.800 LBS/TON	
ALLOWABLE:	1.800 LBS/TON	EFFICIENCY: .0%
	138.99 LBS/HR	

HYDROCARBONS

LOAD IN:	.240 LBS/TON	
ALLOWABLE:	.240 LBS/TON	EFFICIENCY: .0%
	18.53 LBS/HR	

DUST COLLECTED PER DAY: 3.3 TONS(DRY)

TEMP OUT OF PROCESS: 300. F
EXHAUST TEMPERATURE: 100. F

SCFM FLOW: 150000. AT 70. F
ACFM FLOW: 159000. AT 100. F

L/G RATIO: 7.9
PROCESS WATER FLOW: 1190. GPM
COOLING WATER FLOW: 0. GPM
SUSPENDED SOLIDS OUT: 515. MG/L %SOLIDS: .1

CONTROL SYSTEM CONFIGURATION:

- VENTURI SCRUBBER
- MIST ELIMINATOR
- FAN AND DRIVE
- DUCTWORK
- WASTEWATER RECYCLE SYSTEM
- DAMPERS
- OPACITY MONITOR
- WASTE WATER RETURN SYSTEM
- WATER PUMPING SYSTEM
- FAN AND DRIVE ELECTRICAL

FEET OF ADDITIONAL DUCT: 100. DIAMETER: 7.
TOTAL PRESSURE DROP: 90. INCHES
3 FANS @ 1677. HP EACH SPARE FAN CAPACITY: 50.%
OPERATING HOURS AT FULL HP: 7900.
OPERATING HOURS AT REDUCED HP: 0.
STACK HEIGHT: 0. DIAMETER: 0.

CAPITAL COST:

PROCESS: 401. SINTER WINDBOX   UNITS: SINTER   TECHNOLOGY LEVEL: BACT

CAPACITY: .810 MILLION TONS/YEAR

MODULES: 1.00   S.S. VENTURI SCRUBBER

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	296400.	
INSTRUMENTATION	12400.	
PIPING	6800.	
ELECTRICAL	2900.	
FOUNDATIONS	1200.	
STRUCTURAL	11100.	
SITE WORK	200.	
INSULATION	0.	
PROTECTIVE COATING	1200.	
BUILDINGS	7700.	
EQUIPMENT/MATERIAL LABOR	76800.	
DIRECT COST SUBTOTAL		418700.
*** INDIRECT COST ***		
FIELD OVERHEAD	49500.	
CONTRACTORS FEE	17200.	
ENGINEERING	34200.	
FREIGHT	4900.	
OFFSITE WORK	11700.	
TAXES	15400.	
SHAKEDOWN	15100.	
SPARES	15400.	
CONTINGENCY	106900.	
INDIRECT COST SUBTOTAL		272300.
INTEREST DURING INSTALLATION		50500.
TOTAL COST		741500.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		815600.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

MODULES: 1.00 S.S. BLADE TYPE MIST ELIMINATOR

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	37400.	
INSTRUMENTATION	2200.	
PIPING	7800.	
ELECTRICAL	600.	
FOUNDATIONS	1200.	
STRUCTURAL	10400.	
SITE WORK	300.	
INSULATION	0.	
PROTECTIVE COATING	800.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	5300.	
DIRECT COST SUBTOTAL		66000.
*** INDIRECT COST ***		
FIELD OVERHEAD	6300.	
CONTRACTORS FEE	3500.	
ENGINEERING	8000.	
FREIGHT	1400.	
OFFSITE WORK	0.	
TAXES	2800.	
SHAKEDOWN	400.	
SPARES	0.	
CONTINGENCY	18900.	
INDIRECT COST SUBTOTAL		41300.
INTEREST DURING INSTALLATION		2700.
TOTAL COST		110000.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		121000.

CAPITAL COST:

PROCESS: 401. SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

MODULES: 5.00 FAN AND DRIVE (801-2000 BHP)

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	444500.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	31600.	
STRUCTURAL	8100.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	3000.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	17900.	
DIRECT COST SUBTOTAL		505100.
*** INDIRECT COST ***		
FIELD OVERHEAD	20500.	
CONTRACTORS FEE	6100.	
ENGINEERING	2700.	
FREIGHT	2600.	
OFFSITE WORK	0.	
TAXES	21300.	
SHAKEDOWN	25500.	
SPARES	0.	
CONTINGENCY	111400.	
INDIRECT COST SUBTOTAL		190100.
INTEREST DURING INSTALLATION		34800.
TOTAL COST		730000.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		803000.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

MODULES: 1.00 C.S. DUCTWORK UNLINED - 100 FT.

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	29600.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	0.	
STRUCTURAL	0.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	0.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	12300.	
DIRECT COST SUBTOTAL		41900.
*** INDIRECT COST ***		
FIELD OVERHEAD	2700.	
CONTRACTORS FEE	1500.	
ENGINEERING	4500.	
FREIGHT	3900.	
OFFSITE WORK	0.	
TAXES	1600.	
SHAKEDOWN	0.	
SPARES	0.	
CONTINGENCY	12000.	
INDIRECT COST SUBTOTAL		26200.
INTEREST DURING INSTALLATION		2400.
TOTAL COST		70500.
RETROFIT MULTIPLIER		1.6
TOTAL COST WITH RETROFIT		112800.

CAPITAL COST:

PPSPS: 401. SINTER WINDBOX   UNITS SINTER   TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

MODULES: 1.00 WASTEWATER RECYCLE SYSTEM

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	384200.	
INSTRUMENTATION	1387400.	
PIPING	1400.	
ELECTRICAL	2100.	
FOUNDATIONS	400.	
STRUCTURAL	700.	
SITE WORK	100.	
INSULATION	200.	
PROTECTIVE COATING	200.	
BUILDINGS	200.	
EQUIPMENT/MATERIAL LABOR	1400.	
DIRECT COST SUBTOTAL		1778300.
*** INDIRECT COST ***		
FIELD OVERHEAD	1800.	
CONTRACTORS FEE	900.	
ENGINEERING	1800.	
FREIGHT	400.	
OFFSITE WORK	300.	
TAXES	400.	
SHAKEDOWN	600.	
SPARES	600.	
CONTINGENCY	3700.	
INDIRECT COST SUBTOTAL		10500.
INTEREST DURING INSTALLATION		178900.
TOTAL COST		1967700.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		2164500.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: .510 MILLION TONS/YEAR

MODULES: 5.00 C.S. DAMPER GT. 7 FT. DIAMETER

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	53700.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	0.	
STRUCTURAL	0.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	0.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	10400.	
DIRECT COST SUBTOTAL		64100.
*** INDIRECT COST ***		
FIELD OVERHEAD	5600.	
CONTRACTORS FEE	2400.	
ENGINEERING	1000.	
FREIGHT	3500.	
OFFSITE WORK	0.	
TAXES	4700.	
SHAKEDOWN	2400.	
SPARES	3400.	
CONTINGENCY	29600.	
INDIRECT COST SUBTOTAL		52600.
INTEREST DURING INSTALLATION		4000.
TOTAL COST		120700.
RETROFIT MULTIPLIER		1.0
TOTAL COST WITH RETROFIT		120700.

CAPITAL COST:

PESFS: 401. SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

MODULES: 1.00 OPACITY MONITOR

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	7000.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	3700.	
FOUNDATIONS	0.	
STRUCTURAL	8200.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	700.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	1000.	
DIRECT COST SUBTOTAL		20600.
*** INDIRECT COST ***		
FIELD OVERHEAD	2500.	
CONTRACTORS FEE	1500.	
ENGINEERING	4800.	
FREIGHT	300.	
OFFSITE WORK	400.	
TAXES	800.	
SHAKEDOWN	400.	
SPARES	500.	
CONTINGENCY	6300.	
INDIRECT COST SUBTOTAL		17500.
INTEREST DURING INSTALLATION		400.
TOTAL COST		38500.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		42400.

CAPITAL COST:

PPSES: 401.	SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

MODULES: 1.00 WASTE WATER RETURN SYSTEM

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	35000.	
INSTRUMENTATION	0.	
PIPING	16700.	
ELECTRICAL	27100.	
FOUNDATIONS	1600.	
STRUCTURAL	0.	
SITE WORK	1200.	
INSULATION	0.	
PROTECTIVE COATING	1100.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	1600.	
DIRECT COST SUBTOTAL		82300.
*** INDIRECT COST ***		
FIELD OVERHEAD	8100.	
CONTRACTORS FEE	5700.	
ENGINEERING	13700.	
FREIGHT	1200.	
OFFSITE WORK	2400.	
TAXES	3200.	
SHAKEDOWN	4100.	
SPARES	4100.	
CONTINGENCY	24600.	
INDIRECT COST SUBTOTAL		67100.
INTEREST DURING INSTALLATION		7500.
TOTAL COST		156900.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		172600.

CAPITAL COST:

PPSES: 401.	SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

MODULES: 1.00 WATER PUMPING SYSTEM (< 1500GPM)

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	16800.	
INSTRUMENTATION	3500.	
PIPING	8500.	
ELECTRICAL	4700.	
FOUNDATIONS	400.	
STRUCTURAL	0.	
SITE WORK	500.	
INSULATION	0.	
PROTECTIVE COATING	600.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	300.	
DIRECT COST SUBTOTAL		35300.
*** INDIRECT COST ***		
FIELD OVERHEAD	3300.	
CONTRACTORS FEE	1900.	
ENGINEERING	9000.	
FREIGHT	300.	
OFFSITE WORK	600.	
TAXES	700.	
SHAKEDOWN	1000.	
SPARES	1000.	
CONTINGENCY	7400.	
INDIRECT COST SUBTOTAL		25200.
INTEREST DURING INSTALLATION		3000.
TOTAL COST		63500.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		69900.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

MODULES: 3.00 FAN AND DRIVE ELECTRICAL (> 150 BHP)

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	85100.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	0.	
STRUCTURAL	0.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	0.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	29700.	
DIRECT COST SUBTOTAL		114800.
*** INDIRECT COST ***		
FIELD OVERHEAD	14700.	
CONTRACTORS FEE	14900.	
ENGINEERING	7500.	
FREIGHT	1700.	
OFFSITE WORK	4000.	
TAXES	5200.	
SHAKEDOWN	6700.	
SPARES	6700.	
CONTINGENCY	43100.	
INDIRECT COST SUBTOTAL		104500.
INTEREST DURING INSTALLATION		16900.
TOTAL COST		236200.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		259800.

CAPITAL COSTS

PPSFS: 401. SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

TOTAL COST

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	1387700.	
INSTRUMENTATION	1405500.	
PIPING	41200.	
ELECTRICAL	41100.	
FOUNDATIONS	36400.	
STRUCTURAL	36500.	
SITE WORK	2300.	
INSULATION	200.	
PROTECTIVE COATING	7600.	
BUILDINGS	7900.	
EQUIPMENT/MATERIAL LABOR	156700.	
DIRECT COST SUBTOTAL		3127100.
*** INDIRECT COST ***		
FIELD OVERHEAD	115000.	
CONTRACTORS FEE	57600.	
ENGINEERING	87200.	
FREIGHT	20200.	
OFFSITE WORK	19400.	
TAXES	56100.	
SHAKEDOWN	54200.	
SPARES	31700.	
CONTINGENCY	365900.	
INDIRECT COST SUBTOTAL		807300.
INTEREST DURING INSTALLATION		301100.
TOTAL COST		4235500.
TOTAL COST WITH RETROFIT		4682300.

OPERATING COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: .610 MILLION TONS/YEAR

CATEGORY	QUANTITY	RATE	ANNUAL COST ($)
	*** UTILITIES ***		
WATER	112643. KGAL/YR	$ .1450/1000 GAL	16400.
ELECTRICITY	15623474. KWH/YR	$ .0242/KWH	378100.
STEAM	0. MLBS/YR	$ 3.7200/MLBS	0.
FUEL	0. GAL/YR	$ .3800/GAL	0.
	*** OPERATING LABOR ***		
DIRECT	8760. HRS/YR	$13.04/HR	114200.
SUPERVISION	1752. HRS/YR	$15.64/HR	27400.
	*** MAINTENANCE & SUPPLIES ***		
DIRECT LABOR	12116. HRS/YR	$13.04/HR	158000.
SUPERVISION	2424. HRS/YR	$15.64/HR	37900.
MATERIALS			131200.
SUPPLIES			49100.
WATER TREATMENT			187700.

DIRECT OPERATING COST	1100000.
INDIRECT OPERATING COST	340447.
TOTAL OPERATING COST	1440447.
OPERATING COST IN DOLLARS PER TON PRODUCTION	2.36
OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED	1190.52
OPERATING COST AS PERCENT OF CAPITAL COST	30.8
INSTALLATION TIME IN WEEKS	104.
ESTIMATED LIFE OF SYSTEM IN YEARS	15.
KWH PER TON CAPACITY	25.6

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GENERAL INFORMATION:
                                                          UNITS
    PPSES:  401.    SINTER WINDBOX                       SINTER       TECHNOLOGY LEVEL: BACT

    CAPACITY:              1.375 MILLION TONS/YEAR

    PARTICULATE
         LOAD IN:          4.300 LBS/TON          .303 GRS/SCF
         ALLOWABLE:         .284 LBS/TON          .020 GRS/SCF     EFFICIENCY:  93.4%
                          49.37  LBS/HR

    SULFUR DIOXIDE
         LOAD IN:          1.800 LBS/TON
         ALLOWABLE:        1.800 LBS/TON                           EFFICIENCY:    .0%
                         313.29  LBS/HR

    HYDROCARBONS
         LOAD IN:           .240 LBS/TON
         ALLOWABLE:         .240 LBS/TON                           EFFICIENCY:    .0%
                          41.77  LBS/HR

    DUST COLLECTED PER DAY:        7.6 TONS(DRY)

    TEMP OUT OF PROCESS:          300. F
    EXHAUST TEMPERATURE:          100. F

    SCFM FLOW:  288000.    AT     70. F
    ACFM FLOW:  305000.    AT    100. F

    L/G RATIO:                     7.9
    PROCESS WATER FLOW:          2285. GPM
    COOLING WATER FLOW:            0. GPM
    SUSPENDED SOLIDS DOWN:        812. MG/L      %SOLIDS:     .1


    CONTROL SYSTEM CONFIGURATION:

         VENTURI SCRUBBER
         MIST ELIMINATOR
         FAN AND DRIVE
         DUCTWORK
         WASTEWATER RECYCLE SYSTEM
         DAMPERS
         OPACITY MONITOR
         WASTE WATER RETURN SYSTEM
         WATER PUMPING SYSTEM
         FAN AND DRIVE ELECTRICAL


    FEET OF ADDITIONAL DUCT:           150.     DIAMETER: 10.
    TOTAL PRESSURE DROP:                40. INCHES
    3 FANS @ 3600. HP EACH        SPARE FAN CAPACITY:  50.%
    OPERATING HOURS AT FULL HP:     7900.
    OPERATING HOURS AT REDUCED HP:      0.
    STACK HEIGHT:                       0.     DIAMETER:  0.
```

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 1.375 MILLION TONS/YEAR

MODULES: 1.00 S.S. VENTURI SCRUBBER

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	465000.	
INSTRUMENTATION	12400.	
PIPING	9800.	
ELECTRICAL	2900.	
FOUNDATIONS	1800.	
STRUCTURAL	16000.	
SITE WORK	200.	
INSULATION	0.	
PROTECTIVE COATINGS	1800.	
BUILDINGS	11100.	
EQUIPMENT/MATERIAL LABOR	113900.	
DIRECT COST SUBTOTAL		634900.
*** INDIRECT COST ***		
FIELD OVERHEAD	71700.	
CONTRACTORS FEE	24900.	
ENGINEERING	49400.	
FREIGHT	7100.	
OFFSITE WORK	16900.	
TAXES	22300.	
SHAKEDOWN	21800.	
SPARES	22300.	
CONTINGENCY	157500.	
INDIRECT COST SUBTOTAL		393900.
INTEREST DURING INSTALLATION		75200.
TOTAL COST		1104000.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		1214400.

CAPITAL COST:

ARSES: 401. SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL= BACT

CAPACITY: 1.375 MILLION TONS/YEAR

MODULES: 1.00 S.S. BLADE TYPE MIST ELIMINATOR

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	57500.	
INSTRUMENTATION	2200.	
PIPING	10700.	
ELECTRICAL	600.	
FOUNDATIONS	1700.	
STRUCTURAL	14300.	
SITE WORK	500.	
INSULATION	0.	
PROTECTIVE COATING	1100.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	7400.	
DIRECT COST SUBTOTAL		96000.
*** INDIRECT COST ***		
FIELD OVERHEAD	8700.	
CONTRACTORS FEE	4900.	
ENGINEERING	8000.	
FREIGHT	2000.	
OFFSITE WORK	0.	
TAXES	3800.	
SHAKEDOWN	400.	
SPARES	0.	
CONTINGENCY	26000.	
INDIRECT COST SUBTOTAL		53800.
INTEREST DURING INSTALLATION		3700.
TOTAL COST		153500.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		168900.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: 1.375 MILLION TONS/YEAR

MODULES: 3.00 FAN AND DRIVE (2001- BHP)

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT IN MATERIAL	687300.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	36000.	
STRUCTURAL	10700.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	2900.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	16000.	
DIRECT COST SUBTOTAL		756900.
*** INDIRECT COST ***		
FIELD OVERHEAD	22700.	
CONTRACTORS FEE	9300.	
ENGINEERING	2700.	
FREIGHT	2600.	
OFFSITE WORK	0.	
TAXES	33400.	
SHAKEDOWN	36000.	
SPARES	0.	
CONTINGENCY	163500.	
INDIRECT COST SUBTOTAL		270400.
INTEREST DURING INSTALLATION		79000.
TOTAL COST		1106300.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		1216900.

CAPITAL COSTS:

FPSFS: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 1.375 MILLION TONS/YEAR

MODULES: 1.50 — C.S. DUCTWORK UNLINED - 100 FT.

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	61900.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	0.	
STRUCTURAL	0.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	0.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	25200.	
DIRECT COST SUBTOTAL		87100.
*** INDIRECT COST ***		
FIELD OVERHEAD	5500.	
CONTRACTORS FEE	3200.	
ENGINEERING	4500.	
FREIGHT	8000.	
OFFSITE WORK	0.	
TAXES	3400.	
SHAKEDOWN	0.	
SPARES	0.	
CONTINGENCY	24600.	
INDIRECT COST SUBTOTAL		49200.
INTEREST DURING INSTALLATION		4700.
TOTAL COST		141000.
RETROFIT MULTIPLIER		1.6
TOTAL COST WITH RETROFIT		225600.

CAPITAL COST:

PPSFS: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 1.375 MILLION TONS/YEAR

MODULES: 1.00 WASTEWATER RECYCLE SYSTEM

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	538600.	
INSTRUMENTATION	1773600.	
PIPING	1700.	
ELECTRICAL	2700.	
FOUNDATIONS	600.	
STRUCTURAL	800.	
SITE WORK	100.	
INSULATION	200.	
PROTECTIVE COATING	200.	
BUILDINGS	300.	
EQUIPMENT/MATERIAL LABOR	1800.	
DIRECT COST SUBTOTAL		2320600.
*** INDIRECT COST ***		
FIELD OVERHEAD	2400.	
CONTRACTORS FEE	1100.	
ENGINEERING	2200.	
FREIGHT	400.	
OFFSITE WORK	400.	
TAXES	500.	
SHAKEDOWN	700.	
SPARES	700.	
CONTINGENCY	4700.	
INDIRECT COST SUBTOTAL		13100.
INTEREST DURING INSTALLATION		233400.
TOTAL COST		2567100.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		2823800.

CAPITAL COST:

PROCESS: 401. SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: 1.375 MILLION TONS/YEAR

MODULES: 5.00 C.S. DAMPER 61. / FT. DIAMETER

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	79500.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	0.	
STRUCTURAL	0.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	0.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	12600.	
DIRECT COST SUBTOTAL		91900.
*** INDIRECT COST ***		
FIELD OVERHEAD	6800.	
CONTRACTORS FEE	2900.	
ENGINEERING	1000.	
FREIGHT	4300.	
OFFSITE WORK	0.	
TAXES	5700.	
SHAKEDOWN	2400.	
SPARES	4100.	
CONTINGENCY	36100.	
INDIRECT COST SUBTOTAL		63300.
INTEREST DURING INSTALLATION		5400.
TOTAL COST		160600.
RETROFIT MULTIPLIER		1.0
TOTAL COST WITH RETROFIT		160600.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 1.375 MILLION TONS/YEAR

MODULES: 1.00 OPACITY MONITOR

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	7000.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	3700.	
FOUNDATIONS	0.	
STRUCTURAL	8200.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	700.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	1000.	
DIRECT COST SUBTOTAL		20600.
*** INDIRECT COST ***		
FIELD OVERHEAD	2500.	
CONTRACTORS FEE	1500.	
ENGINEERING	4800.	
FREIGHT	300.	
OFFSITE WORK	400.	
TAXES	800.	
SHAKEDOWN	400.	
SPARES	500.	
CONTINGENCY	6300.	
INDIRECT COST SUBTOTAL		17500.
INTEREST DURING INSTALLATION		400.
TOTAL COST		38500.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		42400.

CAPITAL COST:

PSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BAT1

CAPACITY: 1.375 MILLION TONS/YEAR

MODULES: 1.00 WASTE WATER RETURN SYSTEM

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	52300.	
INSTRUMENTATION	0.	
PIPING	24300.	
ELECTRICAL	39500.	
FOUNDATIONS	2300.	
STRUCTURAL	0.	
SITE WORK	1700.	
INSULATION	0.	
PROTECTIVE COATING	1500.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	2300.	
DIRECT COST SUBTOTAL		123900.
*** INDIRECT COST ***		
FIELD OVERHEAD	11800.	
CONTRACTORS FEE	6300.	
ENGINEERING	19900.	
FREIGHT	1800.	
OFFSITE WORK	5600.	
TAXES	4700.	
SHAKEDOWN	5900.	
SPARES	5900.	
CONTINGENCY	35900.	
INDIRECT COST SUBTOTAL		97800.
INTEREST DURING INSTALLATION		11100.
TOTAL COST		232800.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		256100.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 1.375 MILLION TONS/YEAR

MODULES: 1.00 WATER PUMPING SYSTEM (< 1500GPM)

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	25400.	
INSTRUMENTATION	3500.	
PIPING	11800.	
ELECTRICAL	6500.	
FOUNDATIONS	600.	
STRUCTURAL	0.	
SITE WORK	500.	
INSULATION	0.	
PROTECTIVE COATING	800.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	500.	
DIRECT COST SUBTOTAL		49600.
*** INDIRECT COST ***		
FIELD OVERHEAD	4500.	
CONTRACTORS FEE	2700.	
ENGINEERING	9000.	
FREIGHT	400.	
OFFSITE WORK	900.	
TAXES	1000.	
SHAKEDOWN	1400.	
SPARES	1400.	
CONTINGENCY	10200.	
INDIRECT COST SUBTOTAL		31500.
INTEREST DURING INSTALLATION		4100.
TOTAL COST		85200.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		93700.

CAPITAL COST:

PROCESS: 401. SINTER WINDBOX	UNITS SINTER		TECHNOLOGY LEVEL: BACT

CAPACITY: 1.375 MILLION TONS/YEAR

MODULES: 5.00 FAN AND DRIVE ELECTRICAL (> 150 BHP)

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	115100.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	0.	
STRUCTURAL	0.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	0.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	34900.	
DIRECT COST SUBTOTAL		150000.
*** INDIRECT COST ***		
FIELD OVERHEAD	17300.	
CONTRACTORS FEE	17500.	
ENGINEERING	7500.	
FREIGHT	2000.	
OFFSITE WORK	4700.	
TAXES	6100.	
SHAKEDOWN	7800.	
SPARES	7800.	
CONTINGENCY	50600.	
INDIRECT COST SUBTOTAL		121300.
INTEREST DURING INSTALLATION		20900.
TOTAL COST		292200.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		321400.

CAPITAL COST:

PPSFS: 401. SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: 1.375 MILLION TONS/YEAR

TOTAL COST

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	2089400.	
INSTRUMENTATION	1791700.	
PIPING	58300.	
ELECTRICAL	55900.	
FOUNDATIONS	45000.	
STRUCTURAL	50000.	
SITE WORK	3000.	
INSULATION	200.	
PROTECTIVE COATING	9000.	
BUILDINGS	11400.	
EQUIPMENT/MATERIAL LABOR	217600.	
DIRECT COST SUBTOTAL		4331500.
*** INDIRECT COST ***		
FIELD OVERHEAD	153900.	
CONTRACTORS FEE	76300.	
ENGINEERING	109000.	
FREIGHT	29100.	
OFFSITE WORK	26900.	
TAXES	81700.	
SHAKEDOWN	76800.	
SPARES	42700.	
CONTINGENCY	515400.	
INDIRECT COST SUBTOTAL		1111800.
INTEREST DURING INSTALLATION		437900.
TOTAL COST		5881200.
TOTAL COST WITH RETROFIT		6523800.

OPERATING COST:

PPSPS: 401. SINTER WINDBOX	UNITS SINTER		TECHNOLOGY LEVEL: BACT
CAPACITY:	1.375 MILLION TONS/YEAR		
CATEGORY	QUANTITY	RATE	ANNUAL COST ($)
*** UTILITIES ***			
WATER	216650. MGAL/YR	$ .1450/1000 GAL	31400.
ELECTRICITY	29964000. KWH/YR	$ .0242/KWH	725300.
STEAM	0. MLBS/YR	$ 3.7200/MLBS	0.
FUEL	0. GAL/YR	$ .3800/GAL	0.
*** OPERATING LABOR ***			
DIRECT	8760. HRS/YR	$13.04/HR	114200.
SUPERVISION	1752. HRS/YR	$15.64/HR	27400.
*** MAINTENANCE & SUPPLIES ***			
DIRECT LABOR	15595. HRS/YR	$13.04/HR	203300.
SUPERVISION	3119. HRS/YR	$15.64/HR	48800.
MATERIALS			163400.
SUPPLIES			62300.
WATER TREATMENT			209200.

DIRECT OPERATING COST	1585300.
INDIRECT OPERATING COST	408011.
TOTAL OPERATING COST	1993312.
OPERATING COST IN DOLLARS PER TON PRODUCTION	1.45
OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED	721.69
OPERATING COST AS PERCENT OF CAPITAL COST	30.6
INSTALLATION TIME IN WEEKS	104.
ESTIMATED LIFE OF SYSTEM IN YEARS	15.
KWH PER TON CAPACITY	21.8

GENERAL INFORMATION:

PPSFS: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

PARTICULATE
- LOAD IN: 4.500 LBS/TON .318 GRS/SCF
- ALLOWABLE: .270 LBS/TON .020 GRS/SCF, EFFICIENCY: 93.7%
- 73.20 LBS/HR

SULFUR DIOXIDE
- LOAD IN: 1.800 LBS/TON
- ALLOWABLE: 1.800 LBS/TON EFFICIENCY: .0%
- 487.59 LBS/HR

HYDROCARBONS
- LOAD IN: .240 LBS/TON
- ALLOWABLE: .240 LBS/TON EFFICIENCY: .0%
- 65.01 LBS/HR

DUST COLLECTED PER DAY: 11.8 TONS(DRY)

TEMP OUT OF PROCESS: 500. F
EXHAUST TEMPERATURE: 100. F

SCFM FLOW: 427000. AT 70. F
ACFM FLOW: 451000. AT 100. F

L/G RATIO: 7.9
PROCESS WATER FLOW: 3563. GPM
COOLING WATER FLOW: 0. GPM
SUSPENDED SOLIDS OUT: 644. MG/L %SOLIDS: .1

CONTROL SYSTEM CONFIGURATION:

- VENTURI SCRUBBER
- MIST ELIMINATOR
- FAN AND DRIVE
- DUCTWORK
- WASTEWATER RECYCLE SYSTEM
- DAMPERS
- OPACITY MONITOR
- WASTE WATER RETURN SYSTEM
- WATER PUMPING SYSTEM
- FAN AND DRIVE ELECTRICAL

FEET OF ADDITIONAL DUCT: 200. DIAMETER: 12.
TOTAL PRESSURE DROP: 90. INCHES
3 FANS @ 5000. HP EACH SPARE FAN CAPACITY: 41.%
OPERATING HOURS AT FULL HP: 7900.
OPERATING HOURS AT REDUCED HP: 0.
STACK HEIGHT: 0. DIAMETER: 0.

CAPITAL COST:

PPSPS: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

MODULES: 1.00 S.S. VENTURI SCRUBBER

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	610500.	
INSTRUMENTATION	12400.	
PIPING	12200.	
ELECTRICAL	2900.	
FOUNDATIONS	2200.	
STRUCTURAL	19900.	
SITE WORK	200.	
INSULATION	0.	
PROTECTIVE COATING	2200.	
BUILDINGS	13800.	
EQUIPMENT/MATERIAL LABOR	141800.	
DIRECT COST SUBTOTAL		817900.
*** INDIRECT COST ***		
FIELD OVERHEAD	89200.	
CONTRACTORS FEE	31000.	
ENGINEERING	61500.	
FREIGHT	6900.	
OFFSITE WORK	21100.	
TAXES	27700.	
SHAKEDOWN	27100.	
SPARES	27700.	
CONTINGENCY	196100.	
INDIRECT COST SUBTOTAL		490300.
INTEREST DURING INSTALLATION		95600.
TOTAL COST		1403800.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		1544200.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

MODULES: 1.00 S.S. BLADE TYPE MIST ELIMINATOR

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	74400.	
INSTRUMENTATION	2200.	
PIPING	12800.	
ELECTRICAL	600.	
FOUNDATIONS	2000.	
STRUCTIONAL	17100.	
SITE WORK	600.	
INSULATION	0.	
PROTECTIVE COATING	1300.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	8800.	
DIRECT COST SUBTOTAL		119800.
*** INDIRECT COST ***		
FIELD OVERHEAD	10400.	
CONTRACTORS FEE	5900.	
ENGINEERING	6000.	
FREIGHT	2300.	
OFFSITE WORK	0.	
TAXES	4500.	
SHAKEDOWN	400.	
SPARES	0.	
CONTINGENCY	31200.	
INDIRECT COST SUBTOTAL		62700.
INTEREST DURING INSTALLATION		4600.
TOTAL COST		187100.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		205800.

CAPITAL COST:

PPSFS: 401. SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

MODULES: 3.00 FAN AND DRIVE (2001- BHP)

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	848200.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	45100.	
STRUCTURAL	12700.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	3400.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	21400.	
DIRECT COST SUBTOTAL		930800.
*** INDIRECT COST ***		
FIELD OVERHEAD	26900.	
CONTRACTORS FEE	11100.	
ENGINEERING	2700.	
FREIGHT	5300.	
OFFSITE WORK	0.	
TAXES	39500.	
SHAKEDOWN	42700.	
SPARES	0.	
CONTINGENCY	193800.	
INDIRECT COST SUBTOTAL		320000.
INTEREST DURING INSTALLATION		96200.
TOTAL COST		1347000.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		1481700.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX UNITS SINTER TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

MODULES: 2.00 C.S. DUCTWORK UNLINED - 100 FT.

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	100800.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	0.	
STRUCTURAL	0.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	0.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	39900.	
DIRECT COST SUBTOTAL		140700.
*** INDIRECT COST ***		
FIELD OVERHEAD	8800.	
CONTRACTORS FEE	5000.	
ENGINEERING	4500.	
FREIGHT	12600.	
OFFSITE WORK	0.	
TAXES	5300.	
SHAKEDOWN	0.	
SPARES	0.	
CONTINGENCY	39000.	
INDIRECT COST SUBTOTAL		75200.
INTEREST DURING INSTALLATION		7500.
TOTAL COST		223400.
RETROFIT MULTIPLIER		1.6
TOTAL COST WITH RETROFIT		357400.

CAPITAL COST:

PPSPS: 401.	SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

MODULES: 1.00 WASTEWATER RECYCLE SYSTEM

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	660500.	
INSTRUMENTATION	2055100.	
PIPING	2000.	
ELECTRICAL	3100.	
FOUNDATIONS	700.	
STRUCTURAL	1000.	
SITE WORK	100.	
INSULATION	300.	
PROTECTIVE COATING	200.	
BUILDINGS	300.	
EQUIPMENT/MATERIAL LABOR	2100.	
DIRECT COST SUBTOTAL		2725400.
*** INDIRECT COST ***		
FIELD OVERHEAD	2700.	
CONTRACTORS FEE	1300.	
ENGINEERING	2600.	
FREIGHT	500.	
OFFSITE WORK	500.	
TAXES	600.	
SHAKEDOWN	900.	
SPARES	900.	
CONTINGENCY	5400.	
INDIRECT COST SUBTOTAL		15400.
INTEREST DURING INSTALLATION		274100.
TOTAL COST		3014900.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		3316400.

CAPITAL COST:

PPSES: 401.	SINTER WINDBOX	UNITS SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

MODULES: 5.00 C.S. DAMPER GT. 7 FT. DIAMETER

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	100100.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	0.	
STRUCTURAL	0.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	0.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	14100.	
DIRECT COST SUBTOTAL		114200.
*** INDIRECT COST ***		
FIELD OVERHEAD	7500.	
CONTRACTORS FEE	3200.	
ENGINEERING	1000.	
FREIGHT	4700.	
OFFSITE WORK	0.	
TAXES	6400.	
SHAKEDOWN	2400.	
SPARES	4600.	
CONTINGENCY	40100.	
INDIRECT COST SUBTOTAL		69900.
INTEREST DURING INSTALLATION		6400.
TOTAL COST		190500.
RETROFIT MULTIPLIER		1.0
TOTAL COST WITH RETROFIT		190500.

CAPITAL COST:

PPSPS: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

MODULES: 1.00 — CAPACITY FUNCTION

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	7000.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	5700.	
FOUNDATIONS	0.	
STRUCTURAL	6200.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	700.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	1000.	
DIRECT COST SUBTOTAL		20600.
*** INDIRECT COST ***		
FIELD OVERHEAD	2500.	
CONTRACTORS FEE	1500.	
ENGINEERING	4600.	
FREIGHT	500.	
OFFSITE WORK	400.	
TAXES	600.	
SHAKEDOWN	400.	
SPARES	500.	
CONTINGENCY	6500.	
INDIRECT COST SUBTOTAL		17500.
INTEREST DURING INSTALLATION		400.
TOTAL COST		38500.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		42400.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

MODULES: 1.00 WASTE WATER RETURN SYSTEM

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	69100.	
INSTRUMENTATION	0.	
PIPING	30500.	
ELECTRICAL	49600.	
FOUNDATIONS	2800.	
STRUCTURAL	0.	
SITE WORK	2100.	
INSULATION	0.	
PROTECTIVE COATING	1900.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	2900.	
DIRECT COST SUBTOTAL		158900.
*** INDIRECT COST ***		
FIELD OVERHEAD	14800.	
CONTRACTORS FEE	10400.	
ENGINEERING	25000.	
FREIGHT	2200.	
OFFSITE WORK	4500.	
TAXES	5900.	
SHAKEDOWN	7400.	
SPARES	7400.	
CONTINGENCY	45000.	
INDIRECT COST SUBTOTAL		122600.
INTEREST DURING INSTALLATION		14100.
TOTAL COST		295600.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		325200.

CAPITAL COST:

PPSFS: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

MODULES: 1.00 WATER PUMPING SYSTEM (< 1500GPM)

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	32500.	
INSTRUMENTATION	3500.	
PIPING	14000.	
ELECTRICAL	7800.	
FOUNDATIONS	700.	
STRUCTURAL	0.	
SITE WORK	500.	
INSULATION	0.	
PROTECTIVE COATING	1000.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	500.	
DIRECT COST SUBTOTAL		60500.
*** INDIRECT COST ***		
FIELD OVERHEAD	5400.	
CONTRACTORS FEE	3200.	
ENGINEERING	9000.	
FREIGHT	500.	
OFFSITE WORK	1000.	
TAXES	1100.	
SHAKEDOWN	1700.	
SPARES	1700.	
CONTINGENCY	12100.	
INDIRECT COST SUBTOTAL		35700.
INTEREST DURING INSTALLATION		4800.
TOTAL COST		101000.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		111100.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

MODULES: 5.00 FAN AND DRIVE ELECTRICAL (> 150 BHP)

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	134000.	
INSTRUMENTATION	0.	
PIPING	0.	
ELECTRICAL	0.	
FOUNDATIONS	0.	
STRUCTURAL	0.	
SITE WORK	0.	
INSULATION	0.	
PROTECTIVE COATING	0.	
BUILDINGS	0.	
EQUIPMENT/MATERIAL LABOR	37700.	
DIRECT COST SUBTOTAL		171700.
*** INDIRECT COST ***		
FIELD OVERHEAD	16700.	
CONTRACTORS FEE	16900.	
ENGINEERING	7500.	
FREIGHT	2100.	
OFFSITE WORK	5000.	
TAXES	6600.	
SHAKEDOWN	6500.	
SPARES	6500.	
CONTINGENCY	54600.	
INDIRECT COST SUBTOTAL		130400.
INTEREST DURING INSTALLATION		23200.
TOTAL COST		325300.
RETROFIT MULTIPLIER		1.1
TOTAL COST WITH RETROFIT		357800.

CAPITAL COST:

PPSES: 401. SINTER WINDBOX — UNITS: SINTER — TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

TOTAL COST

CATEGORY	COST IN DOLLARS	
*** DIRECT COST ***		
EQUIPMENT OR MATERIAL	2636900.	
INSTRUMENTATION	2073200.	
PIPING	71500.	
ELECTRICAL	67700.	
FOUNDATIONS	53500.	
STRUCTURAL	58900.	
SITE WORK	5500.	
INSULATION	300.	
PROTECTIVE COATING	10700.	
BUILDINGS	14100.	
EQUIPMENT/MATERIAL LABOR	270200.	
DIRECT COST SUBTOTAL		5260500.
*** INDIRECT COST ***		
FIELD OVERHEAD	186900.	
CONTRACTORS FEE	91500.	
ENGINEERING	126600.	
FREIGHT	37400.	
OFFSITE WORK	32500.	
TAXES	96400.	
SHAKEDOWN	91500.	
SPARES	51300.	
CONTINGENCY	623600.	
INDIRECT COST SUBTOTAL		1339700.
INTEREST DURING INSTALLATION		526900.
TOTAL COST		7127100.
TOTAL COST WITH RETROFIT		7932500.

PERATING COST:

		UNITS	
PPSFS: 401.	SINTER WINDBOX	SINTER	TECHNOLOGY LEVEL: BACT

CAPACITY: 2.140 MILLION TONS/YEAR

CATEGORY	QUANTITY	RATE	ANNUAL COST ($)
	*** UTILITIES ***		
WATER	321226. MGAL/YR	$ .1450/1000 GAL	46600.
ELECTRICITY	44316392. KWH/YR	$ .0242/KWH	1072500.
STEAM	0. MLBS/YR	$ 3.7200/MLBS	0.
FUEL	0. GAL/YR	$ .3800/GAL	0.
	*** OPERATING LABOR ***		
DIRECT	8760. HRS/YR	$13.04/HR	114200.
SUPERVISION	1752. HRS/YR	$15.64/HR	27400.
	*** MAINTENANCE & SUPPLIES ***		
DIRECT LABOR	18469. HRS/YR	$13.04/HR	240800.
SUPERVISION	3694. HRS/YR	$15.64/HR	57800.
MATERIALS			189600.
SUPPLIES			73200.
WATER TREATMENT			230700.

DIRECT OPERATING COST	2052800.
INDIRECT OPERATING COST	463336.
TOTAL OPERATING COST	2516136.
OPERATING COST IN DOLLARS PER TON PRODUCTION	1.18
OPERATING COST IN DOLLARS PER TON OF DUST COLLECTED	583.54
OPERATING COST AS PERCENT OF CAPITAL COST	31.7
INSTALLATION TIME IN WEEKS	104.
ESTIMATED LIFE OF SYSTEM IN YEARS	15.
KWH PER TON CAPACITY	20.7

REGRESSION ANALYSIS:

PROCESS: 401. SINTER WINDBOX

UNITS: SINTER

TECHNOLOGY LEVEL: BACT

CAPITAL COST = 17173.9(CAPACITY)$^{.4153}$

R= 1.0000

CAPITAL COST (RETRO) = 17751.2(CAPACITY)$^{.4184}$

R= 1.0000

TOTAL OPERATING COST = 4155.1(CAPACITY)$^{.4568}$

R= .9973

DIRECT OPERATING COST = 1576.0(CAPACITY)$^{.4912}$

R = .9974

APPENDIX H

STATE AIR POLLUTION CONTROL REGULATIONS

Introduction

There are twenty jurisdictions in this study as shown in Table H-1.

Nine types of regulations were considered to be important enough for graphing or tabulation. These fall into three categories, Particulate Emission Regulations, Sulfur Compound Emission Regulations, and Opacity Regulations. Table H-2 shows the nine regulation types and the categories into which they fall.

Particulate Emission Regulations

A particulate emission consists of finely divided solid or liquid particles being introduced into the air from a source such as a stack. There are three types of particulate emission regulations.

The first is the Process Weight Rate Regulation. This type of regulation assigns an allowable particulate emission rate in lb/hr to each hourly rate of throughput. It is generally variable with respect to the finished product rate and for that reason has been graphed for the purposes of this study. See Figures H-1 and H-2.

The next type of particulate emission regulation is Allowable Particulate Emissions for Fuel Burning. As opposed to process weight rate regulations this bases the allowable emission rates on the firing rate (in 10^6 Btu per hour) of the boiler. It assigns an allowable emission rate in pounds per million Btu fired. The allowable emission rate is generally variable with respect to firing rate and is shown in Figures H-3, H-4, and H-5.

The last type of Particulate Emission Regulation to be discussed is grain loading. This type of regulation gives a maximum weight of particulate matter, generally in grains, to be suspended in a given volume of gas, generally in dry standard cubic feet. It is generally applicable to both process operations and fuel burning, but is usually constant with respect to exhaust rate. For that reason it is tabulated and not graphed.

Table H-1. AIR POLLUTION CONTROL JURISDICTIONS

States	Counties	Cities
01 Pennsylvania	13 Wayne Co., Michigan	16 Houston, Texas
02 Ohio	14 Allegheny Co., Pennsylvania	17 E. Chicago, Indiana
03 Kentucky	15 San Bernardino Co., Calif.	18 Chicago, Illinois
04 Maryland		19 Gary, Indiana
05 New York		20 Cleveland, Ohio
06 Indiana		
07 Colorado		
08 Illinois		
09 Texas		
10 Alabama		
11 Utah		
12 West Virginia		

Table H-2. TYPES OF AIR POLLUTION CONTROL REGULATIONS

Particulate Emission Regulations	Sulfur Compound Emission Regulations	Visible Emission Regulations
Process Weight Rate Regulations	SO_2 Emissions for Fuel Burning	Primary Visible Emissions
Particulate Emissions for Fuel Burning	SO_2-Concentration	Fugitive Emissions
Grain Loading	Fuel Sulfur Content	
	H_2S-Concentration	

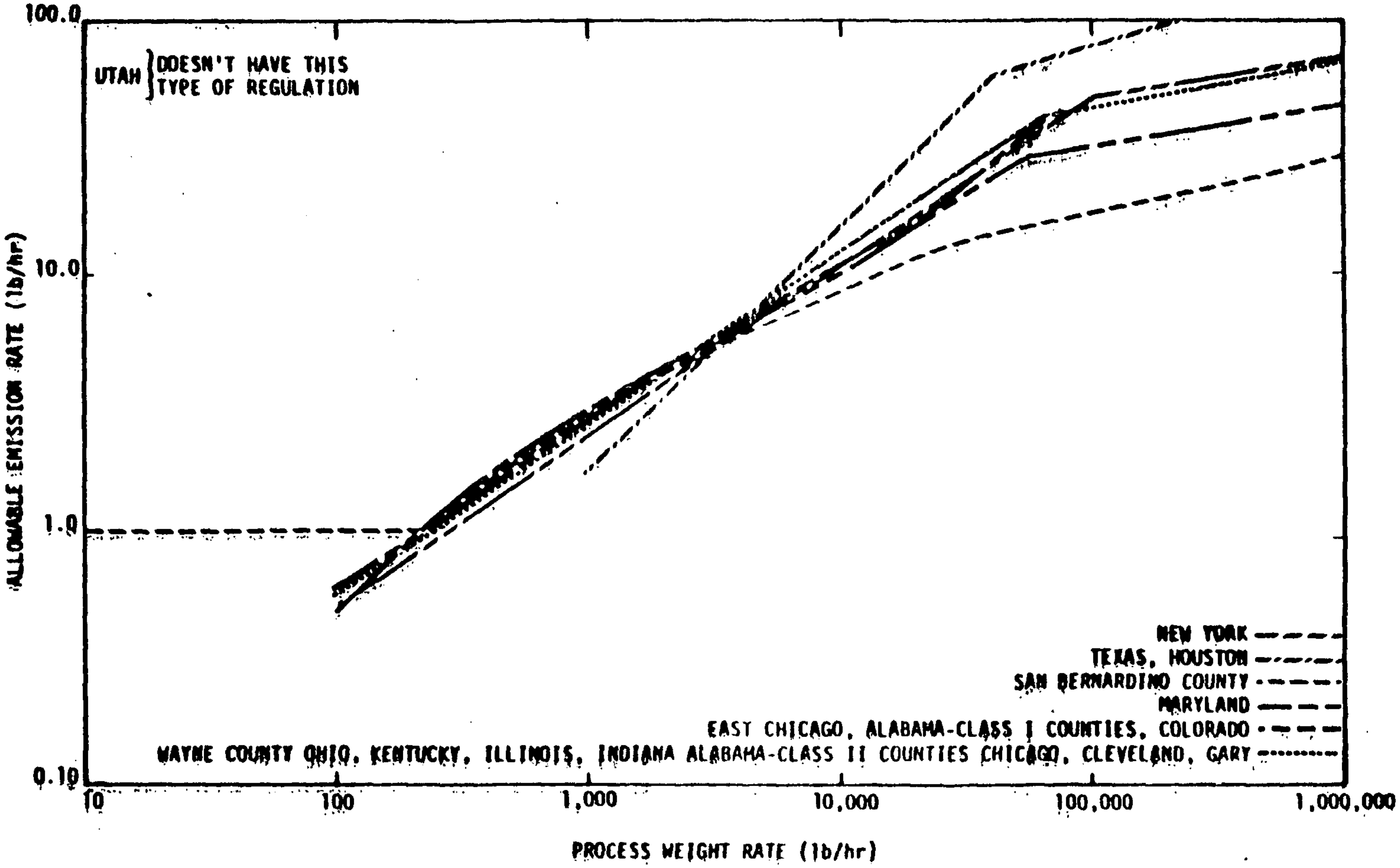

Figure H-1. Allowable particulate emissions based on process weight rate.

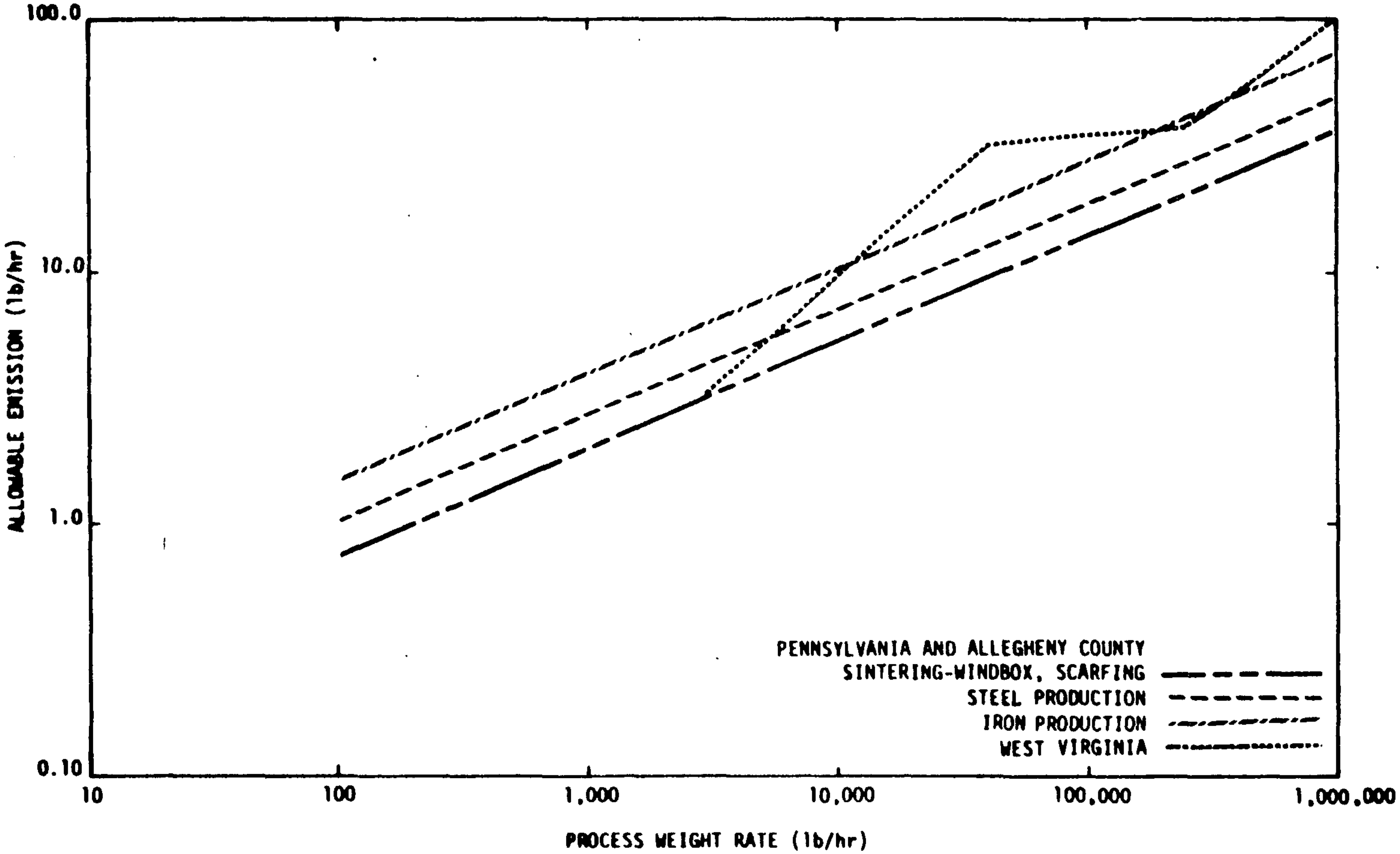

Figure H-2. Process weight regulations.

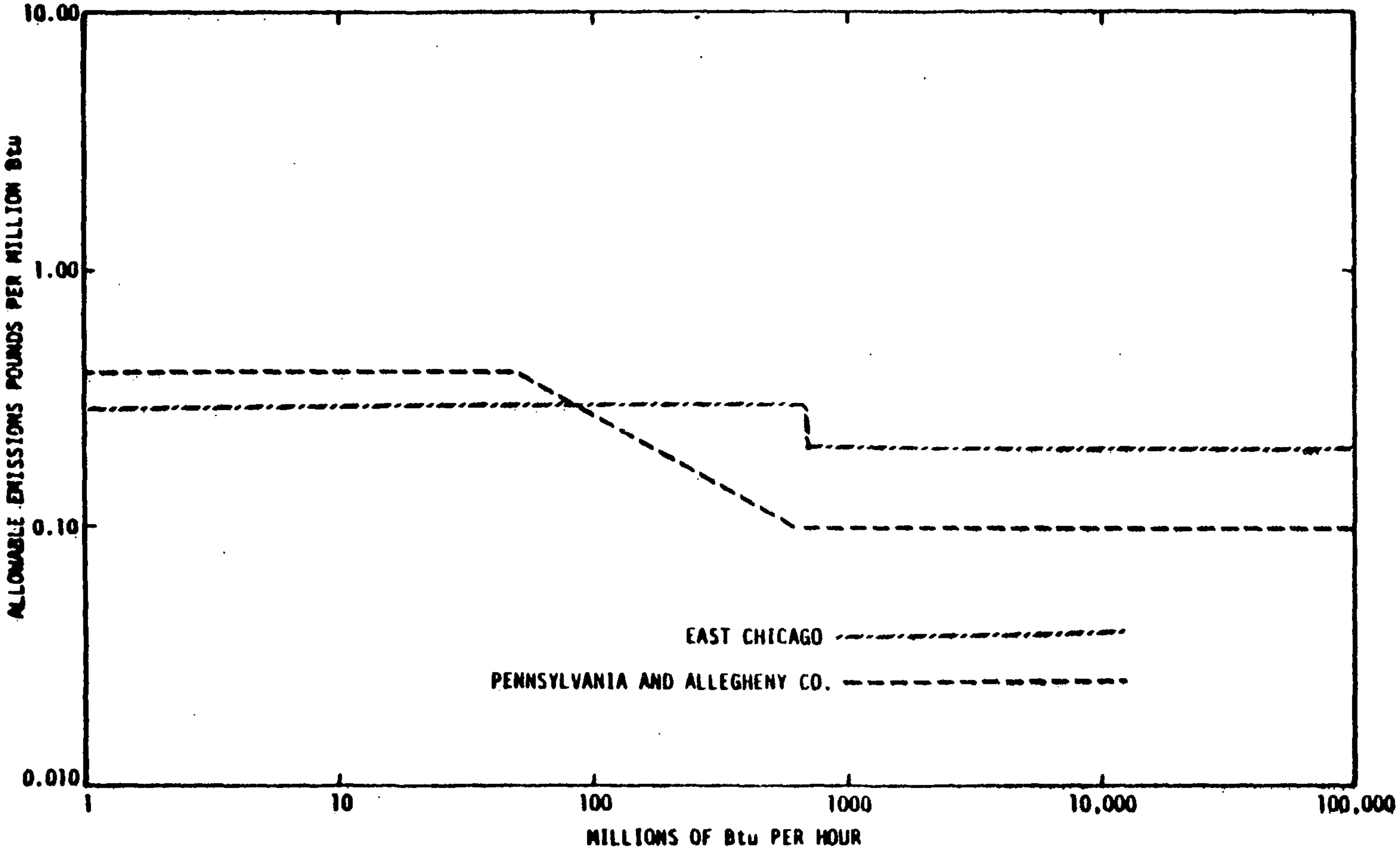

Figure H-3. Fuel burning regulations.

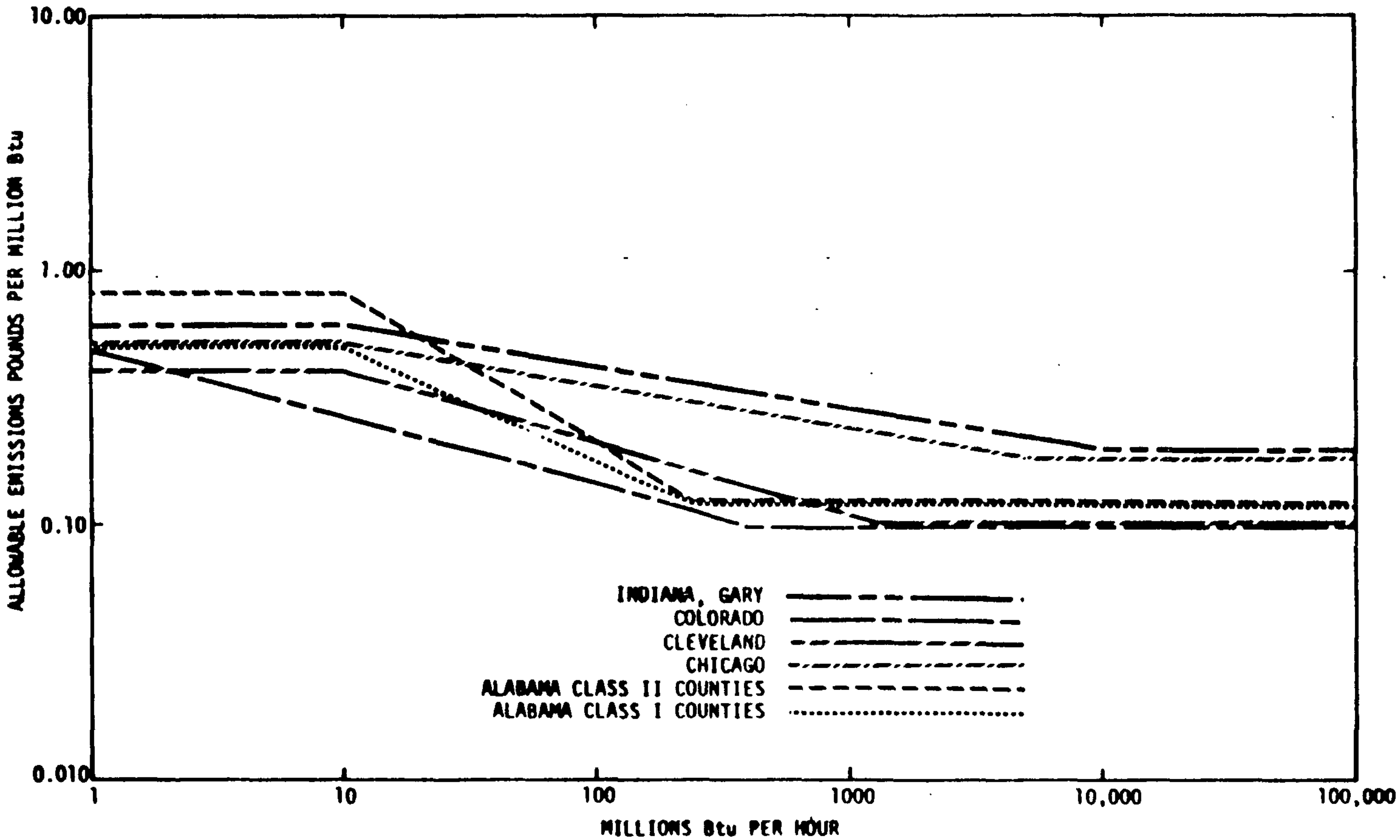

Figure H-4. Fuel burning regulations.

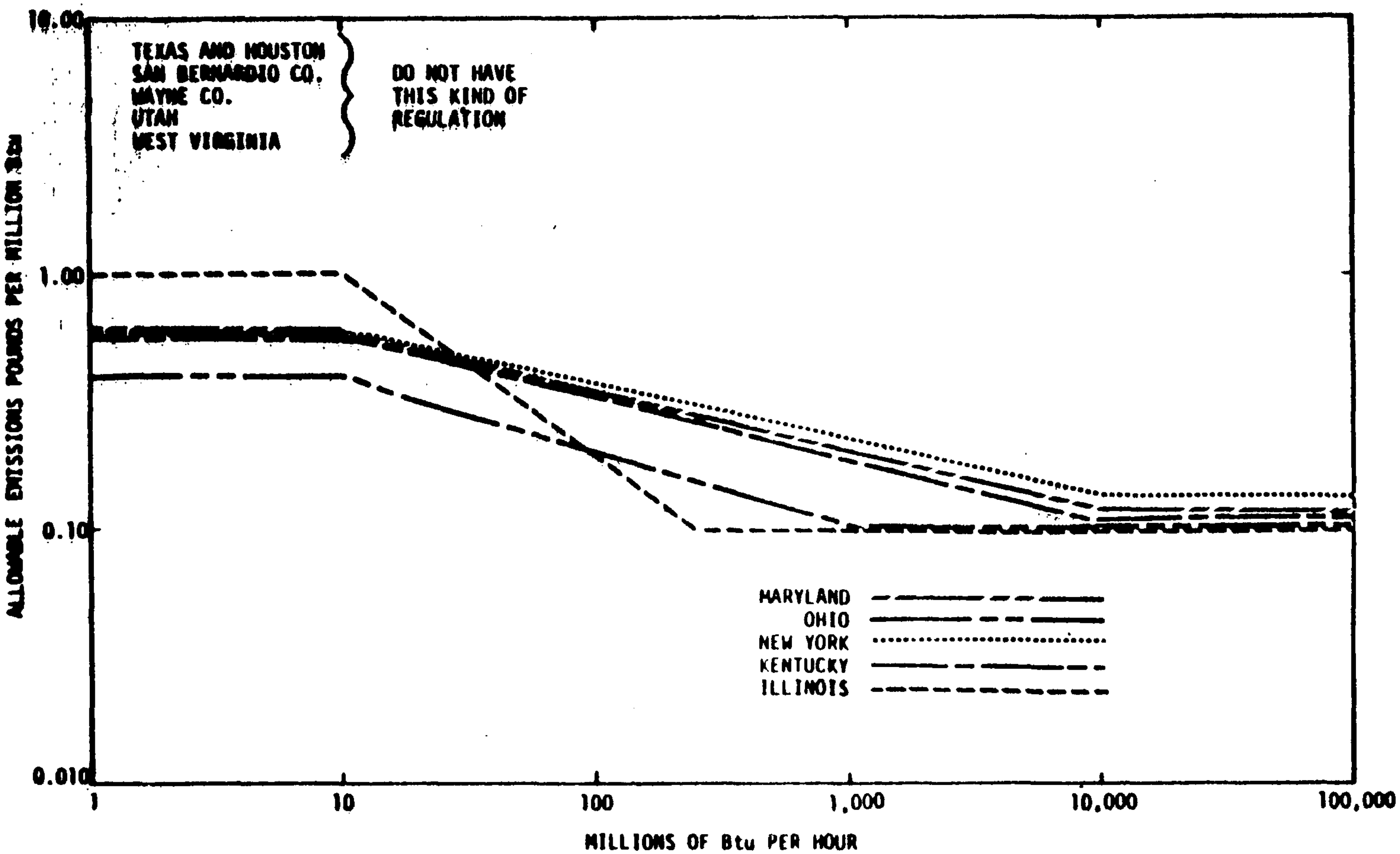

Figure H-5. Fuel burning regulations.

See Table H-3 for further details.

Sulfur Compound Regulations

The first type of sulfur compound regulation is for fuel burning. This regulation generally gives allowable SO_2 emissions in $lb/10^6$ Btu as a function of firing rate in millions of Btu per hour. The allowable emission generally varies with firing rate and is graphed in Figures H-6, H-7, and H-8.

The next type of SO_2 regulation is SO_2 concentration. This type of regulation gives a maximum allowable concentration of SO_2 for a gas stream to be discharged into the atmosphere. It is generaly expressed in parts per million (ppm) and is a constant. Therefore it is presented in Table H-4 rather than graphed.

The third type of Sulfur Compound Emission Regulation is the sulfur content of fuels. This merely gives a maximum allowable elemental sulfur content of fuels. It sometimes varies with the type of fuel, but is always constant for a given fuel. It is presented in Table H-4.

The final type of Sulfur Compound Emission Regulation is for H_2S concentration. It can be expressed in ppm or in grains per dry standard cubic foot, and is generally aimed at the prevention of flaring gas streams containing H_2S above a certain concentration. It is constant for a given jurisdiction and is presented in Table H-4.

Visible Emission Regulations-Opacity

A visible emission is one that can be seen such as smoke. The opacity of a visible emission is its degree of obscuration of light and is expressed as a percentage. The two types of visible emissions, primary and fugitive are each discussed below.

The first type of visible emission regulation is for primary visible emissions, which come out of a stack. These types of regulations generally have a maximum allowable percentage of opacity for the emission. Sometimes a higher percentage of opacity is allowable for several minutes of an hour. For all primary visible emissions the allowable opacity is constant and is presented in Table H-5.

Table H-3. GRAIN LOADING REGULATIONS

Alabama Chicago Cleveland Colorado East Chicago Gary Illinois Indiana New York Ohio Utah	THESE JURISDICTIONS DO NOT HAVE GRAIN LOADING REGULATIONS
Kentucky	0.02 grains/dry standard cubic foot
Maryland	0.03 grains/dry standard cubic foot; 0.05 grains/dry standard cubic foot for processes of 60,000 lb/hr and more
Pennsylvania and Allegheny County	0.04 grains/dry standard cubic foot when discharge rate $<150,000$ dry standard cubic feet per minute $A = 6000\ E^{-1}$ where $150,000 <$ discharge rate $< 300,000$ E is discharge rate 0.02 grains/dry standard cubic foot when discharge rate $>300,000$ dry standard cubic feet per minute
San Bernardino County	They have a table in their regulations
Texas and Houston	$E = 0.048\ q^{.62}$ E is in lb/hr; q is in ACFM
Wayne County	0.10 lb/1000 lb exhaust gas for open hearth, basic oxygen, and electric arc furnaces 0.15 lb/1000 lb exhaust gas for sintering and blast furnaces 0.30 lb/1000 lb exhaust gas for heating and reheating furnaces
West Virginia	0.05 grains/dry standard cubic foot for sintering

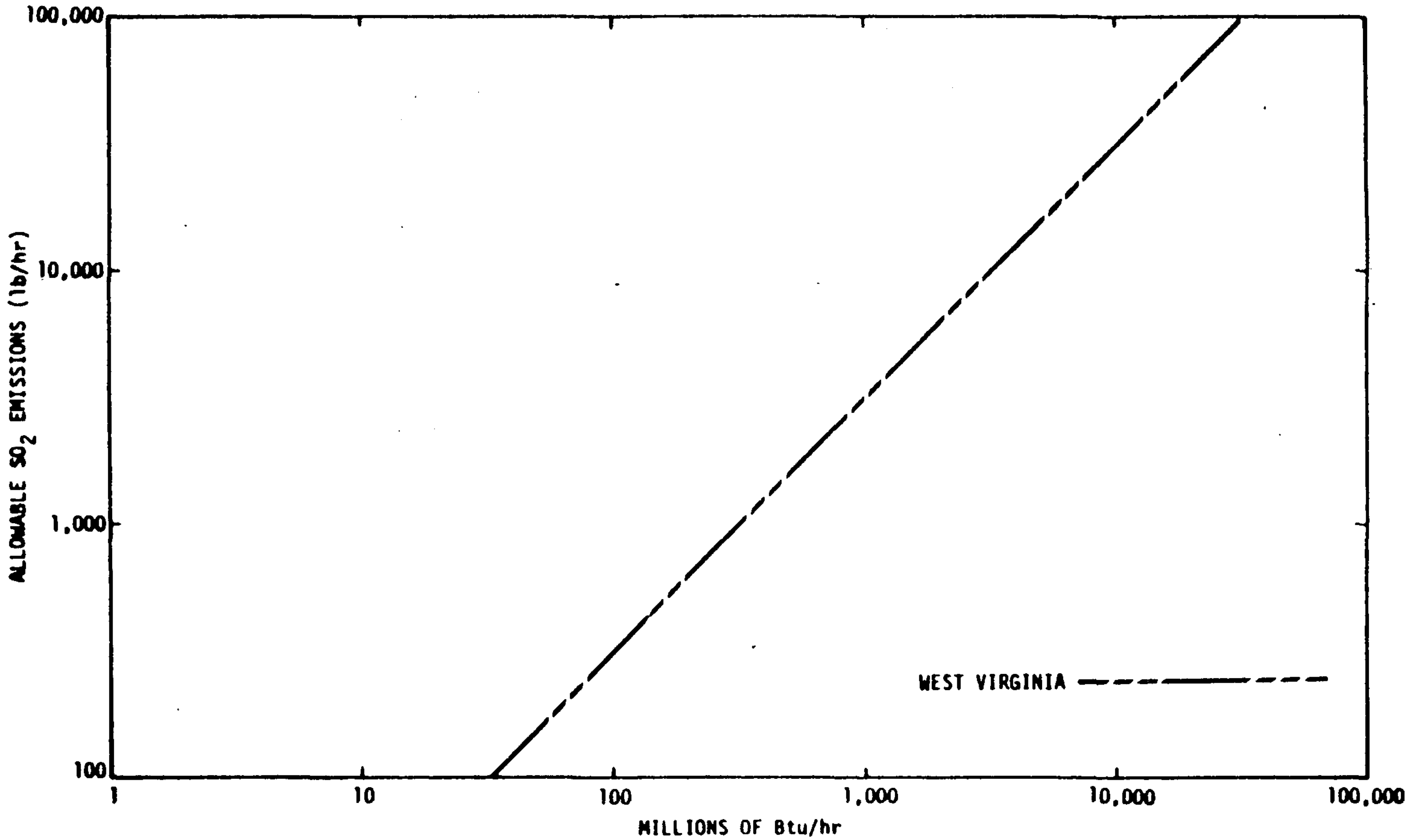

Figure H-6. Allowable SO_2 emissions for fuel burning.

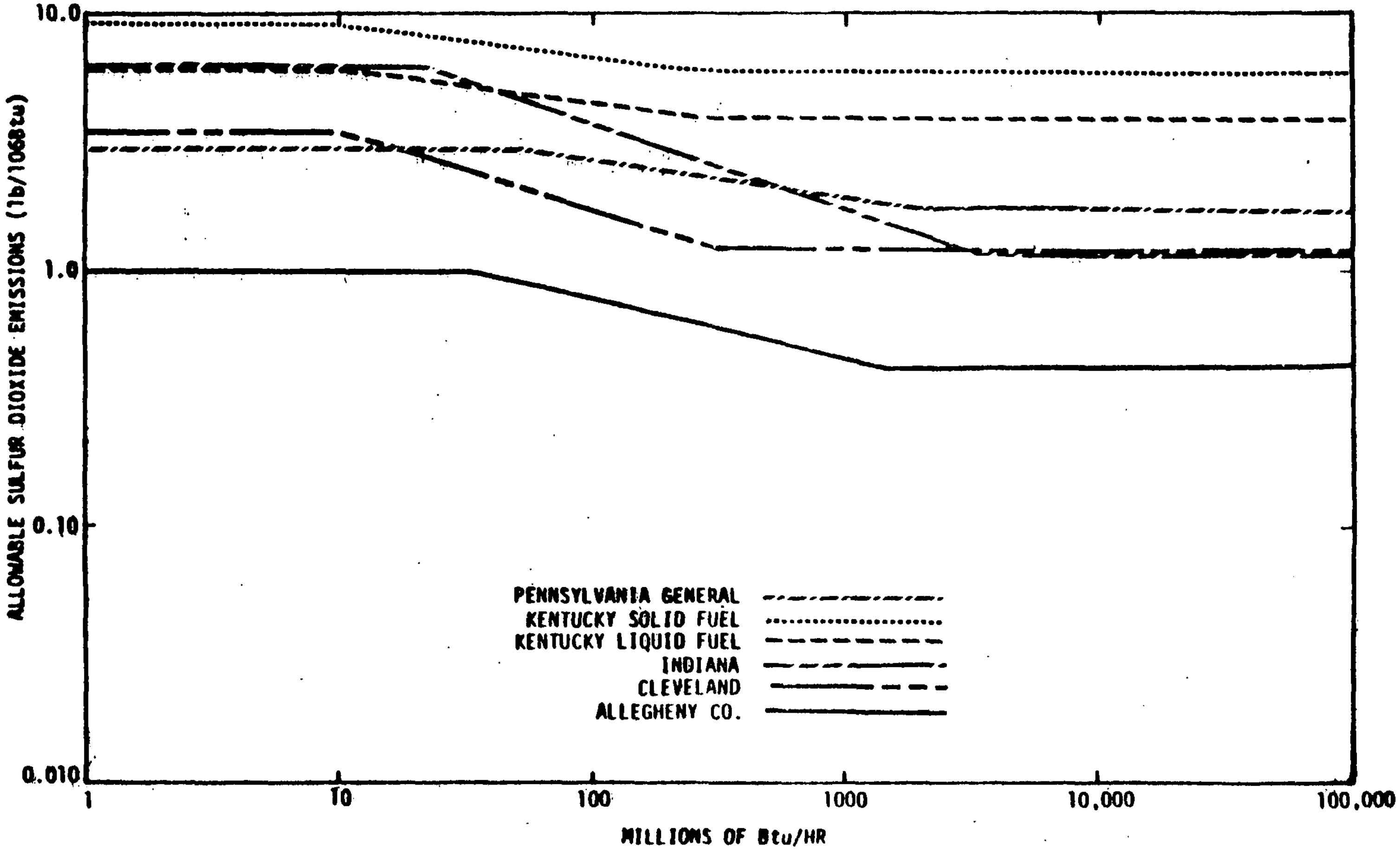

Figure H-7. Allowable SO_2 emissions for fuel burning.

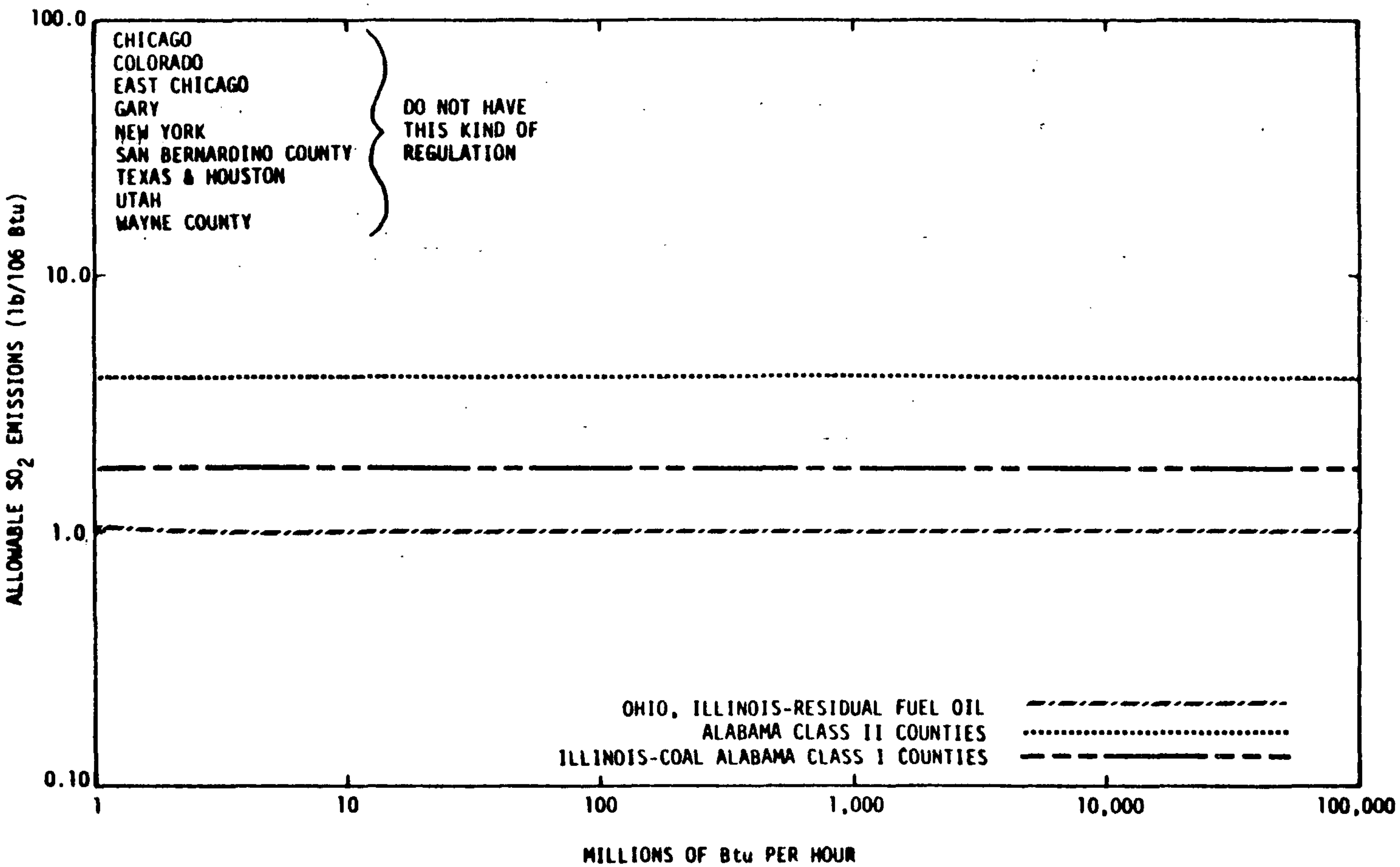

Figure H-8. Allowable SO_2 emissions for fuel burning.

Table H-4. SULFUR EMISSION REGULATIONS

Jurisdiction	Allowable SO_2 concentration	Allowable Sulfur in fuel	Allowable H_2S concentration
Alabama Class I Counties	None	None	150 ppm
Alabama Class II Counties	None	None	150 ppm
Chicago	500 ppm	1%	0.01 ppm
Cleveland	6 lbs per ton of process weight	None	170 grains/100 DSCF
Colorado	500 ppm	None	None
E. Chicago	850 ppm	0.9 lbs of sulfur per million Btu heating value	160 ppm
Gary	None	None	None
Illinois	2000 ppm	Coal 1.8%, Residual fuel oil 1.0% Distillate 0.3%	None
Indiana	None	None	None
Kentucky	2000 ppm	None	10 grains/100 DSCF
Maryland	2000 ppm	Residual fuel oil 2%, Distillate 0.3%, Process gas 0.3%	None
New York	None	Oil 0.75% Coal 0.60%	50 grains/100 DSCF
Ohio	2000 ppm	None	100 grains/100 DSCF
Pennsylvania and Allengheny Co.	500 ppm	None	50 grains/100 DSCF
San Bernadino Co.	None	0.5%	800 ppm
Texas and Houston	Sintering 2500 ppm	None	Based on stack parameters
Utah	None	Oil 1% Coal 1.5%	None
Wayne County	Coal 280 ppm, Residual oil 280 ppm, Distillate 120 ppm	Coal 0.75% Distillate 0.30% Residual 0.30%,	None
West Virginia	2000 ppm	Coal 2.0% Oil 1.5 %	50 grains/100 DSCF

Table H-5. VISIBLE EMISSION REGULATIONS

Jurisidiction	Primary Visible Emissions Regulations - Opacity	Fugitive Emissions Regulations - Opacity
Alabama Class I Counties	Up to 20% opacity Up to 60% opacity 3 min of an hour	Must take reasonable precautions
Alabama Class II Counties	Up to 20% opacity Up to 60% opacity 3 min of an hour	Must take reasonable precautions
Chicago	Up to 30% opacity Up to 40% opacity 4 min out of 30 min	Not visible from beyond property line
Cleveland	Up to 20% opacity Up to 60% opacity 3 min of an hour.	None
Colorado	Up to 20% opacity	Up to 20% opacity but not visible beyond property line
E. Chicago	Up to 40% opacity Above 40% opacity 5 min of an hour	Must take reasonable precautions
Gary	Up to 40% opacity Above 40% opacity 5 min of an hour	Must take reasonable precautions
Illinois	Up to 30% opacity Up to 60% opacity 8 min of an hr	Not visible from beyond property line
Indiana	Up to 40% opacity Above 40% opacity 15 min in 24 hr	67% in excess of upwind concentrations
Kentucky	Up to 20% opacity, PRIORITY I, up to 40% opacity, PRIORITY II & III	Must take reasonable precautions
Maryland	Up to 20% opacity	Must take reasonable precautions
New York	< 20% opacity except for 3 min of an hr.	None
Ohio	Up to 20% opacity Up to 60% opacity 3 min of an hr	Must take reasonable precautions
Pennsylvania and Allegheny Co.	Up to 20% opacity Up to 60% opacity 3 min of an hr	Must take reasonable precautions
San Bernardino County	Up to 20% opacity	Must not be visible beyond property line

(continued)

Table H-5 (continued)

Jurisidiction	Primary Visible Emissions Regulations - Opacity	Fugitive Emissions Regulations - Opacity
Texas and Houston	Up to 20% opacity Above 20% opacity 5 min of an hr	Must take reasonable precautions
Utah	Up to 40% opacity	None
Wayne County	Up to 30% opacity	Must take reasonable precautions
West Virginia	Up to 20% opacity Up to 40% opacity 5 min of an hr	Must have a control system

The second type of visible emission regulation is for fugitive emissions. Fugitive emissions do not come out of a stack, but are rather generated in the open air as for example by leaks or by disrupting a source of particulate matter. An example might be the pushing of coke from the oven into the receiving car. This type of regulation in many cases does not have a maximum allowable opacity but can be summarized by such phrases as "must not be visible beyond property line" or "reasonable precautions must be taken for prevention." The regulations are in general the same for all types of fugitive emissions and are presented in Table H-5.

A number of Production Process Subcategory Emission Sources (PPS-ES) which emit particulate matter do not have a defined emission source or vent. The ore piles in an ore yard is a good example. Heretofore, these sources have generally been treated as a complying source even though no pollutant control system is utilized. In general, none of these sources neatly fits into the scheme of current air pollution regulations insofar as specific emission limitations. The facilities are as follows:

PPS-ES No.	Description
101	Ore yard
201	Coal yard
203	Coal preparation
403	Sinter fugitive-transfer points
503	Coke quenching
504	Coke doors
505	Coke topside
507	Coke handling
702	Cast house fugitive
703	Blast furnace slag pouring
705	Blast furnace slag crushing and screening

PPS-ES No.	Description
805	Open hearth slag crushing and screening
905	BOF slag crushing and screening
1005	Electric furnace slag crushing and screening
801	Open hearth hot metal transfer
901	BOF hot metal transfer
803	Open hearth charging, tapping, and slag pouring
903	BOF charging, tapping, slagging, and sampling
1002	Electric furnace charging and tapping emissions
1101	Conventional casting
1201	Continuous casting
1301	Continuous casting

The types of existing SIP regulations which may be applied to these sources are general prohibitions against pollution, the requirement that reasonable precautions be taken to prevent emissions, process weight rate based emissions, and visible emissions standards. The SIP regulations of each state were studied and the applicable regulation applied to each PPS-ES listed above. Where more than one regulation applied, the more stringent was used. The types of applicable SIP regulations and the resultant control technology by PPS-ES and jurisdiction are shown in Table H-6.

Selection of the required control technology is based on engineering judgment. For example, the prohibition of any visible emissions from a blast furnace cast house is judged to require the application of LAER to that PPS-ES. Where emissions are limited by a process weight rate standard, allowable emissions from a medium size PPS-ES were determined and compared with uncontrolled emissions. This defines the control technology.

Table H-6. CONTROL TECHNOLOGY REQUIRED TO MEET SIP FOR FUGITIVE SOURCES

PPSES	OHIO					INDIANA					ILLINOIS					PENNSYLVANIA					TEXAS				
	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Max. Concentration	Opacity	Control Technology
101		●			RACT					UNC		●			RACT		●			RACT	●				RACT
201		●			RACT					UNC		●			RACT		●			RACT	●				RACT
203		●			RACT			●		RACT			●		RACT				●	RACT			●		RACT
403		●			BACT			●		BACT			●		BACT				●	RACT	●				BACT
503				●	RACT			●		RACT	●				BACT		●			BACT				●	RACT
504/505				●	RACT			●		RACT	●				RACT	●			●	LAER				●	RACT
507		●			RACT			●		UNC			●		UNC		●			RACT				●	RACT
702				●	RACT			●		RACT			●		RACT				●	LAER				●	RACT
703		●			BACT			●		UNC		●			BACT				●	BACT				●	BACT
705/805/905/1005		●			RACT			●		UNC		●			RACT				●	BACT	●				RACT
801/901				●	RACT			●		RACT		●			RACT				●	RACT				●	RACT
803/903				●	RACT			●		RACT			●		RACT				●	BACT*				●	RACT
904		●			RACT			●		UNC		●			RACT				●	RACT				●	RACT
1002				●	BACT			●		UNC		●			BACT				●	BACT				●	BACT
1101		●			UNC			●		UNC		●			UNC				●	UNC				●	UNC
1201/1301		●			RACT			●		UNC		●			BACT				●	BACT				●	BACT

* RACT for PPSES 803

(continued)

Table H-6 (continued)

PPSES	UTAH					WEST VIRGINIA					NEW YORK					MARYLAND					KENTUCKY				
	PPSES-Specific Regulation	•Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	•Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology
101				●	UNC		●			RACT					UNC		●			RACT		●			RACT
201				●	UNC		●			RACT					UNC		●			RACT		●			RACT
203		●			RACT			●		RACT			●		BACT				●	BACT			●		BACT
403		●			BACT		●			BACT			●		RACT		●			BACT			●		BACT
503		●			LEAR			●		RACT	●				RACT				●	LEAR		●			BACT
504/505		●			LEAR		●			RACT	●				RACT				●	LEAR		●			RACT
507		●			RACT			●		UNC	●				RACT		●			RACT			●		UNC
702		●			BACT		●			RACT			●		RACT				●	LEAR			●		RACT
703		●			BACT		●			BACT			●		UNC				●	BACT		●			BACT
705/805/905/1005		●			BACT			●		UNC			●		UNC				●	BACT		●			RACT
801/901		●			RACT		●			RACT			●		RACT				●	RACT		●			RACT
803/903		●			BACT		●			RACT			●		RACT		●		●	BACT			●		BACT
904		●			BACT		●			RACT			●		UNC		●			RACT		●			RACT
1002		●			RACT		●			RACT			●		UNC		●			BACT		●			RACT
1101		●			UNC		●			UNC			●		UNC		●			UNC		●			UNC
1201/1301		●			BACT		●			RACT			●		UNC		●			BACT		●			BACT

• 85% control efficiency required

•Control system req'd. to control all fugitive emissions

(continued)

Table H-6 (continued)

PPSES	ALABAMA					COLORADO					SAN BERNADINO					WAYNE CO.									
	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology	PPSES-Specific Regulation	Gen'l Prohibition	Process Wt. Rate	Opacity	Control Technology
101		●			RACT				●	UNC		●			RACT					UNC					
201		●			RACT				●	UNC		●			RACT					UNC					
203		●			RACT			●		RACT		●			RACT			●		RACT					
403		●			RACT			●		RACT		●			RACT			●		BACT					
503	●				BACT			●		RACT		●			RACT			●		RACT					
504/505	●				BACT				●	BACT		●			RACT			●		RACT					
507	●				RACT			●		UNC		●			RACT			●		RACT					
702				●	RACT				●	UNC		●			RACT			●		UNC					
703			●		UNC			●		UNC		●			RACT			●		UNC					
705/805/905/1005			●		UNC			●		UNC		●			RACT			●		UNC					
801/901			●		RACT			●		RACT		●			RACT			●		RACT					
803/903			●		RACT			●		RACT		●			RACT			●		BACT					
904			●		UNC			●		UNC		●			RACT			●		UNC					
1002				●	BACT				●	BACT		●			RACT			●		UNC					
1101				●	UNC				●	UNC		●			UNC			●		UNC					
1201/1301				●	BACT				●	BACT		●			RACT			●		UNC					

(continued)

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

Capital and operating costs are determined for equipment to control air pollution from all significant emission sources in an integrated steel mill. The facilities of every integrated steel mill in the Unites States are tabulated. Control costs are examined as a function of increasing stringency of control. State and local air pollution regulations applicable to steel mill processes are presented for all jurisdictions in which facilities are located. The calculation of control costs is described as a function of design parameters such as flow, temperature, and efficiency.

17. KEY WORDS AND DOCUMENT ANALYSIS

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