*Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the*

# STEEL MAKING

*Segment of the Iron and Steel Manufacturing*

## Point Source Category

*June 1974*

U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

DEVELOPMENT DOCUMENT

for

EFFLUENT LIMITATIONS GUIDELINES

and

NEW SOURCE PERFORMANCE STANDARDS

for the

STEEL MAKING SEGMENT

of the

IRON AND STEEL MANUFACTURING

POINT SOURCE CATEGORY

Russell E. Train
Administrator

James L. Agee
Acting Assistant Administrator for Water
and Hazardous Materials

Allen Cywin
Director, Effluent Guidelines Division

Edward L. Dulaney
Project Officer

June, 1974

Effluent Guidelines Division
Office of Water and Hazardous Materials
U.S. Environmental Protection Agency
Washington, D. C.  20460

## ABSTRACT

This document presents the findings of an extensive study of the raw steel making operations of the iron and steel industry for the purpose of developing effluent limitations guidelines, Federal standards of performance, and pretreatment standards for this segment of the industry to implement Sections 304, 306, and 307 of the "Act".

Effluent limitations guidelines contained herein set forth the effluent quality attainable through the application of the best practicable control technology currently available (BPCTCA) and the effluent quality attainable through the application of the best available technology economically achievable (BATEA) which must be achieved by existing point sources by July 1, 1977, and July 1, 1983, respectively. The standards of performance for new sources (NSPS) contained herein set forth the effluent quality which is achievable through the application of the best available demonstrated control technology (BADCT), processes, operating methods, or other alternatives.

Supporting data and rationale for development of the effluent limitations guidelines and standards of performance are contained in this report.

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# SECTION I

## CONCLUSIONS

For the purpose of establishing effluent guidelines and standards of performance for the raw steel making operations of the iron and steel industry, the industry was divided into subcategories as follows:

I     By-Product Coke Subcategory

II    Beehive Coke Subcategory

III   Sintering Subcategory

IV    Blast Furnace (Iron) Subcategory

V     Blast Furnace (Ferromanganese) Subcategory

VI    Basic Oxygen Furnace (Semiwet Air Pollution Control Methods) Subcategory

VII   Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory

VIII  Open Hearth Furnace Subcategory

IX    Electric Arc Furnace (Semiwet Air Pollution Control Methods) Subcategory

X     Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory

XI    Vacuum Degassing Subcategory

XII   *Continuous Casting Subcategory*

The selection of these subcategories was based upon distinct differences in type of products produced, production processes, raw materials used, waste waters generated and control and treatment technologies employed. Subsequent waste characterizations of individual plants substantiated the validity of this subcategorization.

The waste characterizations of individual plants visited during this study, and the guidelines developed as a result of the data collected, relate only to the aqueous discharges from the facilities, excluding non-contact cooling waters. Consideration will be given at a later date to proposing thermal discharge limitations on process and noncontact cooling waters. Consideration will also be given at a later date to proposing effluent limitations on the runoffs from stock piles, slag pits and other fugitive waste sources.

# SECTION II

## RECOMMENDATIONS

The effluent limitations guidelines for the iron and steel industry representing the effluent quality obtainable by existing point sources through the application of the best practicable control technology currently available (BPCTCA or Level I) for each industry subcategory, are as follows:

## I. By-Product Coke Subcategory

### BPCTCA Effluent Limitations
Units:  kg pollutant per kkg of product
or:  lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Cyanide | 0.0657 | 0.0219 |
| Phenol | 0.0045 | 0.0015 |
| Ammonia | 0.2736 | 0.0912 |
| Oil & Grease | 0.0327 | 0.0109 |
| Suspended Solids | 0.1095 | 0.0365 |
| pH | 6.0 to 9.0 | |

## II. Beehive Coke Subcategory

### BPCTCA Effluent Limitations
Units:  kg pollutant per kkg of product
or:  lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Cyanide | | |
| Phenol | | |
| Ammonia | | No discharge of |
| Sulfide | | process waste water |
| Oil & Grease | | pollutants to |
| Suspended Solids | | navigable waters |
| pH | | |

VI.   Basic Oxygen Furnace (Semiwet Air Pollution
                Control Methods) Subcategory

BPCTCA Effluent Limitations
Units:   kg pollutant per kkg of product
or:  lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Suspended Solids | | No discharge of |
| | | process waste water |
| pH | | pollutants to navigable waters |


VII.    Basic Oxygen Furnace (Wet Air Pollution
                Control Methods) Subcategory

BPCTCA Effluent Limitations
Units:   kg pollutant per kkg of product
or:  lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Suspended Solids | 0.0312 | 0.0104 |
| pH | 6.0 to 9.0 | |


VIII.   Open Hearth Furnace Subcategory

BPCTCA Effluent Limitations
Units:   kg pollutant per kkg of product
or:  lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Suspended Solids | 0.0312 | 0.0104 |
| pH | 6.0 to 9.0 | |

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## XI. Vacuum Degassing Subcategory

### BPCTCA Effluent Limitations
Units:  kg pollutant per kkg of product
or:  lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Suspended Solids | 0.0156 | 0.0052 |
| pH | | 6.0 to 9.0 |


## XII. Continuous Casting Subcategory

### BCPTCA Effluent Limitations
Units:  kg pollutant per kkg of product
or:  lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Suspended Solids | 0.0780 | 0.0260 |
| Oil & Grease | 0.0234 | 0.0078 |
| pH | | 6.0 to 9.0 |

III.    Sintering Subcategory

### BATEA Effluent Limitations
Units:    kg pollutant per kkg of product
or:    lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Suspended Solids | 0.0156 | 0.0052 |
| Oil & Grease | 0.0063 | 0.0021 |
| Sulfide | 0.00018 | 0.00006 |
| Fluoride | 0.0126 | 0.0042 |
| pH | 6.0 to 9.0 | |

IV.    Blast Furnace (Iron) Subcategory

### BATEA Effluent Limitations
Units:    kg pollutant per kkg of product
or:    lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Suspended Solids | 0.0390 | 0.0130 |
| *Cyanide (A) | 0.0004 | 0.00013 |
| Phenol | 0.0008 | 0.00026 |
| Ammonia | 0.0156 | 0.0052 |
| Sulfide | 0.0005 | 0.00016 |
| Fluoride | 0.0312 | 0.0104 |
| pH | 6.0 to 9.0 | |

*Cyanide (A): Cyanides amenable to chlorination. Reference
ASTM D 2036-72.

VII.     Basic Oxygen Furnace (Wet Air Pollution
                 Control Methods) Subcategory

BATEA Effluent Limitations
Units:  kg pollutant per kkg of product
or:  lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Suspended Solids | 0.0156 | 0.0052 |
| Fluoride | 0.0126 | 0.0042 |
| pH | | 6.0 to 9.0 |

VIII.    Open Hearth Furnace Subcategory

BATEA Effluent Limitations
Units:  kg pollutant per kkg of product
or:  lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Suspended Solids | 0.0156 | 0.0052 |
| Fluoride | 0.0126 | 0.0042 |
| Nitrate (as NO$_3$) | 0.0282 | 0.0094 |
| Zinc | 0.0030 | 0.0010 |
| pH | | 6.0 to 9.0 |

IX.   Electric Arc Furnace (Semiwet Air Pollution
                Control Methods) Subcategory

BATEA Effluent Limitations
Units:  kg pollutant per kkg of product
or:  lb pollutant per 1,000 lb of product

| Pollutant Parameter | Maximum for any One Day Period Shall Not Exceed | Maximum Average of Daily Values for any Period of 30 Consecutive Days |
|---|---|---|
| Suspended Solids | | No discharge of |
| Zinc | | process waste water |
| Fluoride | | pollutants to navigable waters |
| pH | | |

technology, (BADCT) processes, operating methods or other alternatives for each industry sub-category are as follows:

Same as BATEA for all categories except that the nitrate limitations on the open hearth and vacuum degassing subcategories shall not apply.

# SECTION III

## INTRODUCTION

### Purpose and Authority

Section 301(b) of the Act requires the achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best practicable control technology currently available as defined by the Administrator pursuant to Section 304(b) of the Act. Section 301(b) also requires the achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly owned treatment works, which are based on the application of the best available technology economically achievable which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants, as determined in accordance with regulations issued by the Administrator pursuant to Section 304(b) to the Act. Section 306 of the Act requires the achievement by new sources of a Federal standard of performance providing for the control of the discharge of pollutants which reflects the greatest degree of effluent reduction which the Administrator determines to be achievable through the application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

Section 304(b) of the Act requires the Administrator to publish within one year of enactment of the Act, regulations providing guidelines for effluent limitations setting forth the degree of practicable control technology currently available and the degree of effluent reduction attainable through the application of the best control measures and practices achievable including treatment techniques, process and procedure innovations, operation methods and other alternatives.

Section 306 of the Act requires the Administrator, within one year after a category of sources is included in a list published pursuant to Section 306(b) (1) (A) of the Act, to propose regulations establishing Federal standards of performances for new sources within such categories. The Administrator published in the Federal Register of January 16, 1973, a list of 27 source categories. Publication of the list constituted announcement of the Administrator's intention of establishing, under Section 306, standards of performance applicable to new sources within the iron and steel industry which was included within the list published January 16, 1973.

### Summary of Methods Used for Development of the Effluent Limitations Guidelines and Standards of Performance

The effluent limitations guidelines and standards of performance proposed herein were developed in the following manner. The point source category was first studied for the purpose of

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determining whether separate limitations and standards would be required for different segments within a point source category. The analysis was based upon raw material used, product produced, manufacturing process employed, and other factors. The raw waste characteristics for each subcategory were then identified. This included analyses of (1) The source and volume of water used in the process employed and the sources of waste and wastewaters in the plant; and (2) the constituents (including thermal) of all wastewaters including toxic constituents and other constituents which result in taste, odor, and color in water. The constituents of wastewaters which should be subject to effluent limitations guidelines and standards of performance were identified.

The full range of control and treatment technologies existing within each subcategory was identified. This included an identification of each distinct control and treatment technology, including both inplant and end-of-process technologies, which are existent or capable of being designed for each subcategory. It also included an identification in terms of the amount of constituents (including thermal) and the chemical, physical, and biological characteristics of pollutants, of the effluent level resulting from the application of each of the treatment and control technologies. The problems, limitations and reliability of each treatment and control technology and the required implementation time were also identified. In addition, the non-water quality environmental impact, such as the effects of the application of such technologies upon other pollution problems, including air, solid waste, noise and radiation were also identified. The energy requirements of each of the control and treatment technologies were identified as well as the cost of the application of such technologies.

The information, as outlined above, was then evaluated in order to determine what levels of technology constituted the "best practicable control technology currently available," "best available technology economically achievable" and the "best available demonstrated control technology, processes, operating methods, or other alternatives." In identifying such technologies, various factors were considered. These included the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application, the age of equipment and facilities involved, the process employed, the engineering aspects of the application of various types of control techniques, process changes, non-water quality environmental impact (including energy requirements) and other factors.

The data for identification and analyses were derived from a number of sources. These sources included EPA research information, EPA and State environmental personnel, trade associations, published literature, qualified technical consultation, and on-site visits including sampling programs and interviews at steel plants throughout the United States which were known to have above average waste treatment facilities. All references

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TABLE 1

United States Annual Steel Ingot Ton Production
Major Producers
1972

|  | Metric Tons/Year | Ingot Tons/Year |
|---|---|---|
| United States Steel | 31,750,000 | 35,000,000 |
| Bethlehem Steel | 19,960,000 | 22,000,000 |
| Republic Steel | 9,980,000 | 11,000,000 |
| National Steel | 9,520,000 | 10,500,000 |
| Armco Steel | 7,710,000 | 8,500,000 |
| Jones & Laughlin Steel | 7,280,000 | 8,000,000 |
| Inland Steel | 6,800,000 | 7,500,000 |
| Youngstown Sheet & Tube | 5,440,000 | 6,000,000 |
| Wheeling Pittsburgh | 3,540,000 | 3,900,000 |
| Kaiser | 2,720,000 | 3,000,000 |
| McLouth | 1,819,000 | 2,000,000 |
| Colorado Fuel & Iron | 1,360,000 | 1,500,000 |
| Sharon | 1,360,000 | 1,500,000 |
| Interlake | 907,000 | 1,000,000 |
| Alan Wood | 907,000 | 1,000,000 |

TABLE 2  (Cont'd.)

**Republic Steel**

| | | | |
|---|---|---|---|
| Chicago | N.A. | 1,090,000 | 1,810,000 |

**Youngstown Sheet & Tube**

| | | | |
|---|---|---|---|
| East Chicago, Indiana | 1,340,000 | 1,810,000 | 2,630,000 |

**Interlake**

| | | | |
|---|---|---|---|
| Chicago | 613,000 | 680,000 | 907,000 |
| Toledo | 546,000 | 740,000 | --- |

**YOUNGSTOWN, OHIO AREA**

**United States Steel**

| | | | |
|---|---|---|---|
| Youngstown | | 978,000 | 1,620,000 |

**Armco Steel**

| | | | |
|---|---|---|---|
| Middletown, Ohio | 281,000 | 800,000 | 1,420,000 |
| Hamilton, Ohio | 610,000 | 501,000 | 975,000 |

**Republic Steel**

| | | | |
|---|---|---|---|
| Youngstown, Ohio | 874,000 | 728,000 | --- |
| Warren, Ohio | 430,000 | 1,640,000 | 1,810,000 |

**Youngstown Sheet & Tube**

| | | | |
|---|---|---|---|
| Campbell | 1,320,000 | 853,000 | 1,570,000 |
| Brier Hill | 330,000 | 573,000 | 1,040,000 |

**BUFFALO, NEW YORK AREA**

**Bethlehem Steel**

| | | | |
|---|---|---|---|
| Lackawanna | 2,050,000 | 4,490,000 | 5,970,000 |

**National Steel**

| | | | |
|---|---|---|---|
| Hanna, Buffalo | --- | 272,000 | --- |

**Republic Steel**

| | | | |
|---|---|---|---|
| Buffalo | --- | 497,000 | 680,000 |

**Donner-Hanna Coal**

| | | |
|---|---|---|
| Buffalo | 546,000 | (Serves National & Republic) |

TABLE 2 (Cont'd.)

Armco Steel

| | | | |
|---|---|---|---|
| Ashland, Kentucky | --- | 1,040,000 | 1,440,000 |
| Houston, Texas | 365,000 | 550,000 | 700,000 |

Bethlehem Steel

| | | | |
|---|---|---|---|
| Sparrows Point, Md. | 3,010,000 | 5,560,000 | 7,420,000 |

Republic Steel

| | | | |
|---|---|---|---|
| Gadsden, Alabama | 464,000 | --- | --- |
| Birmingham, Alabama | 315,000 | 895,000 | 1,360,000 |
| Massillon, Ohio | 166,000 | 310,000 | --- |
| Canton, Ohio | --- | 290,000 | 800,000 |

Kaiser Steel

| | | | |
|---|---|---|---|
| Fontana, California | 1,360,000 | 2,070,000 | 2,720,000 |

CF&I Steel Corporation

| | | | |
|---|---|---|---|
| Pueblo, Colorado | 1,040,000 | 939,000 | 1,360,000 |
| Roebling, N.J. | | | 230,000 |

Alan Wood

| | | | |
|---|---|---|---|
| Conshohocken, Pa. | 525,000 | 544,000 | 907,000 |

Interlake

| | | | |
|---|---|---|---|
| Erie, Pennsylvania | 242,000 | 380,000 | --- |

TABLE 3 (Cont'd.)

Coke, produced in beehive ovens

Coke, produced in chemical recovery coke ovens

Cold rolled strip steel, flat bright: made in hot rolling mills

Distillates, derived from chemical recovery coke ovens

Fence posts, iron and steel: made in steelworks or rolling mills

Ferroalloys, produced in blast furnaces

Flats, iron and steel: made in steel works and hot rolling mills

Forgings, iron and steel: made in steel works or rolling mills

Frogs, iron and steel: made in steel works or rolling mills

Galvanized hoops, pipes, plates, sheets, and strips: iron and steel

Gun forgings, iron and steel: made in steel works or rolling mills

Hoops, galvanized iron and steel: made in steel works or hot rolling mills

Hot rolled iron and steel products

Ingots, steel

Iron, pig

Iron sinter, made in steel mills

Nut rods, iron and steel: made in steel works or rolling mills

Pipe, iron and steel: made in steel works or rolling mills

Spiegeleisen, made in blast furnaces

Spikes and spike rods, made in steel works or rolling mills

Sponge iron

Stainless steel

Steel works producing bars, rods, plates, sheets, structural shapes, etc.

Strips, galvanized iron and steel: made in steel works or rolling mills

Strips, iron and steel: made in steel works or hot rolling mills

Structural shapes, iron and steel

Tar, derived from chemical recovery coke ovens

Terneplate

Ternes, iron and steel: long or short

Tie plates, iron and steel

Tin free steel

Tin plate

Tool steel

Tube rounds

Tubes, iron and steel: made in steel works or rolling mills

Tubing, seamless: steel

Well casings, iron and steel: made in steel works or rolling mills

Wheels, car and locomotive: iron and steel--"mitse"

Wire products, iron and steel: made in steel works or rolling mills

Wrought pipe and tubing, made in steel works or rolling mills

which is also discussed in this report. A by-product coke plant consists essentially of the ovens in which bituminous coal is heated, out of contact with air, to drive off the volatile components. The residue remaining in the ovens is coke; the volatile components are recovered and processed in the by-product plant to produce tar, light oils, and other materials of potential value, including coke oven gas.

Molten iron for subsequent steelmaking operations is normally produced in a blast furnace. The blast furnace process consists essentially of charging iron ore, limestone, and coke into the top of the furnace and blowing heated air into the bottom. Combustion of the coke provides the heat necessary to obtain the temperature at which the metallurigical reducing reactions take place. The function of the limestone is to form a slag, fluid at the furnace temperature, which combines with unwanted impurities in the ore. One and eight tenths kkg of ore, 0.45 kkg of coke, 0.45 kkg of limestone and 3.2 kkg of air (2, 0.5, 0.5 and 3.5 tons respectively) produce approximately 0.9 kkg of iron, 0.45 kkg of slag and 4.5 kkg of blast furnace gas containing the fines of the burden carried out by the blast (one ton of iron, 0.5 tons of slag and 5 tons of gas). These fines are referred to as flue dust. Molten iron is periodically withdrawn from the bottom of the furnace; the fluid slag which floats on top of the iron is also periodically withdrawn from the furnace. Blast furnace flue gas has considerable heating value and, after cleaning, is burned to preheat the air blast to the furnace.

The blast furnace auxiliaries consist of the stoves in which the blast is preheated, the dry dust catchers in which the bulk of the flue dust is recovered, primary wet cleaners in which most of the remaining flue dust is removed by washing with water, and secondary cleaners such as electrostatic precipitators.

The principal steelmaking methods in use today are the Basic Oxygen Furnace (BOF or BOP), the Open Hearth Furnace, and the Electric Arc Furnace. The steelmaking processes all basically refine the product of the blast furnace. The charge to the steelmaking operations may consist of blast furnace hot metal alone, scrap alone, or both and may also include alloying elements added as necessary to produce the type of steel required. Steel is any alloy of iron containing less than 1.0% carbon. The steelmaking process consists essentially of oxidizing constituents, particularly carbon, down to specified low levels, and then adding various elements to required amounts as determined by the grade of steel to be produced.

The basic raw materials for steelmaking are hot metal or pig iron, steel scrap, limestone, burned lime, dolomite, fluorspar, iron ores, and iron-bearing materials such as pellets or mill scale.

The steelmaking processes produce fume, smoke, and waste gases as the unwanted impurities are burned off and the process vaporizes or entrains a portion of the molten steel into the off-gases.

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A basic oxygen furnace can produce 180 to 270 kkg (200 to 300 tons) or more of steel per hour and allows very close control of steel quality. A major advantage of the process is the ability to handle a wide range of raw materials. Scrap may be light or heavy, and the oxide charge may be iron ore, sinter, pellets, or mill scale.

The annual production of steel in the United States by the basic oxygen process has increased from about 545,000 kkg (600,000 tons) in 1957 to 58 million kkg (64 million tons) in 1971. It is anticipated that basic oxygen production will continue to increase at the expense of open hearth production.

The electric-arc furnace is uniquely adapted to the production of high-quality steels; however, most of the production is carbon steel. Practically all stainless steel is produced in electric-arc furnaces. Electric furnaces range up to 9 meters (30 feet) in diameter and produce from 1.8 to 365 kkg (2 to 400 tons) per cycle in 1.5 to 5 hours.

The cycle in electric furnace steelmaking consists of the scrap charge, the meltdown, the hot metal charge, the molten-metal period, the boil, the refining period, and the pour. The required heat is generated by an electric arc passing from the electrodes to the charge in the furnace. The refining process is similar to that of the open hearth, but more precise control is possible in the electric furnace. Use of oxygen in the electric furnace has been common practice for many years.

Electric-arc furnaces are to be found in almost every integrated steel mill. Many mills operate only electric furnaces, using scrap as the raw material. In most "cold shops" the electric-arc furnace is the sole steelmaking process.

The annual production of steel in the electric-arc furnace has increased from about 7.2 million kkg (8 million tons) in 1957 to some 19 million kkg (21 million tons) in 1971. Although electric-arc furnaces have been small in heat capacity as compared to open hearth or basic oxygen furnaces, a trend towards larger furnaces has recently developed. Electric-arc furnaces are the principal steelmaking process utilized by the so-called mini steel plants which have been built since World War II.

# SECTION IV

## INDUSTRY CATEGORIZATION

An evaluation of the steel making operations was necessary to determine whether or not subcategorization would be required in order to prepare an effluent limitations guideline or guidelines which would be broadly applicable and yet representative and appropriate for the operations and conditions to be controlled. Toward this end an understanding of the operations was required.

## Description of Operations to Make Raw Steel

### Coke Manufacturing

Coke manufacturing is performed as part of an integrated steel mill's function to supply coke which is a basic raw material for the blast furnace. There are two generally accepted methods for manufacturing coke. These are known as the beehive process (nonrecovery) and the by-product or chemical recovery process.

In the by-product method, air is excluded from the coking chambers, and the necessary heat for distillation is supplied from external combustion of fuel gases in flues located within dividing walls between adjacent ovens. Today the by-product process produces about ninety-nine (99) percent of all metallurgical coke. Economic factors have changed the traditional by-product plant operation. Although coke oven gas still remains as a valuable by-product for internal use, the production of light oils, ammonium sulfate and sodium phenolate are not usually profitable.

In the beehive process, air is admitted to the coking chamber in controlled amounts for the purpose of burning the volatile products distilled from the coal to generate heat for further distillation. The beehive produces only coke and no successful attempts have been made to recover the products of distillation.

### Coke Making - By-Product Operation

The desire for a higher quality coke and the economic use of by-products provided the initial impetus in the development of the by-product coke oven.

A by-product coke plant consists essentially of the ovens in which bituminous coal is heated, out of contact with air, to drive off the volatile components. The residue remaining in the ovens is coke; the volatile components are recovered and processed in the by-product plant to produce tar, light oils, and other materials of potential value, including coke oven gas. This process is accomplished in narrow, rectangular, silica brick ovens arranged side by side in groups called batteries. Each coke oven is typically 45 centimeters wide, 4.5 meters high, and 12 meters long (approximately 0.5 x 5 x 13 yards). Heat is

point.   The   water   flows   to   the   naphthalene   sump   where the naphthalene is recovered by skimming and then to a cooling   tower for   recirculation through the final cooler.   A properly designed closed recirculation system should have little or   no   discharged wastewater here, since the cooling tower evaporation balances the moisture   condensation   from   the   gas.   When other than a closed system is used, final cooler water can be the largest   source   of contaminated wastewater.

From   the final coolers, the gas passes through the gas scrubbers in which the   crude   light   oils   are   removed   by   an   absorbent generally   known   as   wash oil.   The crude light oils contain the materials which are further separated and recovered   in   the   by-product   plant.   The   gas   then   goes to a gas holder for use in underfiring the coke ovens and a booster pump which sends   it   to the other mill uses.

Following the gas scrubbers, the light oils are stripped from the wash   oil absorbent by steam distillation; the wash oil is cooled and recirculated to the gas scrubbers.   The   vapors   leaving   the wash   oil still are condensed in the light oil condenser and then flow to the light oil decanter where the light oil and   condensed water   are   separated.   Indirect cooling is generally used in the wash oil cooler and light oil condenser and   no   wastewaters   are produced.   The water separated from the light oil in the decanter is a major source of wastewater.

Two processes are used in the United States for ammonia recovery. They   are   referred to as semidirect and indirect.   Approximately eighty-five (85) percent of the ammonia produced in   coke   plants is   recovered as ammonium sulfate by the semidirect process.   The balance   is   produced   as   concentrated   ammonia   liquor   by   the indirect process.

In   the   indirect   ammonia   recovery   process,   a   portion of the ammonia is dissolved in the flushing liquor.   Additional   ammonia is scrubbed from the gas with water.   An ammonia still is used to concentrate the ammonia liquor for sale in this form.

In the semidirect ammonia recovery process, the ammonia absorber, or   saturator,   follows   the   tar extractor.   Here the gas passes through a dilute sulfuric acid solution in a closed   system   from which ammonium sulfate is crystallized and dried for sale.

The   ammonia   still receives the excess ammonia liquor from which ammonia and other volatile compounds are steam   distilled.   From the   free   leg   of   the ammonia still, ammonia, hydrogen sulfide, carbon dioxide, and hydrogen   cyanide   are   steam   distilled   and returned   to   the gas stream.   Milk of lime is added to the fixed leg of   the   ammonia   still   to   decompose   ammonium   salts;   the liberated ammonia is steam distilled and also returned to the gas stream.   The ammonia liberated in the ammonia still is recovered from the gas as additional ammonium sulfate in the saturators.

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such that a suitable balance between the utilization of sodium hydroxide and the loss of phenol results in the conversion of about fifty (50) percent of the available sodium hydroxide into sodium phenolate with a loss of about five (5) percent of the phenol.

The coke oven gas is sometimes further purified following the light oil scrubbers to remove hydrogen sulfide. The carbonate process is sometimes used to recover elemental sulfur for sale. Some plants employ no ammonia stills or saturators. The Keystone process recovers anhydrous ammonia through absorption in a recycled solution of ammonium phosphate. In a typical absorption cycle, lean forty (40) percent phosphate solution is used to absorb ammonia. The enriched phosphate solution is then reboiled in a distillation tower from which the ammonia vapor is recovered and the phosphate solution is separated for reuse. The nature of the Keystone operation is such that additional light oils are recovered from the gas due to the fact that it is cooled and compressed following the conventional light oil scrubbers. The wastewater produced here would presumably be similar to those from the conventional light oil decanter and agitator.

The crude coal tar is usually sold as produced. At some plants, however, the tar is refined using a continuous type distillation unit with multiple columns and reboilers. Ordinarily continuous distillation results in four fractions: light oils, middle or creosote oils, heavy oils, and anthracene oil which are cuts taken at progressively higher temperatures. The light oils are agitated with sulfuric acid and neutralized with caustic soda after the first crude fractionization and then redistilled.

After naphthalene removal, the phenols and other tar acids are extracted from the middle oil fraction with a caustic solution, neutralized and then fractionally distilled. The wastewaters although small in volume when compared with other coke plant waste sources do contain a variety of organic compounds from process water uses in addition to the cooling and condenser water found from distillation processes.

The most significant liquid wastes discharged from the coke plant are excess ammonia liquor (varying from straight flushing liquor to still waste), final cooling water overflow, light oil recovery wastes, and indirect cooling water. In addition, waste waters may result from coke wharf drainage, quench water overflow, and coal pile runoff.

The volume of ammonia liquor produced (including steam condensate) varied from 100 to 200 l/kkg (24 to 48 gal/ton) of coke at plants using the semidirect ammonia recovery process to 350 to 530 l/kkg (84 to 127 gal/ton) for the indirect process. As indicated above, only a few by-product coke plants utilize the latter process.

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY-PRODUCT COKE PLANT
BY-PRODUCT RECOVERY
PROCESS FLOW DIAGRAM

3-21-73   FIGURE 2

Environmental Protection Agency
Steel Industry Study
By-Product Coke Plant
Light Oil Recovery Refinery
Process Flow Diagram

5-31-73   FIGURE 3
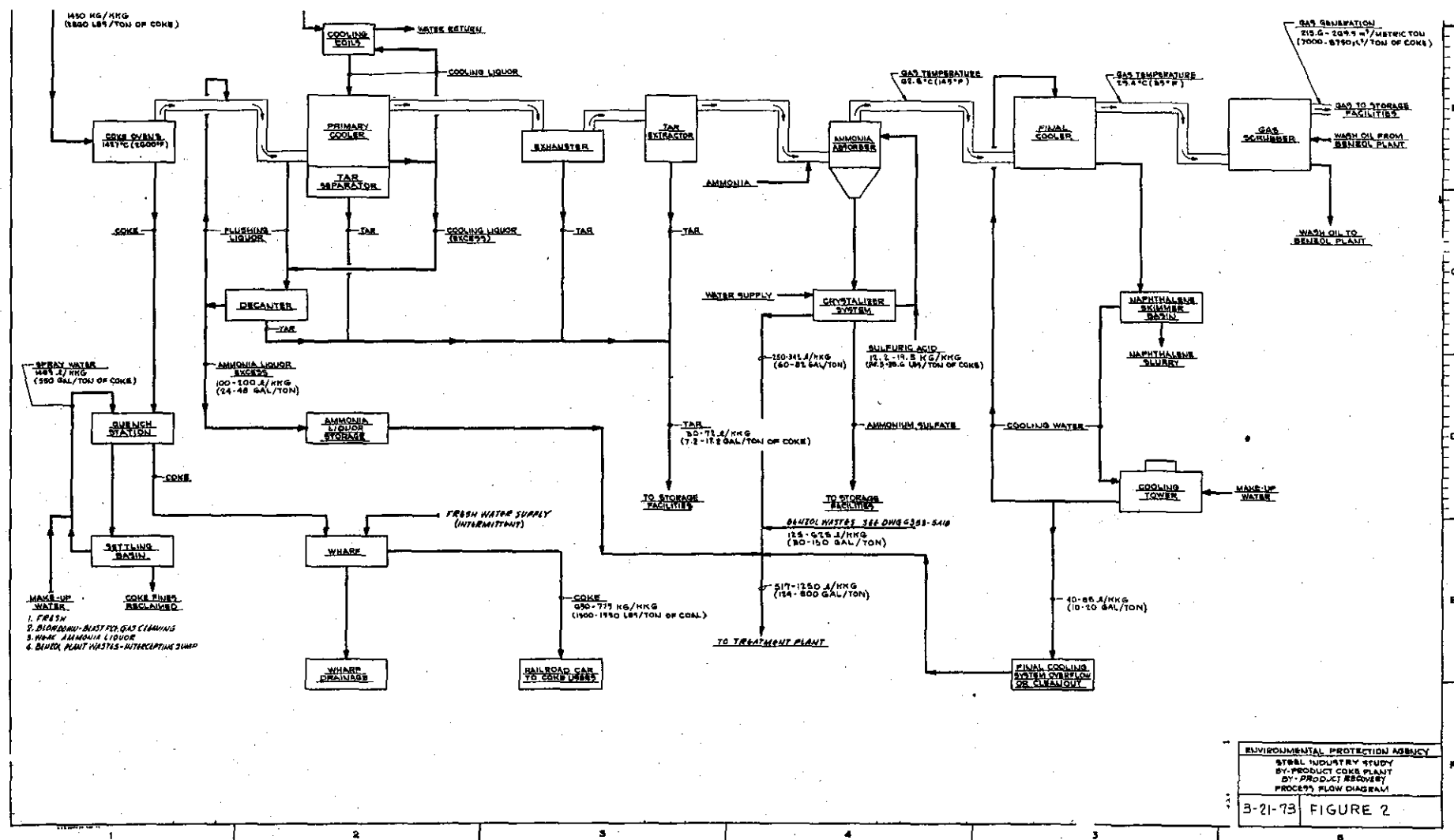
The beehive ovens were popular in the early nineteen hundreds, which was prior to the existence of air pollution regulations. The gases were simply discharged into the atmosphere. The beehive coking industry reached its maximum production in 1916 when more than 31 million kkg (34 million tons) of beehive coke were produced, this being two-thirds (2/3) of the total national coke production. A properly controlled beehive oven will have very little water discharge. If water is not properly regulated, the working area becomes quite sloppy. Therefore, it behooves the operator to regulate the water to insure a good working environment. In some instances, an impoundment lagoon is provided to collect overflow water and settle out coke fines. Discharges from this pond will contain phenol and cyanide.

More specific details of the beehive coke process are shown on Figures 4 and 5.

Sintering Subcategory

The sintering plant as part of today's integrated steel mill has the primary function of agglomerating and recycling fines back to the blast furnace. Fines, consisting of iron bearing wastes such as mill scale and dust from the basic oxygen furnace, open hearth and blast furnace are blended with fine iron ore and limestone to make an agglomerate for charging to the blast furnace.

The sintering is achieved by blending the various iron bearing components and limestone with coke fines which act as a fuel. The mixture is spread evenly on a moving down draft grate and ignited by a gas fired ignition furnace over the bed. After ignition, the down draft of air keeps the coke burning and as it burns, it quickly brings the bed to fusion temperature. As the bed burns, the carbon dioxide is driven from the limestone, and a large part of the sulfur, chloride and fluoride is driven off with the gases. The oil in the mill scale is vaporized and also removed with the gases.

The hot sinter is crushed as it is discharged from the sinter machine and the crushed sinter is screened before it is air cooled on a sinter cooler. After cooling, the sinter is sized in several size fractions. The sizing is necessary to meet the requirements of the blast furnace operators that the feed to the blast furnace be closely sized at any one time. The fines [below 0.6 cm (0.24 in.)] from the screening are recycled to the beginning of the sinter process.

The sinter is very dusty and abrasive; therefore, each transfer must be carefully hooded and dedusted. The submicron sized dust particles which are collected are recycled to the beginning of the process.

The areas of pollution in the sintering plant are the material handling dust control equipment, the dust in the process gases and the volatilized gases and oil in the process gases. The sulfur in the process gas comes primarily from the fact that the

COAL SUPPLY

MINE

COAL CONVEYOR SYSTEM

COAL STORAGE

LARRY CAR

COAL
9090 - 11815 KILOGRAMS/CHARGE
(20,000 - 30,000 LBS./CHARGE)

LARRY CAR

16 - 72 HOURS

COKE

BEEHIVE COKE OVEN

QUENCH WATER

COKE
5909 - 9090 KILOGRAM/CHARGE
(13,000 - 20,000 LBS/CHARGE)

HOT CAR

QUENCH WATER
EXCESS TO RECYCLE
OR DISCHARGE

COKE CONVEYOR SYSTEM

COKE STORAGE

SCREENING STATION

RAILROAD CAR

COKE TO USERS
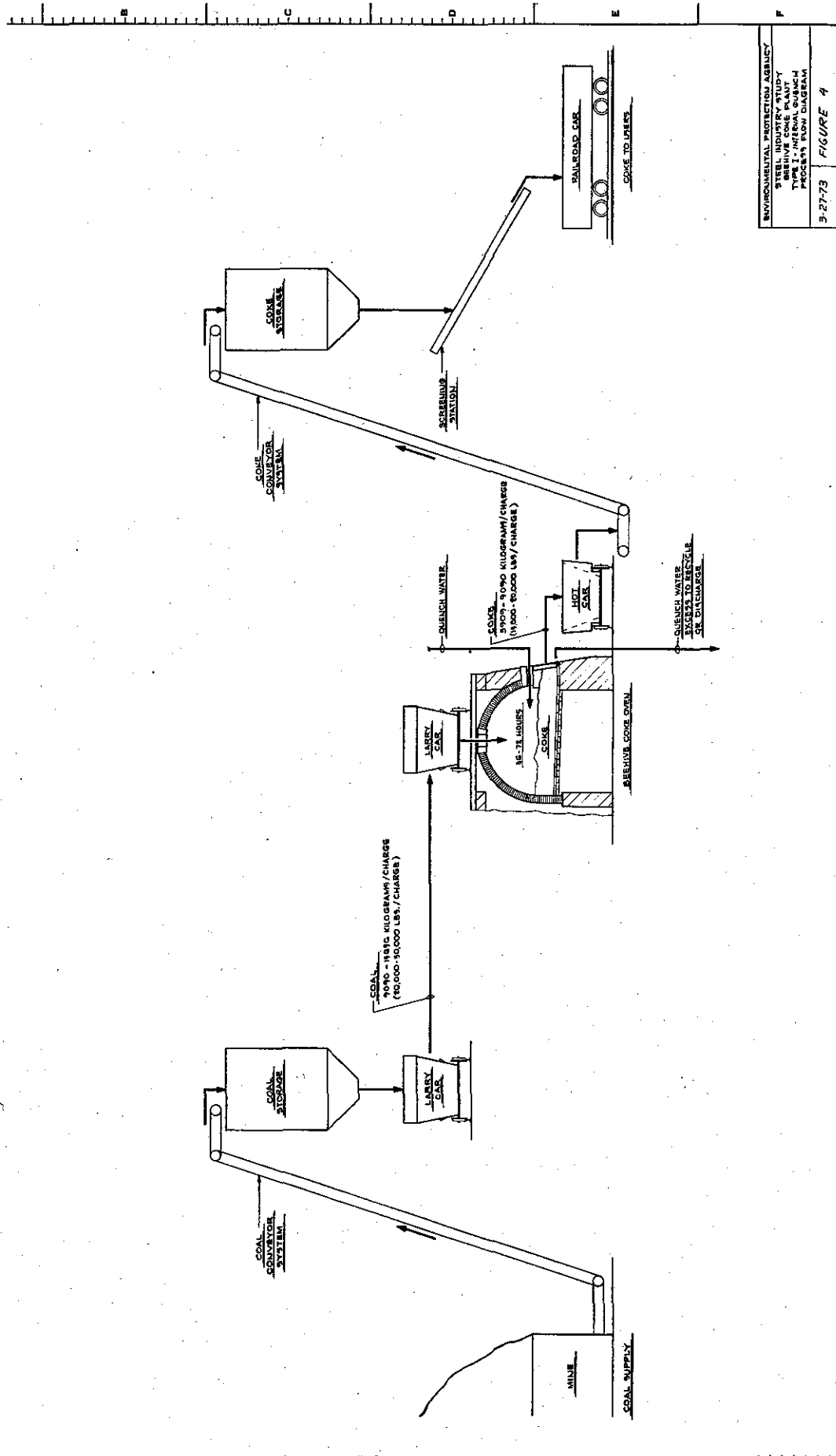
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BEEHIVE COKE PLANT
TYPE II - EXTERNAL QUENCH
PROCESS FLOW DIAGRAM

3-30-73  FIGURE 5

COKE ~ (600 #/S.T.)  (.10 #/S.T.)  (.12 #/SINTER TON)  (.06 #/S.T.)
90 kg/kkg  299-599 g/kkg
(180 #/S.T.)  (.6-1.2 #/S.T.)

ORE BIN | SINTER FINE BIN | SCALE OR LIME BIN | FLUE DUST BIN | GROUND COKE BIN

SINTER MIX CONVEYOR

WATER

PUG MILL

DEDUSTING AIR
1650 m³/kkg (50,000 SCF/SINTER TON)
.004-.008 g/m³/kkg (2-4 GRAINS/SCF/S.T.)
7-14 KILOGRAMS/kkg (14-28 #/S.T.)

DUST COLLECTION PICK-UP POINTS
1) SINTERING MACHINE DISCHARGE CHUTE.
2) DISCHARGE CHUTE TO SINTER COOLER.
3) DISCH. FROM SINTER COOLER TO CONV.
4) HOT FINES RETURN CONVEYOR.
5) CHUTES FROM CONV. TO PRIMARY PUG MILL.
6) DISCH. FROM PRIMARY PUG MILL TO CONV.

HOT END DEDUSTING AIR
3300 m³/kkg (100,000 SCF/SINTER TON)
.013-.017 g/m³/kkg (6-8 GRAINS/SCF/S.T.)
42.5-57 kg/kkg (85-114 #/SINTER TON)

WATER SUPPLY
SPRAY WATER

WASTE GASES

HIGH ENERGY VENTURI SCRUBBER

SEPARATOR

STACK

EFFLUENT WATER

INDUCED DRAFT FAN

SECONDARY DEDUSTING COLLECTOR

PRIMARY DEDUSTING COLLECTOR

SINTER MIX CONVEYOR

WASTE GASES

BALL DRUM

SINTER MIX CONVEYOR

SURGE BIN & ROLL FEEDER

NATURAL GAS
5 m³/kkg (180 ft³/S.T.)

COOLER AIR
6600 m³/kkg (200,000 SCF/S.T.)
.0004-.0008 g/m³/kkg (2-4 GRAINS/SCF/S.T.)
3-6 kg/kkg (6-12 #/SINTER TON)

DRY PRECIPITATORS

SINTER CRUSHER

STACK

FAN

PROCESS GAS
6600 m³/kkg (200,000 SCF/S.T.)
.001-.008 g/m³/kkg (.5-1.0 GRAINS/SCF/S.T.)
42.5-85 kg/kkg (85-170 #/SINTER TON)
SULPHUR ~ .95-1.5 kg/kkg (1.9-3.0 #/S.T.)
CHLORINE ~ 49.9 GRAMS/kkg (.10 #/S.T.)
FLUORINE ~ 49.9 g/kkg (.10 #/SINTER TON)

SINTER MACHINE

HOT SINTER FEEDER & SCREEN

SINTER COOLER

1000 kg/kkg
(2000 #/SINTER TON)

EXHAUST STACK

INDUCED DRAFT FAN W/ GAS TURBINE OR ELECTRIC DRIVE

PRECIPITATED DRY DUST

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING PLANT
TYPE I - WET
PROCESS FLOW DIAGRAM

2-21-73  FIGURE 6

RAW FEED PER TON PRODUCT

| | WEIGHT | SULPHUR | CHLORINE | FLUORINE | OIL |
|---|---|---|---|---|---|
| ORE - | | | | | |
| MILL SCALE - | | | | | |
| B.A. DUST - | | | | | |
| OH. B.A. GR. - | | | | | |
| LIMESTONE - | | | | | |
| COKE - | | | | | |

DUST COLLECTION PICK-UP POINTS

1) SURGE BIN
2) TABLE FEEDER FOR BINS

DEDUSTING AIR

DUST COLLECTION PICK-UP POINTS

1) SINTERING MACHINE DISCHARGE CHUTE.
2) DISCHARGE CHUTE TO SINTER COOLER.
3) DISCH. FROM SINTER COOLER TO CONV.
4) HOT FINES RETURN CONVEYOR.
5) CHUTES FROM CONV. TO PRIMARY PUG MILL.
6) DISCH. FROM PRIMARY PUG MILL TO CONV.

HOT END DEDUSTING AIR

SINTER MIX CONVEYOR

ORE BIN

SINTER FINE BIN

SCALE OR LIME BIN

FLUE DUST BIN

GROUND COKE BIN

WATER

PUG MILL

BALL DRUM

SINTER MIX CONVEYOR

PRIMARY DEDUSTING COLLECTOR

SECONDARY DEDUSTING COLLECTOR

SINTER MIX CONVEYOR

DRY PRECIPITATORS

PRECIPITATED DRY DUST

WASTE GASES

EXHAUST STACK

INDUCED DRAFT FAN W/GAS TURBINE OR ELECTRIC DRIVE

WASTE GASES

STACK

INDUCED DRAFT FAN

BAGHOUSE

DRY DUST

SINTER MACHINE

NATURAL GAS

SURGE BIN / ROLL FEEDER

PROCESS GAS

HOT SINTER FOLDER & SCREEN

SINTER CRUSHER

SINTER COOLER

COOLER AIR

FAN

STACK

Raw Feed Per Ton Product

| | WEIGHT | SULPHUR | CHLORINE | FLUORINE | OIL |
|---|---|---|---|---|---|
| ORE – | 1383.4 #/.44t | 84.9 #/.44t | | | |
| MILLSCALE– | 130.2#/.44t | 10.2 #/.44t | | | |
| BA.DUST– | 80.5#/.44t | 10.9#/.44t | | | |
| OX.FE.SCR– | 10.3#/.44t | 0.5#/.44t | | | |
| LIMESTONE– | 1100.5#/.44t | 1.1#/.44t | | | |
| DUST– | 300.2#/.44t | 0.8#/.44t | | | |
| COKE – | 500.3#/.44t | 30.2#/.44t | | | |
| | (160.2#/S.T.) | (3.1#/S.T.) | | | |

SINTER MIX
CONVEYOR

ORE BIN  SINTER FINE BIN  SCALE OX BIN  FLUX DUST BIN  GROUND COKE BIN

PUG MILL  ← WATER

BALL DRUM

SINTER MIX CONVEYOR

SINTER MACHINE

SURGE BIN / RECL. FEEDER

NATURAL GAS  180 #/#t/s.f.

HOT SINTER FEEDER & SCREEN

SINTER CRUSHER

SINTER COOLER

COOLER AIR  0660 m³/.44t (800,000 SCF/S.T.)
FAN  1000 hp/.44t (1500 #/SINTER Ton)

PROCESS GAS

DUST COLLECTION PICK-UP POINTS

Dust Collection Pick-Up Points

PRIMARY DEDUSTING COLLECTOR

SECONDARY DEDUSTING COLLECTOR

SINTER MIX CONVEYOR

WATER SUPPLY  SPRAY WATER

HIGH ENERGY VENTURI SCRUBBER

SEPARATOR

INDUCED DRAFT FAN

STACK

WASTE GASES  →

EFFLUENT WATER

WATER SUPPLY  SPRAY WATER

HIGH ENERGY VENTURI SCRUBBER

SEPARATOR

INDUCED DRAFT FAN

STACK  WASTE GASES  →

EFFLUENT WATER

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING PLANT
TYPE III WET
PROCESS FLOW DIAGRAM
6-15-73  FIGURE 8

the desired size, they automatically are discharged over the edge. The disc is hooded and vented through a bag type dust collector. The product is discharged into a truck or tote box for removal.

A plant for production of blast furnace feed would consist of a blending and grinding system where the coarser waste material is ground fine enough to pelletize (at least 50% minus 325 mesh). The ground material and fine waste material are blended with a cement binder and the mixture pelletized with a pelletizing disc in a size range from 0.95 to 1.5 cm (0.4 to 0.6 in.). The pellets from the disc are distributed evenly on a curing belt to a depth of about 12 cm. The atmosphere of the curing belt is controlled with the humidity near saturation and the temperature gradually increasing from 20°C to 90°C in approximately three hours. The partially cured pellets are then transferred to a curing bin where they gain final strength in 24 hours. The pellets are screened at 0.6 cm with the fines being recycled through the process. This process virtually eliminates all form of pollution by having no emission except filtered air.

More specific details of the pelletizing process are shown on Figures 9 and 10.

Hot Briquetting Operation

A hot briquetting plant's primary function is to agglomerate steel plant waste material and to make a briquette of sufficient strength to be a satisfactory blast furnace charge. The steel plant wastes may include mill scale, dust from the basic oxygen furnace, open hearth, electric furnace, blast furnace and slag fines from reclamation plants, coke breeze, limestone and pellets. Since hot briquetting plants only process in-plant generated waste, they will be much smaller in size than sintering plants.

The waste will be blended and pelletized to produce a reasonably uniform 1/2 x 1 centimeter diameter pellet for feeding into the fluid bed. The cured pellets are mixed with the hot briquettes from the briquette press and together they pass through a heat exchange drum where the pellets are heated and the briquettes cooled. The heated pellets and cooled briquettes are then separated in a vibrating screen. The preheated pellets are then put into a fluid bed heater where they are heated to approximately 900°C before discharge into the briquetting press. The heat for the fluid bed heater is supplied by the oxidation of the carbon, the iron and the magnetite in the waste material. The discharge temperature is controlled by the amount of fluidizing air added to the fluid bed. The hot gas cyclone is used to remove the hot dust from the air stream and to return the dust to the bottom of the fluid bed where they are discharged to the briquette press.

One of the advantages of hot briquetting is that for a hot process, the air quantity and temperature are kept to minimum.

BASIC
OXYGEN
FURNACE
DUST

OPEN
HEARTH
FURNACE
DUST

ELECTRIC
FURNACE
DUST

PELLETIZING DISC.

TRUCK OR RAIL { DISPOSAL
SINTER PLANT FEED
OPEN HEARTH FEED
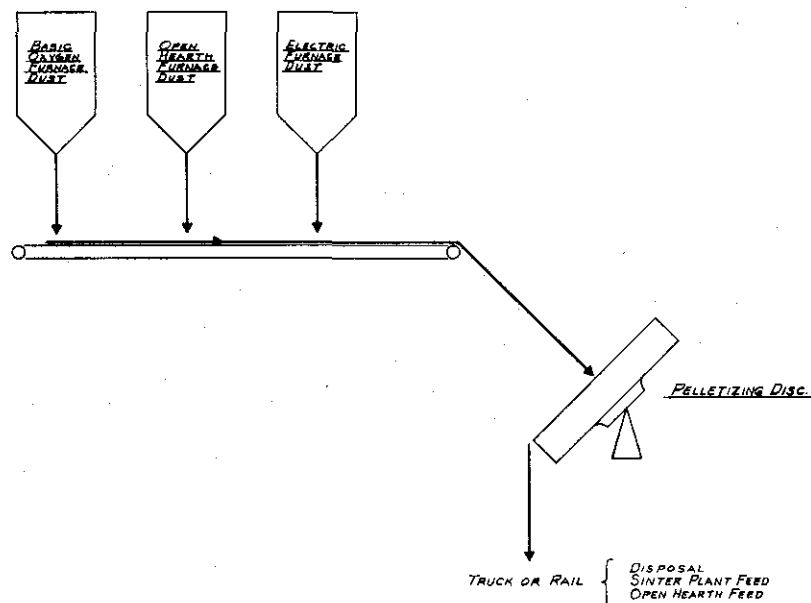
ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
PELLETIZING PLANT
TYPE II - UNCURED
PROCESS FLOW DIAGRAM

4-16-73 | FIGURE 10

DEDUSTING AIR
51.2 m³/METRIC TON (1000 SCF/BRIQUETTE TON)
DUST LOADING
.005-.008 g/m³/kg (3-4 GRAINS/SCF/B.T.)
249.5 g/kg (.5 LB/B.T.)

EXHAUST AIR
249.1 m³/METRIC TON - 500 kg (8000 SCF/BRIQUETTE TON - 500 LB.)
DUST LOADING
.002 g/m³/kg (1 GRAIN/SCF/B.T.)
545.9 g/kg (.1 LB/B.T.)
SULPHUR
49.9 g/kg (.1 LB/B.T.)

MILL SCALE | B.F. DUST | O.H. DUST | B.O.F. DUST | SLAG FINES | COKE FINES

DUST COLLECTOR (BAG TYPE)

FROM DEDUSTING SYSTEM

I.D. FAN    STACK

CYCLONE

DUST COLLECTOR (BAG TYPE)

HOT PROCESS GAS    FINES RECYCLE    DUST    I.D. FAN    STACK

### RAW FEED PER TON PRODUCT (BRIQUETTE TON)

| MATERIAL | WEIGHT | SULPHUR | CHLORINE | FLUORINE | OIL |
|---|---|---|---|---|---|
| MILL SCALE | 505.5 kg/kkg (911 LB/B.T.) | 49.9 g/kg (0.1 LB/B.T.) | — | — | 0.9-5.05 kg/kkg (15-6.1 LB/B.T.) |
| B.F. DUST | 256 kg/kkg (510 LB/B.T.) | 1.5-2.55 kg/kkg (3.0-5.1 LB/B.T.) | 149.7 kg/kkg (0.5 LB/B.T.) | — | — |
| O.H. OR B.O.F. DUST | 265 kg/kkg (510 LB/B.T.) | 2.55-5.1 kg/kkg (5.1-10.5 LB/B.T.) | — | .25-1.35 kg/kkg (0.5-2.7 LB/B.T.) | — |
| SLAG FINES | 102.5 kg/kkg (205 LB/B.T.) | — | — | — | — |
| COKE FINES | 102.5 kg/kkg (205 LB/B.T.) | 0.7-1.05 kg/kkg (1.4-2.1 LB/B.T.) | — | — | — |

FLUID BED

PROCESS AIR BLOWER

BRIQUETTE PRESS

SCREENING STATION

WATER SUPPLY

CURING

PELLETIZING DISC

HEAT EXCHANGE DRUM

BUCKET ELEVATOR

PRODUCT

Approximately 3.5 kkg (3.8 tons) of air are blown through the furnace to make one kkg (1.1 tons) of iron. This air must be compressed to three (3) or four (4) atmospheres and heated to 800°C to 1,000°C before it is injected into the bottom of the furnace. Large steam turbine driven compressors are used for the compression. These turbines may be backpressure, extracting, or condensing in design. If the steam is condensed, large volumes of cooling water are passed through the turbine condensers. The liquid wastes associated with this area would be very similar to those found at utility power generating stations.

After compression, the air is passed through refractory filled vessels called stoves for preheating prior to entering the furnace. Cleaned blast furnace gas is used to preheat the refractory. Two stoves are generally being heated with blast furnace gas while the third stove is preheating the air prior to injection into the furnace. Water is used at the stoves to cool the gas burners and associated equipment.

Because of the high furnace temperatures and the large furnace size, a great deal of cooling water is associated with the operation of a blast furnace. Most plants use once through cooling water, but in some water shortage areas, recirculating cooling systems are used. As a general rule, even in water plentiful areas, some degree of water reuse and recycle is practiced.

The blast furnace proper has a great deal of water cooling associated with it. However, on a blast furnace, the normal temperature rise is very small by comparison to other processes. Rarely is the cooling water temperature rise more than 5°C and frequently it is 1°C or less. In order to conserve water, many plants will take a portion of the cooling water from the furnace and use it in their gas cleaning operations. Other than non-contact cooling water, there should be virtually no wastewater discharges from the furnace proper.

The gases leaving the top of the furnace are hot, dust laden, and traveling at high velocities. The gas consists primarily of a mixture of nitrogen, carbon dioxide, carbon monoxide, and water vapor. In additon to these major components, there are trace amounts of other gases, the most important of which is hydrogen cyanide. This gas is the product of an unwanted reaction of the nitrogen in the air with the hot coke in the furnace. Its concentration is influenced primarily by the temperature of operation. A very hot furnace tends to produce more cyanide than a cooler one. Since the furnace is run on a reducing atmosphere, none of the normal oxides of nitrogen or sulfur are found. Traces of hydrogen sulfide may be present. The gas is explosive and poisonous to the point of fatality on extended exposure mainly because of its carbon monoxide content.

The first step in cleaning the gas so that it can be used as a fuel is to pass it through a settling chamber called a dust catcher to settle out the larger dust particles. This is a dry

Large volumes of water are required to operate a blast furnace and its associated equipment. A major portion of the water is used for the non-contact cooling of the blast furnace hearth and shell, the stove burners and to condense the steam used to drive the air compressors. This water increases approximately 1-5°C in temperature; otherwise it is discharged in essentially its original state.

A lesser portion of the water is used for contact cooling the blast furnace gas and slag quenching as well as for blast furnace gas cleaning. These waters contain settleable solids and traces of various chemicals contained in the blast furnace gas stream and the slag. The blast furnace gas scrubbing water represents the major portion of the wastewater from the blast furnace area.

More specific details of the blast furnace operation are shown on Figures 12, 13, 14 and 15.

Steelmaking Operations

There are three primary methods in use today for the production of steel: the electric arc furnace, the open hearth furnace and the basic oxygen furnace.

The newest method, the basic oxygen furnace, was introduced in the early fifties and is now rapidly replacing the older open hearth practice. In 1972 the basic oxygen process accounted for 56% of steel production, the open hearth 26.3%, and the electric arc furnace 17.7%.

Each method generally uses the same type of basic raw materials to produce the steel and also results in generally the same waste products such as slag (fluxes), smoke, fume and waste gases.

The basic raw materials for the manufacture of steel are hot metal (iron), scrap steel, limestone, burnt lime (CaO), fluorspar ($CaF_2$), dolomite ($MgCO_3$ and $CaCO_3$) and iron ores (oxides of iron). Other iron bearing materials such as pellets and mill scale are used when available. Alloying materials such as ferro manganese, ferro silicon, etc., are used to finish the steel composition to required specifications. These are usually added to the steel ladle, but sometimes they are added directly to the furnace steel bath. The raw materials are shipped, railroaded or trucked into the plant and are unloaded by means of chutes and conveyor systems into storage bins. In some plants, they are unloaded at an unloading station, and mill cranes or special cars charge the raw materials into the furnaces.

The waste products derived from the material handling systems are generally airborne contaminants of dust, fumes, and smoke which do not become waterborne until some type of wet dust collector system is utilized.

All three furnace methods use pure oxygen and/or air to refine the hot metal (iron) and other metallics into steel by oxidizing

BLAST FURNACE GAS (DIRTY) AVG. TEMPERATURE 259.7°C (500°F)
GASES: 3,480 m³ or 6,000 KG/KKG OF IRON   TOP DUST: .02 - .04 GRAINS/m³/METRIC TON
(174,000 ft³ = 10,000 LBS/NKGT TON)   (10 - 15 GRAINS/FT³/INGOT TON)
GAS COMPOSITION (AVG)   DUST COMPOSITION (AVG)
CO₂ — 11.5%            < DUST MICRON
O₂  — 0.01%            C  : 15%
CO  — 26.6%            C  : 50%
H₂  — 3.1%             Fe : 80%
CH₄ — 0.1%            SIO₂: 10%
N₂  — 56.4%
H₂O — 0.05%

WASTE GASES
TO ATMOSPHERE

TO ATMOSPHERE

BLEEDER VALVE

DOWNCOMER

GAS UPTAKE

RECEIVING HOPPER

SKIP CAR (DUMPING)

STORAGE BINS

SKIP CAR (LOADING)

SKIP HOIST

STACK

STOVE (HEATING)

STOVE (BLOWING)

BLAST FURNACE GAS (CLEANED)
10% OF GAS GENERATED

AIR 3500 KG/KKG
(7000 LBS/TON)
Mg. 20 m³/KG. = 14/METRIC TON
(90 ft³ = 25 LBS/INGOT TON)

COLD BLAST (AIR)
FROM BLOWERS

BUSTLE PIPE

HOT BLAST

GAS BURNER

DUST CATCHER

FLUE DUST (40% REMOVED)
42 - 150 kg/METRIC TON
(84 - 300 LBS/INGOT TON)

NATURAL GAS
24 m³. = 203 g/METRIC TON
(865 ft³ = AI LBS/INGOT TON)

BLAST FURNACE

TAPPING HOLE

CINDER NOTCH

HOT METAL (IRON)
RUNNER, SCRAP
g/METRIC TON
(12 LBS/INGOT TON)

HOT METAL (IRON)
AVERAGE ANALYSIS
CARBON (C)        — 4.5%
SILICON (Si)      — 1.10%
MANGANESE (Mn)    — 0.50% MINIMUM
PHOSPHORUS (P)    — 0.114%
SULPHUR (S)       — 0.015%
TEMPERATURE       — 0.97°C (2310°F)

SLAG
500 KG/KKG
(1000 LBS/TON)

SLAG LADLE

SEE SLAG PROCESS
FLOW DIAGRAM

HOT METAL CAR (IRON)

TO HOT METAL USERS
SEE PROCESS FLOW DIAGRAMS

COKE
500 KG/KKG OF IRON
(1000 LBS/TON)

IRON ORE
1000 KG/KKG OF IRON
(4000 LBS/TON)

LIMESTONE
500 KG/KKG OF IRON
(1000 LBS/TON)

PRIMARY SCRUBBER
(VENTURI OR ORIFICE)

SCRUBBER WATER
5120 - 17,670 kg/METRIC TON
(2000 - 3600 GAL/TON)

ONCE THROUGH OR RECYCLED

ENTRAINMENT SEPARATOR
AND
COOLING TOWER

TO STOVES & BOILER H & ETC.
0.05 - 0.1 GRAINS/SCF

CONTAINS 40% OF TOTAL SOLIDS PRODUCED

TO TREATMENT SYSTEM

BLAST FURNACE GAS (DIRTY) AVG. TEMPERATURE 193.3°C (380°F)

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE
TYPE II - PRIMARY & SECONDARY
PROCESS FLOW DIAGRAM

3-20-73    FIGURE 13

STEEL INDUSTRY STUDY
BLAST FURNACE
TYPE III - PRIMARY WET WORKY SECONDARY
PROCESS FLOW DIAGRAM

3-23-73    FIGURE 14

WASTE GASES
TO ATMOSPHERE

TO ATMOSPHERE

BLEEDER VALVE

DOWNCOMER

GAS UPTAKE

COKE — 1.5 T/T Fe Mn

FERRO-MANGANESE

LIMESTONE

SKIP CAR (DUMPING)

RECEIVING HOPPER

SERVICE H₂O
3582g R/METRIC TON
(8,100 GM/TON)

TO BOILERS
CLEANED GAS
0.004 - 0.088 GRAIN/SCF
120 - 158 BTU/SCF

BLAST FURNACE GAS (DIRTY)    AVG. TEMPERATURE 259.7°C (500°F)
GASES: 2080.9 N³ .2614 Kg/METRIC TON
(64,580 FT³ .5018 LB/INGOT TON
GAS COMPOSITION (AVG)    0.15 T DUST / INGOT TON
                         DUST COMPOSITION (AVG)  1/2 TO AVG. 0.5 MICRON
CO₂ - 12.8%              MN  - 15-25%
O₂  - 0.01%             Fe  - 0.5-0.5%
CO  - 28.5%            Na₂O & K₂O - 8 -15%
H₂  - 3.5%             SiO₂ - 4 - 14%
CH₄ - 0.2%            Al₂O₃ - 5 - 11%
N₂  - 54.9%            CaO  - 8 -15%
H₂O - 0.03%           MgO  - 4 - 8%
                       TO₄  - 5 - 7%
                       C    - 7 - 27%

STORAGE BINS

COLD BLAST (AIR) FROM BLOWERS

BLAST FURNACE

BUSTLE PIPE

VENTURI SCRUBBER

DUST CATCHER

SEPARATOR

COOLING TOWER

OXYGEN INJECTION

HOT BLAST 30% O₂

RECYCLE H₂O
9341 R/METRIC TON
2,258 GM/TON

SKIP CAR (LOADING)

STACK

STOVE (HEATING)

STOVE (BLOWING)

GAS BURNER

FLUE DUST TO LAND FILL

TO TREATMENT

TO SEWER

SKIP HOIST

HOT METAL COMPOSITION
MN - 74-82%
SI - 0.5-1.25%
P  - 0.1-0.35%
C  - 0.07-7.5%
S  - < 0.05%
Fe - 7-12%

580 T/DAY

TO SLAG DUMP

SLAG LADLE

BLAST FURNACE GAS (CLEANED)

TO CASTING OPERATION

HOT METAL CAR
FERRO-MANGANESE

1    2    3    4    5    6

hood is sometimes used where the hood clamps tightly over the furnace mouth and prevents the carbon monoxide gas from burning. The gas is then either collected for fuel or burned at the stack outlet.

If venturi scrubbers are used, the majority of the airborne contaminants are mixed with water and discharged as an effluent. Generally, water clarification equipment is provided for treatment of this effluent.

In the case of precipitators, two approaches are used for quenching (cooling) the gases. One is to have an exact heat balance between water required and gas cooling; no effluent is discharged in this case as all of the water is evaporated. The other approach is to pass the gas through a water spray thus oversupplying the water which is discharged as an effluent. This is commonly referred to as a spark box chamber whereas the other is an evaporation chamber.

More specific details of the basic oxygen furnace are shown on Figures 16 through 20.

## Open Hearth Furnace Operation

The open hearth furnace steelmaking process is an older method of producing steel in a shallow rectangular refractory basin or hearth enclosed by refractory lined walls and roof. The furnace front wall is provided with water cooled lined doors for the means of charging raw materials into the furnace. A plugged tap hole at the base of the wall opposite to the doors is provided to drain the finished molted steel into ladles. Open hearth furnaces can utilize an all-scrap steel charge but generally are used with a 50-50 charge of hot metal and steel scrap.

Fuel in the form of oil, coke oven gas, natural gas, pitch, creosote, tar, etc., is burned at one end of the hearth to provide heat for melting of scrap and other process requirements; the type of fuel utilized depends upon the plant economics and fuel availability. The hot gases from the refining process and combustion of fuel travels the length of the hearth above the raw materials charge and is conducted into a flue downward to a regenerator brick chamber called checkerwork or checkers. These brick masses absorb heat and cool the waste gases to 650-750°C. The combustion system burners, checkers and flues are duplicated at each end of furnace, which permits frequent and systematic reversal of flows, flue gases and preheated air for combustion.

A system of valves in the flues effect the gas reversal so that heat stored in checkers is used to preheat the incoming furnace combustion air. In some plants, the gases leaving the checkers pass through waste heat boilers which further reduce the waste gas temperature to 260-315°C. Sometimes pure oxygen is lanced over the bath to speed up the oxidation (refining) cycle. The tap-to-tap time will vary from five to 8 hours with oxygen lancing as opposed to eight to 12 hours without oxygen. Where

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Environmental Protection Agency
Basic Oxygen Furnace
Type I - Dry
Process Flow Diagram

2-22-73    FIGURE 16

Environmental Protection Agency
Steel Industry Study
Basic Oxygen Furnace
Type II - OG-Wet
Process Flow Diagram

2-26-73  FIGURE 17

Environmental Protection Agency
Steel Industry Study
Basic Oxygen Furnace
Type III - Semi-Wet
Process Flow Diagram

2-15-73   FIGURE 18

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Basic Oxygen Furnace Heat Averages

Lime Silica Ratio — 3.0 to 1.0
Yield — 87 to 89%
Hot Metal Charge — 70%
Cold Scrap Charge — 30%
Oxygen Blowing Time — 15 to 20 Minutes
Tap to Tap Heat Cycle — 45 Minutes
Heats Per Day — 92

Liters Per Minute Formula

$\frac{\text{Liters/Metric Tons Heat}}{\text{LPM - Oxygen Blowing Time of 18 Minutes}}$

GPM Formula

$\left(\frac{\text{Gal./Ingot Tons Heat}}{\text{GPM - Oxygen Blowing Time of 18 Minutes}}\right)$

Environmental Protection Agency
Steel Industry Study
Basic Oxygen Furnace
Type II - Low Energy - Wet
Process Flow Diagram

2-22-73   FIGURE 20

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
OPEN HEARTH FURNACE
PROCESS FLOW DIAGRAM

2-8-73   FIGURE 21

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
OPEN HEARTH FURNACE
TYPE II - WET AND DRY
PROCESS FLOW DIAGRAM

2-16-73 | FIGURE 22

Environmental Protection Agency
Steel Industry Study
Open Hearth Furnace
Type III - Wet
Process Flow Diagram

2-21-73  Figure 23

to a teeming or continuous casting area. Sometimes the customer's specifications require further treatment and alloying of the steel for which the steel is then first transported to a vacuum degassing process area.

More specific details of the electric furnace process are shown on Figures 24, 25, 26, and 27.

## Vacuum Degassing Subcategory

In the vacuum degassing process, steel is further refined by subjecting the molten steel to a high vacuum (low pressure). This process further reduces hydrogen, carbon, and oxygen content, improves steel cleanliness, allows production of very low carbon steel and enhances mechanical properties of the steel. Vacuum degassing facilities fall into three major categories:

1. Recirculating degassing, where metal is forced into a refactory-lined degassing chamber by atmospheric pressure, exposed to low pressure (vacuum) and then discharged from chamber.

2. Stream degassing in which falling streams of molten metal are exposed to a vacuum and then collected under vacuum in an ingot mold or ladle.

3. Ladle degassing, where the teeming ladle is subsequently positioned inside a degassing chamber where the metal is exposed to vacuum and stirred by argon gas or electrical induction.

The recirculatory systems are of two types D-H (Dortmund Horder) and the R-H (Ruhrstal-Heraeus).

The R-H system is characterized by a continuous flow of steel through the degassing vessel by means of two nozzles inserted in the teeming ladle molten steel while the D-H system is characterized by a single nozzle inserted in the molten steel. The R-H system degassing chamber and ladle are stationary while the D-H system ladle oscillates up and down.

A four or five stage steam jet ejector with barometric condenser is used to draw the vacuum. A means of providing heat is furnished in the process by electric carbon heating rods to replace heat loss in the process or in some cases to raise the temperature of the steel bath. Alloys are generally added during this process and cycle time is approximately 25 to 30 minutes.

The waste products from vacuum degassing process are condensed steam and waste with iron oxide fumes and CO gases entrained in the discharge effluent.

More specific details of the vacuum degassing process are shown on Figure 28.

Environmental Protection Agency
Steel Electric Furnace
Typical Semi-Wet
Process Flow Diagram

2-7-73   FIGURE 24

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ALTERNATE HOOD SYSTEMS

SMOKE & FUME

TEMPERATURE 71°C (115°F)

FAN

WASTE GASES
TEMPERATURE 71°C (115°F)
N₂, O₂, CO₂

BAGHOUSE
(ALTERNATE)

DRY DUST
Fe₂O₃
F₂O

WASTE GASES
TEMPERATURE 71°C (160°F)
N₂, O₂, CO₂

STACK

FAN

DRY DUST
Fe₂O₃
F₂O

BAGHOUSE

TRANSFORMERS
OIL IMMERSED, WATER
COOLED OR OIL COOLED

FUME & SMOKE FROM
CHARGING OF SCRAP IN FURNACE

5000-125,000
KVA
TRANSFORMER
VAULT
POWER KWH
400-600/TON

WATER OR AIR
COOLED ELECTRIC
CABLES

CARBON OR
GRAPHITE ELECTRODES
S.A.E./6.4/1.T.
CARBON ELECTRODES USED
ON SMALLER FURNACES

LOCAL PERIPHERAL HOOD

FURNACE TAPPING
FUMES & SMOKE

SMOKE & FUME

TEEMING LADLE

See INGOT TEEMING PROCESS
FLOW DIAGRAM

STEEL

See SLAG PROCESS
FLOW DIAGRAM

ROOF CHARGING

CHARGING BOX

DOOR CHARGING

HOT METAL CHARGING
TYPICAL ANALYSIS
C = 4.4%
Si = 1.10%
Mn = 0.50%
P = 0.14%
S = 0.028%
TEMPERATURE = 1371°C (2500°F)

SCRAP STEEL CHARGING
CHOPS, PUNCHING
CHOPS ENDS
PLATE SHEARINGS
ALLOY STEEL SCRAP
CARBON SCRAP BUNDLES

FERRO ALLOYS
FERRO MANGANESE
FERRO MOLY
FERRO SILICON
FERRO CHROME SILICON
FERRO CHROME
FERRO MANGANESE SILICON

FLUXES
LIME
SPAR
COKE
ORES
SAND
LIMESTONE

PELLETS

ELECTRIC FURNACE PARAMETERS
TYPICAL HEAT CYCLE

ELECTRIC FURNACE

Environmental Protection Agency
Steel Industry Study
Electric Furnace
Type II - Dry
Process Flow Diagram
2-22-73   FIGURE 25

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
TYPE III - WET WASHER
PROCESS FLOW DIAGRAM

2-15-73    FIGURE 26

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
TYPE IV - WET CYCLONE
PROCESS FLOW DIAGRAM

6-7-73    FIGURE 27

GAS TEMPERATURES
61.5° GASES (745°-1507°F)

TOTAL VOLUMES FOR 4 HOUR HEAT
DRY GAS: 2739.8 m³/kg ~ 1957.9 /hr (35,035 SCF/iT ~ 66 T/hr.)
DRYGAS+H₂O: 3853.5 m³/kg ~ 2750.8/hr (49,200 SCF/iT ~ 93 T/hr.)
WATER+H₂O: 1113.7 m³/kg ~ 792.9/hr (14,165 SCF/iT ~ 27 T/hr.)

WASTE GASES
DRY GAS: 3531.0 m³/kg ~ same (45,100SCF/iT ~ same)
WATER VAPOR: 5.6 m³/kg ~ 0.3 kg (190SCF/iT ~ 5 LB)
DUST LOADING: 0.004 g/m³/kg ~ 0.052 kg (0.05 GRAINS/SCF/iT ~ 0.1045 LB)

GAS VOLUMES BASED UPON 50% EXCESS AIR
CO₂: 14 m³/kg ~ (6.5 kg (425 SCF/iT ~ 84 LB)
AIR+N₂: 200.6 m³/kg ~ 270.1 kg (2,550 SCF/iT ~ 8,031 LB)
DRYGAS-TOTAL: 213.0 m³/kg ~ 241.1 kg (2775 SCF/iT ~ 33,746.)
WATER+H₂O: 71.28 m³/kg ~ 46.4 kg (3,660 SCF/iT ~ 1,035 LB)

DRY GAS: 1376.9 m³/kg ~ 1697.4 kg (47,650 SCF/iT ~ 877 LB)
WATER VAPOR: 526.6 m³/kg ~ 341/kg (18,200 SCF/iT ~ 76.9 LB)

DRY GAS: 943.8 m³/kg ~ 1010.8 kg (24,500 SCF/iT ~ 2,064 LB)
WATER VAPOR: 37/41 m³/kg ~ 207.8 kg (1,700 SCF/iT ~ 450 LB)

OXYGEN LANCING
50m³ 20 MINUTES (1750 SCM)

MELTDOWN
2½ HOURS

REFINING
1½ HOURS

COOLING WATER
(010-2750/kg) (240-700 GAL/iT)

COOLING WATER
5499.6 /kg (1965 GAL/iT)

COOLING WATER
(2730/kg) (650 GAL/iT)

EFFLUENT
6137.8 /kg (2596 GAL/iT)

STACK
DRAIN
30 s.l./kg (7.5 GAL/iT)

EXHAUST STACK

FAN

SEPARATOR

CLASSIFIER AND PUMP TANK

SCRUBBER

ELBOW (COOLING WATER (010) 5.8 /kg (0876 GAL/iT)

COMBUSTION AIR INTAKE GAP

WATER COOLED ELBOW

CARBON OR GRAPHITE ELECTRODES 5.8 kg/kg (10-10.5 LB/iT) CARBON ELECTRODES USED ON SMALLER FURNACES

TRANSFORMERS WATER COOLED, OIL COOLED AND OIL IMMERSED

50,000-135,000 KVA TRANSFORMER VAULT POWER 400-600 KWH/INGOT TON

WATER COOLING OR AIR COOLED ELECTRIC CABLES

WATER COOLING RINGS, DOOR, ELECTRODE CLAMPS, SIDEWALLS, DOOR FRAMES, ELECTRODE LEADS

STEEL

TEEMING LADLE

SEN INGOT TEEMING PROCESS FLOW DIAGRAM

SEN SLAG PROCESS FLOW DIAGRAM 60-100 kg/kg (0.5-T LB/iT)

1 TON-400 TON HEAT
ELECTRIC FURNACE
YIELD: 88% TO 91%
ALLOY STEELS - DOUBLE SLAG (DE-OXYGEN - REDUCING)
RIMMED + SEMI-KILLED CARBON STL SINGLE SLAG - OXIDIZING
1 TON - 50 TONS/HR PRODUCTION

ELECTRIC FURNACE ROOFS ON LARGER TONNAGE FURNACES ARE HINGED AND PIVOT AWAY FROM FURNACE FOR THE ADDITION OF SCRAP CHARGE. SMALLER TONNAGE FURNACES HAVE FIXED ROOFS AND ARE CHARGED THRU FURNACE DOORS.

FUMES & SMOKE FROM CHARGING OF SCRAP IN FURNACE

ROOF CHARGING

DOOR CHARGING

CHARGING BOX

PURE OXYGEN LANCE (ALTERNATE) 4/5-10.4 m³/kg (135-400 SCF/iT)
FUME GENERATION 5½-5 kg/kg (10-16 LB/iT)

ELECTRIC FURNACE
TYPICAL HEAT CYCLE PARAMETERS
CARBON STEEL HEAT
a.) HEAT SIZE - 200 TON
b.) COLD SCRAP CHARGE -100%
c.) HEAT TIME:
   1. MELTDOWN - 2½ HOURS
   2. REFINING - 1½ HOURS
d.) SLAG PRACTICE - SINGLE
e.) KWH/TON 400-600
f.) ELECTRODE CONSUMPTION 4.5-7 kg/kg (10-14 LB/iT)
g.) OXYGEN LANCED - 83.5 m³ FOR 10 MIN. (2950 SCFM)

HOT METAL CHARGING
TYPICAL AIM ANALYSIS
C: 4.5 %
Si: 1.5 %
Mn: 1.7 %
P: 0.45 %
S: 0.032 %
TEMPERATURE: 1377°C (2550°F)

SCRAP STEEL CHARGING
PLATE PUNCHINGS
CROP ENDS
PLATE SHEARINGS
ALLOY STEEL SCRAP
CARBON SCRAP BUNDLES

FERRO ALLOY ADDITIVES
FERRO MANGANESE
FERRO SILICON
FERRO CHROME SILICON
FERRO CHROME
MANGANESE SILICON

FLUXES
LIME
SPAR
COKE
ORES
SAND
LIMESTONE

PELLETS

BAROMETRIC CONDENSER COOLING WATER
1212 LITERS/MIN (510 GAL./ITP)
TEMPERATURE 29.4°C (85°F)
PRESSURE 2.8 kg/sqcm (40 PSIG)

BAROMETRIC CONDENSER

EJECTOR

STEAM
10.9 kg/MIN (149 LBS/ITP)
TEMP 181°C (360°F)
PRESSURE 10.5 kg/sqcm (150 PSIG)

EJECTOR

SEAL COOLING WATER
241 L/MIN (70 GAL./ITP)
TEMPERATURE 55°C (75°F)
PRESSURE 2.8 kg/sqcm (40 PSIG)
THERMAL UPTAKE 1010 kg.CAL./MIN
(9849 BTU/ITP)

TRANSFORMER BUS TUBE
COOLING WATER
250 LITERS/MIN (00 GAL./ITP)
TEMPERATURE 55°C (95°F)
PRESSURE 10.5 kg/sqcm (150 PSIG)
THERMAL UPTAKE 1169 kg.CAL./MIN
(9610 BTU/ITP)

BAROMETRIC CONDENSER
SEAL LEG WATER
2412 L/MIN (580 GAL./ITP)
TEMPERATURE 40°C (115°F)
PRESSURE : ATMOSPHERIC
THERMAL UPTAKE 44,952 kg.CAL./MIN
(100,000 BTU/ITP)
550 mg/L CONTAMINANTS

HOT WELL

HOT METAL PRODUCT
1093 kg/MIN (2010 LBS/ITP)

BAROMETRIC CONDENSER

MAIN VACUUM VALVE

SEAL RING

HEATING ROD

TRANSFORMER

COLLECTOR

SUCTION NOZZLE

VACUUM LOCK GATE
AIR CYLINDER

FUNNEL

VACUUM LOCK GATE
AIR CYLINDER

LADLE

LADLE CAR

WEIGHT HOPPER

WEIGHT HOPPER
AIR CYLINDER

VACUUM LOCK

VACUUM CHAMBER

VACUUM VESSEL

ADDITIVES
55 KILOGRAMS/MIN
(70 LBS./ITP)

TRANSFORMER BUS TUBE
COOLING WATER
250 L/MIN (00 GAL./ITP)
TEMPERATURE 29.4°C (85°F)
PRESSURE 10.5 kg/sqcm (150 PSIG)

SEAL COOLING WATER
241 L/MIN (70 GAL./ITP)
TEMPERATURE 29.4°C (85°F)
PRESSURE 2.8 kg/sqcm (40 PSIG)

HOT METAL
1000 kg/MIN (2000 LBS/ITP)
TEMPERATURE - 1593°C (2900°F)

The three steelmaking processes are housed in mill buildings and generally the building interior is identified by three main aisles called the charging aisle, furnace aisle, and the teeming aisle. The teeming aisle consists of a long building aisle with elevated brick lined platforms on one side where strings of flat bed railroad cars called "drags" are stationed. A drag generally will consist of five or six coupled cars.

On the bed of each car are stationed cast iron ingot molds and in turn the molds are seated on flat cast iron plates called "stools". The teeming aisle crane holds the ladle over each ingot mold. By means of a ladle stopper rod, operated by personnel stationed on teeming platforms, the steel is poured through a bottom ladle nozzle into the ingot mold. When the mold is filled, the operator closes the stopper rod which blocks the nozzle opening while the teeming crane shifts to the next ingot mold. After finishing pouring the steel, the teeming crane dumps any slag remaining in the ladle and returns for another heat of steel.
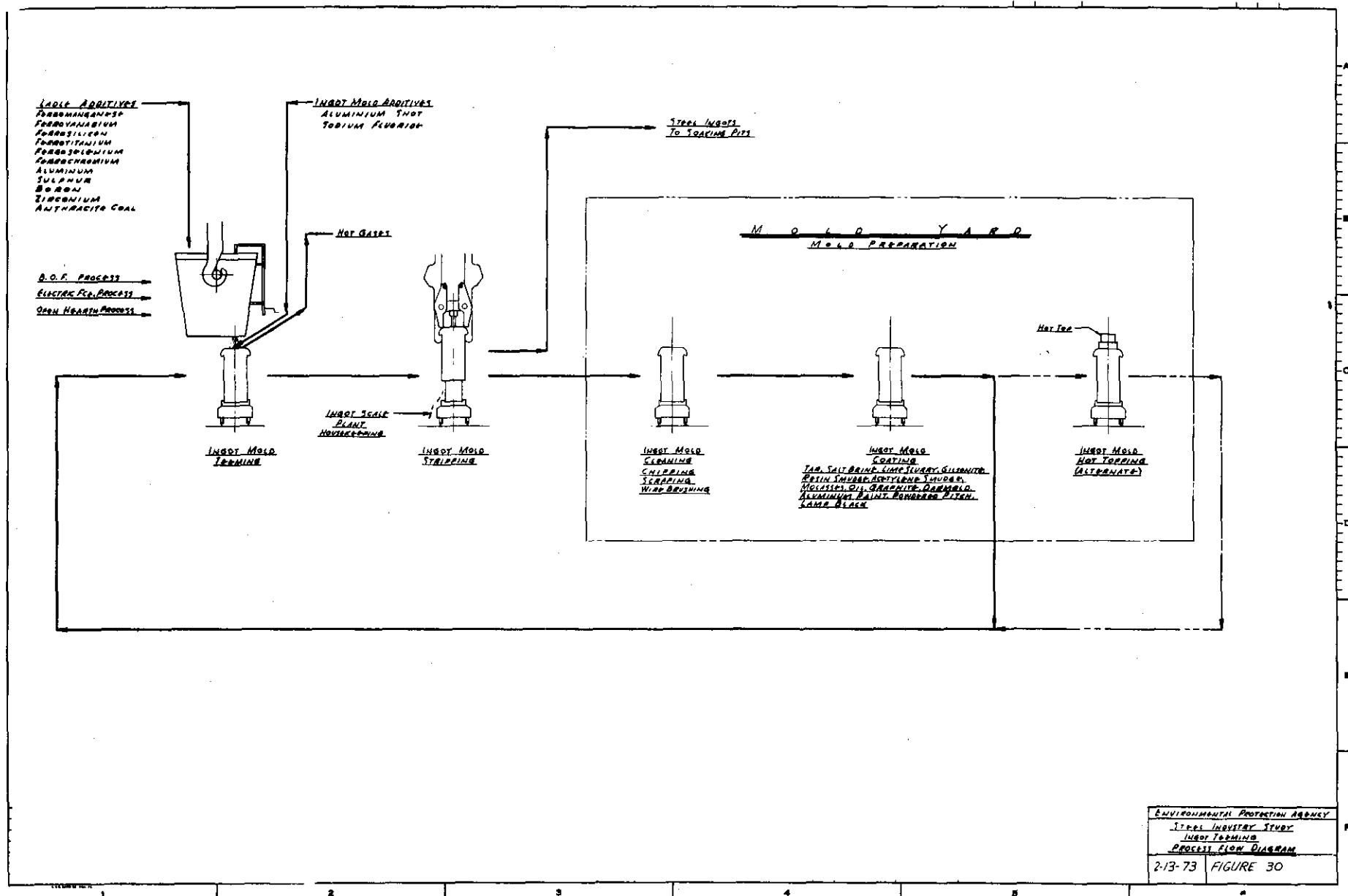
The ingots are allowed to cool so a hard sheet forms and then drags are routed to a mold stripper area where the ingot mold is separated from the hot ingot by means of a special type stripper crane. The hot ingots are then transported to soaking pits where they are reheated in preparation for rolling in rolling mills. The ingot molds are transported to a mold preparation area, where they are cooled, cleaned and sprayed with an anti-sticking compound. During the teeming operation, some materials are added to the steel such as aluminum or lead shot. The aluminum acts as an oxidizing agent whereas lead is added for freer machining type steels. The waste products from teeming and mold cycle are contaminants that are airborne or have been spilled and reach sewers via groundwater.

More specific details of the ingot casting operation are shown on Figure 30.

Pig Casting Operation

The molten iron from the blast furnace is generally used in the molten state in basic oxygen, open hearth, and electric furnaces. Occasionally due to equipment failures and production scheduling, it becomes necessary to cast the surplus molten iron into pigs. This is done in the pig machine.

Most pig machines consist of two strands of endless chains carrying a series of parallel cast-iron molds or troughs with overlapping edges which pass over a head and tail sprocket wheel. Molten iron is poured into the mold near the tail sprocket, solidifies and is cooled by water sprays as the chain rises to the head sprocket. As the chain reverses direction while passing over the head sprocket, the solid pig falls from the mold into waiting railroad cars or trucks. On the return travel of the chain, the molds are sprayed with a lime wash. This acts as a

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LADLE ADDITIVES
FERROMANGANESE
FERROVANADIUM
FERROSILICON
FERROTITANIUM
FERROSELENIUM
FERROCHROMIUM
ALUMINIUM
SELENIUM
BORON
ZIRCONIUM
ANTHRACITE COAL

INGOT MOLD ADDITIVES
ALUMINIUM SHOT
SODIUM FLUORIDE

STEEL INGOTS
TO SOAKING PITS

HOT GASES

B.O.F. PROCESS
ELECTRIC FCE. PROCESS
OPEN HEARTH PROCESS

M O L D   Y A R D
MOLD PREPARATION

HOT TOP

INGOT SCALE
PLANT
HOUSEKEEPING

INGOT MOLD
TEEMING

INGOT MOLD
STRIPPING

INGOT MOLD
CLEANING
CHIPPING
SCRAPING
WIRE BRUSHING

INGOT MOLD
COATING
TAR, SALT BRINE, LIME SLURRY, GILSONITE,
RESIN SMUDGE, ACETYLENE SMUDGE,
MOLASSES, OIL, GRAPHITE, DARKOLD,
ALUMINIUM PAINT, POWDERED PITCH,
LAMP BLACK

INGOT MOLD
HOT TOPPING
(ALTERNATE)

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
INGOT TEEMING
PROCESS FLOW DIAGRAM
2-13-73   FIGURE 30

1        2        3        4        5        6

constitute the most significant factors in the categorization of this most complex industry. Process descriptions are provided in this section of the report delineating the detailed processes along with their products and sources of wastewaters. The use of various gas cleaning equipment, particularly in the steelmaking categories, lends itself to a further subdivision into wet, semiwet, and dry subcategories. Gas cleaning is also discussed under process descriptions. Waste treatability in itself is of such magnitude that in some industries, categorization might be based strictly on the waste treatment process. However, with the categorization based primarily on the process with its products and wastes, it is more reasonable to treat each process waste treatment system under the individual category or subcategory. Waste treatability is discussed at length under Section VII, Control and Treatment Technology. Size and age of the plants has no direct bearing on the categorization. The processes and treatment systems are similar regardless of the age and size of the plant. Tables 24-33 provide, in addition to the plant size, the geographic location of the plant along with the age of the plant and the treatment plant. It can be noted that neither the wastes nor the treatment will vary in respect to the age or size factor. The forementioned tables should be tied back to the discussion in Sections VII and VIII, related to raw waste loads, treatment systems and plant effluents. Therefore, age and size in itself would not substantiate industry categorization.

The number and type of pollutant parameters of significance varies with the operation being conducted and the raw materials used. The waste volumes and waste loads also vary with the operation. In order to prepare effluent limitations that would adequately reflect these variations in significant parameters and waste volumes the industry was subcategorized primarily along operational lines, with permutations where necessary, as indicated in Table 4.

Listings by the main subcategories have been compiled for all steelmaking plants in the United States. They are presented in table form as follows:

| TABLE | SUBCATEGORY |
|-------|-------------|
| XXXVI | By-Product Coke Plants |
| XXXVII | Beehive Coke Plants |
| XXXVIII | Sintering |
| XXXIX | Blast Furnace - Iron Making |
| XL | Blast Furnace - Ferromanganese |
| XLI | Basic Oxygen Furnaces |
| XLII | Open Hearth Furnaces |
| XLIII | Electric Arc Furnaces |
| XLIV | Vacuum Degassing |
| XLV | Continuous Casting |

Tables XXXVI through XLV are on file and available for perusal at the library of the Environmental Protection Agency, Washington, D.C. (Reference No. EP - 03B - 000 - 001).

The following sources were utilized to compile data on plants in each subcategory:

a. Directory of the Iron and Steel Works of the World, 5th Edition, Metal Bulletin Books Ltd., London, England.

b. AISI, Directory of the Iron and Steel Works of the U. S. and Canada, 1970.

c. Directory of Iron and Steel Plants, 1971

d. Battelle Coke Report

e. Iron and Steel Engineer, December, 1969; January, 1973.

f. EPA Project R800625 (unpublished)

g. 33 Magazine, July and October, 1972; July, 1970

h. Keystone Coal Industry Manual.

Selection of Candidate Plants for Visits

A survey of existing treatment facilities and their performance was undertaken to develop a list of best plants for consideration for plant visits. Information was obtained from:

(a) The study contractors personnel
(b) State Environmental Agencies
(c) EPA Personnel
(d) Personal Contact
(e) Literature Search

TABLE 5

CANDIDATES FOR PLANT VISITS

By-Product Coke Plants

| PRODUCTION FACILITIES | WASTEWATER TREATMENT | BASIS FOR SELECTION |
|---|---|---|
| 62 ovens | Non-recovery system, $NH_3$ liquor collected and incinerated. Recovers tars only. All other gaseous and liquid wastes are burned in one of two oxidizers. | *Only full-scale operating plant which incinerates total wastes products. |
| 110 ovens | Non-recovery system. Future - incinerator system for all liquid and gaseous wastes. | Plant due on stream late in 1973. |
| 523 ovens<br><br>C | Free + lime $NH_3$ stills; dephenolize with benzol; wastes to quench tower; final cooler blowdown to $NH_3$ recovery; closed recycle quench, with benzol wastes for make-up; indirect cooler water recycles over cooling tower. | Considerable pre-treatment prior to discharge to Metro-politan Sanitary District |
| 100 ovens | Free + lime $NH_3$ stills; light oils sold to re-finery; final cooler oxidized to lower total cyanide to 10 PPM; quench towers recycle with fresh water make up; indirect cooling to river; other plant wastes to Metropolitan Sanitary District. | Considerable pre-treatment prior to discharge to Metropolitan Sanitary District. |

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CANDIDATE: ( PLANT VISITS

By-Product Coke Plants

| PRODUCTION FACILITIES | WASTEWATER TREATMENT | BASIS FOR SELECTION |
|---|---|---|
| 236 ovens | Free $NH_3$ still only; benzol scrubbing for phenol; recycle final cooler, with blowdown and wastes from $NH_3$ recovery; dephenolizer and other blowdowns to coke quench system. | Wastes used for quenching |
| 1375 ovens | Free $NH_3$ still only; benzol scrubbing for phenol; recycle final cooler, with blowdown and wastes from $NH_3$ recovery, dephenolizer and other blowdowns to coke quench system. | Wastes used for quenching |
| 271 ovens | Free + lime leg $NH_3$ still; benzol scrub for phenols; final cooler blowdown, $NH_3$, phenol blowdown to quencher; indirect cooling to river. | Wastes used for quenching |
| 112 ovens | Free + lime leg $NH_3$ still; benzol scrub for phenols; final cooler blowdown, $NH_3$, phenol wastes to quencher. Indirect cooling over cooling towers & back to intake. | Recycling of most wastes, with only small discharge volume to river |

## CANDIDATES FOR PLANT VISITS

### By-Product Coke Plant

| PRODUCTION FACILITIES | WASTEWATER TREATMENT | BASIS FOR SELECTION |
|---|---|---|
| 151 ovens<br><br>D | Free + lime leg $NH_3$ stills; benzol/toluol phenol recovery; light oils recovered and refined by outside contractor; final and indirect cooling recycles via heat exchanger or tower, with blowdown to $NH_3$ recovery system. Quenching via recycled closed system with fresh water make-up. | *Well-run 55 year old plant. Regarded as excellent by State and regional authorities. |
| 315 ovens<br><br>A | Free and lime leg $NH_3$ stills; proprietary solvent for phenols crude light oil recovery; indirect cooling over towers to recycle; final cooling recycles, with blowdown to $NH_3$ system. Quencher - recycled closed system, with fresh water make up. | *High phenol removal efficiency. |

* Recommended by RICE as selection for sampling program.

  Letter refers to plants that were visited.

# CANDIDATES FOR PLANT VISITS

## Blast Furnace

| PRODUCTION TONS/DAY | TREATMENT FACILITIES | BASIS FOR SELECTION |
|---|---|---|
| 5,600 | Gas Cleaning<br>Orifice plate, towers and electrostatic precipitators.<br>Wastewater<br>50% recycle - 50% discharged untreated to retention lagoon (3 days). Thickeners remove solids. | No Treatment. Retention only.* |
| 13,700 | Gas Cleaning<br>Venturi scrubbers<br>Wastewater<br>Clarifiers, cooling towers, complete recycle, blowdown used to quench slag water. Infiltration into sewers a problem. | No Discharge other than infiltration. |
| 2,400<br><br>O | Gas Cleaning<br>Primary & secondary Venturi scrubbers.<br>Wastewater<br>2 thickeners, sludge filters, cooling tower complete recycle, blowdown to coke and slag quench | No Discharge.* |
| 2,680<br><br>M | Gas Cleaning<br>Venturi Scrubbers and coolers.<br>Wastewater<br>Clarifiers, cooling tower, sludge filter, complete recycle, blowdown to Sanitary Authority. | Blowdown to Sanitary Authority. |

## CANDIDATES FOR PLANT VISITS

## Blast Furnace

| PRODUCTION TONS/DAY | TREATMENT FACILITIES | BASIS FOR SELECTION |
|---|---|---|
| 8,000<br><br>N | Gas Cleaning<br>Variable orifices and spray towers.<br>Wastewater<br>Blowdown from furnace cooling make up to gas cleaning; clarifiers; sludge to sludge drying beds; complete recycle, cooling tower blow-down to slag and coke quench and BOF hood cooling. | No discharge.* |
| 2,600 | Gas Cleaning<br>Venturi and electro-static precipitators.<br>Wastewater<br>Grits chamber; polymer addition; clarifiers; solids to filter; overflow to Buffalo River. Some rinse water. BOF spark box water and rolling mill water also to thickener. | Once through solids removal only. Other wastes are also added to the thickener |
| 2,500 | Gas Cleaning<br>Orifice and electro-static precipitators.<br>Wastewater<br>Grit chamber; polymer addition; clarifier; solids to filter; complete recycle; blowdown to Calumet River. Seeking approval to discharge into Sanitary system. | Recycle system. Blowdown to Calumet River. |

CANDIDATES FOR PLANT VISITS

Steelmaking - BOF

| PRODUCTION TONS/DAY | TREATMENT FACILITIES | BASIS FOR SELECTION |
|---|---|---|
| 8,000 | **Gas Cleaning** | *Semi-wet evaporation chamber |
| | Wet evaporation chamber and dry precipitators with open plate panel hood. | |
| R | **Wastewaters** | |
| | Cooling water is recycled through cooling towers with blow-down. Wet evaporation chamber waters discharged to drag link conveyor tank. Solids settle and discharge water is recycled to sprays and evaporation chamber. | |
| 5,000 7,000 | **Gas Cleaning** | *Semi-wet evaporation |
| | Wet evaporation chamber and dry precipitators with open plate panel hoods. | |
| | **Wastewaters** | *Semi-wet Evaporation |
| | Hood cooling waters recirculated through cooling towers. Wet evaporation chamber waters discharged to drag link conveyor tank. Solids settle and discharge water is recycled to sprays and evaporation chamber. | |

CANDIDATES FOR PLANT VISITS

Steelmaking - BOF

| PRODUCTION TONS/DAY | TREATMENT FACILITIES | BASIS FOR SELECTION |
|---|---|---|
| 9,600 | **Gas Cleaning**<br><br>Open hood steam generation, high energy Venturi scrubbers.<br><br>**Wastewaters**<br><br>Complete recycle with (2) thickeners. Centrifuges for dewatering thickener underflow. Overflow recycled to system.<br><br>**Gas Cooling Waters**<br><br>Recycled through cooling tower with 500 gpm constant blowdown used for reduction of horsepower. | Wet system reported as equal to or very close to level "A" treatment by EPA regional personnel. |
| 8,000<br><br>T | **Gas Cleaning**<br><br>Open hood.<br>Steam generator, high energy Venturi scrubbers.<br><br>**Wastewaters**<br><br>Complete recycle with thickener. Thickener underflow pumped to blast furnace thickener. | *Wet system. |

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# CANDIDATES FOR PLANT VISITS

## Steelmaking - Open Hearth

| PRODUCTION TONS/DAY | TREATMENT FACILITIES | BASIS FOR SELECTION |
|---|---|---|
| 10200 | **Gas Cleaning**<br><br>High energy Venturi scrubbers<br><br>**Wastewaters**<br><br>Discharged to thickener. Thickener overflow recycled, underflow discharged to settling pond. | Wet System |
| 5400 | **Gas Cleaning**<br><br>Wet scrubber system<br><br>**Wastewaters**<br><br>Scrubber waters discharged to thickener. Thickener overflow recycled to scrubbers, underflow to filters | Wet System<br><br>Reported as good treatment by EPA Regional personnel. |

# CANDIDATES FOR PLANT VISITS

## Steelmaking – Electric Furnace

| PRODUCTION TONS/DAY | TREATMENT FACILITIES | BASIS FOR SELECTION |
|---|---|---|
| 1700<br><br>Y | Gas Cleaning – Direct evacuation, spark box and dry precipitator.<br><br>Wastewaters – Spark box waters discharged to a drag link settling chamber, water is recycled to spark box sprays. | *Semi-wet/precipitator |
| 3000<br><br>AA | Gas Cleaning – Flooded disc type high energy Venturi scrubber.<br><br>Wastewaters – Gas cleaning recycled thru scrubbers into quenchers. Discharge from quencher to thickener and recycled underflow to vacuum filters. | *Wet system |
| 1680 | Gas Cleaning – Direct evacuation thru spray disintegrator scrubber.<br><br>Wastewaters – Spray chambers waters discharge to drag link to plant waste treatment system. Disintegrator scrubber discharges to plant waste treatment system. | Wet system |

Letters refer to plants that were visited.

## CANDIDATES FOR PLANT VISITS

### Steelmaking - Continuous Casting

| PRODUCTION TONS/DAY | TREATMENT FACILITIES | BASIS FOR SELECTION |
|---|---|---|
| 4000 | Mold and Machine Cooling<br><br>Recycled closed system thru heat exchangers. Cooling tower on shell side recycle | *BOF<br>Slab Caster |
| AE | Spray Cooling<br><br>Discharged to scale pit to vacuum filters and then to cooling tower and recycled to sprays. | |
| 125T/heat | Mold and Machine Cooling<br><br>Recycled closed system<br><br>Spray Cooling<br><br>Discharged to scale pit to vacuum filters, then to cooling towers and recycled to sprays. | Electric Furnace Billet, Bloom Caster |

# TABLE 6

IRON AND STEELMAKING OPERATIONS
INDUSTRIAL CATEGORIZATION AND
SURVEY REQUIREMENTS

| Main Category | Subcategory | Number of Locations Surveyed | Production Variations Within Subcategory to be Investigated | Intake | Raw Waste | Treated Effluent | Cooling Water | Misc. |
|---|---|---|---|---|---|---|---|---|
| | | | | Composite | | | Grab | |
| I. Coke Making | A. By-Product | 4 | Each of 4 types to preferably have different production unit operations | 1 | 4 | 4 | 1 | 1 |
| | B. Beehive | 3 | 1 - Beehive type<br>1 - Rectangular slot type<br>1 - Once through wastewater | 1 | 2 | 2 | 1 | 1 |
| II. Burden Preparation | A. Sintering | 3 | 3 - same type* | 1 | 3 | 3 | 1 | 1 |
| | B. Pelletizing | ** | - | | | | | |
| | C. Briquetting | ** | - | | | | | |
| III. Iron Making | A. Blast Furnace Iron | 5 | 5 - same type* | 1 | 3 | 3 | 2 | 1 |
| | B. Blast Furnace Ferro Additives | 1 | 1 - FeMn only due to nonavailability of other type ferro alloy furnaces | 1 | 3 | 3 | 2 | 3 |
| IV. Steelmaking | A. Basic Oxygen Furnace | 5 | 2 - semi-wet type<br>3 - wet type | 1 | 3 | 3 | 2 | 2 |
| | B. Open Hearth | 2 | 2 - same type* | 1 | 3 | 3 | 1 | 1 |
| | C. Electric Furnace | 4 | 2 - semi-wet type<br>2 - wet type | 1 | 3 | 3 | 1 | 1 |
| V. Degassing | - | 2 | 1 - DH type<br>1 - RH type | 1 | 3 | 3 | 1 | 1 |
| VI. Continuous Casting | - | 2 | 1 - Billet Caster<br>1 - Slab Caster | 1 | 3 | 3 | 1 | 1 |
| VII. Fugitive Runoffs | A. Ingot Casting | 1 | - | | | | | 1 |
| | B. Pig Casting | 1 | - | | | | | 1 |
| | C. Coal Pile | 1 | - | | | | | 1 |
| | D. Ore Pile | 1 | - | | | | | 1 |
| | E. Stone Pile | 1 | - | | | | | 1 |
| | F. Slagging | 3 | 1 - BF quench type<br>1 - BF spray cooled<br>1 - BOF spray cooled | | | | | 1<br>1<br>1 |

*No major variations in production unit operations expected.

**No plants found operating as an integral part of an integrated steel mill.

# SECTION V

## WATER USE AND WASTE CHARACTERIZATION

### General

The waste water streams for the industry are described individually in their respective sub-categories. Waste loads were developed by actual plant sampling programs at selected better plants on which EPA concurred. Raw waste loads are established as net plant raw waste loads. This is further defined as the contaminants attributable to the process of concern. It is the total or gross process load minus the contaminated load due to background (make-up). In recycle systems it is the change in concentration observed across the process. Fluctuations in the gas concentrations to which the waste waters are exposed and the lag in the waste treatment systems in some cases resulted in negative numbers in the following tables. The concentrations in the recycle stream and in the blowdown may be very high and may require treatment even though the "pick-up" per pass may be small or at times may show as negative. The basic for plant selection was primarily on their waste treatment practices. Therefore, further rationale for selection of the plant sites is presented under Section VII - Control and Treatment Technology.

### Coke Making - By-Product Operation

General process and water flow schematics of a typical by-product coke plant and associated light oil recovery plant are presented on Figures 2 and 3.

Typical products from the carbonization of a metric ton of coal are as follows:

|                  |           |                   |
|------------------|-----------|-------------------|
| Gas              | 336 cu. m.| (12,000 cu ft)    |
| Tar              | 35 1      | (9.2 gal)         |
| Ammonia          | 17 1      | (4.6 gal)         |
| Tar Acids        | 87 1      | (23 gal)          |
| Hydrogen Sulfide | 19 1      | (5 gal)           |
| Light Oil        | 10 1      | (2.6 gal)         |
| Coke             | 636 kg    | (1,400 lb)        |
| Coke Breeze      | 95 kg     | (210 lb)          |

Raw waste loads for by-product coke plants may vary due to the nature of the process, water use systems, moisture and volatility of the coal, and the carbonizing temperature of the ovens. Minimum and maximum values for plant effluents in the study ranged from 171-19,182 1/kkg (41 - 4,600 gal/ton) coke produced.

The most significant liquid wastes produced from the coke plant process are excess ammonia liquor, final cooling water overflow, light oil recovery wastes, and indirect cooling water. In addition, small volumes of water may result from coke wharf drainage, quench water overflow and coal pile runoff.

The volume of ammonia liquor produced (including steam condensate) varies from 100 to 200 l/kkg (24 to 48 gal/ton) of coke produced at plants using the semidirect ammonia recovery process to 350 to 530 l/kkg (84 to 127 gal/ton) for the indirect process. This excess flushing liquor is the major single source of contaminated water from coke making.

Indirect (noncontact) cooling water is not normally considered waste but leaks in coils or tubes may contribute a significant source of pollution.

Direct contact of the gas in the final cooler with sprays of water dissolve any remaining soluble gas components and physically flush out crystals of condensed naphthalene, which is then recovered by skimming or filtration. This final cooler water becomes so highly contaminated that most plants must cool and recirculate this water. When a closed recycle system is not used, this waste water may exceed the raw ammmonia liquor as the source of high contaminant loads.

Condensed steam from the stripping operations and cooling water constitute the bulk of liquid wastes discharged to the sewer. Light oil recovery wastes will vary with the plant process. Flows may vary from 2,100 to 6,300 l/kkg (500 to 1,500 gal/ton) of coke at plants which discharge once-through cooling water to 125 to 625 l/kkg (30 to 150 gal/ton) where cooling water is recycled. Effluent from the light oil recovery plant contains primarily phenol, cyanide, ammonia, and oil.

The quenching of coke requires about 1,463 liters of water per kkg of coke (350 gal/ton). Approximately 35 percent of this water is evaporated by the hot coke and discharges from the quench tower as steam.

A delicate balance is struck in quenching. Most of the fire is quenched, but enough heat should remain in the coke mass to evaporate the water trapped within the coke lumps. Quench station runoffs are collected in a settling basin where coke fines are recovered for other mill uses. The clarified water is recirculated to the quench tower. Evaporative losses, which are obviously quite high, are continuously made up. Past practices have often disposed of contaminated waste waters as make-up to quenching operations, but strong objections from an air pollution standpoint have been voiced. Also, various studies indicate that metal corrosion in the vicinity of quench stations using contaminated make-up is accelerated to the point where replacement costs should actually be charged against this method of eliminating contaminated discharges. Further disadvantages accrue in the blast furnace operations when coke quenched with contaminated waste water is charged to the furnace, increasing the pollution potential of the gas washer waters. Future quenching operations should utilize total recycle of quench wastes, with only fresh water make-ups.

system serves the hot sinter bed, ignition furnace, sinter bed wind boxes, etc., while the other system serves as a dedusting system for sinter crushers, sinter fines conveyors, raw material, storage bins, feeders, etc.

The sinter bed fume collection and exhaust systems also furnish the necessary combustion air to maintain the coke burning which fuses the sinter mix bed on the moving sinter grates. The ignition furnace initially ignites the coke in the sinter bed and the combustion air maintains the burning of the moving bed. The ignition furnaces are fired by natural gas or fuel oils. The combustion air is drawn down through the sinter bed and hot gases and particulates are then exhausted. Any heavy sinter fines materials falling through the sinter grates are gravity settled in the wind box hoppers or are discharged to the sinter fines return conveyor for reprocessing. The combustion exhaust systems require large quantities of air and generally dry electrostatic precipitators are installed at the charge end of the sinter machine to clean the hot exhaust gas.

Table 9 summarizes the net plant raw waste loads for the plants studied. Raw waste loads are presented only for the critical parameters which include fluoride, oil, sulfide, and suspended solids.

## Blast Furnace Operations

General process and water flow schematics of typical blast furnace operations are presented on Figures 12,13,14 and 15. The typical blast furnace requires:

a.   2 kkg of ore,

b.   0.5 kkg of coke,

c.   0.5 kkg limestone,

d.   3.5 kkg of air,

to produce

e.   1.0 kkg iron,

f.   0.5 kkg slag, and

g.   5 kkg of blast furnace gas.

The blast furnace has two basic water uses, cooling water and gas washer water. The blast furnace requires the continuous circulation of cooling water through hollow plates built into the walls of the bosh and stack. Without such cooling, a furnace wall would quickly burn through. Furnace cooling water approximates 21,000 l/kkg (5,000 gal/ton). The most significant parameter from this source is heat pick-up ranging from 2-8°C.

TABLE 9

Characteristics of
Sintering Plant Wastes
Net Plant Raw Waste Loads

| Characteristics | Plants | |
| --- | --- | --- |
| | H | J |
| Flow, l/kkg | 434 | 1420 |
| Suspended Solids, mg/l | 4340 | 19500 |
| Oil and Grease, mg/l | 504 | 457 |
| Fluoride, mg/l | 0.644 | -14.9 |
| Sulfide, mg/l | 188 | 64.4 |

TABLE 10

Characteristics of
Fe-Blast Furnace Plant Wastes
Net Plant Raw Waste Loads

| Characteristics | Plants | | | |
| --- | --- | --- | --- | --- |
| | L | M | N | O |
| Flow, l/kkg | 22500 | 8050 | 14000 | 13000 |
| Ammonia, mg/l | 1.41 | 3.91 | 9.75 | 12.3 |
| Cyanide, mg/l | 1.44 | 0.858 | -0.241 | -0.231 |
| Phenol, mg/l | 0.578 | -0.643 | 0.530 | 0.0853 |
| Suspended Solids, mg/l | 1720 | 651 | 307 | 1170 |
| Fluoride, mg/l | 0.454 | 0.044 | 2.16 | -2.59 |
| Sulfide, mg/l | 4.34 | 38.8 | 0.448 | -1.14 |

cooling systems for these hoods are generally "closed recirculating" using induced draft cooling towers or, if operating at high pressures, evaporative coolers and heat exchangers are used. The pressures vary from 8 atmospheres to 18 atmospheres. These types of hoods are used with the special type fume collection system identified as "OG" or "OFF-GAS" system. In this type of fume collection system, the hood is capped tightly on the furnace mouth, thus preventing combustion of CO gases. The aqueous discharge from this system would be blowdown, or heated cooling water if "once through" cooling were used.

The steam generating hoods are high pressure waste heat boilers which use the combustion heat for generating steam. These systems operate in a range of 28 to 62 atmospheres steam. Only about 22% of the heat generated is used in steam generation, but some plants have additional economizer sections for greater heat transfer efficiency. The aqueous discharge from the steam generator hood is boiler blowdown. Some plants install steam accumulators to even out the cyclic steam production rate while others condense the steam in air/water heat exchangers and recirculate.

The type of fume collection system and hood cooling system selected is not only dependent upon capital costs but also on other plant characteristics such as operating costs, plant location, availability of resources (power, water, etc.), and available pollution abatement equipment (such as existing central water treatment facilities), etc.

The fume collection systems can range from a completely dry precipitator to a semiwet precipitator to a wet, high energy, venturi scrubber. Each particular fume collection system has advantages in relation to the plant characteristics.

The dry type precipitator system usually employs a steam generating hood equipped with a refractory lined evaporation chamber. The aqueous discharge from this fume collection system is zero except for hood blowdown. As the hot gases (1,300°C) exit from the steam generating hood, water sprays condition the gas temperature to 260°C at the evaporative chamber outlet. The evaporation chamber (approximately 9 m diameter x 18 m high) (approximately 10 x 20 yds) provides the required retention time to allow the water sprays to evaporate and mix with the hot gases and reduce the temperature. The precipitator system requires that a minimum of 100% excess air be introduced in the system to insure minimum non-combusted CO carryover to the precipitators. Generally, these systems will yield a 1-2% CO content in the exhaust gases. The semiwet system employs a precipitator too, except the gases are conditioned to 260°C by means of a spark box spray chamber. The spark box spray chamber utilizes an excessive spray water system. The retention time is much less in the spark box. Therefore, in order to condition the gases to the proper temperature, more water is sprayed into the system than can be evaporated. This results in an aqueous discharge from the spark box. Generally, plate panel hoods with 200-300% excess air are

employed with these systems. The capital costs for these systems are less than for steam generating systems with spray chambers.

The aqueous discharge is hot water ranging in temperature from 82-88°C and containing suspended solids of iron oxides ($Fe_2O_3$, FeO) and fluxing materials, lime, etc.

An alternate system to the spark-box spray or dry evaporation chamber system is to install a wetted wall type evaporation chamber. A wetted wall evaporation chamber contains no refractory lining, but uses a water wetted steel surface as the heat resistant medium. These chambers require large quantities of water to insure that the steel surfaces do not become overheated.

The wet, high energy, venturi scrubber fume collection systems generally use steam generating type hoods close coupled with a low energy fixed orifice quencher. As the hot gases exit from the hood, the gases are immediately quenched from 150°C to 83°C.

The gases are hotter exiting from the hood on a wet scrubber system because the maximum excess air admitted to the system is approximately 50% versus the 100-200% for precipitator systems.

The reason for this is to reduce hp consumption and still maintain a minimum residual of CO in the fume collection gases. Sometimes to further reduce wet fume collection system horsepower requirements, large self-contained cooling towers are added to the system to reduce the gas temperatures further from 83°C saturated to 43°C saturated. As the gases are saturated, the cooling is accomplished by strictly gas to water contact and heat transfer.

The cooling towers are checker brick lined enclosed cylindrical steel towers 9 m in diameter by 24-27 m high (approximately 10 by 28 yds). As these cooling systems are installed on the clean gas side of the venturi scrubbers, the cooling waters are recycled after passing through remote induced draft cooling towers with chemical treatment. Make-up water is added to compensate for evaporation loss, blowdown, cooling tower drift, etc.

These systems could be "once through" if quantities of clean water are available.

An alternate wet system to the venturi scrubber system is the wet gas washer and disintegration system. This system has a limited use due to the large gas volume to be handled and thus the high horsepower requirement to operate the disintegrator. Disintegrators operate in the range of 154 to 1,820 cu m/min (5,440 to 65,000 cu ft/min) at 450 kw. Thus six to seven units are required for an average 180 kkg (200 ton) basic oxygen furnace.

The off-gas system uses a quencher and venturi scrubber similar to the open hood combustion type system. The OG system is a

a. Electric Arc Furnace door, electrode ring, roof ring, cable and transformer cooling water system.

b. Fume collection cooling water system.

The Electric Arc Furnace cooling water systems for the roof ring, electrode ring, and door cooling is generally a "once through" system but can be a "closed recirculating" system. The resultant aqueous discharge from these cooling systems is heated cooling water, generally with a temperature increase of 17-22°C.

The type of cooling water systems applied to the electric arc furnace are dependent on furnace size. The smaller tonnage furnaces do not have roof ring cooling, door cooling, etc. The type of fume collection and hood exhaust system is not only dependent upon capital cost but also on other plant characteristics such as operating cost, plant location, availability of resources (power and water), and available pollution abatement facilities. The fume collection systems range from completely dry to semiwet to wet, high energy, venturi scrubbers. Each system has advantages in relation to plant characteristics.

The dry fume collection system consists of baghouses with local exhaust or plant rooftop exhaust hoods. The aqueous discharges from these systems are zero. The local hoods are located at the sources of fume generation (door, electrode openings, etc.). Enough cooling air is drawn into the hoods to temper the hot gases for a baghouse operation, i.e., to approximately 135°C. The rooftop exhaust system exhausts the entire furnace shop.

The semiwet system employs a spark box or spray chamber to condition the hot gases for either a precipitator or baghouse. A spark box is generally used with a precipitator system and a spray chamber for a baghouse system. The spark box conditions the gases to 200°C while the spray chamber conditions gases to 135°C. The aqueous discharge from these systems is controlled and treated with similar systems as used on the spark box chamber on the basic oxygen furnaces. A water cooled elbow is used as the exhaust ductwork and is directly connected to the electric furnace roof. The aqueous discharge from the water cooled elbow is heated cooling water. The systems are generally "once through" with temperature differential of 17-22°C in cooling waters.

The wet high energy venturi scrubber fume collection systems use the water cooled elbow for extracting the gases from the electric arc furnace. Combustion air gaps are always left between the water cooled elbow and fume collection ductwork to insure that all the CO gas burns to $CO_2$ before entering the high energy venturi scrubber or any other fume collection cleaning device. As the hot gases pass through the scrubber, the gases are conditioned and cooled to 83°C. An aqueous discharge is produced that is similar to the basic oxygen waste water.

differential temperature rise is held to approximately 6°C to maintain minimum differential thermal expansion of the mold. A surge tank is installed in the systems for addition of potable water make-up and/or chemical treatment.

The casting molds are copper material, chrome plated, and perform the function of solidifying a hard skin around the molten steel as it passes through the mold into the final spray cooling section. There is no blowdown for the closed system.

The machinery cooling water system is generally an "open recirculating" noncontact system using induced draft cooling towers with chemical treatment as cooling equipment. The cooling water differential rise across the machinery is approximately 14°C. The cooling side of the heat exchangers of the mold cooling system is generally tied into the machinery cooling water system.

The aqueous discharge from the machinery cooling water system is cooling tower blowdown. The machinery cooling water system furnishes cooling for the casting machinery (rolls, etc.) spray chamber cooling plate panels, cut-off torch cooling, etc.

The spray cooling water system is a direct contact water spray cooling of the cast product. As the cast product (slabs, blooms, or billets) emerge from the molds, the waste sprays further cool and harden a thicker skin of the cast product.

Table 16 summarizes the net plant raw waste loads for the plants studied. Raw waste loads are presented only for the critical parameters which include oil and suspended solids.

Ingot Casting

A general process schematic of the operation entailed in ingot casting is presented on Figure 30. Generally, the only water usage associated with ingot casting is the spray cooling of the ingot molds in the mold preparation and cleaning area.

The hot molds are sprayed with water to cool them and at the same time knock off minor amounts of scale adhering to the mold surfaces. The majority of the water used is evaporated in contacting the mold. Any excess spray water, which is usually very minor, falls to the ground where it generally evaporates or permeates into the ground. Since this water is generally good quality mill water containing relatively heavy fractions of scale, which collects on the surface of the ground, its permeation into the ground cannot be considered a source of pollution.

The excess spray water contacting the ground is generally so minor that there is rarely, if ever, sufficient volume to cause an overland runoff from the area. If a runoff problem were to exist from excessive spraying of the molds, any potential pollution problems, which would be confined to suspended scale

## TABLE 14

### Characteristics of
### Electric Furnace Plant Wastes
### Net Plant Raw Waste Loads

| Characteristics | Plants | | | |
| --- | --- | --- | --- | --- |
| | Y | Z | AA | AB |
| Flow, 1/kkg | 406 | 1.01 | 1250 | 751 |
| Fluoride, mg/1 | -28.7 | – | 14.8 | 11.3 |
| Suspended Solids, mg/1 | 863 | 77.4% | 2160 | 42800 |
| Zinc, mg/1 | 13 | – | 405 | 5637 |

## TABLE 15

### Characteristics of
### Degassing Plant Wastes
### Net Plant Raw Waste Loads

| Characteristics | Plants | |
| --- | --- | --- |
| | AC | AD |
| Flow, 1/kkg | 3750 | 813 |
| Suspended Solids, mg/1 | 23.2 | 70.7 |
| Zinc, mg/1 | 2.01 | 7.76 |
| Manganese, mg/1 | 5.72 | 13.3 |
| Lead, mg/1 | 0.471 | 1.39 |
| Nitrate, mg/1 | 25.3 | 3.03 |

## TABLE 16

### Characteristics of
### Continuous Casting Plant Wastes
### Net Plant Raw Waste Loads

| Characteristics | Plants | |
| --- | --- | --- |
| | AE | AF |
| Flow, 1/kkg | 17100 | 6172 |
| Suspended Solids, mg/1 | 7.87 | 74.0 |
| Oil and Grease, mg/1 | 20.5 | 22.0 |

SELECTION OF POLLUTANT PARAMETERS

## Introduction

The selection of the control parameters was accomplished by a three step process. First, a broad list of pollutant parameters to be tested for was established. Second, the list of anticipated control parameters and procedures for check analyses of these critical parameters was established. Third, the data from the field sampling program was evaluated to establish the need to deviate from this list.

## Broad List of Pollutants

Prior to the initiation of the plant visiting and sampling phase of the study it was necessary to establish the list of pollutant parameters that was to be tested for in each type of waste source. These parameters were selected primarily on the basis of a knowledge of the materials used or generated in the operations and on the basis of pollutants known to be present as indicated by previously reported analyses. The purpose of the broad list was to identify those pollutants present in a significant amount but not normally reported or known to be present to such an extent. The parameters that may be present in steel industry waste water streams are presented in table form by operations as follows:

    Table 17 - Coke Making Operations
    Table 18 - Sintering Operation
    Table 19 - Blast Furnace Operations
    Table 20 - Steel Making Operations
    Table 21 - Vacuum Degassing Operation
    Table 22 - Continuous Casting Operation

## Rationale for Selection of Control Parameters

On the basis of prior analyses and experience the major waste water parameters that are generally considered of pollutional significance for the raw steel making operations of the iron and steel industry include ammonia, $BOD\underline{5}$, cyanide, phenol, oil and grease, suspended solids and heat. Other parameters, such as chloride, are present in significant amounts but were not established as control parameters because their presence in the effluent is not as significant and the cost of treatment and technology for removal in these operations is considered to be beyond the scope of best practicable or best available technology at this time. In addition, some parameters cannot be designated as control parameters until sufficient data is made available on which to base effluent limitations or until sufficient data on treatment capabilities is developed.

cyanide less hazardous under normal conditions than the discharge of free cyanides.

## Sintering Subcategory

The dust produced from the sintering plant operation is frequently recovered through the use of wet washers operating on the exhausts of hoods and building ventilators. This wastewater is produced as a result of air pollution abatement measures and occupational health and safety precautions. These waste waters may contain significant amounts of suspended matter, oil, sulfide, and fluoride. The source of these contaminants is dependent upon the variety of materials that are a part of the sinter mix.

## Iron Making Operations

The principal waste water sources from the blast furnace operation are waters used in washing the exit gases free of suspended matter and noncontact cooling of the blast furnace hearth and shell. The gas is also cleaned to allow its use as a fuel. In addition to furnace operating conditions, a carryover in the coke may also result in pollutants that were prevalent in the coke making waste waters. Therefore, iron making blast furnace waste waters may contain ammonia, cyanide, phenol, suspended solids, fluoride and sulfide. The ferromanganese furnace will contain manganese in addition to the normal parameters inherent in the typical iron making furnace.

## Steelmaking Operations

The waterborne wastes from the steelmaking operations result from scrubbing of the gas stream with water to prevent air pollution and for noncontact cooling. Hence, basic oxygen and electric furnace waste waters may contain suspended solids and fluorides. Fluorspar, one of the basic raw materials in steelmaking, is the source of fluorides. The open hearth, due to the nature of its scrap mix, will also contain zinc, and nitrates may result due to the huge volumes of excess air that are used to provide better combustion.

## Vacuum Degassing Subcategory

In the vacuum degassing process, steel is further refined by subjecting the steel in the ladle to a high vacuum in an enclosed refractory lined chamber. Steam jet ejectors with barometric condensers are used to draw the vacuum. In the refining process certain alloys are added which may be drawn into the gas stream. In addition, the system is purged with nitrogen so as to have no residual CO. Therefore, the wastewater products from this operation are condensed steam and waste water containing suspended solids, zinc, manganese, lead, and nitrates.

## Continuous Casting Subcategory

# TABLE 19

IV.   BLAST FURNACE - IRON MAKING OPERATION

V.   BLAST FURNACE - FERROMANGANESE OPERATION

## PARAMETERS

Acidity (Free and Total)
Alkalinity (Pht. and M.O.)
Aluminum
*Ammonia
Berylium
BOD5
Chloride
COD
*Cyanide, Total
Dissolved Solids
Flow
Fluoride
Hardness, Total
Heat
Iron, Total
**Manganese

Nitrate
Nitrogen, Kjeldahl
Oil and Grease
*pH
*Phenol
Phosphorus, Total
Potassium
Sodium
Sulfate
*Sulfide
*Suspended Solids
Thiocyanate
TOC
Total Solids
Color
T.O.N.

*Indicates parameters on which standard raw waste load was developed.

**Indicates additional parameter on ferromanganese furnace.

TABLE 22

### PARAMETERS

| | |
|---|---|
| Acidity (Free and Total) | Mercury |
| Alkalinity (Pht. and M.O.) | Nitrate |
| Aluminum | *Oil and Grease |
| Color | *pH |
| Copper | Phosphorus, Total |
| Dissolved Solids | Silica, Total |
| *Flow | Sulfate |
| Hardness, Total | Sulfide |
| Heat | Sulfite |
| Iron, Total | *Suspended Solids |
| Lead | Total Solids |
| Manganese | Zinc |
| T.O.N. | |

*Indicates parameter on which standard waste load was developed.

## Environmental Impact of Pollutants

### pH, Acidity and Alkalinity

Acidity and alkalinity are reciprocal terms. Acidity is produced by substances that yield hydrogen ions upon hydrolysis and alkalinity is produced by substances that yield hydroxyl ions. The terms "total acidity" and "total alkalinity" are often used to express the buffering capacity of a solution. Acidity in natural waters is caused by carbon dioxide, mineral acids, weakly dissociated acids, and the salts of strong acids and weak bases. Alkalinity is caused by strong bases and the salts of strong alkalies and weak acids.

The term pH is a logarithmic expression of the concentration of hydrogen ions. At a pH of 7, the hydrogen and hydroxyl ion concentrations are essentially equal and the water is neutral. Lower pH values indicate acidity while higher values indicate alkalinity. The relationship between pH and acidity or alkalinity is not necessarily linear or direct.

Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and can thus add such constituents to drinking water as iron, copper, zinc, cadmium and lead. The hydrogen ion concentration can affect the "taste" of the water. At a low pH water tastes "sour". The bactericidal effect of chlorine is weakened as the pH increases, and it is advantageous to keep the pH close to 7. This is very significant for providing safe drinking water.

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Dead fish, associated algal blooms,

things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic and therefore decomposable nature, solids use a portion or all of the dissolved oxygen available in the area. Organic materials also serve as a seemingly inexhaustible food source for sludgeworms and associated organisms.

Turbidity is principally a measure of the light absorbing properties of suspended solids. It is frequently used as a substitute method of quickly estimating the total suspended solids when the concentration is relatively low.


## Phenols

Phenols and phenolic wastes are derived from petroleum, coke, and chemical industries; wood distillation; and domestic and animal wastes. Many phenolic compounds are more toxic than pure phenol; their toxicity varies with the combinations and general nature of total wastes. The effect of combinations of different phenolic compounds is cumulative.

Phenols and phenolic compounds are both acutely and chronically toxic to fish and other aquatic animals. Also, chlorophenols produce an unpleasant taste in fish flesh that destroys their recreational and commercial value.

It is necessary to limit phenolic compounds in raw water used for drinking water supplies, as conventional treatment methods used by water supply facilities do not remove phenols. The ingestion of concentrated solutions of phenols will result in severe pain, renal irritation, shock and possibly death.

Phenols also reduce the utility of water for certain industrial uses, notably food and beverage processing, where it creates unpleasant tastes and odors in the product.

## Zinc

Occurring abundantly in rocks and ores, zinc is readily refined into a stable pure metal and is used extensively for galvanizing, in alloys, for electrical purposes, in printing plates, for dye-manufacture and for dyeing processes, and for many other industrial purposes. Zinc salts are used in paint pigments, cosmetics, pharmaceuticals, dyes, insecticides, and other products too numerous to list herein. Many of these salts (e.g., zinc chloride and zinc sulfate) are highly soluble in water; hence it is to be expected that zinc might occur in many industrial wastes. On the other hand, some zinc salts (zinc carbonate, zinc oxide, zinc sulfide) are insoluble in water and consequently it is to be expected that some zinc will precipitate and be removed readily in most natural waters.

In zinc-mining areas, zinc has been found in waters in concentrations as high as 50 mg/1 and in effluents from metal-

Fluorides in sufficient quantity are toxic to humans, with doses of 250 to 450 mg giving severe symptoms or causing death.

There are numerous articles describing the effects of fluoride-bearing waters on dental enamel of children; these studies lead to the generalization that water containing less than 0.9 to 1.0 mg/l of fluoride will seldom cause mottled enamel in children, and for adults, concentrations less than 3 or 4 mg/l are not likely to cause endemic cumulative fluorosis and skeletal effects. Abundant literature is also available describing the advantages of maintaining 0.8 to 1.5 mg/l of fluoride ion in drinking water to aid in the reduction of dental decay, especially among children.

Chronic fluoride poisoning of livestock has been observed in areas where water contained 10 to 15 mg/l fluoride. Concentrations of 30 - 50 mg/l of fluoride in the total ration of dairy cows is considered the upper safe limit. Fluoride from waters apparently does not accumulate in soft tissue to a significant degree and it is transferred to a very small extent into the milk and to a somewhat greater degree into eggs. Data for fresh water indicate that fluorides are toxic to fish at concentrations higher than 1.5 mg/l.

## Cyanide

Cyanides in water derive their toxicity primarily from undissolved hydrogen cyanide (HCN) rather than from the cyanide ion ($CN^-$). HCN dissociates in water into $H^+$ and $CN^-$ in a pH-dependent reaction. At a pH of 7 or below, less than 1 percent of the cyanide is present as $CN^-$; at a pH of 8, 6.7 percent; at a pH of 9, 42 percent; and at a pH of 10, 87 percent of the cyanide is dissociated. The toxicity of cyanides is also increased by increases in temperature and reductions in oxygen tensions. A temperature rise of 10°C produced a two- to threefold increase in the rate of the lethal action of cyanide.

Cyanide has been shown to be poisonous to humans, and amounts over 18 ppm can have adverse effects. A single dose of about 50-60 mg is reported to be fatal.

Trout and other aquatic organisms are extremely sensitive to cyanide. Amounts as small as .1 part per million can kill them. Certain metals, such as nickel, may complex with cyanide to reduce lethality, especially at higher pH values, but zinc and cadmium cyanide complexes are exceedingly toxic.

When fish are poisoned by cyanide, the gills become considerably brighter in color than those of normal fish, owing to the inhibition by cyanide of the oxidase responsible for oxygen transfer from the blood to the tissues.

## Ammonia and Nitrates

in color and usually occur in spots and streaks. Waters containing manganous bicarbonate cannot be used in the textile industries, in dyeing, tanning, laundering, or in hosts of other industrial uses. In the pulp and paper industry, waters containing above 0.05 ppm manganese cannot be tolerated except for low-grade products. Very small amounts of manganese--0.2 to 0.3 ppm--may form heavy encrustations in piping, while even smaller amounts may form noticeable black deposits.

## Sulfides

Sulfides are oxidizable and therefore can exert an oxygen demand on the receiving stream. Their presence in amounts which consume oxygen at a rate exceeding the oxygen uptake of the stream can produce a condition of insufficient dissolved oxygen in the receiving water. Sulfides also impart an unpleasant taste and odor to the water and can render the water unfit for other uses.

Sulfides are constitutents of many industrial wastes such as those from tanneries, paper mills, chemical plants, and gas works; but they are also generated in sewage and some natural waters by the anaerobic decomposition or organic matter. When added to water, soluble sulfide salts such as $Na_2S$ dissociate into sulfide ions which in turn react with the hydrogen ions in the water to form $HS-$ or $H_2S$, the proportion of each depending upon the resulting pH value. Thus, when reference is made to sulfides in water, the reader should bear in mind that the sulfide is probably in the form of $HS-$ or $H_2S$.

Owing to the unpleasant taste and odor which result when sulfides occur in water, it is unlikely that any person or animals will consume a harmful dose. The thresholds of taste and smell were reported to be 0.2 mg/l of sulfides in pulp-mill wastes. For industrial uses, however, even small traces of sulfides are often detrimental. Sulfides are of little importance in irrigation waters.

The toxicity of solutions of sulfides toward fish increases as the pH value is lowered, i.e., the $H_2S$ or $HS-$ rather than the sulfide ion, appears to be the principle toxic agent. In water containing 3.2 mg/l of sodium sulfide, trout overturned in two hours at pH 9.0, in 10 minutes at pH 7.8, and in four minutes at pH 6.0. Inorganic sulfides have provided fatal to sensitive fishes such as trout at concentrations between 0.5 and 1.0 mg/l as sulfide, even in neutral and somewhat alkaline solutions. (143)

## Lead

Some natural waters contain lead in solution, as much as 0.4-0.8 mg/l, where mountain limestone and galena are found. In the U.S.A., lead concentrations in surface and ground waters used for domestic supplies range from traces to 0.04 mg/l averaging about 0.01 mg/l.

low as 0.1 mg/l have been reported toxic or lethal to fish. Other studies have shown that the toxicity of lead toward rainbow trout increases with a reduction of the dissolved-oxygen concentration of the water. (143).

SECTION VII

CONTROL AND TREATMENT TECHNOLOGY

## Introduction

Plant studies were conducted in each subcategory at plants that were deemed to be the best relative to performance levels attained by their treatment facilities. The plants visited were selected by the EPA from a list of candidate plants complied by the industry study contractor. Table 23 presents a brief summary of treatment practices employed at all plants visited in this study and shows the variability of treatment techniques employed in the industry. Included in each subcategory are tables presenting the size, location, and ages of the plants that were visited.

## Range and Permutations of Treatment Technology and Current Practice as Exemplified by Plants Visited During the Study

In each subcategory, a discussion is presented on the full range of technology employed within the industry followed by a discussion on the treatment practices, effluent loads, and reduction benefits at the plants that were visited. The effluent is stated in terms of gross plant effluent waste load.

## By-Product Coke Subcategory

A variety of methods for treating coke plant wastes has been practiced in the past, changing under the influence of economic conditions, and increasing restrictions on effluent quality. The recovery of sodium phenolate, ammonium sulfate or phosphate, and light oils has become unprofitable for most coke plants in the face of competition from other industries, primarily petrochemical. But at the same time, the need to recover increasing amounts of these and other materials present in the waste water has greatly increased if the plants expect to comply with the effluent standards required to upgrade stream conditions. Processes designed to recover percent quantities of pollutants may not be effective in reducing waste loads to minute fractions of a pound per ton of coke produced, or fractions of a milligram per liter of water discharged.

Various degrees of treatment, usually in the form of by-products recovery, have been practiced at different coke plants. In addition, other techniques will need to be developed and perfected to remove objectionable parameters from wastes prior to discharge to streams. An ultimate goal would be the total elimination of liquid wastes which have contacted dirty gas streams, provided that no detrimental effects on air or land use occur. A summary of the control and treatment technology practiced for the by-product operations follows:

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|                  |                  |
|------------------|------------------|
| PLANT            | PRACTICE         |

II  Coke Making
      Beehive

      E        Coke quench wastewaters treated via settling, followed by discharge to receiving stream.

      F        Coke quench wastewaters treated via settling and complete recycle.  No aqueous discharge to receiving stream.

      G        Coke quench wastewaters treated via settling and complete recycle.  No aqueous discharge to receiving stream.

III Burden Preparation
      Sintering

      H        Sinter plant wet scrubber wastewaters combined with blast furnace and other unidentified wastewaters and treated via chemical coagulation and thickening, followed by discharge to receiving stream.

      I        Sinter plant wastewaters combined with blast furnace gas cleaning system wastewaters and treated via thickening alkaline chlorination, sand filtration and recycle with blowdown. Blowdown is discharged to receiving stream.

      J        Sinter plant scrubber system wastewaters combined with underflow from blast furnace treatment system thickener and treated via thickening.  A portion of the thickener overflow is blown down to a sanitary authority, while the majority is passed through a cooling tower and recycled for reuse.

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| Plant | Practice |
|---|---|

**Fe Blast Furnace** (Cont'd.)

O      Blast furnace gas cleaning system wastewaters are treated via thickening, evaporative cooling, and recycle with blow-down. Blowdown is used for slag and coke quenching and BOF hood sprays and is completely evaporated. No aqueous discharge to a receiving stream.

P      Blast furnace gas cleaning system wastewaters treated via thickening followed by complete recycle. No aqueous discharge to a receiving stream.

**V   Blast Furnace**
**Ferromanganese**

Q      Venturi scrubber wastewaters treated via thickening and complete recycle to the scrubbers. Gas cooler wastewaters discharged to a receiving stream without treatment.

**VI, VII   Basic Oxygen Furnaces**

R   (VI)      Gas cleaning system wastewaters treated via chemical coagulation, settling, followed by a complete recycle. No aqueous discharge to a receiving stream.

S   (VII)      Gas cleaning system wastewaters treated via thickening, followed by recycle with blowdown to a receiving stream.

T   (VII)      Gas cleaning system wastewaters treated via classification, thickening, followed by recycle with blowdown.

| Plant | Practice |
|-------|----------|

### Electric Furnace (Cont'd.)

AB  (X)  Blowdown from gas cleaning water recycle system is treated via thickening and extended settling, followed by discharge to a receiving stream.

### XI  Vacuum Degassing

AC  Vacuum degassing wastewaters combined with non-contact BOF cooling waters, a portion blown down to a receiving stream, and the remainder passed through a cooling tower before reuse. Thus, no treatment of raw wastewaters prior to blowdown.

AD  Degassing wastewaters combined with continuous caster waste-waters and treated via settling, filtration, evaporative cooling and recycle with blowdown to a receiving stream.

### XII  Continuous Casting

AE  Wastewaters treated via settling, filtration, followed by recycle with blowdown to a receiving stream. A portion of the recycled water is subjected to evaporative cooling before reuse.

AF  Continuous caster wastewaters combined with degasser waste-waters and treated via settling, filtration, evaporative cooling and recycle with blowdown to a receiving stream.

1. The construction of in-plant biological treatment plants utilizing large, aerated lagoons and bacterial cultures specifically acclimated to break down phenols, cyanides and/or ammonia into non-toxic products.

2. Provision of sufficient pre-treatment of by-product coke plant wastes to render them acceptable for treatment in municipally-owned sewage treatment plants.

3. Distillation and incineration of the total coke plant waste load in carefully controlled combustion systems. No by-products other than coke oven gases are recovered and no liquid effluents are discharged.

4. Improved solvent extraction techniques for recovery of more phenolics through the use of more selective solvents.

5. Carbon adsorption has been utilized to treat chemical and refinery wastes which are quite similar to by-product coke plant wastes. The technique is widely used on large volume flows, and should be considered potentially applicable to coke plant problems.

g. Oxidation using chlorine compounds is being applied, but not on a broad scale. It can be used more effectively where the waste volume has been minimized and the waste loads have first been reduced by other methods.

h. Additional research is continuing on new treatment methods and their possible applications to coke plant wastes:

1. Development of improved biological systems. Systems currently in use preferentially eliminate one or two of the objectionable trace materials left after other treatment methods, while tolerating fairly high concentrations of other pollutants. The biological degradation of these materials in a multistage system is possible, also.

2. Oxidation using ozone or other strong oxidants is receiving considerable attention. Past efforts have been disappointing when attempted on raw waste waters, but are worth investigating as a polishing technique after gross quantities are removed by more conventional methods.

## Plant Visits

Four by-product coke plants were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 24 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief

descriptions and drawings of the individual waste water treatment systems are presented.

## Plant A - Figure 32

Once-through system. Light oil and weak ammonia liquor waste waters are treated in a free leg ammonia still and with proprietary solvent extraction. Direct discharge of ammonium sulphate crystallizer effluent.

Normal gross plant effluent waste load is estimated at 638 l/kkg of coke (153 gal/ton) flow, and 0.61 kg ammonia, 0.042 kg BOD5, 0.062 kg cyanide and 0.00087 kg phenol per kkg (lb/1,000 lb) of coke produced.

Overall removals of ammonia, BOD5, cyanide and phenol are 44.6%, 95.4%, 89.6%, and 99.6%, respectively.

## Plant B - Figure 33

Once-through system. Light oil cooling and weak ammonia liquor waste waters treated biologically (activated sludge) for removal of phenols.

Normal gross plant effluent waste load is estimated at 306 l/kkg of coke (108 gal/ton) flow, (without dilution water), and 0.52 kg ammonia, 0.0102 kg BOD5, 0.0169kg cyanide, 0.0000288 kg phenol, 0.00113 kg oil and grease, 0.074 kg suspended solids and 0.0000117 kg sulfide per kkg (lb/1,000 lb) of coke produced.

Overall removals of ammonia, BOD5, cyanide, phenol, oil and grease, suspended solids, and sulfide are 28.8%, 98.5%, 71.8%, 99.8%, 99.1%, 0%, and 99.96%, respectively.

## Plant C - Figure 34

Weak ammonia liquor waste water treated in once-through system with dephenolizer followed by ammonia still operating on both free and fixed legs followed by settling basins. Light oil waste water used as make-up for coke quench station with closed recycle system. Normal gross plant effluent waste load is estimated at 174 l/kkg of coke (41 gal/ton) flow and 0.08 kg ammonia, 0.091 kg BOD5, 0.0115 kg cyanide, 0.037 kg phenol, 0.00316 kg oil and grease, 0.0174 kg suspended solids and 0.019 kg sulfide per kkg (lb/1,000 lb) of coke produced.

Overall net removals of ammonia, BOD5, cyanide, phenol, oil and grease, suspended solids, and sulfide are 92.9%, 47.7%, 18.4%, 73.4%, 80.2%, 74.4%, and 37.0%, respectively.

## Plant D - Figure 35

Weak ammonia liquor waste water treated in once-through system with desulfurizer tower followed by dephenolizer followed by ammonia still operating on both free and fixed legs. Non-

FIGURE 1: BY-PRODUCT COKE MANUFACTURING

PLANT: A

PRODUCTION: 4,672.1 METRIC TONS COKE PER DAY
(5,085 TONS COKE PER DAY)

| ENVIRONMENTAL PROTECTION AGENCY | | |
|---|---|---|
| STEEL INDUSTRY STUDY BY-PRODUCT COKE PLANT WASTEWATER TREATMENT SYSTEM WATER FLOW DIAGRAM | | |
| 3-22-73 | FIGURE | 32 |

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PROCESS : BY-PRODUCT COKE MANUFACTURING
PLANT : B
PRODUCTION : 4050.2 METRIC TONS COKE PER DAY
( 4,450 TONS COKE PER DAY )

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY-PRODUCT COKE PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM
3-22-73    FIGURE 53

PROCESS 1 BY-PRODUCT COKE MANUFACTURING
PLANT-C
PRODUCTION: 5,595.4 METRIC TONS COKE PER DAY
(6,195 TONS COKE PER DAY)

FRESH WATER MAKE-UP

SETTLING BASIN

QUENCH STATION #2

0-2.5 L/SEC. (0-40 GPM)

WHARF

COKE

WASTE AMMONIA LIQUOR

8.8 L/SEC. (139 GPM)

PHENOL REMOVAL

LIGHT OILS

PHENOLIZED LIGHT OILS

CAUSTIC SCRUBBER FORMS SODIUM PHENOLATE

NaOH

DEPHENOLIZED LIQUOR

SODIUM PHENOLATE

TREATED EFFLUENT TO SANITARY AUTHORITY
10± L/SEC (168 GPM)

LIME SETTLING BASIN DETENTION TIME 2.5 HRS

CaO

AMMONIA STILL

FREE LEG

LIME

FIXED LEG

STEAM

LIME

NH3

NH3 TO ABSORBER

SAMPLING POINTS

FINAL COOLER BLOWDOWN

QUENCH STATION #1 & #3

0-8.5 L/SEC. (0-140 GPM)

SETTLING BASIN

WHARF

COKE

LIGHT OIL RECOVERY WASTE WATERS

| ENVIRONMENTAL PROTECTION AGENCY | |
| STEEL INDUSTRY STUDY BY-PRODUCT COKE WASTEWATER TREATMENT WATER FLOW DIAGRAM | |
| 5-7-73 | FIGURE 34 |

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PROCESS: BY-PRODUCT COKE MANUFACTURING
PLANT: D
PRODUCTION: 1490.0 METRIC TONS COKE PER DAY
( 1650 TONS COKE PER DAY)

AMMONIA LIQUOR STORAGE

COOLER & DECANTER TANK

2.84 L/SEC. (45 GPM)

CERAMIC FILTERS

DECANTER

BACKFLUSH

DEPHENOLIZER

DEPHENOLIZED WATER

SOLVENT DECANT

SOLVENT RECOVERY

FREE & FIXED AMMONIA STILL

STEAM

LIME SLURRY

SERVICE WATER SAMPLE TAKEN IN LIME SLURRY MAKE-UP AREA.

1.26 L/SEC. (15 GPM)

AMMONIA STILL/FFS8 EFFLUENT 3.79 L/SEC. (60 GPM)

SOLVENT TANK

AMMONIA TO AMMONIUM SULFATE PRODUCTION

SODIUM PHENOLATE TO PHENOL REFINING

SAMPLING POINT

PLANT OUTFALL 599.17 L/SEC. (9480 GPM)

ONCE THROUGH COOLING WATER 594.16 L/SEC. (9420 GPM)

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SAMPLING POINTS

PROCESS : B&B HIVE COKE MANUFACTURING
PLANT : F
PRODUCTION : 107 METRIC TONS COKE PER DAY
(1200 TONS COKE PER DAY)

QUENCH WATER

HOT COKE

1   2   3   4   5

COKE OVEN BATTERIES

QUENCH STATION

DISCHARGE WATER

QUENCH STATION
EFFLUENT FLOW
21.5 ℓ/SEC
(340 GPM)

SETTLING POND

SETTLING POND

WATER DISCHARGED TO RIVER

TOTAL DISCHARGE
TO RIVER
21.5 ℓ/SEC
(340 GPM)

SEEPAGE
DISCHARGE
TO RIVER

DISCHARGE WATER

QUENCHED AT OVENS

30.7 ℓ/SEC
(486 GPM)

RAW WATER HOLDING TANK

RAW WATER SUPPLY

PUMP HOUSE

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
B&B HIVE COKE PLANT
WASTE WATER TREATMENT
WATER FLOW DIAGRAM

3-23-73   FIGURE 36

COKE OVENS

HOT COKE

QUENCH STATION

QUENCHED COKE

QUENCH WATER DISCHARGE
21.5 ℓ/ SEC
(340 GPM)

ELEVATED HOLDING TANK

CLEAR WELL

RAM COOLING WATER
INTERMITTENT LOW FLOW
APPROX. .13 ℓ/ SEC.
(2 GPM )

RECYCLED QUENCH WATER
30.7 ℓ/ SEC
(486 GPM)

SETTLING BASIN

MAKE-UP WATER
9.2 ℓ/ SEC
(146 GPM)

RAM COOLING WATER
INTERMITTENT LOW FLOW
APPROX. .13 ℓ/ SEC.
( 2 GPM )

RAW WATER HOLDING TANK

PUMP STATION

RAW WATER SUPPLY

△ SAMPLING POINTS

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BEE HIVE COKE PLANT WASTEWATER TREATMENT SYSTEM WATER FLOW DIAGRAM — STEEL INDUSTRY STUDY — ENVIRONMENTAL PROTECTION AGENCY — FIGURE 98

## TABLE 25

### Plant Age and Size
### Coke Making - Beehive

| Plant | Location | Production kkg/day | Plant Installed Year | Treatment Plant Installed Year |
|---|---|---|---|---|
| E | Middle Atlantic | 907 | 1963 | 1963 |
| F | Middle Atlantic | 907 | 1970 | 1970 |
| G | Northeastern | 559 | 1960 | 1960 |

Normal gross effluent waste load is zero since there is no discharge.

## Sintering Subcategory

Treatment of sinter plant aqueous wastes primarily centers on two basic systems dependent on the scrubbing system employed.

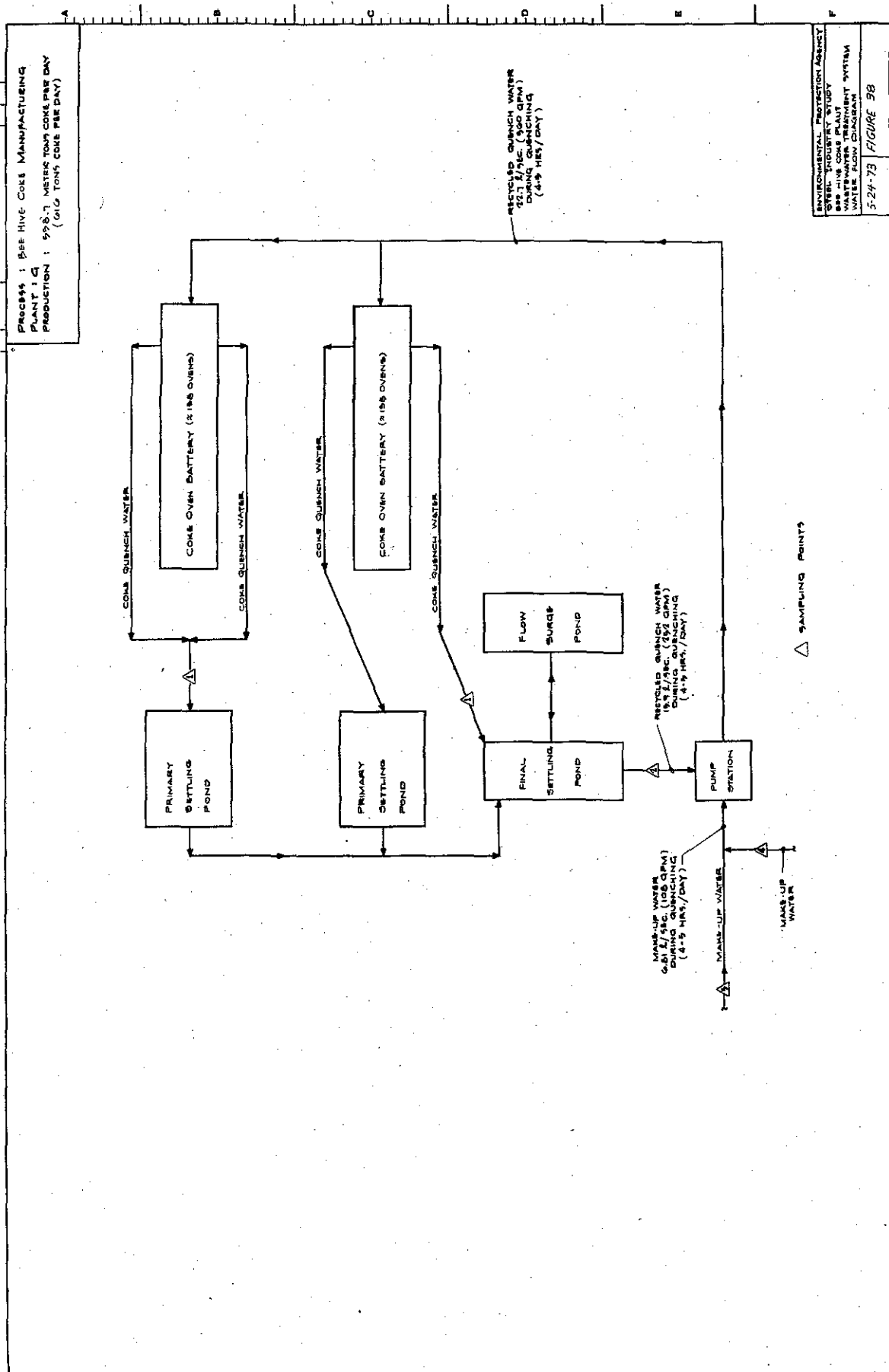When scrubbers are used for the dedusting systems, the scrubber aqueous discharges are either "once-through" or "recycled" through a thickener. The thickener underflow is decanted with centrifuges or vacuum filters with the filtrates being returned to the thickeners and the filter cake being returned to the sinter plant.

When high energy venturi scrubbers are used in place of pre-cipitators for the sinter bed exhaust system, the scrubber aqueous discharges are treated in the same manner as the dedusting system, but may require magnetic or chemical floc-culation to increase the settling efficiencies.

## Plant Visits

Four sintering plants were visited during the survey. However, the data are not as complete as with other subcategories of the project. This is due to several reasons, namely:

a.  Tie-in with other plant processes, such as the blast furnace. This poses a problem in determining the effectiveness of the treatment facility on the sinter plant portion of the waste waters.

b.  The effluent of one plant was not sampled due to the malfunctioning of a portion of the treatment equipment.

c.  Failure of one plant to provide information relative to costs and daily production. Sampling was performed but the data could not be correlated.

Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 26 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and individual wastewater treatment systems are presented.

## Plant H - Figure 40

Sinter plant scrubber waste waters are combined with blast furnace and other steel making waste waters and treated via chemical coagulation and thickening followed by discharge to the receiving stream.

No effluent sample was obtained due to a malfunction of the chemical treatment system.

PROCESS: SINTERING
PLANT: J
PRODUCTION: 2292.4 METRIC TONS SINTER PER DAY
(2599 TONS SINTER PER DAY)

SINTER PLANT
GAS SCRUBBER SYSTEM
(TWO SCRUBBERS)

EVAPORATION LOSS
3.15 TO 6.31 l/SEC. (50 TO 100 GPM)
4.73 l/SEC. AVG. (75 GPM AVG)

41.01 TO 44.17 l/SEC. (650 TO 700 GPM)
42.99 l/SEC. AVG. (675 GPM AVG)

VACUUM
FILTERS

3.15 l/SEC. (50 GPM)

37.86 l/SEC.
(600 GPM)

41.01 l/SEC.
(650 GPM)

SERVICE WATER
MAKE UP

UNDERFLOW
FROM BLAST FURNACE
THICKENER

12.62 l/SEC. (200 GPM) SLURRY

EVAPORATION
1.97 l/SEC. (25 GPM)

0 TO 12.6 l/SEC. (0 TO 200 GPM)
6.31 l/SEC. AVG. (100 GPM AVG)

50.48 l/SEC.
(800 GPM)

SECONDARY THICKENER
(8.19 m. DIA.
(40'-0" DIA.)
OVERFLOW RATE
26 l/m². / MIN.
(0.64 GAL/FT². /MIN)

COOLING
TOWER

BLOWDOWN
9.46 TO 18.93 l/SEC. (150 TO 300 GPM)
12.62 l/SEC. AVG. (200 GPM AVG)

TO
SANITARY
AUTHORITY

3.15 l/SEC. (50 GPM) SLURRY LINE

△ SAMPLING POINTS

PROCESS: BURDEN PREPARATION (SINTERING)

PLANT: H

PRODUCTION: 9160.6 METRIC TONS SINTER PER DAY
(9500 TONS SINTER PER DAY)

SINTER
PLANT
WET
SCRUBBERS

SINTER PLANT
SUMP

(≈0.1 ft³/sec (≈50 GPM))

BLAST FURNACE
& OTHER SOURCES

POLYMER ADDITIVE

FILTRATE

THICKENER

THICKENER

TO
RIVER

FILTER

SOLIDS TO
SINTER PLANT

△ SAMPLING POINTS

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-21-73    FIGURE 40

TABLE 26

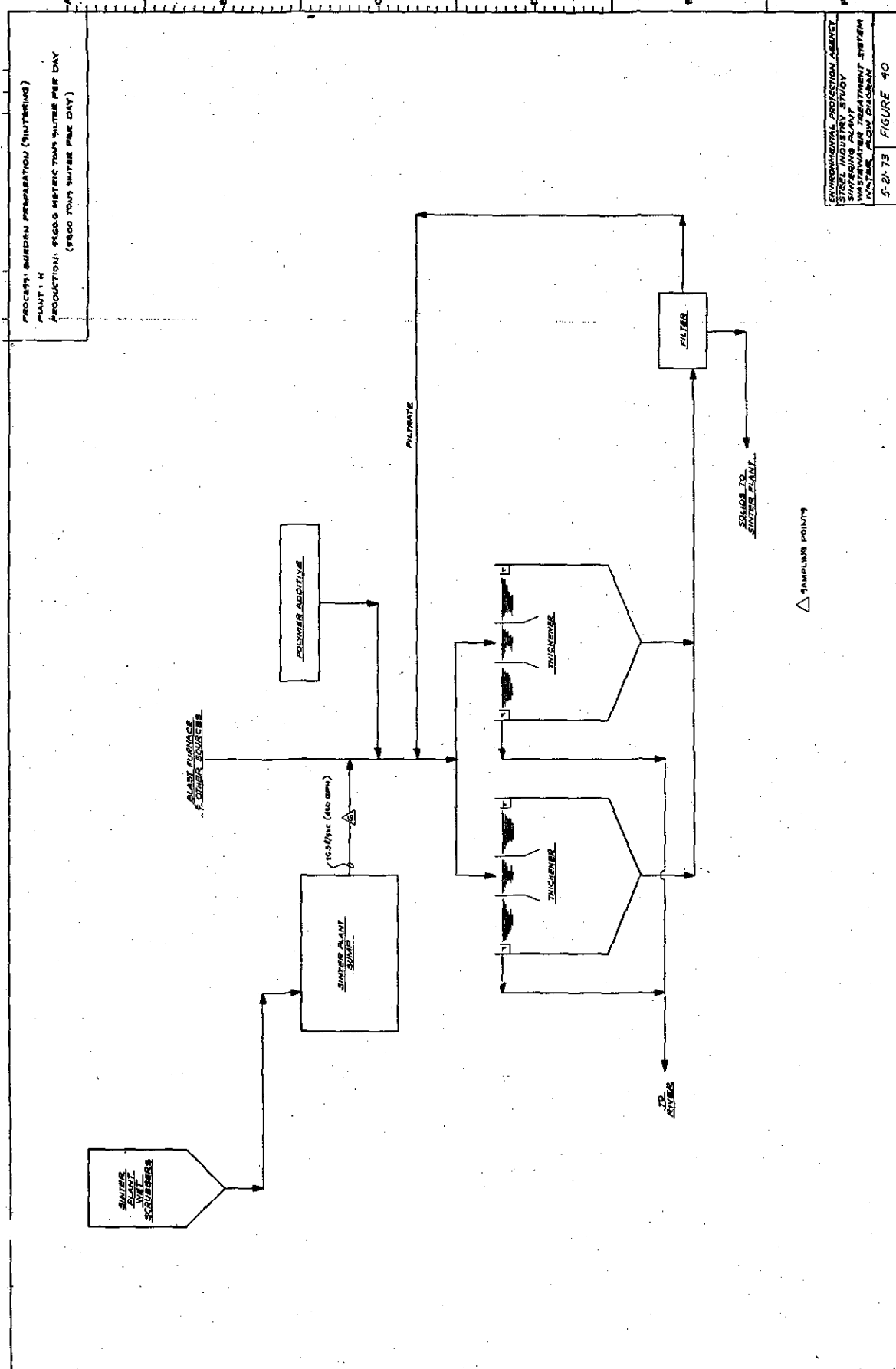Plant Age and Size
Burden Preparation - Sintering (II-A)

| Plant | Location | Production kkg/day | Plant Installed Year | Treatment Plant Installed Year |
|-------|----------|--------------------|--------------------|------------------------------|
| H | Middle Atlantic | 5300 | | 1940 |
| I | Northern Great Lakes | | | |
| J | Northern Great Lakes | 2300 | | 1971 |
| K | Northeastern | | | |

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## Plant J - Figure 39

Gas scrubber water on a tight recycle system. Loop contains gas scrubbers, thickener and cooling tower.

Normal gross plant effluent waste load is estimated at 475 l/kkg of sinter (114 gal/ton) flow, and 0.000474 kg oil and grease, 0.00427 kg suspended solids, 0.00403 kg fluoride, and 0.00511 kg sulfide per kkg (lb/1,000 lb) of sinter produced.

Overall removals for oil and grease and suspended solids are approximately 100% and for sulfides are 94.5%.

## Blast Furnace Operations

Several different treatment systems have been used throughout the years to treat the waste water from blast furnace gas cleaning systems. Some of these have been fairly successful; however, others are experimental in nature and have yet to be resolved. They are listed here according to the degree of treatment they provide. The basic treatment system was designed for the removal of particulate matter and not for the removal of the chemicals in the waste waters. The ultimate treatment system is the one that not only removes the solids but also the chemicals from the waste.

a. The simplest system for treating blast furnace gas wash water has been a rectangular settling tank. Here the solids were allowed to settle and the clarified overflow water discharged to the receiving stream. The settled material is removed from an idle unit by a clam shell bucket and trucked to landfill while material settles out in a second unit. This is the simplest type of settling tank; however, the handling of the wet sludge created many problems. These have been replaced by more sophisticated equipment which pumps the settled sludge to vacuum filters for further dewatering.

b. The rectangular settling tank has been replaced with a circular thickener or clarifier. The dirty water from the gas scrubber enters in the center, the solids settle to the bottom, and the clarified water overflows around the circumference of the tank. The sludge is pumped from the bottom of the thickener to vacuum filters where the solids are filtered from the water and the filtrate returned to the thickener. The overflow water from the thickener is discharged to the receiving stream as most of the solids have been removed. Most all blast furnaces are equipped with this type of system for the removal of suspended solids in the wash water. This system, however, does not appreciably affect the chemical composition of the water.

c. A few plants have modified the above system to discharge the clarified overflow from the thickener back into the water intake for the total plant water system. Here the water is diluted with incoming fresh water and used throughout the

various noncontact cooling systems within the plant as well as for make-up water to the blast furnace gas cleaning system. In these plants, the noncontact cooling water is discharged at a point not near the plant intake. Returning the clarified water from the thickener to the plant intake dilutes the water and treats it by aeration in cooling towers, etc., in a noncontact cooling system of the plant. It is then discharged in an area where it cannot be picked up by the water intake pumps. This system makes no attempt to treat the chemical wastes other than by dilution and aeration throughout the noncontact cooling system.

d. At least one plant is taking the thickener overflow from a once through system and passing it through a continuous alkaline chlorination system for the total destruction of cyanide and phenols. The effluent from the alkaline chlorination treatment system goes to a clarifier and sand filter prior to being returned to the plant intake water system for recycle through the plant. This treated effluent shows virtually complete elimination of suspended solids, cyanide, phenol, and sulfide. Ammonia concentrations are also reduced by 70 percent, and the treated waters that are recycled to the plant intake are normally of higher quality than the raw river water used as make-up. The blend of treated and raw water is not only used as process water in the sinter plant and blast furnace gas washer system, but also as process water for merchant mills and blooming mills in other areas of the manufacturing complex.

e. Recycle systems are also in use in some plants. The thickener overflow is collected in a tank and returned to the gas cleaning system without the benefit of a cooling tower to cool the water. This system takes advantage of the surface cooling effect of the thickener; however, it operates at a higher recirculation water temperature than in other systems. The blowdown from this recycle system is discharged to the local stream. The sludge is pumped to a vacuum filter for further dewatering and recovery. There are only a few plants operating with this type system.

f. The basic recycle system in use today uses a thickener to remove the solids from the blast furnace gas wash water. The thickener overflow goes into a tank and is pumped to a cooling tower where the water is cooled and returned to the gas washer for reuse. The system is also equipped with a vacuum filter to dewater the sludge and the filtrate is returned to the thickener. The effluent from the system is the blowdown from the cooling tower which is free of settleable solids. This is discharged to the local streams. No effort is made to treat the chemical composition of the wash water; however, the aeration in the cooling tower tends to oxidize and reduce the chemical composition of these waters.

g.  At least one steel company is using a bio-oxidation system for the destruction of cyanide. Information available on this system is limited; however, the large volumes of water requiring treatment and the sensitivity of bio-oxidation systems requires careful attention to details of operation.

h.  At least one blast furnace is operating a wash water recycle system without a discharge to the receiving stream by discharging the blowdown to the local sanitary authority for treatment in the sewage treatment plant. This appears to be working out satisfactorily. There is a question, however, whether the sewage treatment plant is effectively treating the chemical blowdown, or diluting the waste to where it cannot be found. Few sewage treatment systems are designed to handle this increased hydraulic loading. Any municipal treatment system receiving the blowdown from a blast furnace gas wash water system is likely to impose strict limitations on the volume and composition of water that it can handle. Problems therefore develop during periods of upset and equipment cleaning on how to handle the extra waste water. Overloading the municipal treatment system could cause undue problems for the municipality.

i.  Another route to the disposal of the waste water from a blast furnace gas wash water system is a complete recycle system with thickeners, cooling towers, and vacuum filters with precise control over the blowdown from the system. The blowdown is totally evaporated by slag and coke quenching and in the BOF hood cooling. Several plants are doing this; however, not all blast furnaces have the advantage of readily available coke quenching and BOF hood cooling operations convenient to their site. This system therefore may not apply to all blast furnaces. In addition, trace amounts of chemicals are released into the atmosphere to become an air pollution problem. The extent of this air pollution problem has not been established.

j.  Blowdowns from recycle systems may be handled in ways other than by discharge to receiving streams. Incineration of the blowdown is one method of accomplishing this. This would be practical only if surplus blast process gas fuel were available to operate the incinerator. It would, however, oxidize or destroy the chemical components of the waste. If the total evaporation of slag and coke quenching is a satisfactory method for eliminating the dissolved solids from recycle system, then evaporation using available waste heat from the blast furnace could also be used.

A zero discharge from the gas wash water system could be accomplished by demineralizing the blowdown and returning the condensate to the system as demineralized makeup water. The concentrated brine could be disposed of as a concentrated brine, it could be taken to complete dryness, or it could be further concentrated and the solids crystallized out and removed by filters and disposed of in landfill.

Incineration, demineralization, and evaporation by waste heat recovery have not been tried. However, these are ways of eliminating the blowdowns from these systems and should be investigated.

There is presently being designed a recycle system for the blast furnace gas wash water system that will have no blowdown other than the moisture in the filter cake that leaves the system via the vacuum filters. Preliminary tests and calculations have indicated that such a system is possible. If this system is made to work, it would be the ultimate way of operating a blast furnace recycle system with no blowdown. However, this system would not be applicable to all blast furnaces.

The ultimate disposal of blast furnace gas wash water is the operation of a system with no blowdown to the receiving stream. Several plants are operating in this manner; however, no one system can be applied to all mills.

## Plant Visits

Five iron making blast furnaces and one ferro-manganese blast furnace were visited during the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Tables 27 and 28 present a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and drawings of the individual waste water treatment systems are presented.

## Plant L - Figure 41

Gas cleaning water on loose recirculation system with maximum blowdown. Loop includes gas scrubber, thickener, alkaline chlorination unit, and sand filter.

Normal gross plant effluent waste load is estimated at 22,518 l/kkg of iron (5,400 gal/ton) flow, and 0.084 kg ammonia, 0.0005 kg cyanide, 0.0014 kg phenol, 1.1 kg suspended solids, and 0.0043 kg sulfide per kkg (lb/1,000 lb) of iron produced.

Overall removals of ammonia, cyanide, phenol, suspended solids, and sulfide are 24.9%, 98.5%, 90.1%, 97.3%, and 96.1%, respectively.

## Plant M - Figure 42

Gas cleaning water on tight recycle system with minimal blowdown. Loop includes scrubbers, thickener and cooling tower.

Normal gross plant effluent load is estimated at 513 l/kkg of iron (123 gal/ton) flow, and 0.040 kg ammonia, 0.0087 kg cyanide, 0.00184 kg phenol, 0.0436 kg suspended solids, and 0.00249 kg sulfide per kkg (lb/1,000 lb) of iron produced.

Overall removals for ammonia, cyanide, phenol, suspended solids, and sulfide are 0%, 0%, 0%, 99.2%, and 0%, respectively.

## Plant N - Figure 43

Gas cleaning water on tight recycle system with minimal blowdown. Loop includes scrubbers, thickener, and cooling tower.

Normal gross effluent waste load is estimated at 421 l/kkg (1.1 gal/ton) flow, and 0.112 kg ammonia, 0.0078 kg cyanide, 0.0000144 kg phenol, 0.0164 kg suspended solids, and 0.00175 kg sulfide per kkg (lb/1,000 lb) of iron produced.

Overall removals for ammonia, cyanide, phenol, suspended solids, and sulfide are 20.1%, 0.0%, 99.8%, 99.6%, and 0.0%, respectively.

## Plant O - Figure 44

Gas cooling and cleaning water on tight recycle system with minimal blowdown. Loop includes gas coolers and scrubbers, thickeners, and cooling towers.

Normal gross plant effluent waste load is estimated at 440 l/kkg of iron (104 gal/ton) flow, and 0.0434 kg ammonia, 0.00469 kg cyanide, 0.0000044 kg phenol, 0.0199 kg suspended solids, and 0.00299 kg sulfide per kkg (lb/1,000 lb) of iron produced.

Overall removals of ammonia, cyanide, phenol, suspended solids, and sulfide are 73.0%, 0.0%, 99.6%, 99.9%, and 0.0%, respectively.

## Plant Q - Figure 45

Once-through gas cooling system. Gas cleaning water on closed recycle loop. Loop includes gas scrubber and thickener.

Normal gross effluent waste load is estimated at 24,000 l/kkg of ferromanganese (5,700 gal/ton) flow, and 3.92 kg ammonia, 2.54 kg cyanide, 0.144 kg manganese, 0.011 kg phenol, 1.78 kg suspended solids, and 2.42 kg sulfide per kkg (lb/1,000 lb) of ferromanganese produced.

Overall removals of ammonia, cyanide, phenol, suspended solids, and sulfide are 0%, 0%, 0%, 99.2%, and 0% respectively.

## Basic Oxygen Furnace Operation

The waste water produced is primarily the result of the fume collection system employed. There is no discharge on the dry type precipitator system and hence no waste water treatment is involved.

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE & SINTER PLANT
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

6-5-73    FIGURE 41

206

PROCESS: IRON MAKING (#6 BLAST FURNACE)

TYPE: II

PLANT: M

PRODUCTION: 3174.3 METRIC TONS (IRON PER DAY)
(3500 TONS IRON PER DAY)

PROCESS: IRON MAKING (#6 BLAST FURNACE)

315.1 ℓ/SEC.
(5000 GPM)

A. FURNACE GAS WASHERS

B. FURNACE GAS WASHERS

157.5 ℓ/SEC.
(2500 GPM)

189.1 ℓ/SEC.
(3000 GPM)

315.1 ℓ/SEC.
(5000 GPM)

SERVICE WATER MAKE-UP

25.2 ℓ/SEC.
(400 GPM)

COOLING TOWER

EVAPORATION
6.3 ℓ/SEC.
(100 GPM)

BLOWDOWN TO SANITARY AUTHORITY
6.3 ℓ/SEC.
(100 GPM)

302.9 ℓ/SEC.
(4800 GPM)

17.4 m. DIA. THICKENER (60 FT. DIA.)
(PRIMARY)
OVERFLOW RATE 30.6 ℓ/m²/MIN
(0.75 GAL./FT²/MIN)

UNDERFLOW
6.3 ℓ/SEC.
(100 GPM)

TO SINTER PLANT THICKENER

SLURRY PUMPS

△ SAMPLING POINTS

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-24-73    FIGURE 42

# TABLE 27

## Plant Age and Size
### Iron Making - Fe Blast Furnaces

| Plant | Location | Production kkg/day | Plant Installed Year | Treatment Plant Installed Year |
|-------|----------|--------------------|----------------------|--------------------------------|
| L | Northern Great Lakes | 2200 | 1941-1945 | 1971 |
| M | Northern Great Lakes | 3175 | | |
| N | Central Pacific | 1950 | 1941-1945 | 1959 |
| O | Southern Texas | 1500 | 1941-1945 | 1969 |
| P | Northeastern | N/A | 1900 | ---- |

PROCESS: IRON MAKING (Fe BLAST FURNACE)
TYPE: I
PLANT: N
PRODUCTION: 9491 METRIC TONS IRON PER DAY
(9149 TONS IRON PER DAY)

ENVIRONMENTAL PROTECTION AGENCY
"STEEL INDUSTRY STUDY"
BLAST FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-25-73 | FIGURE 43

△ SAMPLING POINTS

211

PROCESS : IRON MAKING (Pb BLAST FURNACES)
TYPE : II
PLANT : O
PRODUCTION : 11094.6 METRIC TONS IRON PER DAY
(9640 TONS IRON PER DAY)

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE
WASTE WATER TREATMENT SYSTEM
SCHEMATIC DIAGRAM
6-2-73    FIGURE 44

215

PROCESS: IRON MAKING (IRON BLAST FURNACE)

TYPE: III

PLANT: Q

PRODUCTION: 500.9 METRIC TONS FERROMANGANESE PER DAY
(551 TONS FERROMANGANESE PER DAY)

To Boiler Hse

SERVICE WATER
199.7 L/sec.
(3159 GPM)

GAS COOLER

To Tower
189.1 L/sec.
(3000 GPM)

DE ENVIRONMENT 90%

VENTURI SCRUBBER

SEPARATOR

98.6 L/sec.
(9100 GPM)

MAKE UP WATER
9.5 L/sec.
(150 GPM)

953 L/sec.
(1049 GPM)

THICKENER

FILTRATE

VACUUM FILTER

FILTER CAKE TO SLAG PILE

△ SAMPLING POINTS

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE
WASTE WATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

6-7-73    FIGURE 45

The semiwet system employs a precipitator and gas conditioning in a spark box spray chamber. The spark box spray system utilizes an excessive spray water system.

The basic type of water control treatment system applied to this aqueous discharge is generally a steel or concrete rectangular settling tank containing a motorized flight conveyor for removing the settled solids. The water is allowed to settle some solids and then overflowed to the plant sewers while the flight conveyor removes the settled solids for truck disposal. Approximately 22-30% of the dust load ejected from the furnaces is precipitated out in the spark box chamber and discharged to the settling tank. These systems can be upgraded by magnetic and chemical flocculation systems, thus precipitating more of the submicron iron oxide fines.
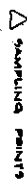
These systems can be arranged for a zero aqueous discharge by adding make-up water and recycling the water back into the spark box spray system.

An alternate system to the spark-box spray or dry evaporation chamber system is to install a wetted wall type evaporation chamber. A wetted wall evaporation chamber contains no refractory lining, but uses a water wetted steel surface as the heat resistant medium. These chambers require large quantities of water to insure that the steel surfaces do not become overheated. The aqueous discharges from these systems are generally discharged to a settling chamber, make-up water is added with chemical treatment, and the water is recycled back to the evaporation chamber system. These systems employ the same water treatment techniques as the spark box discharges except the precipitated dust load is somewhat less (10%) as these systems are a cross between the spark box and dry evaporation chambers.

The wet high energy venturi scrubber fume collection systems generally use steam generating type hoods close coupled with a low energy fixed orifice quencher. As the hot gases exit from the hood, the gases are immediately quenched from 150°C to 85°C saturation temperature.

The aqueous discharge from the scrubber fume collection system is from the primary quencher with the effluent being discharged to thickeners. Most systems have thickeners for settlement of solids. Flocculation polymers systems are generally installed to aid settlement. The overflow from the thickener is discharged to the plant sewers and the underflow from the thickeners is passed through filters for decanting with the filtrate being returned to the thickener while the filter cake is sent to the sintering plant for recycling. These systems can become recycling systems by adding make-up water to compensate for water evaporation in the primary quencher.

The treated water is pumped into the venturi scrubber and recycled from the venturi scrubber to the primary quencher.

Head Water Cooling Tower

Lance Cooling Water Return

Lance Cooling Water Supply

Head & Pumps Cooling Water

Head & Pumps Cooling Water

Secondary Sprays Water

#2 B.O.F. Head

To Spark Boxes

#3 B.O.F. Stack

Clarifier Underflow (Not running during sampling period)

49.8 L/sec. (790 GPM AVG.)

(6/1/72) (30 GPM) MAKE-UP

Spray Water Pumps

Settling Tanks (2)

48.0 L/sec. (760 GPM AVG.)

#3 B.O.F. Head

To Spark Boxes

#3 B.O.F. Stack

Flushing Ring

Ladle

Primary Sprays Water

Cascade Sprays Water

△ SAMPLING POINTS

220

Figure 47. Basic Oxygen Furnace Waste Water Treatment System

PROCESS: STEELMAKING (BOF)
TYPE: II
PLANT: 5
PRODUCTION: 5735.8 METRIC TONS STEEL PER DAY
(6340 TONS STEEL PER DAY)

SAMPLING POINTS ▽

Filter Making & Vacuum Pumps

Cleaning System

EVAPORATION (63 GPM) 4.2 l/sec.

781.0 l/sec (4405 GPM)

FILTER CAKE WITH 0.68 KG/SEC (10 GPM) MOISTURE

211 l/sec (3345 GPM)

From River Water Intake

Make up Water (183 GPM) 11.5 l/sec

VACUUM FILTERS

To Sewer 250 GPM 14.5 l/sec

270 l/sec (4280 GPM)

966.0 l/sec (15310 GPM)

Clarifier

33 l/sec (530 GPM)

THICKENER-2

FILTRATE & WASHINGS 4.4 l/sec (70 GPM)

757 l/sec (12170 GPM)

Distribution Box

281 l/sec (4978 GPM)

Misc Cooling Water (198 GPM) 12 l/sec

130

STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE
WASTE WATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

ENVIRONMENTAL PROTECTION AGENCY
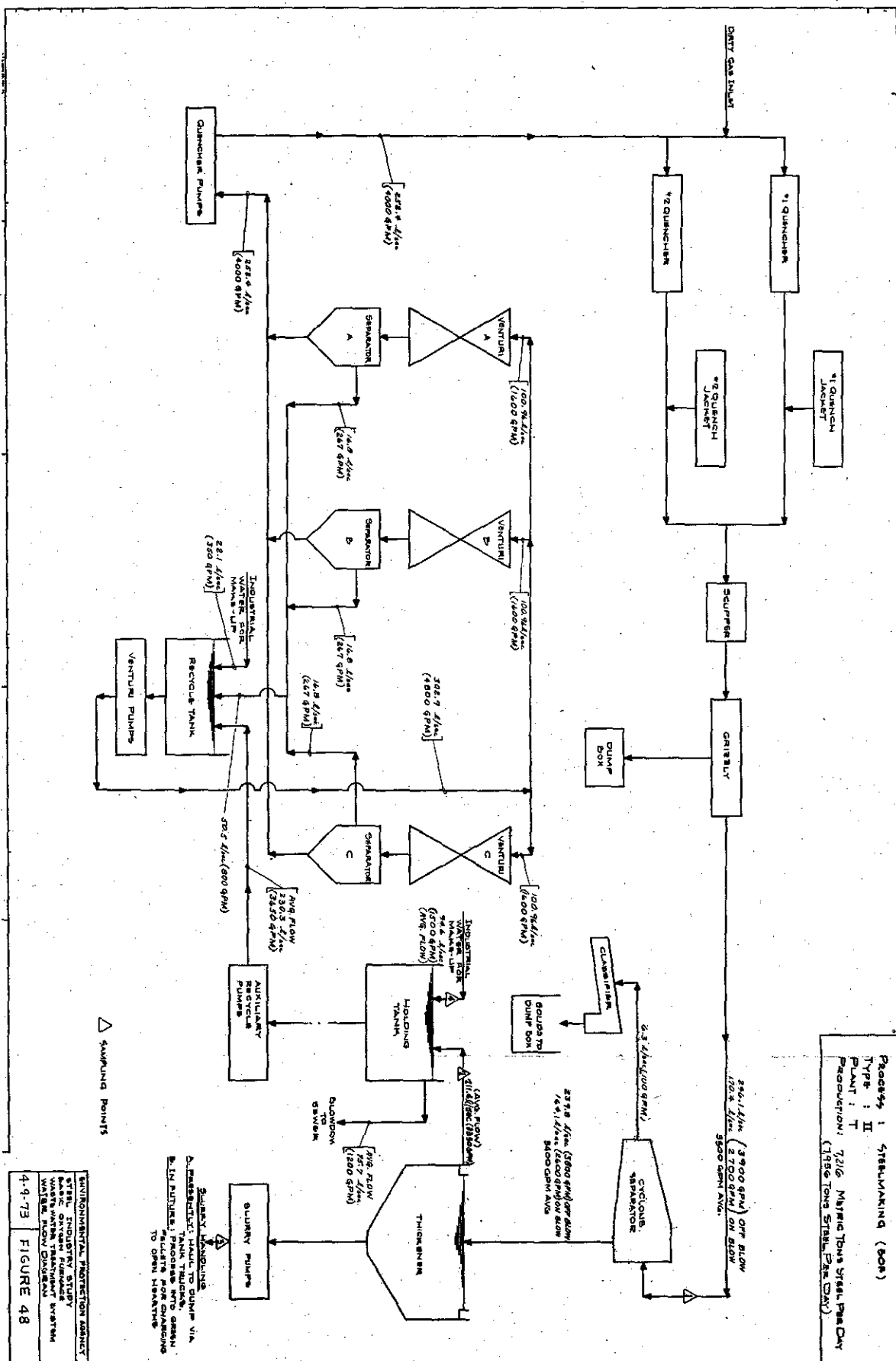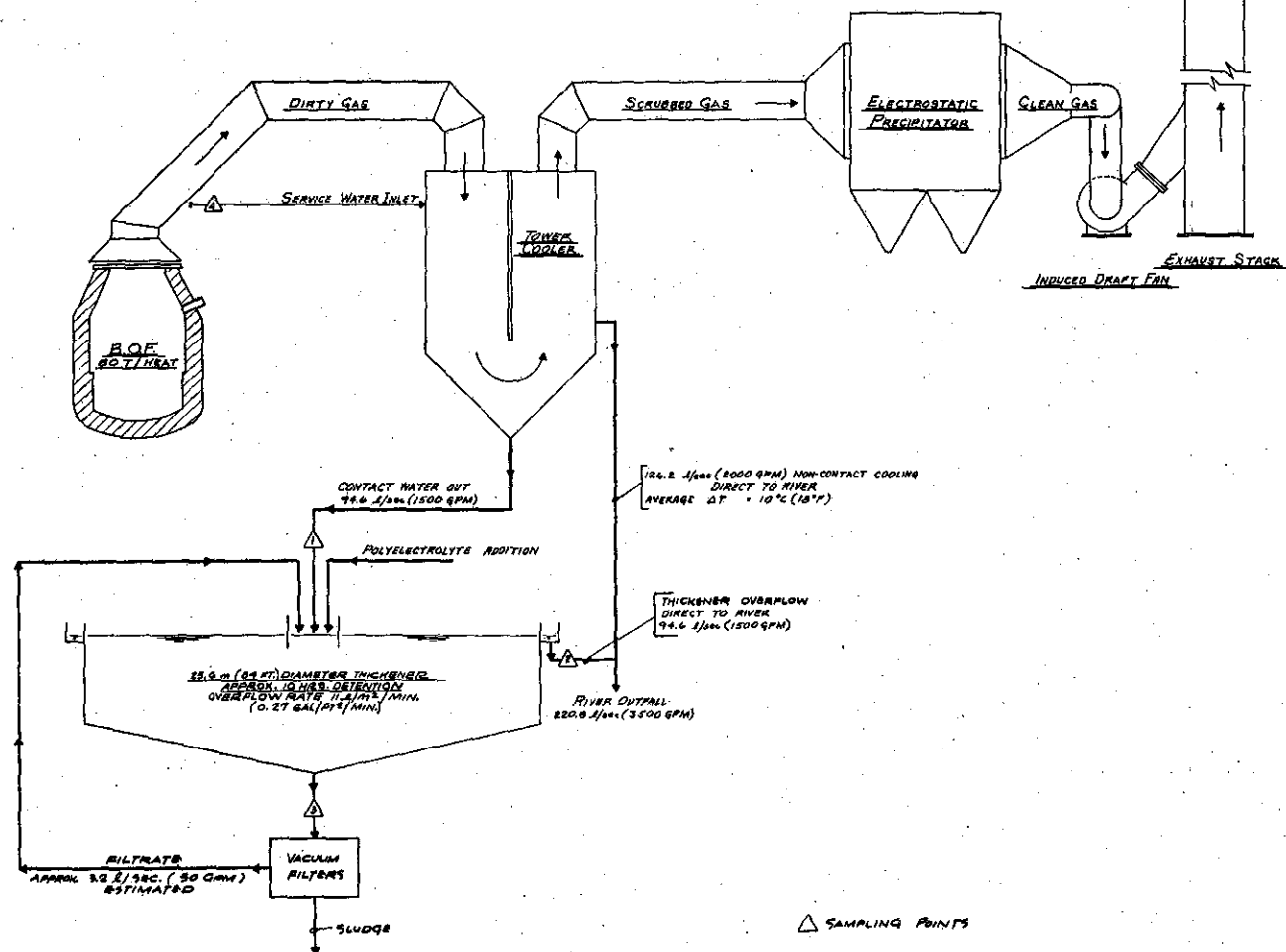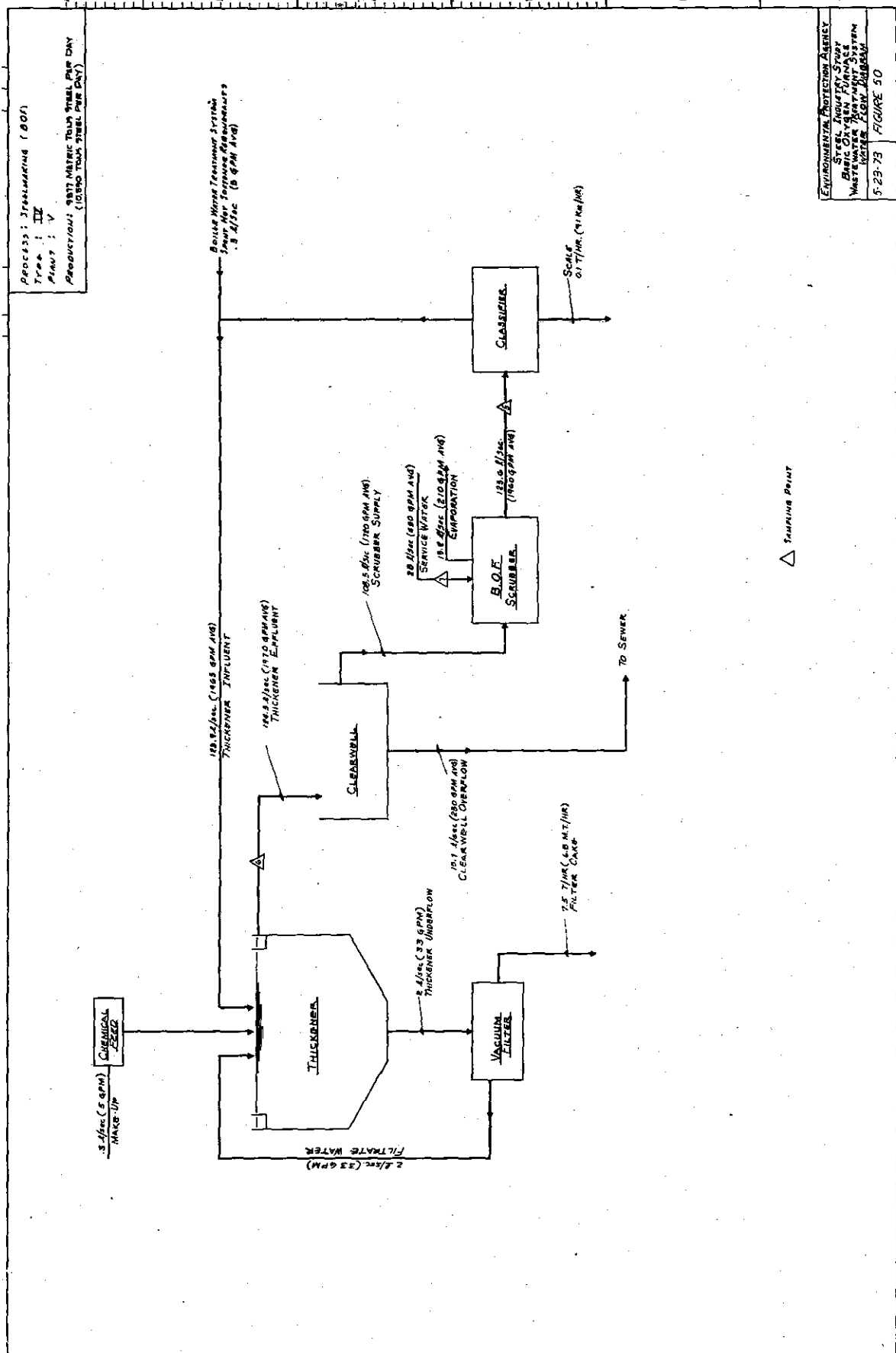
4-9-73    FIGURE 48

# TABLE 29

## Plant Age and Size
## Steel Making - Basic Oxygen Furnaces

| Plant | Location | Production kkg/day | Plant Installed Year | Treatment Plant Installed Year |
|-------|----------|--------------------|-----------------------|--------------------------------|
| R | Middle Atlantic | 5300 | 1967 | 1967 |
| S | Middle Atlantic | 5760 | 1968 | 1968 |
| T | Middle Atlantic | 7217 | 1966 | 1966 |
| U | Northern Great Lakes | 2690 | 1959 | 1960 & 1964 |
| V | Middle Atlantic | 9880 | 1967 | 1967 |

Basic Oxygen Furnace Wastewater Treatment System — Water Flow Diagram

DIRTY GAS

SCRUBBED GAS

ELECTROSTATIC PRECIPITATOR

CLEAN GAS

EXHAUST STACK

INDUCED DRAFT FAN

SERVICE WATER INLET

TOWER COOLER

B.O.F.
80 T/HEAT

CONTACT WATER OUT
94.6 ℓ/sec (1500 GPM)

126.2 ℓ/sec (2000 GPM) NON-CONTACT COOLING
DIRECT TO RIVER
AVERAGE ΔT · 10°C (18°F)

POLYELECTROLYTE ADDITION

THICKENER OVERFLOW
DIRECT TO RIVER
94.6 ℓ/sec (1500 GPM)

25.6 m (84 FT.) DIAMETER THICKENER
APPROX. 10 HRS. DETENTION
OVERFLOW RATE 11 ℓ/m² / MIN.
(0.27 GAL/FT²/MIN.)

RIVER OUTFALL
220.8 ℓ/sec (3500 GPM)

FILTRATE
APPROX. 3.2 ℓ/sec. ( 50 GPM )
ESTIMATED

VACUUM FILTERS

SLUDGE

△ SAMPLING POINTS

PROCESS : STEELMAKING (BOP)
TYPE : II
PLANT : U
PRODUCTION : 2691 METRIC TONS STEEL PER DAY
(2967 TONS STEEL PER DAY)

227

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-2-73    FIGURE 49

PROCESS: STEELMAKING (BOF)
TYPE: IV
PLANT: V
PRODUCTION: 9877 METRIC TONS STEEL PER DAY
(10,890 TONS STEEL PER DAY)

Boiler Water Treatment System)
Input Hot Softening Requirements
.3 l/sec (5 GPM Avg)

.3 l/sec (5 GPM)
MAKE-UP

CHEMICAL FEED

THICKENER

103.9 l/sec (1465 GPM Avg)
THICKENER INFLUENT

124.2 l/sec (1970 GPM Avg)
THICKENER EFFLUENT

2.1 l/sec (33 GPM)
THICKENER UNDERFLOW

VACUUM FILTER

2 l/sec (33 GPM)
FILTRATE WATER

7.5 T/HR (6.8 MT/HR)
FILTER CAKE

CLEARWELL

108.5 l/sec (1710 GPM Avg)
SCRUBBER SUPPLY

15.1 l/sec (230 GPM Avg)
CLEARWELL OVERFLOW

TO SEWER

B.O.F. SCRUBBER

28 l/sec (450 GPM Avg)
SERVICE WATER

18.9 l/sec (210 GPM Avg)
EVAPORATION

123.6 l/sec (1960 GPM Avg)

CLASSIFIER

SCALE
0.1 T/HR (.41 Kg/HR)

△ SAMPLING POINT

The aqueous discharges are treated the same as the BOF except pH adjustment has to be added to adjust for the acidic wastes being discharged.

## Plant Visits

Two open hearth shops were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 30 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and drawings of the waste water treatment systems are presented.

## Plant W - Figure 51

This plant utilizes thickening and recycle with blowdown (approximately 16%) to treat waste waters generated in its gas cleaning system.

Gross plant effluent loads from the system are 214 l/kkg of steel (51.4 gal/ton) flow, and 0.0173 kg of suspended solids, 0.0316 kg fluoride, 0.00471 kg nitrate, and 0.0057 kg zinc per kkg (lb/1,000 lb) of steel produced.

Overall removals for suspended solids, fluoride, nitrate, and zinc are 98.27%, 42.37%, 91.28%, and 0.0%, respectively.

## Plant X - Figure 52

This plant utilizes chemical coagulation, thickening, and recycle with blowdown (approximately 21%) to treat waste waters generated in its gas cleaning system.

Gross plant effluent loads from the system are 500 l/kkg of steel (120 gal/ton) flow, and 0.0256 kg suspended solids, 0.032 kg fluoride, 0.149 kg nitrate, and 0.595 kg zinc per kkg (lb/1,000 lb) of steel produced.

Overall removals for suspended solids, fluoride, nitrate, and zinc are 99.7%, 10%, 0.0%, and 70.47%, respectively.

## Electric Arc Furnace Operation

The furnace collection systems range from completely dry to semiwet to wet, high energy, venturi scrubbers.

The dry fume collection system consists of baghouses with local exhaust or plant rooftop exhaust hoods. The aqueous discharges from these systems are zero.

The semiwet system employs a spark box or spray chamber to condition the hot gases for either a precipitator or baghouse. A spark box is generally used with a precipitator system, and a spray chamber with a baghouse system. The spark box conditions

the gases to 200°C while the spray chamber conditions them to 135°C. The aqueous discharge from these systems is controlled and treated with similar systems are used on the spark box chamber on the basic oxygen furnace.

The wet high energy venturi scrubber fume collection systems use the water cooled elbow for extracting the gases from the electric arc furnace. Combustion air gaps are always left between the water cooled elbow and fume collection ductwork to insure that all the CO gas burns to CO2 before entering the high energy venturi scrubber or any other fume collection cleaning device. As the hot gases pass through the scrubber, the gases are conditioned and cooled to 182°F saturation temperature.

The aqueous discharge from the wet scrubber system is handled in the same manner as the BOF.

## Plant Visits

Four electric furnace shops were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 31 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility. Brief descriptions and drawings of the individual waste water treatment systems are presented.

## Plant Y - Figure 53

This plant utilizes chemical coagulation, magnetic flocculation, sedimentation, and total recycle to treat those waste waters generated in the gas cleaning system.

The system has zero aqueous discharge.

The system effects 100% removal of fluoride and suspended solids.

## Plant Z - Figure 54

This plant utilizes closely controlled moisture addition to their gas cleaning system to produce a sludge of sufficient solids concentration to allow direct solids disposal.
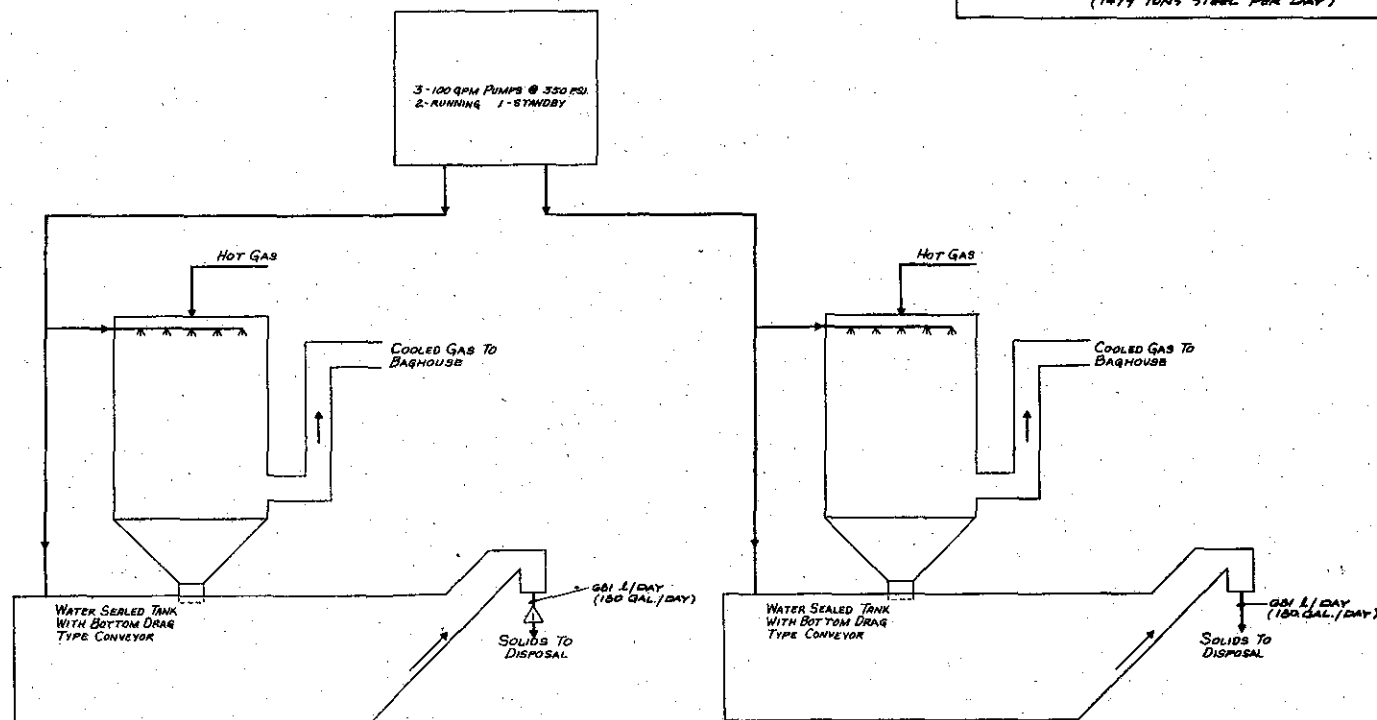
There is no aqueous discharge from the system.

The system effects 100% removal of suspended solids.

## Plant AA - Figure 55

This plant utilizes classification and clarification on a once-through basis to treat waste waters generated in the gas cleaning system.

Figure 51. Steel Industry Study — Wastewater Treatment System, Water Flow Diagram.

PROCESS: STEELMAKING (O.H.)
TYPE II
PLANT 'N'
PRODUCTION: 9190.7 METRIC TONS STEEL PER DAY
(10,089 TONS STEEL PER DAY)

△ SAMPLING POINTS

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
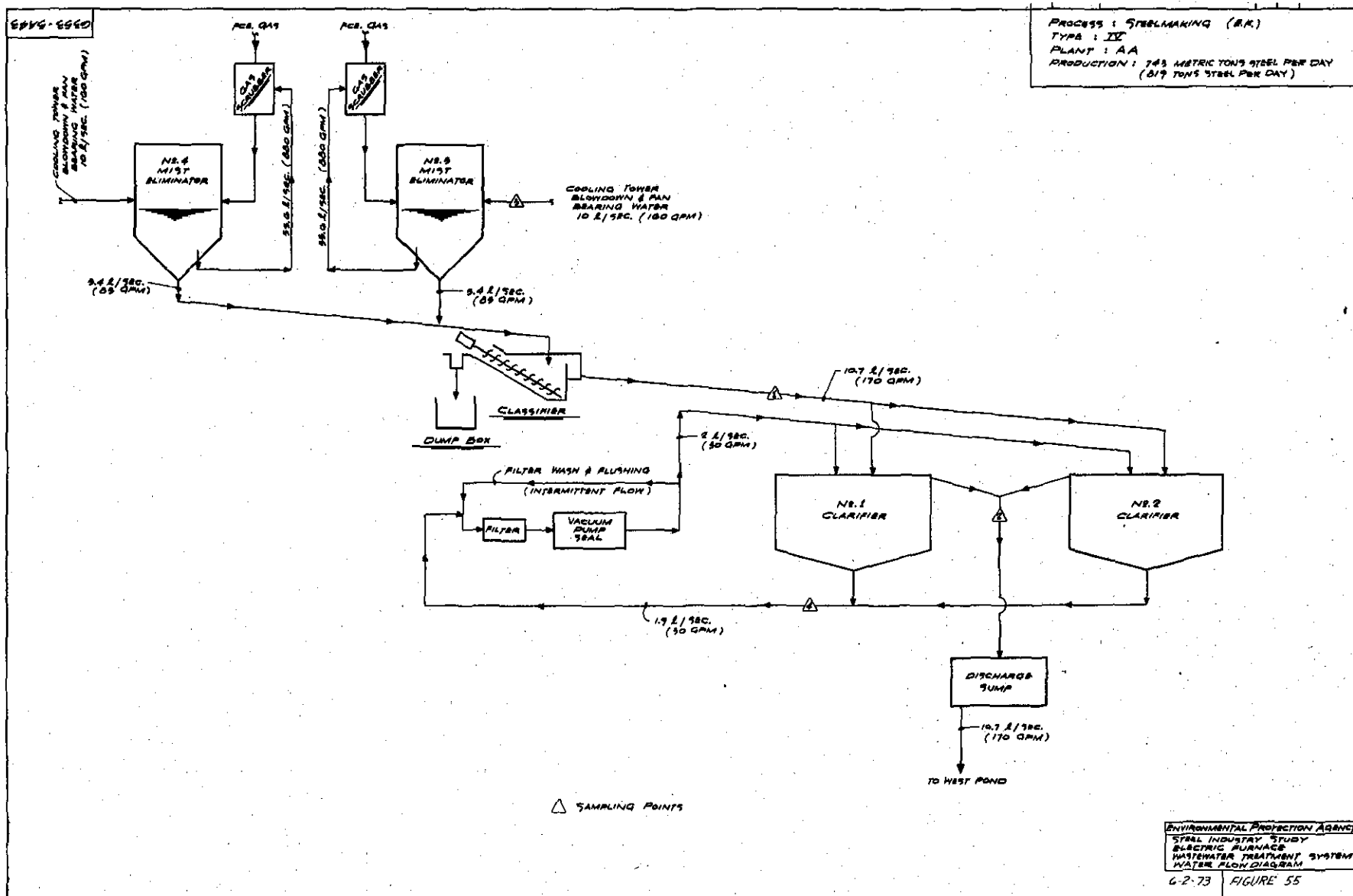WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

4-27-73    FIGURE 51

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PROCESS: STEELMAKING (O.H.)
TYPE: III
PLANT: X
PRODUCTION: 3185.9 METRIC TONS STEEL PER DAY
(3507 TONS STEEL PER DAY)

CLARIFIER
BASEMENT SUMP

FILTRATE
FLOOR DRAINS
VACUUM PUMP COOLING WATER
SPRAY WATER (TO CLEAN FILTER MEDIA)

MINOR INTERMITTENT FLOWS

LIME FEED
(MAINTAIN pH 8.0)

88.1 ℓ/SEC.
(1400 GPM)

88.1 ℓ/SEC.
(1400 GPM)

FILTRATE

THICKENER

VACUUM
FILTERS

BLOWDOWN
18.9 ℓ/SEC.
(300 GPM)

TO SEWER
OR DEEP BED
FILTER

69.4 ℓ/SEC.
(1100 GPM)

MAKE-UP
(BLOWDOWN FROM COOLING TOWERS)

MAKE-UP
SOFTENED FILTERED WATER

37.9 ℓ/SEC.
(600 GPM)

107.3 ℓ/SEC.
(1700 GPM)

GAS
SCRUBBER

EVAPORATION
18.9 ℓ/SEC.
(300 GPM)

△ SAMPLING POINTS

Process: Steel Making (EF)
Type: I
Plant: Y
Production: 1810.4 Metric Tons Steel Per Day
(1996 Tons Steel Per Day)

CITY WATER SUPPLY → NON-CONTACT COOLING WATER → TRANSFORMER VAULT → 14.1 LITERS/SEC. (224 GPM) → TO SEWER

POLYMER FEED SYSTEM

MAKE-UP WATER

FLAME TRAP

FLAME TRAP SUMP → 8.5 LITERS/SEC. (135 GPM) → DRAG LINK CONVEYOR

SETTLING TANK

SLUDGE BASIN

9.1 LITERS/SEC. (145 GPM)

17.7 LITERS/SEC. (280 GPM)

MAKE-UP WATER

1.3 LITERS/SEC. (20 GPM)

19.4 LITERS/SEC. (308 GPM)

CITY WATER SUPPLY → NON-CONTACT COOLING WATER → TRANSFORMER VAULT → 14.1 LITERS/SEC. (224 GPM) → TO SEWER

△ SAMPLING POINTS

PROCESS : STEELMAKING (E.F.)
TYPE: II
PLANT: II
PRODUCTION : 1341.9 METRIC TONS STEEL PER DAY
(1479 TONS STEEL PER DAY)

3 - 100 GPM PUMPS @ 350 PSI.
2 - RUNNING    1 - STANDBY

HOT GAS

COOLED GAS TO
BAGHOUSE

WATER SEALED TANK
WITH BOTTOM DRAG
TYPE CONVEYOR

681 L/DAY
(180 GAL./DAY)

SOLIDS TO
DISPOSAL

HOT GAS

COOLED GAS TO
BAGHOUSE

WATER SEALED TANK
WITH BOTTOM DRAG
TYPE CONVEYOR

681 L/DAY
(180 GAL./DAY)

SOLIDS TO
DISPOSAL

△ SAMPLING POINTS

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-8-73    FIGURE . 54

SAMPLING POINTS

PROCESS : STEELMAKING (E.F.)
TYPE : IV
PLANT : AA
PRODUCTION : 743 METRIC TONS STEEL PER DAY
(819 TONS STEEL PER DAY)

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC FURNACE
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

6-2-73    FIGURE 55

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## TABLE 30

### Plant Age and Size
### Steel Making - Open Hearth Furnaces (IV-B)

| Plant | Location | Production kkg/day | Plant Installed Year | Treatment Plant Installed Year |
|-------|----------|--------------------|-----------------------|---------------------------------|
| W | Middle Atlantic | 9150 | 1952 | 1968 |
| X | Middle Atlantic | 3330 | 1949-1955 | 1970 |

TABLE 31

Plant Age and Size
Steel Making - Electric Furnaces

| Plant | Location | Production kkg/day | Plant Installed Year | Treatment Plant Installed Year |
|-------|----------|--------------------|-----------------------|--------------------------------|
| Y | Middle Atlantic | 1810 | 1955 | 1969 |
| Z | Northern Great Lakes | 1340 | 1967 | 1968 |
| AA | Southern Texas | 740 | 1967 | 1967 |
| AB | Southern Texas | 1451 | 1971 | 1971 |

Gross plant effluent loads from the system are 1,250 l/kkg of steel (299 gal/ton) flow, and 0.0258 kg fluoride and 0.074 kg suspended solids per kkg (lb/1,000 lb) of steel processed.

Overall removals of fluoride and suspended solids observed are 0% and 97.3%, respectively.

## Plant AB - Figure 56

This plant utilizes recycle with blowdown (approximately 6%), with treatment of the blowdown via thickening and extended settling to treat waste waters generated in the gas cleaning system.

Gross plant effluent loads are 680 l/kkg of steel (162 gal/ton) flow, and 0.0081 kg fluoride, and 0.015 kg suspended solids per kkg (lb/1,000 lb) of steel processed.

Net overall removals of fluoride and suspended solids are 7.8% and 99.95%, respectively.

## Vacuum Degassing Operation

The condensed steam and heated cooling water is discharged from the barometric condenser in a hot well. The water from the hot well is either discharged or is routed into a combination water treatment system that services other steelmaking facilities. The water rate for the barometric condensers systems is approximately 85-175 l/sec (20 - 41 gal/sec) with temperature increases of 20-30°C. Inert gases, for example argon, are injected for mixing of the molten steel bath and nitrogen is used for purging the system before breaking the vacuum. The latter practice can result in high nitrate concentrations in the waste waters.

## Plant Visits

Two degassing plants were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 32 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility.
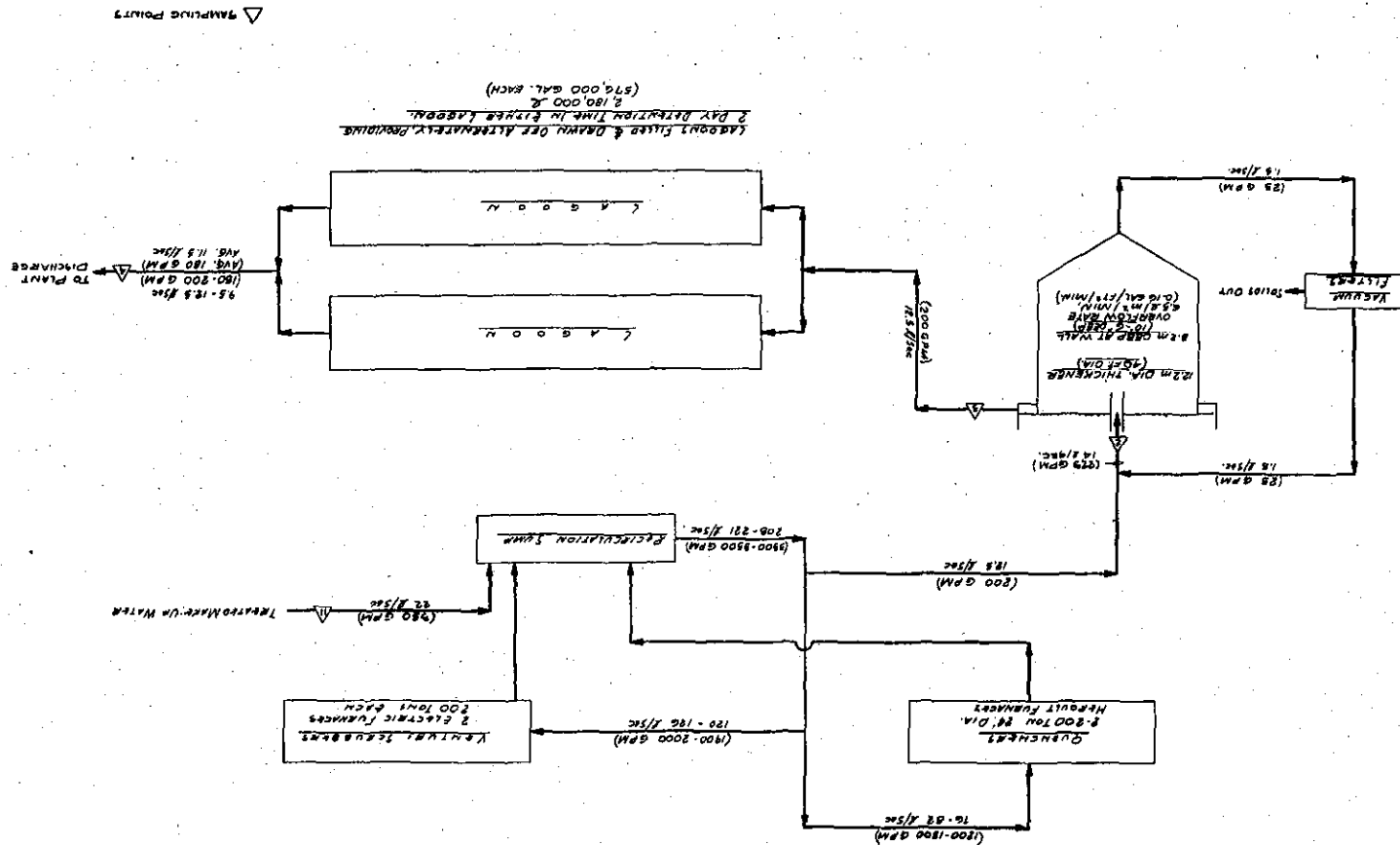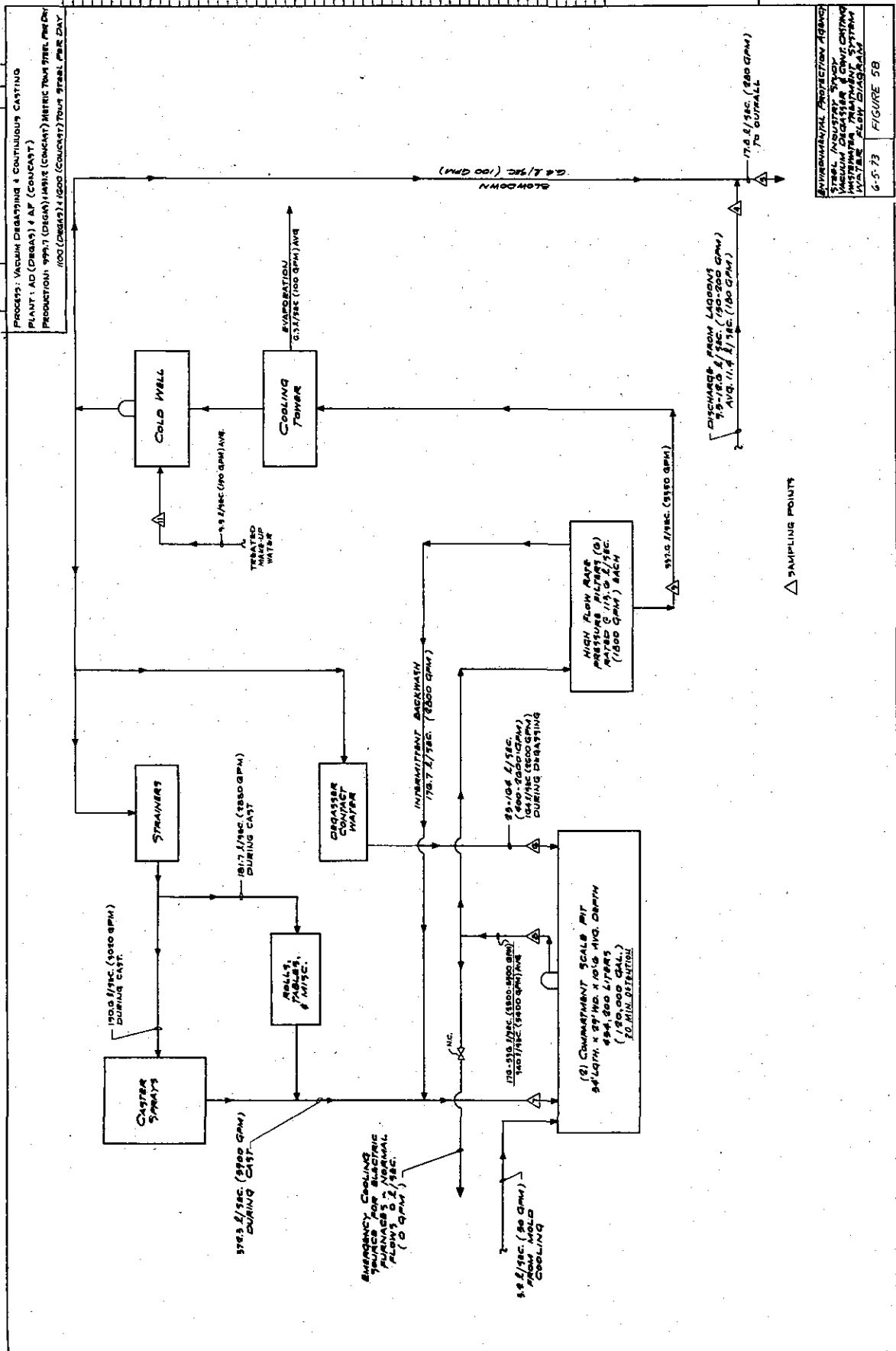
## Plant AC - Figure 57

Vacuum degasser waste water or tight recycle loop with minimal blowdown. Loop contains cooling tower for heat dissipation.

Normal gross effluent waste load is estimated to be 67 l/kkg of steel (16 gal/ton) flow, 10,900 Btu of heat per kkg (9,940 Btu/ton) and 0.00011 kg lead, 0.0012 kg manganese 0.0068 kg nitrate, 0.0035 kg suspended solids, and 0.0015 kg zinc per kkg (lb/1,000 lb) of steel processed.

Overall removals of heat, lead, manganese, nitrate, suspended solids and zinc are 72.4%, 93.4%, 92.9%, 94.6%, 96.0% and 79.4%, respectively.

## Plant AD - Figure 58

Degasser waste water is on a moderately tight recycle loop with scale pit, filter, and cooling tower.

Normal gross effluent waste load is estimated to be 46 1/kkg of steel (10.9 gal/ton) flow, and 0.0000046 kg lead, 0.000127 kg manganese, 0.0 kg nitrate, 0.00168 kg suspended solids, and 0.0000416 kg zinc per kkg (lb/1,000 lb) of steel processed.

Overall removals of heat, lead, manganese, nitrate, suspended solids, and zinc are 98.8%, 99.6%, 100%, 94.9%, 97.1% and 99.4%, respectively.

## Continuous Casting Subcategory

The spray water system water discharge is an open recirculating system with make-up and blowdown using either settling chamber scale pits with drag link conveyors or flat bed type filters for scale and oil removal. The effluent from the scale pit or filtrate from the flat bed filters is sometimes reduced in temperature by pumping it through induced draft cooling towers before recycling the waters back to the spray system. Approximately 5-10% of the spray water is evaporated during the spray of the cast product. The aqueous discharge from this system is blowdown.

## Plant Visits

Two continuous casting plants were visited in the study. Detailed descriptions of the plant waste water treatment practices are presented on individual drawings. Table 33 presents a summary of the plants visited in respect to geographic location, daily production, plant age, and age of the treatment facility.

## Plant AE - Figure 59

Caster waste water is on a moderately tight recycle loop. The loop contains scale pit, filter, and cooling tower.

Normal gross plant effluent waste load is estimated to be 463 1/kkg of steel (111 gal/ton) flow, and 0.0020/kg oil and grease, and 0.00202 kg suspended solids per kkg (lb/1,000 lb) of steel processed.

Overall removals of oil and grease and suspended solids are 99.4% and 98.7%, respectively.

## Plant AF - Figure 58

PROCESS: STEELMAKING (EF)
TYPE: IX
PLANT: AD
PRODUCTION: 1451.2 METRIC TONS STEEL PER DAY
(1600 TONS STEEL PER DAY)

▽ SAMPLING POINTS

Environmental Protection Agency
Steel Industry Study
Electric Furnace
Waste Water Treatment System
Water Flow Diagram
6-2-73
FIGURE 56

LAGOON

LAGOON

LAGOONS FILLED & DRAWN OFF ALTERNATELY, PROVIDING
2 DAY DETENTION TIME IN FILLED LAGOON.
2,180,000 ℓ
(576,000 GAL. EACH)

TO PLANT
DISCHARGE
95 - 18.5 ℓ/sec
(180-300 GPM)
(AVG. 180 GPM)
AVG. 11.5 ℓ/sec

12.5 ℓ/sec
(200 GPM)

12.2 m DIA. THICKENER
(40 FT. DIA.)
8 L.M. DEEP AT WALL
10-E DEEP
OVERFLOW RATE
45.8 m³/m²/MIN
(0.16 GAL. FT²/MIN)

SOLIDS OUT
VACUUM
FILTERS

1.5 ℓ/sec
(25 GPM)

1.8 ℓ/sec
(28 GPM)

14 ℓ/sec
(229 GPM)

RECIRCULATION SUMP
208 - 221 ℓ/sec
(3300-3500 GPM)

18.5 ℓ/sec
(300 GPM)

TREATED MAKE-UP WATER
42 ℓ/sec
(680 GPM)

VENTURI SCRUBBERS
2 ELECTRIC FURNACES
200 TONS EACH

120 - 126 ℓ/sec
(1900-2000 GPM)

QUENCHERS
2-200 TON 24' DIA.
HEROULT FURNACES

76 - 88 ℓ/sec
(1200-1800 GPM)

Cooling Tower System - Degassing and BOP

△ Sampling Points

PROCESS: VACUUM DEGASSING
PLANT: AC
PRODUCTION: 5964.5 METRIC TONS STEEL PER DAY
(6574 TONS STEEL PER DAY)

MAKE UP WATER

COOLING WATER

STEAM
11,674 l/sec
(26,070 lb/hr)

18.1 l/sec (288 GPM) → EVAPORATION LOSS

1.8 l/sec (28 GPM) → WIND LOSS

113 l/sec (1,800 GPM)

VACUUM DEGAS BARO. COND. 252 l/sec (4000 GPM) PLUS STEAM ΔT = 15°C (27°F)

HOT WELL

AFTER COOLER'S (AIR COMPRESSORS) 4 l/sec (70 GPM) ΔT = 11°C (20°F)

AIR COMPRESSORS 7 l/sec (110 GPM) ΔT = 17°C (30°F)

BOP LANCE HEAT EXCH. 180 l/sec (2850 GPM) ΔT = 11°C (20°F)

FLUX CHUTES 76 l/sec (1200 GPM) ΔT = 17°C (30°F)

MISCELLANEOUS 19 l/sec (300 GPM) ΔT = 8°C (15°F)

OIL COOLERS (BOF FURNACE) 6 l/sec (100 GPM) ΔT = 17°C (30°F)

VACUUM DEGAS COOLING 50 l/sec (800 GPM) ΔT = 8°C (15°F)

WATER COOLED HEAT SHIELDS 44 l/sec (700 GPM) ΔT = 8°C (20°F)

VESSEL COVER TBSOL. GATES (WASTE HEAT BOILER) 94 l/sec (690 GPM) ΔT = 17°C (30°F)

SLAG HOPPER DUMP GATES (WASTE HEAT BOILER) 17 l/sec (266 GPM) ΔT = 17°C (30°F)

BASSE WAGON 118 l/sec (180 GPM) ΔT = 8°C (15°F)

714.9 l/sec (11,353 GPM)

119 l/sec (1,896 GPM)

BLOWDOWN 57 l/sec (115 GPM)

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
VACUUM DEGASSING
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

5-23-73 | FIGURE 57

PROCESS: VACUUM DEGASSING & CONTINUOUS CASTING
PLANT: AD (DEGAS) & AF (CONCAST)
PRODUCTION: 999.7 (DEGAS) & 1143.6 (CONCAST) METRIC TONS STEEL PER DAY
1100 (DEGAS) & 1300 (CONCAST) TONS STEEL PER DAY

EVAPORATION
6.3 l/sec. (100 GPM) AVG.

SLOWDOWN
6.4 l/sec. (100 GPM)

17.6 l/sec. (280 GPM)
TO OUTFALL

DISCHARGE FROM LAGOONS
9.5-12.6 l/sec. (150-200 GPM)
AVG. 11.4 l/sec. (180 GPM)

COLD WELL

COOLING TOWER

TREATED MAKE-UP WATER
5.7 l/sec. (90 GPM) AVG.

STRAINERS

DEGASSER CONTACT WATER

HIGH FLOW RATE PRESSURE FILTERS (6)
RATED @ 113.6 l/sec.
(1800 GPM) EACH

231.0 l/sec. (3650 GPM)

INTERMITTENT BACKWASH
170.7 l/sec. (2800 GPM)

181.7 l/sec. (2850 GPM)
DURING CAST

170.8 l/sec. (2650 GPM)
DURING CAST

ROLLS, TABLES & MISC.

CASTER SPRAYS

379.3 l/sec. (5900 GPM)
DURING CAST

EMERGENCY COOLING SOURCE FOR ELECTRIC FURNACES 0 l/sec. NORMAL FLOWS 0 l/sec.
(0 GPM)

(2) COMPARTMENT SCALE PIT
54' LGTH. X 27' WD. X 10'6 AVG. DEPTH
454,200 LITERS
(120,000 GAL.)
20 MIN. DETENTION

89-104 l/sec.
(400-1650 GPM)
541 l/sec. (8600 GPM) DURING DEGASSING

170-310 l/sec. (2600-4900 GPM)
340 l/sec. (5400 GPM) AVG.

3.8 l/sec. (60 GPM)
FROM MOLD COOLING

N.C.

SAMPLING POINTS

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
VACUUM DEGASSER & CONT. CASTING
WASTEWATER TREATMENT SYSTEM
WATER FLOW DIAGRAM

6-5-73    FIGURE 58

Process: Continuous Casting
Plant: A6
Production: 8845 Metric Tons Steel Per Day (9137 Tons Steel Per Day)



Make Up Water — 0.847/sec. (1016 GPM)
Wind Loss — 7.8/sec (124 GPM)
Evaporation Loss — 13.4/sec (213 GPM)

Cooling Tower

601 l/sec (9515 GPM)

Mach. Evaporation Loss — 32 l/sec (500 GPM)

Primary Spray Cooling Coil — 51.3 l/sec (810 GPM) ΔT = 14°C (30°F)
Withdrawal & Straightener Rolls — 28 l/sec (440 GPM) ΔT = 16°C (30°F)
Secondary Cooling Slab Spray — 324 l/sec (5130 GPM) ΔT = 25°C (45°F)
Scale Flushing At Torch Cutting & Slab Flume — 77 l/sec (760 GPM)
Super-Garbage Slab Flume — 13 l/sec (200 GPM) ΔT = 0°C (0°F)
Sluice Garbage Slab Flume Cont. Mach. — 98 l/sec (1560 GPM) ΔT = 0°C (0°F)

114 l/sec (1450 GPM)
565 l/sec (8960 GPM)

116 l/sec (2150 GPM)

Scale Sump

565 l/sec (8960 GPM)

Basin Filtered Water

Filter

568 l/sec (9000 GPM)

Filter Cake — 1302 - 1589 Kg/Hr (3000 - 8500 #/Hr)

416 l/sec (6600 GPM)

Blowdown — 18.9/sec (248 GPM)

△ Sampling Points

## TABLE  32

### Plant Age and Size
### Vacuum Degassing

| Plant | Location | Production kkg/day | Plant Installed Year | Treatment Plant Installed Year |
|-------|----------|--------------------|----------------------|---------------------------------|
| AC | Middle Atlantic | 5950 | 1970 | 1970 |
| AD | Southern Texas | 1000 | 1971 | 1971 |

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## TABLE 33

### Plant Age and Size
### Continuous Casting

| Plant | Location | Production kkg/day | Plant Installed Year | Treatment Plant Installed Year |
|-------|----------|--------------------|----------------------|--------------------------------|
| AE | Middle Atlantic | 2850 | 1969 | 1970 |
| AF | Southern Texas | 1450 | 1971 | 1971 |

Caster waste water is on a tight recycle system with minimal blowdown. Recycle loop contains scale pit, filter, and cooling tower.

Normal gross effluent waste load is estimated to be 344 1/kkg (82.5 gal/ton) of steel flow, with less than 0.000172 kg oil and grease and 0.0127 kg suspended solids per kkg (lb/1.000 lb) of steel produced.

Overall removals of oil and grease and suspended solids are 99.9% and 97.2%, respectively.

These results are summarized in Tables 34 through 43.

## Base Level of Treatment

In developing the technology, guidelines, and incremental costs associated with the application of the technologies subsequently to be selected and designated as one approach to the treatment of effluents to achieve the BPCTCA, BATEA, and NSPS effluent qualities, it was necessary to determine what base or minimum level of treatment was already in existence for practically all plants within the industry in any given sub-category. The different technology levels were then formulated in an "add-on" fashion to these base levels. The various treatment models (levels of treatment) and corresponding effluent volumes and characteristics are listed in Tables 44 through 54. Since these tables also list the corresponding costs for the average size plant, these tables are presented in Section VIII.

It was obvious from the plant visits that many of the plants in existence today have treatment and control facilities with capabilities that exceed the technologies chosen to be the base levels of treatment. Even though many plants may be superior to the base technology it was necessary, in order to be all-inclusive of the industry as a whole, to start at the base level of technology in the development of treatment models and incremental costs.

# SECTION VIII

## COST, ENERGY, AND NONWATER QUALITY ASPECTS

### Introduction

This section will discuss the incremental costs incurred in applying the different levels of pollution control technology. The analysis will also describe energy requirements, nonwater quality aspects (including sludge disposal, by-product recovery, etc.), and their techniques, magnitude, and costs for each level of technology.

It must be remembered that some of the technology beyond the base level may already be in use. Also, many possible combinations and/or permutations of various treatment methods are possible. Thus, not all plants will be required to add all of the treatment capabilities or incur all of the incremental costs indicated to bring the base level facilities into compliance with the effluent limitations.

### Costs

The water pollution control costs for the plants visited during the study is presented in Tables 34 through 43. The treatment systems, gross effluent loads, and reduction benefits were described in Section VII. The costs were estimated from data supplied by the plants. The results are summarized as follows:

| Subcategory | | Plant | Cost per unit weight of product | | |
|---|---|---|---|---|---|
| | | | $/kkg | $/ton | Product |
| I | By-Product Coke | A | 0.855 | 0.776 | Coke |
| | | B | 0.118 | 0.107 | Coke |
| | | C | 0.789 | 0.716 | Coke |
| | | D | 0.847 | 0.769 | Coke |
| II | Beehive Coke | E | *0.074 | *0.068 | Coke |
| | | F | *0.039 | *0.036 | Coke |
| | | G | 0.023 | 0.021 | Coke |
| III | Sintering | J | *0.085 | *0.077 | Sinter |
| IV | Blast Furnace (Iron) | L | 1.033 | 0.937 | Iron |
| | | M | *0.122 | *0.111 | Iron |
| | | N | 0.172 | 0.156 | Iron |
| | | O | 1.022 | 0.927 | Iron |
| V | Blast Furnace (FeMn) | Q | 4.220 | 3.830 | FeMn |
| VI | BOF (Semiwet) | R | 0.160 | 0.145 | Steel |
| | | U | *0.161 | *0.146 | Steel |
| VII | BOF (Wet) | S | 0.176 | 0.160 | Steel |
| | | T | **0.052 | **0.047 | Steel |
| | | V | 0.326 | 0.296 | Steel |
| VIII | Open Hearth | W | 0.083 | 0.075 | Steel |
| | | X | 0.345 | 0.313 | Steel |

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| IX | Electric Arc (Semi-Wet) | Y | 0.106 | 0.096 | Steel |
|----|-------------------------|----|-------|-------|-------|
|    |                         | Z | 0.046 | 0.042 | Steel |
| X  | Electric Arc (Wet)      | AA | 0.507 | 0.460 | Steel |
|    |                         | AB | 0.985 | 0.894 | Steel |
| XI | Vacuum Degassing        | AC | 0.051 | 0.046 | Steel |
|    |                         | AD | 0.215 | 0.195 | Steel |
| XII | Continuous Casting     | AE | 0.487 | 0.442 | Steel |
|    |                         | AF | 1.620 | 1.470 | Steel |

 * Capital recovery cost only, operating cost not available
** Total operating cost less capital recovery

## Base Level and Intermediate Technology, Energy and Nonwater Impact

The base levels of treatment and the energy requirements and nonwater quality aspects associated with intermediate levels of treatment are discussed below by subcategories.

### By-Product Coke

1.  Base Level of Treatment:  Phenol removal and free-leg ammonia stripping of ammonia liquor in a once-through system.  Pond for suspended solids removal.  Once-through noncontact primary cooler effluent and tight final cooler recycle system with blowdown to dephenolizer.  Benzol waste to  dephenolizer and pH neutralization by addition of acid.

2.  Additional energy requirements:

    a.  Treatment Alternative I:

    Additional  power  will be required to improve the quality of the effluent of the waste water treatment system used in fume cleaning  of  the  by-product  coke  process  to  meet  the anticipated  1977  standards.  The additional energy utilized will be 0.22 kwh/kkg (0.20 kwh/ton) of  coke  produced.  For the typcial 2,414  kkg/day  (2,660  ton/day)  facility  the additional power required will be  21.63  kw  (29  hp).  The additional  operating  cost  for  this  addition  will  be approximately $2,175.00.

    b.  Treatment Alternative II:

    The additional energy utilized will  be  3.12  kwh/kkg  (2.83 kwh/ton)  of  coke  produced.  For the typical 2,414 kkg/day (2,660 ton/day) facility, the additional power required  will be  313.32  kw  (420 hp).  The annual operating cost for this addition  to  the  installation  will  be  approximately $31,500.00.

TABLE 34
WATER EFFLUENT TREATMENT COSTS
Coke Making - By-Products
I-A

| PLANT | A | B | C | D | | | RANGE | |
|---|---|---|---|---|---|---|---|---|
| INITIAL INVESTMENT | $ 2,352,200 | $ 699,100 | $ 4,000,000 | $ 2,000,000 | | | | |
| ANNUAL COSTS: | | | | | | | | |
| COST OF CAPITAL | 99,700 | 29,600 | 169,500 | 84,800 | | | | |
| DEPRECIATION | 235,200 | 69,900 | 400,000 | 200,000 | | | | |
| OPER & MAINT | 140,300 | 46,100 | 137,700 | 174,100 | | | | |
| ENERGY & POWER | 966,100 | 28,200 | 848,200 | 4,400 | | | | |
| TOTAL | $ 1,441,300 | $ 173,800 | $ 1,555,400 | $ 463,300 | | | | |
| $/TON | 0.776 | 0.107 | 0.716 | 0.769 | | | 0.107 - 0.776 | |
| $/1000 GAL TRT | 5.59 | 0.843 | 19.4 | 19.6* | | | 0.843 - 19.6 | |

### AVERAGE NET PLANT RAW WASTE LOAD

| PARAMETERS | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 139 | - | 127 | - | 37 | - | 4600 | ≤ | | | 37 - 4600 | - |
| Ammonia | 2.20 | 1900 | 1.46 | 1380 | 2.26 | 7330 | 1.49 | 39 | | | 1.46 - 2.26 | 39 - 7330 |
| BOD$_5$ | 1.79 | 1550 | 1.35 | 1280 | 0.346 | 1120 | 0.456 | 12 | | | 0.346 - 1.79 | 12 - 1550 |
| Cyanide | 0.118 | 102 | 0.120 | 110 | 0.0282 | 91 | 0.293 | 7.7 | | | 0.0282 - 0.293 | 7.7 - 110 |
| Phenol | 0.519 | 450 | 0.374 | 350 | 0.279 | 910 | 0.232 | 6.1 | | | 0.232 - 0.519 | 6.1 - 910 |
| Oil & Grease | - | - | 0.254 | 240 | 0.0314 | 101 | 0.082 | 2.1 | | | 0.0314 - 0.254 | 2.1 - 240 |
| Suspended Solids | - | - | 0.0381 | 36 | 0.130 | 421 | 0.880 | 23 | | | 0.0381 - 0.880 | 23 - 421 |
| Sulfide | - | - | 0.665 | 629 | 0.0606 | 197 | 0.161 | 4.2 | | | 0.0606 - 0.665 | 4.2 - 629 |

### AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

| PARAMETERS | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 153 | - | 108 | - | 41 | - | 4600 | - | | | 41 - 4600 | - |
| Ammonia | 1.22 | 958 | 1.04 | 1160 | 0.159 | 471 | 0.07 | 1.8 | | | 0.07 - 1.22 | 1.8 - 1160 |
| BOD$_5$ | 0.0816 | 64.1 | 0.0204 | 22.7 | 0.181 | 537 | 0.192 | 5 | | | 0.0204 - 0.192 | 5 - 537 |
| Cyanide | 0.123 | 96.4 | 0.0339 | 37.7 | 0.0230 | 68 | 0.311 | 8.1 | | | 0.0230 - 0.311 | 8.1 - 96.4 |
| pH | - | 8.5 | - | 7.5 | - | 9.5-11.8 | - | 7.5 | | | - | 7.5 - 11.8 |
| Phenol | 0.00174 | 1.37 | 0.0000575 | 0.0639 | 0.0741 | 219 | 0.002 | 0.0521 | | | 0.0000575 - 0.0741 | 0.0521 - 219 |
| Oil & Grease | - | - | 0.00225 | 2.5 | 0.00632 | 18.7 | 0.000768 | 0.02 | | | 0.000768 - 0.00632 | 0.02 - 18.7 |
| Sulfide | - | - | 0.000234 | 0.26 | 0.0382 | 113 | 0.0576 | 1.5 | | | 0.000234 - 0.0576 | 0.26 - 113 |
| Suspended Solids | - | - | 0.147 | 163 | 0.0348 | 103 | 0.269 | 7.0 | | | 0.0348 - 0.269 | 7.0 - 163 |

NOTE: Based on the actual volume treated 39.3 gal/TON

TABLE 35
WATER EFFLUENT TREATMENT COSTS
*Coke Making - Beehive*
I-B

| PLANT | E | F | G | | | RANGE |
|---|---|---|---|---|---|---|
| INITIAL INVESTMENT | $ 4,000 | $ 7,500 | $ 19,500 | | | |
| ANNUAL COSTS: | | | | | | |
| COST OF CAPITAL | 170 | 320 | 830 | | | |
| DEPRECIATION | 400 | 750 | 1,950 | | | |
| OPER & MAINT | 24,100 | 12,000 | 1,200 | | | |
| ENERGY & POWER | 0 | 0 | 680 | | | |
| TOTAL | $ 24,670 | $ 13,070 | $ 4,660 | | | |
| $/TON | 0.0676 | 0.0358 | 0.0207 | | | 0.0207 - 0.0676 |
| $/1000 GAL TRT | 0.138 | 0.0731 | 0.169 | | | 0.0731 - 0.169 |

AVERAGE NET PLANT RAW WASTE LOAD

| PARAMETERS | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 490 | - | 490 | - | 123 | - | | | | | 123 - 490 | - |
| Ammonia | 0.00134 | 0.33 | 0 | 0 | 0 | 0 | | | | | 0 - 0.00134 | 0 - 0.33 |
| $BOD_5$ | 0.0122 | 3.0 | 0 | 0 | 0 | 0 | | | | | 0 - 0.0122 | 0 - 3.0 |
| Cyanide | 0.0000082 | 0.002 | 0 | 0 | 0 | 0 | | | | | 0 - 0.0000082 | 0 - 0.002 |
| Phenol | 0.0000449 | 0.01 | 0 | 0 | 0 | 0 | | | | | 0 - 0.0000449 | 0 - 0.01 |
| Suspended Solids | - | - | 0.12 | 29 | 0.74 | 722 | | | | | 0.12 - 0.74 | 29 - 722 |

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

| PARAMETERS | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 490 | - | 0 | - | 0 | - | | | | | 0 - 490 | - |
| Ammonia | 0.00098 | 0.24 | 0 | 0 | 0 | 0 | | | | | 0 - 0.00098 | 0 - 0.24 |
| $BOD_5$ | 0.00408 | 1.00 | 0 | 0 | 0 | 0 | | | | | 0 - 0.00408 | 0 - 1.0 |
| Cyanide | 0.0000163 | 0.00404 | 0 | 0 | 0 | 0 | | | | | 0 - 0.0000163 | 0 - 0.00404 |
| pH | - | 7.1 | | | | | | | | | | |
| Phenol | 0.0000571 | 0.0140 | 0 | 0 | 0 | 0 | | | | | 0 - 0.0000571 | 0 - 0.0140 |
| Suspended Solids | 0.147 | 36.01 | 0 | 0 | 0 | 0 | | | | | 0 - 0.147 | 0 - 36.01 |

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| PLANT | H | J | | | | | RANGE | |
|-------|---|---|--|--|--|--|-------|--|
| INITIAL INVESTMENT | N/A | $ 500,000 | | | | | | |
| ANNUAL COSTS: | | | | | | | | |
| COST OF CAPITAL | | 21,200 | | | | | | |
| DEPRECIATION | | 50,000 | | | | | | |
| OPER & MAINT | | N/A | | | | | | |
| ENERGY & POWER | | N/A | | | | | | |
| TOTAL | N/A | $ 71,200+ | | | | | | |
| $/TON | | 0.0770+ | | | | | | |
| $/1000 GAL TRT | | 0.226+ | | | | | | |

**AVERAGE NET PLANT RAW WASTE LOAD**

| PARAMETERS | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 |
|------------|--------|------|--------|------|--------|------|--------|------|--------|------|--------|------|
| Flow (gal/TON) | 104 | - | 341 | - | | | | | | | 104 - 341 | - |
| Fluoride | 0.000554 | 0.644 | -0.0425 | -14.9 | | | | | | | -0.0425 - 0.000554 | -14.9 - 0.644 |
| Oil & Grease | 0.437 | 504 | 1.30 | 457 | | | | | | | 0.437 - 1.3 | 457 - 504 |
| Sulfide | 0.163 | 188 | 0.183 | 64.4 | | | | | | | 0.163 - 0.183 | 64.4 - 188 |
| Suspended Solids | 3.76 | 4340 | 55.4 | 19500 | | | | | | | 3.76 - 55.4 | 4340 - 19500 |

**AVERAGE GROSS PLANT EFFLUENT WASTE LOAD**

| PARAMETERS | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 |
|------------|--------|------|--------|------|--------|------|--------|------|--------|------|--------|------|
| Flow | No Flow data | | 114 | | | | | | | | | |
| Fluoride | | | 0.008055 | 8.5 | | | | | | | | |
| Oil & Grease | | | 0.000947 | 1.0 | | | | | | | | |
| pH | | 9.6 | | 12.8 | | | | | | | | |
| Sulfide | | | 0.01022 | 10.8 | | | | | | | | |
| Suspended Solids | | | 0.00853 | 9 | | | | | | | | |

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## TABLE 37
### WATER EFFLUENT TREATMENT COSTS
### Iron Making - Fe Blast Furnace

| TRT CONTROL TECH | L | M | N | O | | RANGE |
|---|---|---|---|---|---|---|
| INITIAL INVESTMENT | $ 3,650,000 | $ 1,000,000 | $ 641,300 | $ 3,275,000 | | |
| ANNUAL COSTS: | | | | | | |
| COST OF CAPITAL | 154,700 | 42,400 | 27,200 | 138,800 | | |
| DEPRECIATION | 365,000 | 100,000 | 64,100 | 327,500 | | |
| OPER & MAINT | 120,600 | N/A | 26,000 | 95,200 | | |
| ENERGY & POWER | 180,900 | N/A | 3,300 | Incl. | | |
| TOTAL | $ 821,200 | $ 142,400+ | $ 122,600 | $ 561,500 | | |
| $/TON | 0.937 | 0.111+ | 0.156 | 0.927 | | 0.111+ - 0.937 |
| $/1000 GAL TRT | 0.174 | 0.0576+ | 0.0467 | 0.297 | | 0.0467 - 0.297 |

### AVERAGE NET PLANT RAW WASTE LOAD

| PARAMETERS | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 5400 | - | 1930 | - | 3350 | - | 3123 | - | | | 1930 - 5400 | - |
| Ammonia | 0.0636 | 1.41 | 0.0628 | 3.9 | 0.272 | 9.75 | 0.321 | 12.3 | | | 0.0628 - 0.321 | 1.41 - 12.3 |
| Cyanide | 0.0647 | 1.44 | 0.0138 | 0.858 | -0.00602 | -0.241 | -0.00602 | -0.231 | | | -0.00672 - 0.0647 | -0.241 - 1.44 |
| Fluoride | 0.0205 | 0.454 | -0.00071 | -0.044 | 0.0604 | 2.16 | -0.0673 | -2.59 | | | -0.0673 - 0.0604 | -2.59 - 2.16 |
| Phenol | 0.0260 | 0.578 | -0.0104 | -0.643 | 0.0148 | 0.530 | 0.00222 | 0.0853 | | | -0.0104 - 0.0260 | -0.643 - 0.578 |
| Sulfide | 0.195 | 4.34 | 0.623 | 38.8 | -0.0125 | -0.448 | -0.0296 | -1.14 | | | -0.0296 - 0.623 | -1.14 - 38.8 |
| Suspended Solids | 77.6 | 1720 | 10.5 | 651 | 8.57 | 307 | 30.3 | 1170 | | | 8.57 - 77.6 | 307 - 1720 |

### AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

| PARAMETERS | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON* | mg/l* | lb/TON | mg/l | lb/TON | mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 24000 | - | 123 | - | 101 | - | 104 | - | | | 101 - 24,000 | - |
| Ammonia | 0.168 | 0.843 | 0.0799 | 78 | 0.223 | 265 | 0.0867 | 100 | | | 0.0799 - 0.223 | 0.843 - 265 |
| Cyanide | 0.00100 | 0.005 | 0.0174 | 17 | 0.0157 | 18.6 | 0.00937 | 10.8 | | | 0.001 - 0.0174 | 0.005 - 18.6 |
| Fluoride | 0.0980 | 0.49 | 0.0236 | 23 | 0.00874 | 10.4 | 0.0191 | 22 | | | 0.00874 - 0.0980 | 0.49 - 23 |
| pH | | 7.7 | | 7.8 | | 7.2 | | 7.7 | | | | 7.2 - 7.8 |
| Phenol | 0.00280 | 0.014 | 0.00368 | 3.59 | 0.0000288 | 0.034 | 0.0000087 | 0.01 | | | 0.0000087 - 0.00368 | 0.010 - 3.59 |
| Sulfide | 0.00860 | 0.043 | 0.00497 | 4.85 | 0.00050 | 4.16 | 0.00598 | 6.9 | | | 0.00350 - 0.00860 | 0.043 - 6.9 |
| Suspended Solids | 2.20 | 11 | 0.0871 | 85 | 0.0327 | 38.8 | 0.0399 | 46 | | | 0.0327 - 2.2 | 11 - 85 |

* NOTE: This is discharged to coke quench and slag quenchers and BOF hood spray, but not to a receiving stream.

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TABLE 38

WATER EFFLUENT TREATMENT COSTS
Iron Making - Fe-Mn Blast Furnace
III-B

| PLANT | O | | | | | | RANGE |
|---|---|---|---|---|---|---|---|
| INITIAL INVESTMENT | $ 2,215,000 | | | | | | |
| ANNUAL COSTS: | | | | | | | |
| COST OF CAPITAL | 93,900 | | | | | | |
| DEPRECIATION | 221,500 | | | | | | |
| OPER & MAINT | 406,300 | | | | | | |
| ENERGY & POWER | 90,200 | | | | | | |
| TOTAL | $ 811,900 | | | | | | |
| $/TON | 3.83 | | | | | | |
| $/1000 GAL TRT | 0.495 | | | | | | |

AVERAGE NET PLANT RAW WASTE LOAD

| PARAMETERS | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 7730 | | | | | | | | | | | |
| Ammonia | 7.35 | 114 | | | | | | | | | | |
| Cyanide | 1.52 | 23.6 | | | | | | | | | | |
| Manganese | 55.0 | 833 | | | | | | | | | | |
| Phenol | 0.00836 | 0.130 | | | | | | | | | | |
| Sulfide | -0.171 | -2.66 | | | | | | | | | | |
| Suspended Solids | 322 | 5000 | | | | | | | | | | |

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

| PARAMETERS | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 5700 | | | | | | | | | | | |
| Ammonia | 7.83 | 165 | | | | | | | | | | |
| Cyanide | 5.08 | 107 | | | | | | | | | | |
| Manganese | 0.287 | 6.05 | | | | | | | | | | |
| pH | | 8.7 | | | | | | | | | | |
| Phenol | 0.0219 | 0.46 | | | | | | | | | | |
| Sulfide | 4.84 | 102 | | | | | | | | | | |
| Suspended Solids | 2.56 | 54 | | | | | | | | | | |

## TABLE 39
### WATER EFFLUENT TREATMENT COSTS
### Steelmaking - Basic Oxygen
### IV-A

| PLANT | R | S | U | V | T' | RANGE |
|---|---|---|---|---|---|---|
| INITIAL INVESTMENT | $ 400,000 | $ 1,730,000 | $ 1,108,000 | $ 5,382,000 | N/A | |
| ANNUAL COSTS: | | | | | | |
| COST OF CAPITAL | 16,900 | 73,300 | 46,900 | 227,600 | N/A | |
| DEPRECIATION | 40,000 | 173,000 | 110,800 | 538,200 | N/A | |
| OPER & MAINT | 395,000 | 72,200 | N/A | 411,300 | $ 7,800 | |
| ENERGY & POWER | INCL. | 52,800 | N/A | INCL. | 128,800 | |
| TOTAL | $ 451,900 | $ 371,300 | $ 157,700 | $ 1,177,100 | $136,600 | |
| $/TON | 0.145 | 0.160 | 0.146 | 0.296+ | 0.0470 | 0.0470+ - 0.296 |
| $/1000 GAL TRT | 1.11 | 0.157 | 0.200+ | 1.14+ | 0.0765 | 0.0765+ - 1.14 |

### AVERAGE NET PLANT RAW WASTE LOAD

| PARAMETERS | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 130 | - | 1020 | - | 728 | - | 259 | - | 615 | - | 130 - 1020 | - |
| Fluoride | - | - | - | - | 0.0143 | 2.36 | 0.00596 | 2.76 | 0.0560 | 10.9 | 0.00596 - 0.0560 | 2.36 - 10.9 |
| Suspended Solids | 0.348 | 321 | 1.53 | 180 | 2.40 | 396 | 11.5 | 5330 | 19.1 | 3730 | 0.348 - 19.1 | 180 - 5330 |

### AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

| PARAMETERS | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow(gal/TON) | No Discharge | | 52.2 | | 728 | | 33 | | 217 | | 0-728 | |
| Fluoride | | | - | - | 0.0227 | 3.75 | - | - | 0.0257 | 14.5 | 0.0227-0.0257 | 3.75-14.5 |
| pH | | | | 9.3 | | 12 | | 6.4 | | 9.4 | | 6.4-12 |
| Suspended Solids | | | 0.00956 | 22 | 0.230 | 38 | 0.0110 | 40 | 0.127 | 70.5 | 0.00956-0.230 | 22-70.5 |

TABLE 40
WATER EFFLUENT TREATMENT COSTS
Steelmaking - Open Hearth
IV-8

| PLANT | W | X | | | | RANGE |
|---|---|---|---|---|---|---|
| INITIAL INVESTMENT | $ 974,000 | $ 1,925,000 | | | | |
| ANNUAL COSTS: | | | | | | |
| COST OF CAPITAL | 41,300 | 81,600 | | | | |
| DEPRECIATION | 97,400 | 192,500 | | | | |
| OPER & MAINT | 7,600+ | 138,500 | | | | |
| ENERGY & POWER | 128,600 | 6,200 | | | | |
| TOTAL | $ 274,900+ | $ 418,800 | | | | |
| $/TON | 0.0746+ | 0.313 | | | | 0.0746+- 0.313 |
| $/1000 GAL TRT | 0.123+ | 0.569 | | | | 0.123+- 0.569 |

AVERAGE NET PLANT RAW WASTE LOAD

| PARAMETERS | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 607 | - | 550 | - | | | | | | | 550 - 607 | - |
| Fluoride | 0.108 | 21.4 | 0.0742 | 16.2 | | | | | | | 0.0742 - 0.108 | 16.2 - 21.4 |
| Nitrate | 0.102 | 20.2 | 0.152 | 33.2 | | | | | | | 0.102 - 0.152 | 20.2 - 33.2 |
| Suspended Solids | 1.96 | 388 | 17.8 | 3880 | | | | | | | 1.96 - 17.8 | 388 - 3880 |
| Zinc | 0.0104 | 2.06 | 4.03 | 880 | | | | | | | 0.0104 - 4.03 | 2.06 - 880 |

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

| PARAMETERS | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 | lb/TON | mg/1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 51.4 | | 118 | | | | | | | | 51.4-118 | |
| Fluoride | 0.0632 | 148 | 0.0639 | 65 | | | | | | | 0.0632-0.0639 | 65-148 |
| Nitrate | 0.00942 | 22 | 0.298 | 303 | | | | | | | 0.00942-0.298 | 22-303 |
| pH | | 3.4-1.8 | | 6.1 | | | | | | | | |
| Suspended Solids | 0.0345 | 80 | 0.0511 | 52 | | | | | | | 0.0345-0.0511 | 52-80 |
| Zinc | 0.0113 | 26.5 | 1.19 | 1210 | | | | | | | 0.0113-1.19 | 26.5-1210 |

## TABLE 41
### WATER EFFLUENT TREATMENT COSTS
### Steelmaking - Electric
### IV-C

| PLANT | Y | Z | AA | AB | | RANGE |
|---|---|---|---|---|---|---|
| INITIAL INVESTMENT | $ 341,000 | $ 133,300 | $ 338,500 | $ 1,250,000 | | |
| ANNUAL COSTS: | | | | | | |
| COST OF CAPITAL | 14,500 | 5,700 | 14,300 | 53,000 | | |
| DEPRECIATION | 34,100 | 13,300 | 33,900 | 125,000 | | |
| OPER & MAINT | 5,600 | 3,100 | 89,200 | 343,900 | | |
| ENERGY & POWER | 15,800 | 600 | INCL. | - | | |
| TOTAL | $ 70,000 | $ 22,700 | $ 137,400 | $ 521,900 | | |
| $/TON | 0.0961 | 0.0420 | 0.460 | 0.894 | | 0.0420 - 0.894 |
| $/1000 GAL TRT | 0.986 | 172 | 1.54 | 4.96 | | 0.986 - 172 |

### AVERAGE NET PLANT RAW WASTE LOAD

| PARAMETERS | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 97.4 | - | 0.243 | - | 299 | - | 180 | - | | | 0.243 - 299 | - |
| Fluoride | -0.0233 | -28.7 | - | - | 0.0369 | 14.8 | 0.0169 | 11.3 | | | -0.0233 - 0.0369 | -28.7 - 14.8 |
| Suspended Solids | 0.700 | 863 | 1.57 | 77.4% | 5.38 | 2160 | 64.2 | 42,800 | | | 0.700 - 64.2 | 863 - 77.4% |

### AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

| PARAMETERS | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (Gal/TON) | | | | | 299 | | 162 | | | | 0 - 299 | |
| Fluoride | No | | No | | 0.0515 | 20.7 | 0.0162 | 12 | | | 0-0.0515 | 0-20.7 |
| PH | | | | | | 7.9 | | 7.9 | | | | |
| Suspended Solids | Discharge | | Discharge | | 0.144 | 58 | 0.0310 | 23 | | | 0-0.144 | 0-58 |

TABLE 43
WATER EFFLUENT TREATMENT COSTS
Continuous Casting
VI

| PLANT | AE | AF | | | | RANGE |
|---|---|---|---|---|---|---|
| INITIAL INVESTMENT | $ 2,314,000 | $ 2,062,600 | | | | |
| ANNUAL COSTS: | | | | | | |
| COST OF CAPITAL | 97,900 | 87,200 | | | | |
| DEPRECIATION | 231,400 | 206,300 | | | | |
| OPER & MAINT | 176,900 | 567,400 | | | | |
| ENERGY & POWER | INCL | INCL | | | | |
| TOTAL | $ 506,200 | $ 860,900 | | | | |
| $/TON | 0.442 | 1.47 | | | | 0.442 - 1.47 |
| $/1000 GAL TRT | 0.108 | .999 | | | | 0.108 - 0.999 |

AVERAGE NET PLANT RAW WASTE LOAD

| PARAMETERS | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 4110 | | 1480 | | | | | | | | 1480 - 4110 | |
| Oil and Grease | 0.703 | 20.5 | 0.270 | 22.0 | | | | | | | 0.270 - 0.703 | 20.5 - 22.0 |
| Suspended Solids | 0.270 | 7.87 | 0.909 | 74.0 | | | | | | | 0.270 - 0.909 | 7.87 - 74.0 |

AVERAGE GROSS PLANT EFFLUENT WASTE LOAD

| PARAMETERS | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l | lb/TON | mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flow (gal/TON) | 111 | | 82.5 | | | | | | | | 82.5-111 | |
| Oil & Grease | 0.00402 | 4.35 | <0.000344 | <0.5 | | | | | | | <0.000344 - 0.00402 | <0.5-4.35 |
| pH | | 6.8 | | 7.7-6.8 | | | | | | | | 6.8-7.7 |
| Suspended Solids | 0.00403 | 4.36 | 0.0254 | 37 | | | | | | | 0.00403- 0.0254 | 4.36-37 |

3. Non-Water Quality Aspects (Both Alternates):

   a.   Air Pollution:   There are two potential types of emissions of air pollution significance in a typical coke plant.   These are associated with the following major components or operations of the by-products recovery equipment:

      i    tar collection from the flushing system

      ii   free NH3 recovery in an ammonia still

      iii  once-through coke quenching with a sump for settling out fines

      iv   once-through final cooler.

      The two types of emissions are volatile (gaseous) materials and suspended particulate matter.   If a vapor recirculation or solvent extraction facility for dephenolization is added to the system, significant reductions in both parameters are achieved.

   b.   Solid Waste Disposal:   A number of different solid wastes are generated by treatment systems to upgrade the quality of the effluent from by-product coke oven fume cleaning.   Among these are coke fines, tar sludges, dirty phenolates, blowdown sludge, lime sludge and sludges from the aeration lagoon.   The coke fines are internally consumed through reuse in the mill, and the tar sludges are further refined (usually by outside contractors) or are incinerated.   The remaining solid waste products can best be disposed of as landfill.

## Beehive Coke

1. Base Level of Treatment: Once-through system with settling of the coke quench waters.

2. Additional Energy Requirements:   Additional power will be necessary when bringing the quality of the effluent of the water treatment system used in the fume cleaning of the beehive coke making process up to the anticipated standard for 1977.   The additional energy consumed will be 1.35 kwh/kkg (1.23 kwh/ton) of coke produced.   For the typical 662.5 kkg/day (730 tons/day) facility, the additional power required will be 37.3 kw (50 hp).   The annual cost for operating this new installation will be approximately $3,750.00.

3. Non-Water Quality Aspects

   a.   Air Pollution:   In beehive coke ovens, the items of air pollutional significance are gaseous emissions and suspended particulate matter which include smoke, dust,

# TABLE 44

## IRON AND STEELMAKING OPERATIONS
## CONTROL AND TREATMENT TECHNOLOGY
## FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY:  By-Product Coke

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|
| A.  Ammonia liquor treatment via free still only; dephenolizer; settling pond for solids; light oil recovered for sale to outside contractors; quench water recycles with no blowdown; final cooler water recycles with blowdown to dephenolizer; crystalizer barometric condenser water once-through to settling pond. | mg/l<br>NH₃ 1000<br>Phenol 5<br>CN⁻ 90<br>BOD₅ 300<br>S⁼ 25<br>O&G 20<br>SS 50<br>pH 6-9 | Widely practiced in industry. Subject to upsets from slug loads. Fair. | Requires constant attention to maintenance & housekeeping. Heated discharges | 6 months | 1 acre (200' x 200') | Quenching with contaminated water, releases volatiles to air. | Coke fines are useable in plant. Solids to landfill. |
| Alternate I - Physical/ Chemical<br><br>B.  To (A), add lime and steam to fixed leg of ammonia still; neutralize prior to settling. | NH₃ 125<br>Phenol 2<br>CN⁻ 30<br>BOD₅ 150<br>S⁼ 10<br>O&G 15<br>SS 50<br>pH 6-9 | Used by some plants in industry. Good. | Same as in (A). Lime addition requires care in handling. | 6 months | 1 acre (200' x 200') | Volatile compounds released to air. | Same as in (A), with additional sludge from lime addition. |

* Listed in order of increasing effectiveness

TABLE 44 (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: By-Product Coke

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| C. To (B), add aeration; aggressive chemical oxidation; neutralization; break point chlorination; clarification and/or filtration; carbon adsorption. Recycle crystallizer effluent through final cooler water recycle system. | $NH_3$<br>Phenol<br>$CN^-$<br>$BOD_5$<br>$S^=$<br>O&G<br>SS<br>pH | mg/l<br>10<br>0.5<br>0.25<br>20<br>0.3<br>10<br>10<br>6-9 | Chemical oxidation practiced at some blast furnace (iron) plants; other technology from chemical, refining & water treatment industries. Very good. | Part of technology untested on coke plant wastes. Very close control of intermediate steps must be practiced. | 1-3 years | 1-1/2 acre (200' x 400') | Volatile compounds released to air. | Same as (A), with additional sludge from neutralization steps. |
| Alternate II - Biological<br>B. To (A), add lime and steam to fixed leg of ammonia still; abandon dephenolizer; neutralize; add single stage bio-oxidation for phenol removal. | $NH_3$<br>Phenol<br>$CN^-$<br>$BOD_5$<br>$S^=$<br>O&G<br>SS<br>pH | 125<br>1<br>20<br>100<br>1.0<br>10<br>50<br>6-9 | Used by some plants in industry. Good. | Same as in (A). Lime addition requires care in handling. | 6 months | 1 acre (200' x 200') | Volatile compounds released to air. | Same as in (A), with additional sludge from neutralization steps. |

* Listed in order of increasing effectiveness

TABLE 44    (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY:  By-Product Coke

| Treatment and/or Control Methods Employed* | Resulting Ef- fluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| C.  To (B), add aeration; multistage biological treatment; neutralization; and filtration; recycle crystallizer effluent· through final cooler water recycle system. | NH$_3$ Phenol CN$^-$ BOD$_5$ S$^=$ O&G SS pH | mg/l 10 0.5 0.25 20 0.3 10 10 6-9 | Single-stage biological oxidation practiced at some coke plants; other tech- nology from chemical, refining & water treat- ment indus- tries. Very good. | Part of technology untested on coke plant wastes. Very close control of intermediate steps must be practiced. | 1-3 years | 1-1/2 acre (200' x 400') | Volatile compounds released to air. | Same as (A), with forma- tion of biological sludges added. |
| D.  As an option to (A), (B) and (C) above, distillation of all partly detarred gases and liquids by con- trolled combustion.  No liquid discharges. | NH$_3$ Phenol CN$^-$ BOD$_5$ S$^=$ O&G SS pH | 0 0 0 0 0 0 0 - | Used at some coke plants. Effective· elimination of waste load from water, but transfers load to air. | Can be done only at plants where impact on air qual- ity can be tolerated. Of limited application | 8-12 months | 1/2 acre (100' x 200') | High impact on air quality. | Formation of ashes. |

* Listed in order of increasing effectiveness

TABLE 44 (cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

By Product Coke Subcategory
Alternate I - Physical/Chemical

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | A | BPCTCA B | BATEA C | D[1] |
|---|---|---|---|---|
| Investment | 4,482,074 | 168,460 | 666,930 | 1,738,426 |
| Annual Costs: | | | | |
| Capital | 192,729 | 7,299[2] | 28,678 | 74,751 |
| Depreciation | 448,207 | 28,077[2] | 66,693 | 173,843 |
| Operation & Maintenance | 156,872 | 5,896 | 23,342 | 60,844 |
| Carbon Column Rental | -- | -- | 245,400 | - |
| Sludge Disposal | 13,897 | 13,897 | 1,620 | - |
| Energy & Power | 15,000 | 2,175 | 37,500 | 600 |
| Chemical | 1,942 | 46,090 | 139,500 | 1,205,000 |
| Steam Generation | 32,400 | 48,600 | - | - |
| TOTAL | 861,047 | 152,034 | 542,733 | 1,515,038 |

| Effluent Quality: Effluent Constituents Parameters - units | Raw Waste Load | Resulting Effluent Levels | | | |
|---|---|---|---|---|---|
| Flow, gal/ton | 175 | 175 | 175 | 100 | 0 |
| Ammonia, mg/l | 2,000 | 1,000 | 125 | 10 | 0 |
| Phenol, mg/l | 360 | 5 | 2 | 0.5 | 0 |
| Cyanide, mg/l | 200 | 90 | 30 | 0.25 | 0 |
| BOD$_5$, mg/l | 1,200 | 300 | 150 | 20 | 0 |
| Sulfide, mg/l | 400 | 25 | 10 [3] | 0.3 | 0 |
| Oil & Grease, mg/l | 120 | 20 | 15 | 10 | 0 |
| Suspended solids, mg/l | 90 | 50 | 50 | 10 | 0 |
| pH | 6-9 | 6-9 | 6-9 | 6-9 | - |

(1) Incremental to capital costs and depreciation for Level A

(2) Based on 6 year depreciation rate to allow for conversion to biological for BATEA.

(3) Value to be expected from typical treatment plant utilizing BPCTCA treatment technology

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TABLE 44 (cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

By Product Coke Subcategory
Alternate II - Biological

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | A | BPCTCA B | BATEA C | |
|---|---|---|---|---|
| Investment | 4,482,094 | (440,610)[1] 462,610 | 494,716 | |
| Annual Costs: | | (18,946)[1] | | |
| Capital | 192,729 | 19,892 | 21,272 | |
| Depreciation | 448,207 | (44,061)[1] 46,261 | 49,472 | |
| Operation & Maintenance | 156,872 | 16,191 | 17,314 | |
| Sludge Disposal | 13,897 | 14,127 | - | |
| Energy & Power | 15,000 | 31,500 | 22,500 | |
| Chemical | 1,942 | 68,406 | 4,248 | |
| Steam Generation | 32,400 | 48,600 | - | |
| TOTAL | 861,047 | 244,977 241,831[1] | 114,806 | |

| Effluent Quality: Effluent Constituents Parameters - units | Raw Waste Load | Resulting Effluent Levels | | | |
|---|---|---|---|---|---|
| Flow, gal/ton | 175 | 175 | 175 | 100 | |
| Ammonia, mg/l | 2000 | 1000 | 125 | 10 | |
| Phenol, mg/l | 360 | 5 | 1 | 0.5 | |
| Cyanide, mg/l | 200 | 90 | 20 | 0.25 | |
| BOD$_5$, mg/l | 1200 | 300 | 100 | 20 | |
| Sulfide, mg/l | 400 | 25 | 1.0[2] | 0.3 | |
| Oil & Grease, mg/l | 120 | 20 | 10 | 10 | |
| Suspended solids; mg/l | 90 | 50 | 50 | 10 | |
| pH | 6-9 | 6-9 | 6-9 | 6-9 | |

(1) This assumes that neutralization has already been installed ($22,000) in preparation for meeting BPCTCA with physical-chemical treatment

(2) Value expected of typical treatment plant utilizing BPCTCA treatment technology

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TABLE 45

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY:  Beehive Coke

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|
| A.  Install settling pond to collect coke fines. No reduction in flows. | mg/l<br>$NH_3$  0.20<br>$CN^=$  0.003<br>Phenol  0.009<br>$BOD_5$  1.0<br>SS  25<br>Temp  80°C<br>pH  6-9 | Practiced in this industry. Must be periodically cleaned of settled fines. | High thermal load | 1 month | 1/2 acre (100'x 200') for settling pond | By their very nature, beehives pollute air | Coke fines, which can be reused |
| B.  Complete recycle – no aqueous blowdown. Make-up water required. Critical parameters reach equilibrium | Zero aqueous discharge | Widely practiced in this industry. Requires attention to prevent leaks or overloads | Higher operating temperatures Steam problems in winter. | 2-4 months | No additional space compared with treatment Method A | Same as treatment Method A | Same as treatment Method A |

* Listed in order of increasing effectiveness

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TABLE 45 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Beehive Coke Subcategory

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | A | BPCTCA-BATEA B | | |
|---|---|---|---|---|
| Investment | $ 99,024 | $ 50,510 | | |
| Annual Costs: | | | | |
| Capital | 4,258 | 2,170 | | |
| Depreciation | 9,902 | 5,051 | | |
| Operation & Maintenance | 3,466 | 1,770 | | |
| Sludge Disposal | 4,200 | | | |
| Energy & Power | | 3,750 | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| TOTAL | $ 21,826 | $ 12,741 | | |

| Effluent Quality: Effluent Constituents Parameters - units | Raw Waste Load | Resulting Effluent Levels | | | |
|---|---|---|---|---|---|
| Flow, gal/ton | 300 | 300 | 0 | | |
| Suspended solids,mg/l | 400 | 25 | 0 | | |
| Ammonia, mg/l | 0.35 | 0.20 | 0 | | |
| Cyanide, mg/l | 0.004 | 0.003 | 0 | | |
| $BOD_5$, mg/l | 3 | 1 | 0 | | |
| Phenol, mg/l | 0.01 | 0.009 | 0 | | |
| pH | 6-9 | 6-9 | - | | |
| | | | | | |
| | | | | | |
| | | | | | |

hydrogen sulfide, phenols and materials resulting from the destructive distillation of coal. If the system is tightened up, some of these contaminants can be washed out of the exhaust gases and the solids can be processed and utilized in ways outlined in the "Solid Waste Disposal" section.

b. Solid Waste Disposal: Solid wastes will be generated by processing the scrub water and reusing coke fines in the system.

## Sintering

1. Base Level of Treatment: Once-through system consisting of treatment of waste water via a classifier and thickener with vacuum filter for solids dewatering.

2. Additional Power Requirements: To meet the anticipated 1977 standard utilizing a wet system in cleaning the emissions from the sinter process, modifications will be required to the waste water treatment system. The additional energy consumed will be 0.68 kwh/kkg (0.62 kwh/ton) of sinter produced. For the typical 2,704 kkg/day (2,980 tons/day) sinter plant, 223.8 kw (300 hp) will have to be added. The annual operating cost for the additional equipment will be $22,500.00.

3. Non-Water Quality Aspects

a. Air Pollution: The main air pollution problem associated with the sinter process will be suspended particulate matter. Although the exhaust gases will be passed through a wash and 40% recycled, 0.1 kkg of particulate emission per kkg (lb/1,000 lb) of exhaust gas will be emitted into the atmosphere.

b. Solid Waste Disposal: The solid waste from the waste system will be internally consumed in the sinter process.

## Blast Furnace (Iron)

1. Base Level of Treatment: Once-through system. Treatment system utilizes thickener with polyelectrolyte addition and vacuum filter for solids dewatering.

2. Additional Energy Requirements: To bring the quality of the effluent of the water treatment system utilized in the fume collection of the blast furnace (iron) process up to the anticipated standard for 1977 the additional energy consumed will be 2.68 kwh/kkg (2.44 kwh/ton) of iron made. The additional power required for the typical 2,995 kkg/day (3,300 tons/day) blast furnace facility will be 335.7 kw (450 hp). The annual operating cost for this additional consumption of power will be approximately $33,750.00.

TABLE 46

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: __Sintering_____

| Treatment and/or Control Methods Employed* | Resulting Ef- fluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| A. Aqueous discharge from scrubber through classifier to thickener "once-through" Overflow to sewer, under- flow through vacuum filters to Sinter Plant or land filled, filtrate recycled to thickener. | S.S. O&G S= F pH | mg/1 40 45 65 30 8-10 | Widely practiced, usually in conjunction with blast furnace operations. Dependable System. | No reduction of heat load or dissolved chemicals | 18 months | 1 acre (200'x200') | Air: Particulate 0.1#/1000# exhaust gasses | Solids consumed internally |
| B. Same as Item (A) except with chemical polymer flocculation in thickener. | S.S. O&G S= F pH | mg/1 20 45 65 30 8-10 | Usually in- cluded with blast fur- nace treat- ment system. Improves solids removal | No reduction of heat load or dissolved chemicals. | 18 months | 1 acre (200'x200') | Air: Particulate 0.1#/1000# exhaust gasses | Solids consumed internally |

* Listed in order of increasing effectiveness

TABLE 46 (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: ___Sintering___

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| | | mg/l | | | | | | |
| C. Same as (B) except thickener overflow recycled to scrubber system with blowdown. Oil skimmer added to thickener. Add neutralization of blowdown. | S.S.<br>O&G⁻<br>S⁼<br>F⁻<br>pH | 50<br>10<br>20<br>50<br>6-9 | Recycle increases certain constituent concentrations but reduces loads. | No reduction of heat load. Increase in dissolved chemical concentrations. | 18 months | 1 acre (200'x200') | Air: Particulate 0.1#/1000# exhaust gases. | Solids consumed internally |
| D. Same as Item (C) except blowdown treated through improved settling with aeration, lime treatment for F⁻, neutralization, and sedimentation. | S.S.<br>O&G<br>S⁼<br>F-<br>pH | 25<br>10<br>0.3<br>20<br>6-9 | S⁼ & F⁻ removals practiced in other industries successfully. Process must be monitored | Requires close attention to treatment systems. | 18 months | 1-1/2 acre (200'x300') | Air: Particulate 0.1#/1000# exhaust gases | Solids consumed internally, and other solids to landfill |
| E. Same as Item (D) except additonal F⁻ removal via activated alumina treatment. | S.S.<br>O&G<br>S⁼<br>F⁻<br>pH | 10<br>3<br>0.3<br>5<br>6-9 | F⁻ removal demonstrated on pilot scale; technology subject to scaling up to full size. | Requires close attention to treatment systems. | 18 months | 1-1/2 acre (200'x300') | Air: Particulates 0.1#/1000# exhaust gases | Solids consumed internally, and other solids to landfill |

* Listed in order of increasing effectiveness

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TABLE 46 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Sintering Subcategory

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | A | BPCTCA | | BATEA | |
|---|---|---|---|---|---|
| | | B | C | D | E |
| Investment | $ 548,150 | $ 26,621 | $228,315 | $294,224 | $ 221,270 |
| Annual Costs: | | | | | |
| Capital | 23,570 | 1,145 | 9,818 | 12,652 | 9,510 |
| Depreciation | 54,815 | 2,662 | 22,831 | 29,422 | 22,127 |
| Operation & Maintenance | 19,185 | 932 | 7,991 | 10,298 | 7,745 |
| Sludge Disposal | | | | | 825 |
| Energy & Power | 12,450 | 675 | 7,050 | 14,775 | |
| Chemical | | 2,000 | 713 | 1,360 | 57 |
| TOTAL | $ 110,020 | $ 7,414 | $ 48,403 | $ 68,507 | $ 40,264 |

| Effluent Quality: Effluent Constituents Parameters - units | Raw Waste Load | Resulting Effluent Levels | | | | |
|---|---|---|---|---|---|---|
| | | | | BPCTCA | | |
| Flow, gal/ton | 250 | 250 | 250 | 50 | 50 | 50 |
| Suspended solids, mg/l | 8,000 | 40 | 20 | 50 | 25 | 10 |
| Oil & grease, mg/l | 600 | 45 | 45 | 10 | 10 | 3 |
| Sulfide, mg/l | 200 | 65 | 65 | 20[1] | 0.3 | 0.3 |
| Fluoride, mg/l | 30 | 30 | 30 | 50[1] | 20 | 5 |
| pH | 8-10 | 8-10 | 8-10 | 6-9 | 6-9 | 6-9 |

(1) Value that can be obtained utilizing BPCTCA treatment technology

TABLE 47

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: Blast Furnace (Iron)

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| A. Once-through – solids removed via thickener and vacuum filter. Polymer added to improve settling. | SS<br>CN$^-$<br>Phenol<br>NH$_3$<br>S$^{=3}$<br>F$^-$<br>pH | mg/l<br>50<br>2.0<br>1.0<br>10<br>4<br>5<br>7-9 | Widely used, SS removal efficiency depends upon sludge level & filter schedule. | Removes suspended solids, and a minor portion of volatiles. | 12-18 mo. | 1/2 acre (100' x 200') | Volatiles lost through surface evaporation | Iron oxide sludge to sinter plant or landfill |
| B. To A, add recycle over cooling tower, discharge blowdown only. | SS<br>CN$^-$<br>Phenol<br>NH$_3$<br>S$^{=3}$<br>F$^-$<br>pH | 50<br>15<br>4<br>125<br>6<br>40<br>6-9 | Used in steel industry. Reliable if properly spared. Sludge level controls solids overflow. | Removes most suspended solids plus much of chemical load, although concentrations increase. | 18-24 mo. | 3/4 acre (150' x 200') | Water spray & volatiles to atmosphere | Iron oxide sludge to sinter plant |

* Listed in order of increasing effectiveness

TABLE 47 (Cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY:  Blast Furnace (Iron)

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|
| C. To B, add treatment of blowdown via alkaline chlorination; precipitation of fluorides with lime; neutralization, filtration and carbon adsorption. | mg/l<br>SS        10<br>CN⁻      0.25<br>Phenol    0.5<br>NH₃      10<br>S⁼       0.3<br>F⁻       20<br>pH       6-9 | Alkaline chlorination used at some plants. Carbon adsorption used in other industries. Treatments subject to equipment failures. | May require batch treatment of blowdown to assure performance. High operating costs. | 18-24 mo. | 3/4 acre (150' x 200') | Increased demand for chlorine, causing increase in pollution from chlorine production & power supply. | Iron oxide sludge to Sinter Plant. Sludge from neutralization step to landfill. |

* Listed in order of increasing effectiveness

## TABLE 47 (Cont.)

### WATER EFFLUENT TREATMENT COSTS
### STEEL INDUSTRY

#### Blast Furnace (Iron) Subcategory

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | A | BPCTCA<br>B | BATEA<br>C | |
|---|---|---|---|---|
| Investment | 2,030,569 | 1,476,673 | 413,033 | |
| Annual Costs: | | | | |
| Capital | 87,314 | 63,497 | 17,761 | |
| Depreciation | 203,057 | 147,667 | 41,303 | |
| Operation & Maintenance | 71,070 | 51,683 | 14,456 | |
| Carbon Column Rental | – | – | 184,900 | |
| Sludge Disposal | 97,893 | – | 320 | |
| Energy & Power | 43,500 | 33,750 | 8,625 | |
| Chemical | 58,500 | – | 24,589 | |
| TOTAL | 561,334 | 296,597 | 291,954 | |

Effluent Quality:

| Effluent Constituents Parameters – units | Raw Waste Load | Resulting Effluent Levels | | | |
|---|---|---|---|---|---|
| Flow, gal/ton | 3900 | 3900 | 125 | 125 | |
| Ammonia, mg/l | 10 | 10 | 125 | 10 | |
| Phenol, mg/l | 1.0 | 1.0 | 4 | 0.5 | |
| Cyanide, mg/l | 2.0 | 2.0 | 15 | 0.25 | |
| Sulfide, mg/l | 20 | 4.0 | 6 [1] | 0.3 | |
| Suspended solids, mg/l | 1600 | 50 | 50 | 10 | |
| Fluoride, mg/l | 5 | 5 | 40 [1] | 20 | |
| pH | 7-9 | 7-9 | 6-9 | 6-9 | |

(1) Value expected for typical treatment plant utilizing BPCTCA treatment technology

TABLE 47 (FeMn)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY:  Blast Furnace (Ferromanganese)

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| A. Once thru gas cooler discharge; closed recycle of Venturi scrubber discharge through thickener, and vacuum filter. Polymer added to aid settling. | SS<br>Phenol<br>CN⁻<br>NH₃<br>S⁼<br>Mn<br>pH | mg/l<br>100<br>1.0<br>100<br>200<br>120<br>16<br>8-10 | Used in this industry. Requires attention to recycle system. | High dissolved solids in recycled water;pickup of volatiles from scrubber recycled water in gas cooler water. | 18-24 mo. | 3/4 acre (150' x 200') | Volatiles are lost to atmosphere | Filter cake not reuseable in process. Must go to landfill. |
| B. Closed recycle of Venturi scrubber as in A; separate recycle of gas cooler water over cooling tower, with pH control. Blowdown to sewer, and to makeup for Venturi scrubber recycle system. | SS<br>Phenol<br>CN⁻<br>NH₃<br>S⁼<br>Mn<br>pH | 100<br>4<br>30<br>200<br>30<br>16<br>6-9 | Used in the past in this industry. Requires constant attention to separate recycle systems. | High concentrations of dissolved material due to recycling;blowdown loads are reduced, but concentrations are high. | 18-24 mo. | 1 acre (200' x 200') | Volatiles are lost to atmosphere over the cooling tower. | Filter cake not reuseable in process. Must go to landfill. |

* Listed in order of increasing effectiveness

TABLE   47 (Fe-Mn)(cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY:   Blast Furnace (Ferromanganese)

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|
| C.   Same as in B, with treatment of gas cooler system blowdown via alkaline chlorination ; neutralization; filtration; and carbon adsorption. | mg/l<br>SS      10<br>Phenol  0.5<br>CN⁻    0.25<br>$NH_3$   10<br>S⁼     0.3<br>Mn      5<br>pH     6-9 | Part of technology used at some iron making blast furnaces; other systems tested on pilot scale. Requires attention to details. Very good. | High operating costs.  May require batch treatment of blowdown to assure performance. | 18-24 months | 1 acre (200' x 200') | Increased demand for chlorine, causing increase in pollution from chlorine production and power supply. | Additional sludges formed during neutralization. |

* Listed in order of increasing effectiveness

TABLE 47 (FeMn)(Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Blast Furnace (Ferromanganese) Subcategory

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | A | BPCTCA B | BATEA C | |
|---|---|---|---|---|
| Investment | 962,971 | 1,725,624 | 320,946 | |
| Annual Costs: | | | | |
| Capital | 41,407 | 74,202 | 13,800 | |
| Depreciation | 96,297 | 172,562 | 32,095 | |
| Operation & Maintenance | 33,703 | 60,396 | 11,233 | |
| Carbon Column Rental | – | – | 432,400 | |
| Sludge Disposal | 136,875 | 10,297 | – | |
| Energy & Power | 9,750 | 33,525 | 5,325 | |
| Chemical | 15,000 | 1,985 | 28,537 | |
| TOTAL | 333,032 | 352,967 | 523,390 | |

Effluent Quality:

Resulting Effluent Levels

| Effluent Constituents Parameters  -  units | Raw Waste Load | | | | |
|---|---|---|---|---|---|
| Flow, gal/ton | 7700 | 5500 | 250 | 250 | |
| Ammonia, mg/l | 250 | 200 | 200 | 10 | |
| Phenol, mg/l | 4.0 | 1.0 | 4.0 | 0.5 | |
| Cyanide, mg/l | 100 | 100 | 30 | 0.25 | |
| Sulfide, mg/l | 150 | 120 | 30 [1] | 0.3 | |
| Suspended solids, mg/l | 5000 | 100 | 100 | 10 | |
| Manganese, mg/l | 800 | 16 | 16 [1] | 5 | |
| pH | 9-12 | 8-10 | 6-9 | 6-9 | |

(1) Value to be expected from typical treatment plant utilizing BPCTCA treatment technology.

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3. Non-Water Quality Aspects

   a. Air Pollution: Although the blast furnace exhaust fumes will be passed through a cleaning system and utilized in system heating, pollution of air will still be generated. The problem will arise from "slips" which are caused by arching of the furnace charge. The arch breaks and the burden slips into the void. This causes a rush of gas to the top of the furnace, which develops abnormally high pressures which are greater than the gas-cleaning equipment can handle. Bleeders are then opened to release the pressure which results in a dense cloud of dust being discharged to the atmosphere.

   b. Solid Waste Disposal: There should be no problem in disposing of the solid waste which will be generated. It can be internally consumed in the sinter process plant.

## Blast Furnace (Ferromanganese)

1. Base Level of Treatment: Scrubber water on closed recycle system with thickener and vacuum filters for solids dewatering. Gas cooler water once-through.

2. Additional Power Requirements: Additional electrically driven equipment will have to be installed to bring the quality of the effluent of the water treatment system used in the fume collection of the ferro-manganese blast furnace iron making process up to the anticipated standard for 1977. The additional energy consumed will be 10.7 kwh/kkg (9.76 kwh/ton) of iron produced. For the typical 744 kkg/day (820 tons/day) ferro-manganese blast furnace, the power required will be 333.5 kw (547 hp). The annual cost for electrical power to operate the new equipment will be $33,525.00.

3. Non-Water Quality Aspects

   a. Air Pollution: The ferro-manganese blast furnace gas is more difficult to clean. In fact, if uncontrolled, this process could be one of the most prolific pollution producers of any of the metallurgical processes.

   b. Solid Waste Disposal: Same as iron making blast furnace (iron).

## Basic Oxygen Furnace Operation

## Semi-Wet Systems

1. Base Level of Treatment: Once-through system. Treatment of waste waters via thickening with addition of polymer, and with a vacuum filter for dewatering of solids.

2. Additional Energy Requirements:  Additional power will be necessary when bringing the quality of the effluent of the water treatment system utilized in the fume collection of the BOF (semiwet) steelmaking process up to the anticipated standard for 1977.  The additional energy utilized will be 0.34 kwh/kkg (0.28 kwh/ton) of steel produced.  For the typical 4,429 kkg/day (4,880 tons/day) BOF facility, the additional power required will be 62.66 kw (84 hp).  The annual operating cost for this additional installation will be approximately $6,300.00.

3. Non-Water Quality Aspects

   a.  Air Pollution:  In the BOF (semiwet) method of steel-making, the air pollution problem of primary signifi-cance will be suspended particulate matter.  Although the furnace exhaust fumes will have been passed through a dust wash, 0.1 pound of particulate emission per 1,000 pounds of exhaust gases will be emitted into the atmosphere.

   b.  Solid Waste Disposal:  The solid waste that will be generated by the fume collection system for the BOF (semiwet) process of steelmaking should present no problem.  It can be internally consumed in the sinter process plant.

## Wet Systems

1. Base Level of Treatment:  Once-through system.  Treatment system includes classifier and thickener with vacuum filter for solids dewatering.

2. Additional Energy Requirements:  To bring the quality of the effluent of the water treatment system utilized in the fume collection of the BOF (wet) steel manufacturing process up to the anticipated standard for 1977, additional energy will be necessary.  The additional energy consumed will be 0.44 kwh/kkg (0.40 kwh/ton) of steel made.  The additional power required for the typical 6,888 kkg/day (7,590 tons/day) BOF facility will be 125.3 kw (168 hp).  The annual operating cost for this additional consumption of power will be approximately $12,600.00.

3. Non-Water Quality Aspects

   a.  Air Pollution:  The air pollution problem of primary significance in the BOF (wet) method of steelmaking will be particulate emissions.  Although the furnace exhaust fumes will be passed through a dust removing bath, 0.1 kg of suspended particulate matter per kkg (lb/1,000 lb) of exhaust gases will be emitted into the atmosphere.

   b.  Solid Waste Disposal:  There should be no problem in disposing of the solid waste generated by the fume

TABLE 48

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: Basic Oxygen Furnace (Semi-Wet)

| Treatment and/or Control Methods Employed* | Resulting Ef-fluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| | | mg/l | | | | | | |
| A.  Thickener with polymer and/or magnetic flocculation "once-through"; overflow to sewer, underflow thru vacuum filters, filter cake recycled to sinter plant or landfill filtrate recycled to thickener. | SS<br>F⁻<br>pH | 50<br>20<br>10-12 | Widely used in steel industry. Good system. | Must control surges to system; no reduction of heat load. | 15 mo. | 1/4 acre (100' x 100') | Air: Particu-late 0.1#/1000# exhaust gases | Solids consumed internally or used as landfill. |
| B.  Same as Item A except overflow recycled to process spray system thru recycle pump system.  No aqueous discharge. | SS<br>F⁻<br>pH | 0<br>0<br>– | Practiced by many plants in steel industry. Very good. | Requires more atten-tion than once-through systems. | 15 mo. | 1/4 acre (100' x 100') | Air: Particulate 0.1#/1000# exhaust gases | Solids consumed internally or used as landfill. |

* Listed in order of increasing effectiveness

TABLE 49

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: Basic Oxygen Furnace (Wet)

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| Fume Collection System with Boiler Hoods | | | | | | | | |
| A. Aqueous discharge from primary scrubber to classifier to thickener. "Once-thru", overflow to sewer, underflow thru vacuum filters, filter cake recycled to sinter plant or landfilled, filtrate recycled to thickener. | SS<br>F⁻<br>pH | mg/l<br>80<br>30<br>6-9 | Widely practiced in industry; good | No reduction of heat load must control surges | 18 months | 1 acre (200'x 200') | Air:<br>Particulate<br>0.1#/1000#<br>exhaust gases | Solid waste consumed internally |
| B. To A, add magnetic and/ or chemical polymer flocculation | SS<br>F⁻<br>pH | 40<br>30<br>6-9 | Widely practiced in industry; very good | Same as Item A | 18 months | 1 acre (200'x 200') | Air:<br>Particulate<br>0.1#/1000#<br>exhaust gases | Solid waste consumed internally |
| C. To B, add thickener overflow recycle system with blowdown; neutralization of blowdown stream. | SS<br>F⁻<br>pH | 50<br>50<br>6-9 | Widely practiced in industry; very good | Dissolved material is concentrated by recycle | 18 months | 1 acre (200'x 200') | Air:<br>Particulate<br>0.1#/1000#<br>exhaust gases | Solid waste consumed internally. Additional sludges from neutralization to landfill. |

* Listed in order of increasing effectiveness

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TABLE 49 (Cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: Basic Oxygen Furnace (Wet)

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| D. To C, add blowdown treatment via settling with coagulation; lime treatment and neutralization. | SS<br>F⁻<br>pH | mg/l<br>25<br>20<br>6-9 | Used in controlling steel and other industry wastes; excellent. | Lime addition requires care in handling; adds to solids wastes generation problem. | 18 mo. | 1-1/2 acre (200' x 300') | Air:<br>Particulate<br>0.1#/1000#<br>exhaust gases | Solid waste consumed internally; additional sludges to landfill. |
| E. To D, add activated alumina treatment; filtration. | SS<br>F⁻<br>pH | 10<br>.5<br>6-9 | Used in water treatment; excellent | Technology untested on steel plant wastes; requires attention to all preceding steps. | 18 months | 1-1/2 acre (200'x 300') | Air:<br>Particulate<br>0.1#/1000#<br>exhaust gases | Solid waste consumed internally; additional sludges to landfill. |

* Listed in order of increasing effectiveness

TABLE 49 (Cont.)

## WATER EFFLUENT TREATMENT COSTS
## STEEL INDUSTRY

Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | A | BPCTCA B | C | BATEA D | E |
|---|---|---|---|---|---|
| Investment | $ 1,308,722 | $ 27,058 | $ 437,326 | $ 363,251 | $ 359,630 |
| Annual Costs: | | | | | |
| Capital | 56,275 | 1,163 | 18,805 | 15,619 | 15,465 |
| Depreciation | 130,872 | 2,706 | 43,732 | 36,325 | 35,963 |
| Operation & Maintenance | 45,805 | 947 | 15,306 | 12,713 | 12,587 |
| Sludge Disposal | 138,627 | | | 1,040 | |
| Energy & Power | 30,000 | 675 | 11,925 | 10,575 | 4,500 |
| Chemical | | 131,400 | 1,822 | 6,197 | 29 |
| TOTAL | $ 401,579 | $136,891 | $ 91,590 | $ 82,469 | $ 68,544 |

| Effluent Quality: Effluent Constituents Parameters  –  units | Raw Waste Load | Resulting Effluent Levels | | BPCTCA | BATEA | |
|---|---|---|---|---|---|---|
| Flow, gal/ton | 600 | 600 | 600 | 50 | 50 | 50 |
| Suspended solids, mg/l | 2,000 | 80 | 40 | 50 | 25 | 10 |
| Fluoride, mg/l | 30 | 30 | 30 | 50 [1] | 20 | 5 |
| pH | 6-9 | 6-9 | 6-9 | 6-9 | 6-9 | 6-9 |

(1) Value that can be obtained utilizing BPCTCA treatment technology

TABLE 50

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: Open Hearth

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| | | mg/1 | | | | | | |
| A. Aqueous discharge from primary quencher to classifier to thickener, "once through" overflow to sewer underflow through vacuum filters, filter cake recycled to sinter plant or landfilled. Filtrate returned to thickener. | S.S. $F^-$ $NO_3^-$ Zn pH | 80 20 35 220 3-7 | Currently used in steel industry; fair | No reduction of heat load; must control surges. | 18 months | 1 acre (200'x200') | Air: Particulate 0.1#/1000# exhaust gasses | Solid Waste consumed internally |
| B. Same as Item (A) but with thickener magnetic and/or chemical flocculation | S.S. $F^-$ $NO_3^-$ Zn pH | 50 20 35 200 3-7 | Currently used in steel industry; good. | No reduction of heat load must control surges; polymer feed must be maintained | 18 months | 1 acre (200'x200') | Air: Particulate 0.1#/1000# exhaust gasses | Solid Waste consumed internally |

* Listed in order of increasing effectiveness

TABLE 50 (Cont.)

## WATER EFFLUENT TREATMENT COSTS
## STEEL INDUSTRY

### Open Hearth Furnace Subcategory

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | A | BPCTCA B | C | BATEA D | E |
|---|---|---|---|---|---|
| Investment | $ 892,416 | $ 27,203 | $ 505,700 | $ 1,567,347 | $ 468,822 |
| **Annual Costs:** | | | | | |
| Capital | 38,373 | 1,170 | 21,745 | 67,395 | 20,160 |
| Depreciation | 89,242 | 2,720 | 50,570 | 156,735 | 46,882 |
| Operation & Maintenance | 31,235 | 952 | 17,700 | 54,857 | 16,408 |
| Sludge Disposal | 40,515 | | | 4 | |
| Energy & Power | 12,750 | 675 | 12,000 | 12,000 | 7,500 |
| Chemical | | 40,500 | 1,140 | 17,872 | 28 |
| TOTAL | $ 212,115 | $ 46,017 | $ 103,155 | $ 308,863 | $ 90,978 |

**Effluent Quality:**

| Effluent Constituents Parameters – units | Raw Waste Load | Resulting Effluent Levels | | BPCTCA | | |
|---|---|---|---|---|---|---|
| Flow, gal/ton | 600 | 600 | 600 | 50 | 50 | 50 |
| Suspended solids, mg/1 | 2,000 | 80 | 50 | 50 | 25 | 10 |
| Fluoride, mg/1 [1] | 20 | 20 | 20 | 100 [2] | 20 | 5 |
| Nitrate, mg/1 [1] | 35 | 35 | 35 | 150 [2] | 45 | 45 |
| Zinc, mg/1 [1] | 400 | 220 | 200 | 25 [2] | 5 | 3 |
| pH | 3-7 | 3-7 | 3-7 | 6-9 | 6-9 | 6-9 |

[1] A wide range in fluoride, nitrate, and zinc levels are found depending on types of of raw materials used, fuels, and other operating conditions.
[2] Value to be expected from typical treatment plant utilizing BPCTCA treatment technology

TABLE 51

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: Electric Arc Furnace (Semi-Wet)

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| A. Discharge from spark box or flame trap to classifier to thickener; overflow recycled to spark box or flame trap; underflow through vacuum filters, filtrate returns to thickener; sludge to sinter or landfill. | SS<br>F⁻<br>pH | $\frac{mg/l}{0}$<br>0<br>- | Currently practiced by steel plants of this type. Excellent | No reduction of heat load. Spray system requires much maintenance. | 12 months | 1/8 acre (50' x 100') | Air: Particulate 0.1#/1000# exhaust gases | Solids consumed internally or used as landfill. |

* Listed in order of increasing effectiveness

TABLE 51 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Electric Arc Furnace (Semi-wet Air Pollution Methods) Subcategory

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | BPCTCA BATEA | | | |
|---|---|---|---|---|
| Investment | $ 615,825 | | | |
| Annual Costs: | | | | |
| Capital | 26,481 | | | |
| Depreciation | 61,582 | | | |
| Operation & Maintenance | 21,554 | | | |
| Energy & Power | 17,550 | | | |
| Sludge Disposal | 7,446 | | | |
| Chemical | 1,500 | | | |
| | | | | |
| | | | | |
| TOTAL | $ 136,113 | | | |

| Effluent Quality: Effluent Constituents Parameters   -   units | Raw Waste Load | Resulting Effluent Levels | | | |
|---|---|---|---|---|---|
| Flow, gal/ton | 100 | 0 | | | |
| Suspended solids,mg/l | 2,000 | 0 | | | |
| Fluoride, mg/l | 25 | 0 | | | |
| pH | 6-9 | - | | | |

TABLE 52

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: Electric Arc Furnace (Wet)

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| A. Aqueous discharge from scrubber & separator thru classifier to a thickener. "Once-thru" thickener overflow to sewer, underflow thru vacuum filters, filter cake recycled to sinter plant or landfilled, filtrate recycled to thickener. | SS<br>F⁻<br>Zn<br>pH | mg/l<br>100<br>20<br>16<br>6-9 | Used in steel industry; good. Minimum maintenance and downtime. | No reduction of heat load. must control surges. Most EAF plants have no sinter plants nearby. | 18 months | 1 acre (200' x 200') | Air:<br>Particulate 0.1#/1000# exhaust gases | Solid wastes consumed internally or used as landfill. |
| B. Same as Item (A) but with thickener magnetic and/or chemical polymer flocculation. | SS<br>F⁻<br>Zn<br>pH | 50<br>20<br>16<br>6-9 | Used in steel industry; good. | Same as Item (A) | 18 months | 1 acre (200' x 200') | Air:<br>Particulate 0.1#/1000# exhaust gases | Solid wastes consumed internally or used as landfill. |

* Listed in order of increasing effectiveness

TABLE 52 (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: Electric Arc Furnace (Wet)

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| | | mg/l | | | | | | |
| C. Same as Item B except thickener overflow recycled to scrubber system with blowdown. | SS<br>F⁻<br>Zn<br>pH | 50<br>75<br>10<br>6-9 | Widely used in steel industry. Very good. | Same as Item (A) | 18 months | 1 acre (200'x 200') | Air: Particulate 0.1#/1000# exhaust gases | Solid wastes consumed internally or used as landfill. |
| D. Same as Item C except blowdown treated with lime addition, neutralization, and sedimentation. | SS<br>F⁻<br>Zn<br>pH | 25<br>20<br>5<br>6-9 | Currently in use by some plants in other industries; technically transferable. Excellent. | Same as Item (A) | 18 months | 1-1/2 acre (200' x 300') | Air: Particulate 0.1#/1000# exhaust gases | Solid wastes consumed internally or used as landfill. |
| E. Same as Item D, except additional treatment of blowdown with activated alumina and pressure filtration. | SS<br>F⁻<br>Zn<br>pH | 10<br>5<br>3<br>6-9 | Used in water treatment industry; technically transferable. Excellent. | Same as Item (A) | 18 months | 1-1/2 acre (200'·x 300") | Air: Particulate 0.1#/100# exhaust gases | Solid wastes consumed internally or used as landfill. |

* Listed in order of increasing effectiveness

TABLE 52 (Cont.)

## WATER EFFLUENT TREATMENT COSTS
## STEEL INDUSTRY

Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | A | BPCTCA | | BATEA | E |
|---|---|---|---|---|---|
| | | B | C | D | |
| Investment | $ 493,740 | $ 27,203 | $ 194,820 | $ 286,148 | $ 230,025 |
| Annual Costs: | | | | | |
| Capital | 21,231 | 1,170 | 8,377 | 12,304 | 9,890 |
| Depreciation | 49,374 | 2,720 | 19,482 | 28,615 | 23,003 |
| Operation & Maintenance | 17,280 | 952 | 6,819 | 10,015 | 8,050 |
| Energy & Power | 12,450 | 675 | 5,625 | 7,500 | 1,500 |
| Sludge Disposal | 11,716 | | | 416 | |
| Chemical | | 4,200 | | 720 | 7 |
| | | | | | |
| TOTAL | $ 112,051 | $ 9,717 | $ 40,303 | $ 59,570 | $ 42,450 |

Effluent Quality:

| Effluent Constituents Parameters   -   units | Raw Waste Load | Resulting Effluent Levels | | | | |
|---|---|---|---|---|---|---|
| | | | | BPCTCA | BATEA | |
| Flow, gal/ton | 240 | 240 | 240 | 50 | 50 | 50 |
| Suspended solids, mg/l | 3,500 | 100 | 50 | 50 | 25 | 10 |
| Fluoride, mg/l | 20 | 20 | 20 | 75 [1] | 20 | 5 |
| Zinc, mg/l | 20 | 16 | 16 | 10 [1] | 5 | 3 |
| pH | 6-9 | 6-9 | 6-9 | 6-9 | 6-9 | 6-9 |

(1) Value to be expected from typical treatment plant utilizing BPCTCA treatment technology

Although the furnace exhaust fumes will have been scrubbed, 0.1 kkg of particulate emission per kkg(lb/lb) of exhaust gases will be emitted into the atmosphere.

b.  Solid Waste Disposal: The solid waste that will be generated by the fume collection system for the electric furnace (semiwet) process of steelmaking should present no problem. It can be internally consumed in the sinter process plant.

## Wet Systems

1.  Base Level of Treatment: Once-through system. The water treatment system is comprised of a classifier, thickener, and vacuum filter for dewatering of solids.

2.  Additional Power Requirements: To bring the quality of the effluent of the water treatment system utilized in the fume collection of the electric furnace (wet) steel manufacturing process up to the EPA standard for 1977, additional energy will be necessary. The additional energy consumed will be 0.92 kwh/kkg (0.83 kwh/ton) of steel made. The additional power required for the typical 1,652 kkg/day (1,820 tons/day) facility of this type will be 63 kw (84 hp). The annual operating cost for this additional consumption of power will be approximately $6,300.00.

3.  Non-Water Quality Aspects

    a.  Air Pollution: The air pollution problem of primary significance in the electric furnace (wet) method of steelmaking will be particulate emissions. Although the furnace exhaust fumes will be passed through a dust removing bath, 0.1 kg of suspended particulate matter per kkg(lb/1,000 lb) of exhaust gases will be emitted into the atmosphere.

    b.  Solid Waste Disposal: There should be no problem in disposing of the solid waste generated by the fume collection system for the electric furnace (wet) process for the manufacture of steel. It can be internally consumed in the sinter process plant.

## Vacuum Degassing

1.  Base Level of Treatment: Once-through system. Treatment involves a scale removal classifier.

2.  Additional Energy Requirements: Additional power will be necessary when bringing the quality of the effluent from the water treatment system utilized in the barometric condensers for the vacuum degassing process up to the anticipated standard for 1977. The additional energy utilized will be 11.4 kwh/kkg (10.3 kwh per ton) of steel produced. For the

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typical 472 kkg/day (520 tons/day) vacuum degassing facility, the additional power required will be 224 kw (300 hp). The annual operating cost for this additional power consumption will be approximately $22,500.00.

3. Non-Water Quality Aspects

   a. Air Pollution: Non-condensable gases are vented to the atmosphere during degassing.

   b. Solid Waste Disposal: The solid waste that will be generated by the creation of a vacuum for the degassing process should present no problem. It can be internally consumed in the sinter process plant.

## Continuous Casting

1. Base Level of Treatment: Recycle system utilizing scale pit settling, oil skimming, flat bed filtration and cooling towers.

2. Additional Energy Requirements: Additional power will not be required to meet proposed standards for 1977 since the base level is the BPCTCA treatment model.

3. Non-Water Quality Aspects

   a. Air Pollution: Non-condensable gases and fumes are generated during continuous casting operations but to a relatively minor extent.

   b. Solid Waste Disposal: The solid waste generated can be consumed internally in the sinter plant.

## Advanced Technology, Energy and Nonwater Impact

The energy requirements and nonwater quality aspects associated with the advanced treatment technology for each subcategory are discussed below.

## By-Product Coke

1. Additional energy requirements:

   a. Treatment Alternative I:

   To improve the quality of the waste water treatment systems effluent from the anticipated 1977 standard to the anticipated 1983 standard, additional power consuming equipment is necessary. The additional power requirements will be 373 kw (500 hp) for the typical 2,414 kkg/day (2,660 ton/day) by-product coke making facility. The annual operating cost for this additional equipment will be $37,500.00.

TABLE 53

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY: Vacuum Degassing

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| A. Scale sump or settling basin for solids removal. "Once-through"- overflow to sewer. Solids recycled to Sinter plant. | SS<br>Pb<br>Mn<br>NO$_3^-$<br>Zn<br>pH | mg/l<br>100<br>2.5<br>15<br>80<br>20<br>6-9 | Used in steel industry. | Surges must be controlled. No reduction in heat load. | 18 months | 1 acre (200'x200') | Gases pass off to atmosphere | Solids consumed internally |
| B. Same as Item (A) except overflow recycled via cooling tower to degassing unit with blowdown to sewer. | SS<br>Pb<br>Mn<br>NO$_3^-$<br>Zn<br>pH | 50<br>2.0<br>10<br>175<br>15<br>6-9 | Used in steel industry. | Surges must be controlled. No reduction in heat load. | 18 months | 1 acre (200'x 200') | Gases pass off to atmosphere | Solids consumed internally. |
| C. Same as Item (B) except blowdown is treated by lime addition; coagulation/ flocculation; anaerobic de-nitrification; neutralization; and final clarification. | SS<br>Pb.<br>Mn<br>NO$_3^-$<br>Zn<br>pH | 25<br>0.5<br>5<br>45<br>5<br>6-9 | Some treatment methods used in this and related industries. Denitrification is not necessary where N$_2$ is not used in the process. Very good. | Surges must be controlled. No reduction in heat load. Denitrification untested on steel plant wastes. | 18 months | 1/2 acre (100' x 200') | Gases pass off to atmosphere | Solids consumed internally. Additional solids from lime treatment to landfill. |

* Listed in order of increasing effectiveness

TABLE   53 (cont.)

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY:   Vacuum Degassing

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| D.  Same as Item (C) except for final treatment of blowdown via pressure filtration. | SS Pb Mn NO$_3^-$ Zn pH | $\frac{mg/l}{10}$ 0.3 3 45 3 6-9 | Used in steel industry. Very good. | Surges must be controlled.  No reduction in heat load. | 18 months | 1/4 acre (100' x 100') | Gases pass off to atmosphere | Solids consumed internally. Additional solids to landfill. |

* Listed in order of increasing effectiveness

TABLE 53 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Vacuum Degassing Subcategory

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | A | BPCTCA B | BATEA C | D |
|---|---|---|---|---|
| Investment | $ 259,774 | $ 423,797 | $ 307,170 | $ 60,008 |
| **Annual Costs:** | | | | |
| Capital | 11,170 | 18,224 | 13,208 | 2,581 |
| Depreciation | 25,977 | 42,379 | 30,717 | 6,000 |
| Operation & Maintenance | 9,092 | 14,832 | 10,750 | 2,100 |
| Sludge Disposal | 36 | | 31 | |
| Energy & Power | | 22,500 | 29,250 | 2,250 |
| Chemical | | | 753 | |
| TOTAL | $ 46,275 | $ 97,935 | $ 84,709 | $ 12,931 |

| Effluent Quality: Effluent Constituents Parameters - units | Raw Waste Load | Resulting Effluent Levels | | | |
|---|---|---|---|---|---|
| Flow, gal/ton | 560 | 560 | 25 | 25 | 25 |
| Suspended solids,mg/l | 200 | 100 | 50 | 25 | 10 |
| Lead, mg/l | 3.0 | 2.5 | 2.0 (3) | 0.5 | 0.3 |
| Manganese, mg/l | 20 | 15 | 10 (3) | 5 | 3 |
| Nitrate, mg/l (1) | 80 | 80 | 175 (3) | 45 | 45 |
| Zinc, mg/l (2) | 30 | 20 | 15 (3) | 5 | 3 |
| pH | 5-10 | 6-9 | 6-9 (3) | 6-9 | 6-9 |

(1) If nitrogen gas is used to purge system, nitrate concentrations can be
    very high. If inert gases are used, nitrates are negligible

(2) Zinc concentration depends on type of scrap used in steelmaking process

(3) Value expected of typical treatment plant utilizing BPCTCA technology

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TABLE 54

IRON AND STEELMAKING OPERATIONS
CONTROL AND TREATMENT TECHNOLOGY
FOR RELATED CATEGORIES AND SUBCATEGORIES

CATEGORY/SUBCATEGORY:  Continuous Casting

| Treatment and/or Control Methods Employed* | Resulting Effluent Levels for Critical Constituents | | Status and Reliability | Problems and Limitations | Implementation Time | Land Requirements | Environmental Impact Other Than Water | Solid Waste Generation and Primary Constituents |
|---|---|---|---|---|---|---|---|---|
| | | mg/l | | | | | | |
| A. Recycle system with scale pit; overflow recycled via flat bed filter to cooling tower to caster spray system with blowdown to sewer. Oil skimming at scale pit surface. | SS<br>O & G<br>pH | 50<br>15<br>6↔9 | Used in this industry. Good. Scale and oil removal facilities must be maintained. | No reduction in heat load. Pit must be kept clean to prevent solids build up and washover. | 12 mo. | 1/8 acre (50'x 100') | None | Solids consumed internally. Oil sold for reprocessing or incinerated. |
| B. Same as Item A except blowdown treatment by pressure filtration. | SS<br>O & G<br>pH | 10<br>10<br>6↔9 | Widely used in this industry. Excellent. Scale and oil removal facilities must be maintained. | No reduction in heat load Pit must be kept clean to prevent solids build up and washover. | 15 mo. | 1/4 acre (100' x 100') | None | Solids consumed internally. Additional solids to landfill. |

* Listed in order of increasing effectiveness

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TABLE 54 (Cont.)

WATER EFFLUENT TREATMENT COSTS
STEEL INDUSTRY

Continuous Casting Subcategory

| Treatment or Control Technologies Identified under Item III of the Scope of Work: | BPCTCA | BATEA | | |
|---|---|---|---|---|
| | A | B | | |
| Investment | 1,980,816 | 99,170 | | |
| Annual Costs: | | | | |
| Capital | 85,175 | 4,264 | | |
| Depreciation | 198,081 | 9,917 | | |
| Operation & Maintenance | 69,328 | 3,470 | | |
| Sludge Disposal | 730 | - | | |
| Energy & Power | 36,975 | 9,000 | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| TOTAL | 390,289 | 26,651 | | |

| Effluent Quality: Effluent Constituents Parameters - units | Raw Waste Load | Resulting Effluent Levels | | | |
|---|---|---|---|---|---|
| Flow, gal/ton | 4200 | 125 | 125 | | |
| Oil & grease, mg/l | 30 | 15 | 10 | | |
| Suspended solids, mg/l | 50 | 50 | 10 | | |
| pH | 6-9 | 6-9 | 6-9 | | |

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b.   Treatment Alternative II:

Additional power will be necessary to improve the effluent water discharges to meet anticipated 1983 standards. The additional power consumption will be 2.02 kwh/kkg (1.83 kwh/ton) of steel produced. The additional power requirements will be 223.8 kw (300 hp) for the typical 2,424 kkg/day (2,600 ton/day) by-product coke making facility. The annual operating cost due to this additional equipment will be $22,500.00.

2.   Non-Water Quality Aspects (Both Alternates):

a.   Air Pollution: Same as 1977

b.   Solid Waste Disposal:   Same as 1977

## Beehive Coke

1.   Additional Energy Requirements: No additional power will be required to comply with the anticipated 1983 EPA standard.

2.   Non-Water Quality Aspects

a.   Air Pollution:  Same as 1977

b.   Solid Waste Disposal:  Same as 1977

## Sintering

1.   Additional Power Requirements: To improve the quality of the waste water treatment system effluent from the anticipated 1977 standard to the anticipated 1983 standard, additions will have to be made to the system. The additional energy consumption will be 1.31 kwh/kkg (1.18 kwh/ton) of sinter produced. For the typical 2,704 kkg/day (2,980 tons/day) facility 147 kw (197 hp) will have to be added to the system. The operating cost for this 147 kw (197 hp) will be $14,755.00 per year.

2.   Non-Water Quality Aspects

a.   Air Pollution:  Same as 1977

b.   Solid Waste Disposal:  Same as 1977

## Blast Furnace (Iron)

1.   Additional Power Requirements:  To bring the quality of the effluent of the waste water treatment system used in the dust cleaning of the blast furnace (iron) making process from the anticipated standard for 1977 to the anticipated standard for 1983, requires additional electrical powered equipment. The additional energy consumption will be 0.68 kwh/kkg (.62 kwh/ton) of iron produced. For the typical 2,995 kkg/day

(3,300 tons/day) blast furnace facility, the additional power required will be 85.8 kw (115 hp). The annual operating cost for the additional equipment will be approximately $8,625.00.

2. Non-water Quality Aspects

   a. Air Pollution:  Same as 1977

   b. Solid Waste Disposal:  Same as 1977

## Blast Furnace (Ferromanganese)

1. Additional Power Requirements:  Additional electrically powered equipment will have to be added to the 1977 system to improve the waste water treatment system effluent to meet the anticipated standard for 1983. The additional energy consumed will be 1.71 kwh/kkg (1.55 kwh/ton) of iron produced. For the average 744 kkg/day (820 tons/day) facility, the additional power required will be 53 kw (71 hp). The additional operating cost will be approximately $5,325.00 per year.

2. Non-Water Quality Aspects

   a. Air Pollution:  Same as 1977

   b. Solid Waste Disposal:  Same as 1977

## Basic Oxygen Furnace Operation

## Semi-Wet Systems

1. Additional Power Requirements:  No additional power will be necessary to bring the water quality to meet the anticipated 1983 standard.

2. Non-Water Quality Aspects:

   a. Air Pollution:  Same as 1977

   b. Solid Waste Disposal:  Same as 1977

## Wet Systems

1. Additional Power Requirements:  Additional equipment will be required to improve the waste water system to the anticipated 1983 standard. The additional energy consumption will be 0.15 kwh/kkg (.14 kwh/ton) of steel produced. For the typical 6,888 kkg/day (7,590 tons/day) BOF wet facility, the additional power required will be 105 kw (141 hp). The annual operating cost for the consumption of this extra power will be approximately $10,575.00.

2. Non-Water Quality Aspects

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a.  Air Pollution: The additional waste water equipment required will not affect the quality of the exhaust gases released to the atmosphere. The particulate emissions will be the same as they were for 1977.

b.  Solid Waste Disposal: Same as 1977

## Open Hearth Furnace

1.  Additional Power Requirements: Additional equipment will be required to improve the quality of the wastewater treatment system utilized in the fume collection of the open hearth steel manufacturing process to the anticipated standard for 1983. The additional energy consumption will be 0.45 kwh/kkg (0.39 kwh/ton) of steel produced. For the typical 6,716 kkg/day (7,400 tons/day) open hearth facility, the additional power required will be 119 kw (160 hp). The annual operating cost for the consumption of this added power will be approximately $12,000.00.

2.  Non-Water Quality Aspects

a.  Air Pollution: The additional waste water equipment required will not affect the quality of the exhaust gases released to the atmosphere. The particulate emissions will be the same as they were for 1977.

b.  Solid Waste Disposal: Same as 1977.

## Electric Arc Furnaces

### Semi-Wet Systems

1.  Additional Power Requirements: No additional power requirements over 1977.

2.  Non-Water Quality Aspects

a.  Air Pollution: Same as 1977

b.  Solid Waste Disposal: Same as 1977

### Wet Systems

1.  Additional Power Requirements: Additional equipment will be required to improve the quality of the effluent of the waste water treatment system utilized in the fume collection of the electric furnace (wet) steel manufacturing process to meet the anticipated standard for 1983. The additional energy consumption will be 0.98 kwh/kkg (0.89 kwh/ton) of steel produced. For the typical 1,652 kkg/day (1,820 tons/day) electric furnace (wet) facility, the additional power required will be 75 kw (100 hp). The annual operating cost for the consumption of this extra power will be approximately $7,500.00.

2. Non-Water Quality Aspects

   a. Air Pollution: The additional equipment required will
      not affect the quality of the exhaust gases released to
      the atmosphere. The particulate emissions will be the
      same as they were at 1977.

   b. Solid Waste Disposal: Same as 1977

## Vacuum Degassing

1. Additional Power Requirements: To improve the quality of the
   waste water treatment system effluent to the anticipated 1983
   standard, will require additional equipment. The additional
   power requirement is 291 kw (390 hp) or 15.9 kwh/kkg (14.4
   kwh/ton) of steel produced. The cost to operate this
   additional equipment will be $29,250.00.

2. Non-Water Quality Aspects

   a. Air Pollution: Same as 1977

   b. Solid Waste Disposal: Same as 1977

## Continuous Casting Operation

1. Additional Power Requirements: Additional equipment will be
   required to improve the water to meet the anticipated 1983
   standard. The additional energy consumption will be 2.2
   kwh/kkg (2.0 kwh/ton) of steel produced. The additonal power
   requirements will be 89.5 kw (120 hp) for the typical 971
   kkg/day (1070 ton/day) continuous casting facility. The
   annual operating cost due to the addition of this equipment
   will be $9,000.

2. Non-Water Quality Aspects

   a. Air Pollution: Same as 1977

   b. Solid Waste Disposal: Same as 1977

## Full Range of Technology in Use or Available to the Steel Industry

The full range of technology in use or available to the steel
industry today is presented in Tables 44 to 54. In addition to
presenting the range of treatment methods available, these tables
also describe for each method:

1. Resulting effluent levels for critical constituents

2. Status and reliability

3. Problems and limitations

4.  Implementation time

5.  Land requirements

6.  Environmental impacts other than water

7.  Solid waste generation

## Basis of Cost Estimates

Costs associated with the full range of treatment technology including investment, capital depreciation, operating and maintenance, and energy and power, are presented on water effluent cost tables corresponding to the appropriate category technology in Tables 44 to 54.

Costs were developed as follows:

1.  National annual production rate data was collected and tabulated along with the number of plants in each subcategory. From this, an "average" size plant was established.

2.  Flow rates were established based on the data accumulated during the survey portion of this study and from knowledge of what flow reductions could be obtained with minor modifications. The flow is here expressed in l/kkg or gal/ton of product.

3.  Then a treatment process model and flow diagram was developed for each subcategory.

    This was based on knowledge of how most industries in a certain subcategory handle their wastes, and on the flow rates established by 1 and 2 above.

4.  Finally, a quasi-detailed cost estimate was made on the basis of the developed flow diagram.

Total annual costs in August, 1971, dollars were developed by adding to the total operating costs (including all chemicals, maintenance, labor, energy and power) the capital recovery costs. Capital recovery costs consist of the depreciation and interest charges based on a ten year straight line depreciation and on a 7% interest rate, respectively.

The capital recovery factor (CRF) is normally used in industry to help allocate the initial investment and the interest to the total operating cost of a facility. The CFR is equal to i plus i divided by a-1, where a is equal to 1 + i to the power n. The CFR is multiplied by the initial investment to obtain the annual capital recovery. That is: (CFR) (P) = ACR. The annual depreciation is found by dividing the initial investment by the depreciation period (n = 10 years). That is, P/10 = annual depreciation. Then the annual cost of capital has been assumed

to be the total annual capital recovery minus the annual depreciation. That is, ACR - P/10 = annual cost of capital.

Construction costs are dependent upon many different variable conditions and in order to determine definitive costs the following parameters were established as the basis of estimates. In addition, the cost estimates as developed reflect only average costs.

a. The treatment facilities are contained within a "battery limit" site location and are erected on a "green field" site. Site clearance costs such as existing plant equipment relocation, etc., are not included in cost estimates.

b. Equipment costs are based on specific effluent water rates. A change in water flow rates will affect costs.

c. The treatment facilities are located in close proximity to the steelmaking process area. Piping and other utility costs for interconnecting utility runs between the treatment facilities' battery limits and process equipment areas are not included in cost estimates.

d. Sales and use taxes or freight charges are not included in cost estimates.

e. Land acquisition costs are not included in cost estimates.

f. Expansion of existing supporting utilities such as sewage, river water pumping stations, and increased boiler capacity are not included in cost estimates.

g. Potable water, fire lines and sewage lines to service treatment facilities are not included in cost estimates.

h. Limited instrumentation has been included for pH and fluoride control, but no automatic samplers, temperature indicators, flow meters, recorders, etc., are included in cost estimates.

j. The site conditions are based on:

1. No hardpan or rock excavation, blasting, etc.
2. No pilings or spread footing foundations for poor soil conditions.
3. No well pointing.
4. No dams, channels, or site drainage required.
5. No cut and fill or grading of site.
6. No seeding or planting of grasses and only minor site grubbing and small shrubs clearance; no tree removal.

k. Controls buildings are prefabricated buildings, not brick or block type.

l. No painting, pipe insulation, and steam or electric heat tracing are included.

m. No special guardrails, buildings, lab test facilities, signs, or docks are included.

Other factors that affect costs but cannot be evaluated:

a. Geographic location in United States.

b. Metropolitan or rural areas.

c. Labor rates, local union rules, regulations, and restrictions.

d. Manpower requirements.

e. Type of contract.

f. Weather conditions or season.

g. Transportation of men, materials, and equipment.

h. Building code requirements.

j. Safety requirements.

k. General business conditions.

The cost estimates do reflect an on-site "Battery Limit" treatment plant with electrical sub-station and equipment for powering the facilities, all necessary pumps, treatment plant interconnecting feed pipe lines, chemical treatment facilities, foundations, structural steel, and control house. Access roadways within battery limits area are included in estimates based upon 3.65 cm (1.5 inch) thick bituminous wearing course and 10 cm (4 inch) thick sub-base with sealer, binder, and gravel surfacing. A 9 gage chain link fence with three strand barb wire and one truck gate was included for fencing in treatment facilities area.

The cost estimates also include a 15% contingency, 10% contractor's overhead and profit, and engineering fees of 15%.

# SECTION IX

## EFFLUENT QUALITY ATTAINABLE THROUGH THE APPLICATION OF THE BEST PRACTICABLE CONTROL TECHNOLOGY CURRENTLY AVAILABLE

### EFFLUENT LIMITATIONS GUIDELINES

## Introduction

The effluent limitations which must be achieved by July 1, 1977, are to specify the effluent quality attainable through the application of the Best Practicable Control Technology Currently Available. Best Practicable Control Technology Currently Available is generally based upon the average of the best existing performance by plants of various srize the, ages and unit processes within the industrial subcategory. This average is not based upon a broad range of plants within the steel industry, but based upon performance levels achieved by plants purported by the industry or by regulatory agencies to be equipped with the best treatment facilities. Experience demonstrated that in some instances these facilities were exemplary only in the control of a portion of the waste parameters present. In those industrial categories where present control and treatment practices are uniformly inadequate, a higher level of control than any currently in place may be required if the technology to achieve such higher level can be practicably applied by July 1, 1977.

Considerations must also be given to:


a. the size and age of equipment and facilities involved

b. the processes employed

c. non-water quality environmental impact (including energy requirements)

d. the engineering aspects of the application of various types of control techniques

e. process changes

f. the total cost of application of technology in relation to the effluent reduction benefits to be achieved from such application.

Also, Best Practicable Control Technology Currently Available emphasrize the treatment facilities at the end of a manufacturing process but includes the control technologies within the process itself when the latter are considered to be normal practice within an industry.

A further consideration is the degree of economic and engineering reliability which must be established for the technology to be "currently available." As a result of demonstration projects, pilot plants and general use, there must exist a high degree of confidence in the engineering and economic practicability of the technology at the time of commencement of construction or installation of the control facilities.

## Rationale for Selection of BPCTCA

The following paragraphs summarize the factors that were considered in selecting the categorization, water use rates, level of treatment technology, effluent concentrations attainable by the technology, and hence, in the establishment of the effluent limitations for BPCTCA.

Size and Age of Facilities and Land Availability Considerations:

As discussed in Section IV, the age and size of steel industry facilities has little direct bearing on the quantity or quality of wastewater generated. Thus, the ELG for a given subcategory of waste source applies equally to all plants regardless of size or age. Land availability for installation of add-on treatment facilities can influence the type of technology utilized to meet the ELG's. This is one of the considerations which can account for a range in the costs that might be incurred.

Consideration of Processes Employed:

All plants in a given subcategory use the same or similar production methods, giving similar discharges. There is no evidence that operation of any current process or subprocess will substantially affect capabilities to implement the best practicable control technology currently available. At such time that new processes, such as direct reduction, appear imminent for broad application the ELG's should be amended to cover these new sources. No changes in processes employed are envisioned as necessary for implementation of this technology for plants in any subcategory. The treatment technologies to achieve BPCTCA are end of process methods which can be added onto the existing treatment facilities.

Consideration of Nonwater Quality Environmental Impact:

Impact of Proposed Limitations on Air Quality:

The increased use of recycle systems and stripping columns have the potential for increasing the loss of volatile substances to the atmosphere. Recycle systems are so effective in reducing waste water volumes, and hence waste loads to and from treatment systems, and in reducing the size and cost of treatment systems that a tradeoff must be accepted. Recycle systems requiring the use of cooling towers have contributed significantly to reductions of effluent loads while contributing only minimally to air pollution problems. Stripper vapors have been successfully

recovered as usable byproducts or can be routed to incinerators. Careful operation of either system can avoid or minimize air pollution problems.

Impact of Proposed Limitations on Solid Waste Problems:

Consideration has also been given to the solid waste aspects of water pollution controls. The processes for treating the waste waters from this industry produce considerable volumes of sludges. Much of this material is inert iron oxide which can be reused profitably. Other sludges not suitable for reuse must be disposed of in landfills since they are composed chiefly of chemical precipitates which could be little reduced by incineration. Being precipitates, they are by nature relatively insoluble and non- hazardous substances requiring minimal custodial care.

In order to ensure long-term protection of the environment from harmful constituents, special consideration of disposal sites should be made. All landfill sites should be selected so as to prevent horizontal and vertical migration of these contaminants to ground or surface waters. In cases where geologic conditions may not reasonably ensure this, adequate mechanical precautions (e.g., impervious liners) should be taken to ensure long-term protection to the environment. A program of routine periodic sampling and analysis of leachates is advisable. Where appropriate the location of solid hazardous materials disposal sites, if any, should be permanently recorded in the appropriate office of legal jurisdiction.

Impact of Proposed Limitations on Energy Requirements:

The effects of water pollution control measures on energy requirements has also been determined. The additional energy required in the form of electric power to achieve the effluent limitations proposed for BPCTCA and BATEA amounts to less than 1.5% of the 51.6 billion kwh of electrical energy used by the steel industry in 1972.

The enhancement to water quality management provided by these proposed effluent limitations substantially outweighs the impact on air, solid waste, and energy requirements.

Consideration of the Engineering Aspects of the Application of Various Types of Control Techniques:

The level of technology selected as the basis for BPCTCA limitations is considered to be practicable in that the concepts are proven and are currently available for implementation and may be readily applied as "add-ons" to existing treatment facilities.

Consideration of Process Changes:

No in-process changes will be required to achieve the BPCTCA limitations although recycle water quality changes may occur as a

result of efforts to reduce effluent discharge rates. Many plants are employing recycle, cascade uses, or treatment and recycle as a means of minimizing water use and the volume of effluents discharged. The limitations are load limitations (unit weight of pollutant discharged per unit weight of product) only and not volume or concentration limitations. The limitations can be achieved by extensive treatment of large flows; however, an evaluation of costs indicates that the limitations can usually be achieved most economically by minimizing effluent volumes.

Consideration of Costs versus Effluent Reduction Benefits:

In consideration of the costs of implementing the BPCTCA limitations relative to the benefits to be derived, the limitations were set at values which would not result in excessive capital or operating costs to the industry.

To accomplish this economic evaluation, it was necessary to establish the treatment technologies that could be applied to each subcategory in an add-on fashion, the effluent qualities attainable with each technology, and the costs. In order to determine the added costs, it was necessary to determine what treatment processes were already in place and currently being utilized by most of the plants. This was established as the base level of treatment.

Treatment systems were then envisioned which, as add-ons to existing facilities, would achieve significant waste load reductions. Capital and operating costs for these systems were then developed for the average size facility. The average size was determined by dividing the total industry production by the number of operating facilities. The capital costs were developed from a quasi-detailed engineering estimate of the cost of the components of each of the systems. The annual operating cost for each of the facilities was determined by summing the capital recovery (basis ten year straight line depreciation) and capital use (basis 7% interest) charges, operating and maintenance costs, chemical costs, and utility costs.

Cost effectiveness diagrams were then prepared to show the pollution reduction benefits derived relative to the costs incurred. As expected, the diagrams show an increasing cost for treatment per percent reduction obtained as the percent of the initial pollutional load remaining decreased. The BPCTCA limitations were set at the point where the costs per percent pollutant reduction took a sharp break upward toward higher costs per percent of pollutant removed. These cost effectiveness diagrams are presented in Section X.

The initial capital investment and annual expenditures required of the industry to achieve BPCTCA were developed by multiplying the costs (capital or annual) for the average size facility by the number of facilities operating for each subcategory. These costs are summarized in Table 79 in Section X.

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After selection was made of the treatment technology to be designated as one means to achieve the BPCTCA limitations for each subcategory, a sketch of each treatment model was prepared. The sketch for each subcategory is presented following the table presenting the BPCTCA limitations for the subcategory.

## Identification of Best Practicable Control Technology Currently Available - BPCTCA

Based on the information contained in Sections III through VIII of this report, a determination has been made that the quality of effluent attainable through the application of the Best Practicable Control Technology Currently Available is as listed in Tables 55 through 66. These tables set forth the ELG's for the following subcategories of the steel industry:

| | |
|---|---|
| I | By-Product Coke Subcategory |
| II | Beehive Coke Subcategory |
| III | Sintering Subcategory |
| IV | Blast Furnace (Iron) Subcategory |
| V | Blast Furnace (Ferromanganese) Subcategory |
| VI | Basic Oxygen Furnace (Semiwet Air Pollution Control Methods) Subcategory |
| VII | Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory |
| VIII | Open Hearth Furnace Subcategory |
| IX | Electric Arc Furnace (Semiwet Air Pollution Control Methods) Subcategory |
| X | Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory |
| XI | Vacuum Degassing Subcategory |
| XII | Continuous Casting Subcategory |

ELG's have not been set for Pelletizing and Briquetting Operations because plants of this type were not found to be operating as an integral part of any steel mill. These operations will be considered in mining regulations to be proposed at a later date since they are normally operated in conjunction with mining operations.

In establishing the subject guidelines, it should be noted that the resulting limitations or standards are applicable to aqueous waste discharge only, exclusive of non-contact cooling waters. In the section of this report which discusses control and

specific contaminants listed. In each case where inadequate control was found, corrective measures could be applied to attain recommended sources.

The rationale used for developing the BPCTCA effluent limitations guidelines is summarized below for each of the subcategories. All effluent limitations guidelines are presented on a "gross" basis since for the most part, removals are relatively independent of initial concentrations of contaminants. The ELG's are in kilograms of pollutant per metric ton of product or in pounds of pollutant per 1,000 pounds of product and in these terms only. The ELG's are not a limitation on flow, type of technology to be utilized, or concentrations to be achieved. These items are listed only to show the basis for the ELG's and may be varied as the discharger desires so long as the ELG loads per unit of production are met.

## By-Product Coke Operation

Following is a summary of the factors used to establish the effluent limitations guidelines applying to the by-product coke operation. As far as possible, the stated limits are based upon performance levels attained by the selected coke plants surveyed during this study. Where treatment levels can be improved by application of additional, currently available control and treatment technology, the anticipated reduction of waste loads was included in the estimates. Three of the four plants surveyed were producing less than 730 l of effluent/kkg (175 gal/ton) of coke produced. The fourth plant was diluting their effluent with contaminated final cooler water. Two of the four plants were disposing of a portion of their wastes in coke quenching. Even if this practice is discontinued, it can still be shown by analysis of the plants surveyed, the data presented by Black, McDermott, et al (Reference 22), and by employing internal recycle followed by minimal blowdown on the final cooler waters, that the effluent can be reduced to 730 l/kkg (175 gal/ton). This is summarized as follows:

| | | |
|---|---|---|
| Waste ammonia liquor | 104 l/kkg | 25 gal/ton |
| Steam condensate, lime slurry | 75 l/kkg | 18 gal/ton |
| Benzol plant wastes | 125 l/kkg | 30 gal/ton |
| Final cooler blowdown | 84 l/kkg | 20 gal/ton |
| Barometric condenser effluent | 342 l/kkg | 82 gal/ton |
| TOTAL | 730 l/kkg | 175 gal/ton |

The ELG's were therefore established on an effluent flow basis of 730 l/kkg (175 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies.

Some by-product coke plants are required to install and operate desulfurization units for separate removal of hydrogen sulfide from coke oven gas. The most common $H_2S$ recovery process consists of a chamber where potash or soda ash slurry is used as a scrubbing medium for absorbing hydrogen sulfide, which is in

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY-PRODUCT COKE SUBCATEGORY
ALTERNATE N° 1
BPCTCA MODEL

10-19-73    FIGURE 60

AMMONIA ... 125 mg/l
BOD$_5$ ... 100 mg/l
CYANIDE ... 20 mg/l
OIL & GREASE ... 10 mg/l
PHENOL ... 1 mg/l
SULFIDE ... 1.0 mg/l
SUSP. SOLIDS ... 50 mg/l
pH ... 6-9
FLOW ... 730 l/kkg (175 gal/ton)

VACUUM FILTER

SOLIDS FOR DISPOSAL

AIR BLOWERS

ACID

TO AMMONIUM HYDROXIDE OR AMMONIUM SUL-FATE PRODUCTION

MAKE-UP FROM SERVICE WATER

SOFTENER

STEAM 83.4 l/kkg (20 GAL/TON)

BOILER

BOILER TREATMENT CHEMICALS

REGENERANTS

BLOW DOWN

334.9 l/kkg (80 GAL/TON)

EFFLUENT

FIXED AMMONIA STILL

DEPHENOLIZER (ABANDONED)

LIME

125.1 l/kkg (30 GAL/TON)

83.4 l/kkg (20 GAL/TON)

COOLING TOWER

MAKE-UP WATER

BENZOL WASTE

FINAL COOLING

CRYSTALLIZER

PRIMARY COOLER SYSTEM

FREE AMMONIA STILL

WASTE AMMONIA LIQUOR 104.1 l/kkg (25 GAL/TON)

AMMONIA ... 2000 mg/l
BOD$_5$ ... 1200 mg/l
CYANIDE ... 200 mg/l
OIL & GREASE ... 120 mg/l
PHENOL ... 360 mg/l
SULFIDE ... 400 mg/l
SUSP SOLIDS ... 90 mg/l
pH ... 6-9

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY PRODUCT COKE SUBCATEGORY
ALTERNATE N°2
BPCTCA MODEL

——— BASE LEVEL SYSTEM
BPCTCA MODEL
– – – ALTERNATE N°2
BPCTCA MODEL

10-25-73   FIGURE 60A

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turn liberated by distillation under vacuum. Up to 83 additional liters/kkg (20 gal/ton) of contaminated condensate is produced per ton of coke. This waste is returned to the ammonia still for treatment, where its volume is increased to 104 l/kkg (25 gal/ton) of coke by the addition of lime slurry and further condensation of steam. Plants operating this type of desulfurization equipment will generate up to 834 l/kkg (200 gal/ton) of waste water, instead of the 730 l/kkg (175 gal/ton) shown above.

By-product coke plants using the indirect rather than the semidirect ammonia recovery process produce 375.4 l/kkg (90 gallons per ton) more weak ammonia liquor than the semidirect system on which the guidelines above were based. This increase in WAL volume is partially offset by reductions in other waste sources. These reductions are related to the absence of final coolers and of barometer condensers associated with the operation of crystalizers. The provision added to Section 420.12 of the regulation allows for a 30 percent increase in waste loads corresponding to an increase in waste water volume from 730 to 938 l/kkg (175 to 225 gallons per ton).

## Phenol

All of the plants surveyed were treating for phenol reduction by either solvent extraction or biological oxidation. One of the four plants was using biological treatment and was obtaining less than 0.1 mg/l phenol in the final effluent. Another plant, using solvent extraction techniques, was producing a dephenolizer effluent containing less than 0.5 mg/l of phenol. However, this effluent was mixed with untreated barometric condenser effluent to produce a final effluent containing 1.37 mg/l of phenol. It became evident from review of the respective plant flow sheets that the remainder of the plants surveyed could accomplish similar reductions by treating their barometric condenser effluent and by tightening up on the final cooling water discharge so as to be able to route the blowdown through the treatment system, thereby avoiding unnecessary dilution or contamination of the final treated effluent. The ELG for phenol was therefore based on 2 mg/l at 730 l/kkg (175 gal/ton) and the recommended control and treatment technologies for accomplishing this are as shown in Table 55. This guideline should apply to the BPCTCA standard since it should be readily attainable under the constraints and definitions of the BPCTCA guidelines.

## Cyanide

None of the plants surveyed were intentionally practicing cyanide removal, except for the reduction coincidental to ammonia stripping, phenol extraction or biological processes employed for ammonia and phenol removals. Two of the plants were discharging relatively high loads of cyanides, either as untreated crystallizer effluent or through contamination of final cooling water discharges. The remaining two plants were recycling such waste streams through treatment, and yielded cyanide

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concentrations of 38 and 68 mg/l in effluent flows of 450 and 170 l/kkg (108 and 41 gal/ton), respectively. These loads would be equivalent to 23 and 16 mg/l based on a 730 l/kkg (175 gal/ton) total effluent flow. The smaller of these two concentrations reflects the load from a plant which currently disposes of a portion of the raw waste load as quench water. This practice is not applicable to many areas where air pollution problems must be considered, and this waste should be routed to treatment instead. For this reason, a somewhat higher cyanide load would be expected in this waste water discharge.

The technologies for accomplishing this level of treatment are shown in Table 55.

## Ammonia

Of the four by-product coke plants surveyed, only two were operating both legs of their ammonia stills to achieve significant stripping of the fixed ammonia waste loads. These plants discharged 471 and 138 mg/l at flow rates of 171 l/kkg (41 gal/ton) and 217 l/kkg (52 gal/ton), respectively, which are equivalent to concentrations of 110 and 41 mg/l based on 730 l/kkg (175 gal/ton) total effluent flow. Since these surveys were completed, additional data has been acquired from a by-product coke plant utilizing a well designed, properly operated, free and fixed leg ammonia still. Normal operations at this plant consistently yield effluents containing less than 100 mg/l, and at times approach a zero $NH_3$-N concentration. The ELG for ammonia nitrogen has been conservatively set at 125 mg/l based on a 730 l/kkg (175 gal./ton) total effluent flow. Actual plants operating free and fixed leg ammonia stills are achieving this limitation.

## Oil and Grease

Oil and grease concentration data were collected at 3 of the 4 plants surveyed. Despite relatively high raw waste loads (50 - 280 mg/l), final effluent concentrations were reduced during treatment to 2.5, 18.7 and 0.02 mg/l in discharge flow rates of 450, 171 and 19,182 l/kkg (108, 41 and 4,600 gal/ton), respectively. Basing these loads on a uniform 730 l/kkg (175 gal/ton) discharge flow rate results in concentrations too low to accurately measure by the most readily available analytical techniques. The ELG for oil and grease has been conservatively set at 15 mg/l based on 730 l/kkg (175 gal/ton) total effluent flow. All three plants for which oil and grease data are available are achieving this limit.

## Suspended Solids

Data on suspended solids were collected at 3 of the 4 plants surveyed. Discharges contained 163, 103 and 7 mg/l suspended solids at flow rates of 450,171 and 19,182 l/kkg (108, 41 and 4,600 gal/ton), respectively. A review of the data from the

first plant listed above (the Bio-oxidation Treatment System) revealed an abnormal discharge of suspended solids during one of the four visits to the plant. Portions of the activated sludge biomass were floating to the surface of the aeration loagoon and were being carried out in the effluent. Under more normal operating conditions during three other visits to the same plant, the average concentration of suspended solids in the effluent was 80 mg/l. Using this value, plus the values from the other two plants above, and basing these loads on a 730 l/kkg (175 gal/ton) discharge flow rate results in equivalent concentrations of 49, 24, and 184 mg/l, respectively. The plant discharging the 19,182 l/kkg (4600 gal/ton) total effluent at a final concentration of only 7 mg/l produced the highest solids load, due to the discharge of most of that flow without treatment. The other two plants were practicing sedimentation, so their effluents provide the basis for establishing an ELG for suspended solids of 50 mg/l based on 730 l/kkg (175 gal/ton) total effluent flow. Two of the three plants for which suspended solids data are available normally achieve this limit.

## pH

Three of the four plants surveyed fell within the pH constraint range of 6.0 to 9.0, thus providing a basis for establishing this range as the BPCTCA ELG. Any plant falling outside this range can readily remedy the situation by applying appropriate neutralization procedures to the final effluent.

## Beehive Coke Operation

Currently, two of the three exemplary beehive operations surveyed practice zero (0) aqueous discharge. The BPCTCA limitation is therefore "no discharge of process waste water pollutants." The control and treatment technology required would include provision for an adequate settling basin, and a complete recycle of all water collected from the process back to the process, with fresh water make-up as required. The system reaches equilibrium with respect to critical parameters, but provision must be made for periodic removal of settled solids from the basin. Actual operating costs are modest.

## Sintering Operation

The only direct contact process water used in the sintering plant is water used for cooling and scrubbing off gases from the sintering strand. As with steelmaking, there are wet and dry types of systems. The sintering strand generally has two (2) independent exhaust systems, the dedusting system at the discharge end of the machine, and the combustion and exhaust system for the sinter bed. Each one of these systems can either be wet or dry as defined in the process flow diagrams types I, II, III, shown as Figures 6, 7, and 8, respectively.

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TABLE 56

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Beehive Coke

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS | | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST | |
|---|---|---|---|---|---|
| | Kg/KKg[1] (LB/1000 LB) | mg/l[2] | | $/KKg | $/TON |
| *Cyanide$_T$ Phenol Ammonia (as NH$_3$) BOD$_5$ Oil and grease Suspended Solids pH Flow | No discharge of process wastewater pollutants to navigable waters (excluding all non contact cooling water) | | Settling basin; complete recycle with no aqueous blowdown - make-up water as required. System reaches equilibrium with respect to critical parameters. | 0.0527 | 0.0478 |

(1) Kilograms per metric ton of coke produced or pounds per 1,000 pounds of coke produced.
(2) Milligrams per liter based on 417 liters effluent per kkg of coke produced (100 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of pre-liminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

* Total cyanide

PROCESS

AMMONIA    0.35 mg/L
BOD5       3 mg/L
CYANIDE    0.004 mg/L
PHENOL     0.01 mg/L
SUSP SOLIDS 400 mg/L
PH         6-9
FLOW       1251.4/kkg (300 GAL/TON)

POND (S)

MAKE-UP

AMMONIA    0.20 mg/L
BOD6       1 mg/L
CYANIDE    0.003 mg/L
PHENOL     0.009 mg/L
SUSP.SOLIDS 25 mg/L
PH         6-9
FLOW       1251.4/kkg (300 GAL/TON)

| ——————— | BASE LEVEL SYSTEM |
| ——————— | BPCTCA & BATEA MODEL |

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BEEHIVE COKE SUBCATEGORY
BPCTCA MODEL

| 11-13-73 | FIGURE G1 |

TABLE   57

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY   Sintering

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS | | CONTROL & TREATMENT TECHNOLOGY [3] | ESTIMATED [4] TOTAL COST | |
|---|---|---|---|---|---|
| | Kg/KKg [1] (LB/1000 LB) | mg/1 [2] | | $/KKg | $/TON |
| Suspended Solids | 0.0104 | 50 | Thickener with chemical flocculation; tight recycle with minimal blowdown to control cycles of concentration | | |
| Oil and Grease | 0.0021 | 10 | Natural adsorption to settling solids in thickener; provision required for surface skimming | 0.0565 | 0.0513 |
| pH | | 6.0-9.0 | Neutralization | | |
| Flow: | | | Most probable value for tight system is 209 liters effluent per kkg of sinter produced (50 gal/ton)(excluding all non contact cooling water). | | |

(1) Kilograms per metric ton of sinter produced or pounds per 1000 pounds of sinter produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of sinter produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

PROCESS

FLUORIDE 30 mg/L
OIL & GREASE 608 mg/L
SULFIDE 300 mg/L
SUSP SOLIDS 8000 mg/L
pH 6-10
FLOW 1043.1/l.kg (250 GAL/TON)

SOLIDS TO DISPOSAL

OIL

VACUUM FILTER

POLY ELECTROLYTE

MAKE-UP

ACID

pHC

FLUORIDE <50 mg/L
OIL & GREASE <10 mg/L
SULFIDE <20 mg/L
SUSP. SOLIDS <50 mg/L
pH 6-9
FLOW 209.1/l.kg (50GAL/TON)

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING SUBCATEGORY
BPCTCA MODEL

BASE LEVEL SYSTEM
BPCTCA MODEL

11-16-73

FIGURE 62

Generally the sinter bed exhaust systems are dry precipitation systems with the dedusting exhaust systems split between wet and dry.

Three sintering plants were visited, but two of the three systems were deleted from the comparison. These two systems were deleted because the intricate wastewater treatment system utilized made separate identification of unit raw waste and unit effluent loads from the sintering operation virtually impossible.

The third sintering plant had wet scrubber systems for both the dedusting and sinter bed exhaust systems. The wastewater treatment system was composed of a classifier and a thickener; a portion of the thickener overflow was recirculated and the rest went to blowdown. The underflow was filtered through vacuum filters.

For the one plant considered under this study, the effluent flow was 475 l/kkg (114 gal/ton) of sinter produced. This value, however, represents a blowdown equivalent to approximately 30% of the process recycle flow of 1422 l/kkg (341 gal/ton). The 114 gal/ton effluent flow also represents the total blowdown from this combined sinter plant - blast furnace waste treatment and recycle facility. Therefore, the magnitude of the effluent flow was considered _inadequate_, i.e., excessive, since simply tightening up the recycle loop can reduce the effluent discharge by more than 50 percent. In doing this, more attention may have to be paid to control of heat buildup and scaling and/or corrosive conditions in the recycle system. The ELG's were therefore established on the basis of 209 l/kkg (50 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. This proposed 209 l/kkg (50 gal/ton) is identical to the effluent flow limitations actually found (under this study) for the Open Hearth and BOF gas scrubber recycle systems; thus the technology should be readily transferable to a sinter plant since the type of recycle system and many of the aqueous contaminants are identical. This guideline should apply to the BPCTCA limitations since this value is readily attainable under the constraints and definitions of the BPCTCA guidelines.

After reviewing the laboratory analyses, the critical parameters were established as suspended solids, oils and grease, sulfides, fluoride, and pH. However, cost considerations dictated that treatment systems for sulfide and fluoride reduction could only be included in the BATEA treatment models. The ELG's for BPCTCA were, therefore, established on the basis of 209 l/kkg (50 gal/ton) of sinter produced and the concentrations achievable by the applicable treatment technologies indicated below.

Suspended Solids

The one plant studied showed less than 10 mg/l total suspended solids in the final effluent. This excellent reduction can be credited to the presence of substantial oil in the raw waste

which tends to act as a mucilage on the suspended solids. Similar phenomena have long been known to be responsible for enhancing removal of fine suspended solids in deep bed sand filters. The ELG for total suspended solids was, however, based on 50 mg/l at 209 l/kkg (50 gal/ton) to be consistent with the ELG set for BPCTCA for this parameter for all other subcategories, except one which could not achieve this concentration. The technologies for achieving this are as shown in Table 57.

## Oil and Grease

Oil was found to be 1 mg/l in the final effluent of the one plant studied. It is felt a less restrictive ELG based on 10 mg/l at 209 l/kkg (50 gal/ton). should be adopted since only one plant was used in the survey and for the reasons stated in the discussion under By-Product Coke Operations. The technologies for achieving this ELG are presented in Table 57 and for the most part center around the natural adsorption to the suspended solids as previously discussed.

## pH

For the one plant studied, the pH was found to be 12.7 in the final effluent, apparently due to the use of lime fluxing agents in the sintering process. Although the presence of lime in the process water enhances removal of fluorides, pH levels in this range would definitely have to be classed as harmful and the utilization of cost effective control technology judged to be inadequate. Therefore, the BPCTCA permissible range for pH was set at 6.0-9.0. This range can be attained by use of conventional, well-established neutralization techniques.

## Blast Furnace (Iron) Subcategory

Waste treatment practices in blast furnace operations center primarily around removal of suspended solids from the contaminated gas scrubber waters. In past practice, little attention has been paid to treatment for other aqueous pollutants in the discharge. Water conservation is practiced in many plants by employing recycle systems. Three of the four plants surveyed were practicing tight recycle with minimum blowdown. Discharges from these three plants were all under 521 l/kkg (125 gal/ton) of iron produced. The ELG's were therefore established on the basis of an effluent flow of 521 l/kkg (125 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. The fourth plant surveyed was running close to a once-through system and was judged inadequate with respect to water conservation, since blast furnace recycle is a well established art.

A survey of four iron producing blast furances resulted in the following recommendations for effluent standards:

## Suspended Solids

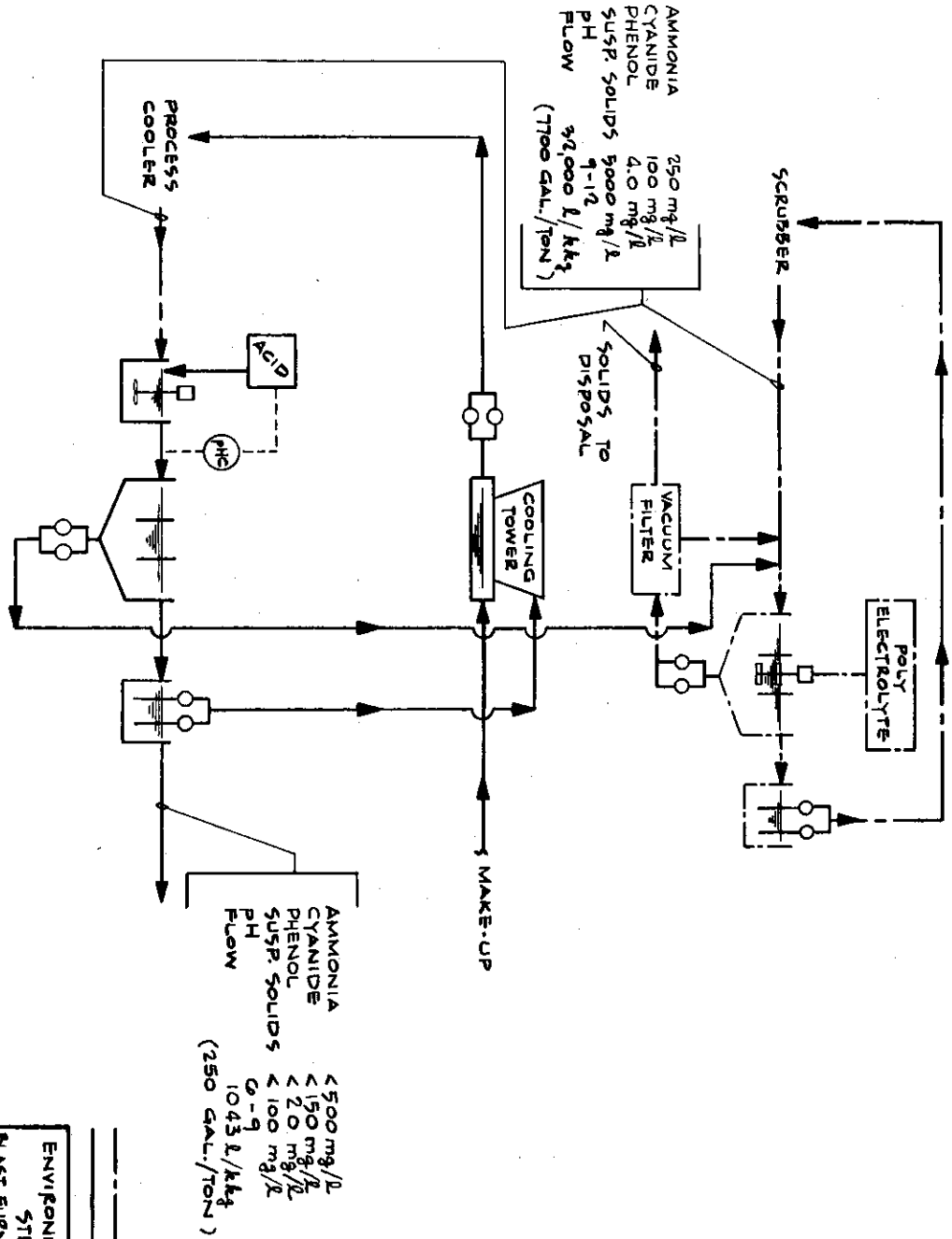## TABLE 58

## BPCTCA — EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY  Blast Furnace (Iron)

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS Kg/KKg[1] (LB/1000 LB) | mg/1[2] | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0260 | 50 | Thickening with polymer addition | | |
| *Cyanide$_T$ | 0.0078 | 15 | Vacuum filtration of thickener sludge | | |
| Phenol | 0.0021 | 4 | Recycle loop utilizing cooling tower | 0.271 | 0.246 |
| Ammonia (as NH$_3$) | 0.0651 | 125 | | | |
| pH | 6.0-9.0 | | | | |
| Flow: | | | Most probable value for tight system is 522 liters effluent per kkg of iron produced (125 gal/ton) (excluding all non contact cooling water) | | |

(1)  Kilograms per metric ton of iron produced or pounds per 1,000 pounds of iron produced.
(2)  Milligrams per liter based on 522 liters effluent per kkg of iron produced (125 gal/ton).
(3)  Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4)  Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

* Total cyanide

PROCESS

| | | |
|---|---|---|
| AMMONIA | 10 mg/l | |
| CYANIDE | 2.0 mg/l | |
| FLUORIDE | 5 mg/l | |
| PHENOL | 1.0 mg/l | |
| SULFIDE | 20 mg/l | |
| SUSP. SOLIDS | 1600 mg/l | |
| pH | 7-9 | |
| FLOW | 16,260 l/kkg (3900 GAL/TON) | |

| | | |
|---|---|---|
| AMMONIA | <125 mg/l | |
| CYANIDE | <15 mg/l | |
| FLUORIDE | <40 mg/l | |
| PHENOL | <4 mg/l | |
| SULFIDE | <6 mg/l | |
| SUSP. SOLIDS | <50 mg/l | |
| pH | 6-9 | |
| FLOW | 521 l/kkg (125 GAL/TON) | |

POLY ELECTROLYTE

COOLING TOWER

MAKE-UP

VACUUM FILTER

---- BASE LEVEL SYSTEM
—— BPCTCA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE (IRON) SUBCATEGORY
BPCTCA MODEL

11-13-73    FIGURE G3

The three plants surveyed and operating on a tight recycle were experiencing suspended solids in their effluents ranging from 39 to 85 mg/l, whereas the plant operating close to once-through was achieving 11 mg/l suspended solids in the final effluent. This could be expected since higher TDS levels in recycle systems have been known to inhibit agglomeration and settling of suspended solids. The technology is well established for reducing iron laden suspended solids to less than 50 mg/l. The majority of plants around the country are operating on a once-through basis. The BPCTCA limitation for suspended solids has been established on the basis of 50 mg/l at 521 l/kkg (125 gal/ton) based on the proposed use of known technology for reducing blast furnace suspended solids to the indicated level. Three of the surveyed plants were achieving the effluent load directly and the fourth plant, producing the effluent containing 85 mg/l of suspended solids, was also achieving the effluent load by virtue of further treatment of the blowdown in the sinter plant waste treatment facility.

## Cyanide

All of the plants surveyed were experiencing cyanides in their blowdown of 19 mg/l or less. No intentional treatment for cyanide removal was being practiced since the blowdowns were being disposed of on site. The one plant operating on a close to once-through basis was achieving 0.005 mg/l cyanide in the final effluent by the use of alkaline chlorination. The BPCTCA limitation on cyanide is based on 15 mg/l at 521 l/kkg (125 gal/ton). Three of the four plants surveyed are achieving this effluent load directly. The fourth plant was exceeding this load by 12% but the effluent was receiving further treatment in the sinter plant waste treatment facility. The technology for accomplishing this level of treatment is shown in Table 58.

## Phenol

Of the four plants surveyed, the effluent phenols ranged from 0.01 to 3.6 mg/l. The close to once-through plant was reducing phenols via the alkaline chlorination system. In the recycle systems, many plants were experiencing reduction of phenols in the cooling tower as evidenced by close examination of the analytical data in and out of the towers. Further reduction of phenols was sometimes noted across the thickeners. Much of the loss of phenol is inherent in the operation of a recycle system. Further reductions could be readily accomplished by discontinuing the use of green coke or coke quenched with water which is contaminated with phenol in the blast furnace. Studies have shown that the adsorbed phenols carry directly through to the blast furnace gas scrubber waters. The BPCTCA limitation for phenols is based on 4 mg/l at 521 l/kkg (125 gal/ton). The technology for accomplishing the limitation is shown in Table 58. All four plants surveyed are currently achieving the BPCTCA effluent limitation for phenol.

## Ammonia

The three plants surveyed employing tight recycle were experiencing ammonia values in their blowdown ranging from 78 to 265 mg/l.

The one plant operating on a close to once-through basis was achieving 0.8 mg/l ammonia in the final effluent - probably due to dilution effects as well as oxidation of the ammonia by chlorine. The BPCTCA limitation for ammonia is based on 125 mg/l at 521 l/kkg (125 gal/ton). Table 58 is referred to for further identification of the technology. Three of the plants surveyed are currently achieving the BPCTCA effluent limitation for ammonia. The average effluent load of all four plants surveyed is less than the load limitation.

## pH

Of the four plants surveyed, the pH of the effluents fell well within the range of 6.0 - 9.0 which is established as the BPCTCA permissible range.

## Blast Furnace (Ferromanganese) Operation

Only one operating ferro-manganese furnace was found for the survey. The one plant surveyed was operating with a once-through system on the gas cooler and with a totally closed recycle system on the venturi scrubber. The flow through the gas cooler was 5,700 gallons effluent per ton of ferro-manganese produced. This flow would have to be considered inadequate, i.e. excessive, since there is no reason precluding running a recycle system identical to that of the iron producing blast furnaces. Under the iron producing blast furnace recycle plants, the effluent flow was found to be 521 l/kkg (125 gal/ton) which was equivalent to a blowdown rate of 4.25% of the recycle rate. The BPCTCA limitations are based on an effluent volume of 1042 l/kkg (250 gal/ton) which is 4.25% of the total recycle flow rate on the one ferromanganese blast furnace plant surveyed. The ferromanganese furnace operates at a higher temperature than the blast furnace producing iron and thus may require higher recycle and blowdown rates.

## Suspended Solids, Cyanide, Phenol, Ammonia

The above indicated critical parameters are the same pollutants found in iron producing blast furnaces. Because of the higher temperature operation, however, the cyanide and ammonia loads produced are greater.

Since the one plant surveyed was judged to be inadequate with respect to the application of good water conservation practice, the BPCTCA effluent limitations have been based on the loads that can be achieved by a plant equipped with a neutralized recycle system producing an effluent of 1042 l/kkg (250 gal/ton). A facility so equipped should achieve the following concentrations:

## TABLE 59

### BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Blast Furnace (Ferromanganese)

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS Kg/KKg [1] (LB/1000 LB) | mg/l [2] | CONTROL & TREATMENT TECHNOLOGY [3] | ESTIMATED [4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended solids | 0.1043 | 100 | Thickener with polymer additon | | |
| *Cyanide$_T$ | 0.0312 | 30 | Vacuum filtration of thickener underflow | | |
| Phenol | 0.0042 | 4 | *Scrubber water recycle with* evaporative cooling | 1.30 | 1.18 |
| Ammonia (as NH$_3$) | 0.2086 | 200 | pH adjustment | | |
| pH | 6.0-9.0 | | | | |

Flow:    Most probable value for tight system is 1043 liters effluent per kkg of ferromanganese produced (250 gal/ton)(excluding all non contact cooling water)

(1)   Kilograms per metric ton of ferromanganese produced, or pounds per 1,000 pounds of, ferromanganese produced.
(2)   Milligrams per liter based on 1043 liters effluent per kkg of ferromanganese produced (250 gal/ton).
(3)   Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4)   Costs may vary some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications requried to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental required above those facilities which are normally existing within a plant.

*Total cyanide

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AMMONIA          250 mg/l
CYANIDE          100 mg/l
PHENOL           4.0 mg/l
SUSP. SOLIDS     5000 mg/l
pH               7-12
FLOW             41,000 l/kkg
                 (7700 GAL./TON)

AMMONIA          < 500 mg/l
CYANIDE          < 150 mg/l
PHENOL           < 2.0 mg/l
SUSP. SOLIDS     < 100 mg/l
pH               6-9
FLOW             1043 l/kkg
                 (250 GAL./TON)

PROCESS COOLER
ACID
PHC
SCRUBBER
COOLING TOWER
VACUUM FILTER
SOLIDS TO DISPOSAL
POLY ELECTROLYTE
MAKE-UP

——————  BASE LEVEL SYSTEM
- - - - -  BPCTCA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE-FERROMANGANESE SUBCATEGORY
BPCTCA MODEL

| 11-13-79 | FIGURE 64 |

| Suspended Solids | 100 mg/l |
|---|---|
| Cyanide | 150 mg/l |
| Ammonia | 500 mg/l |
| Phenol | 20 mg/l |

The BPCTCA limitations have been based on these concentrations at a flow of 1042 l/kkg (250 gal/ton). Since the one plant surveyed is not equipped with a recycle system on the gas cooler or for neutralization of the effluent, the surveyed plant does not presently meet the limitations.

pH

The pH of the plant surveyed fell within the range of 6.0 - 9.0 which is established as the BPCTCA permissible range.

Basic Oxygen Furnace Operation

The only direct contact process water used in the BOF plant is the water used for cooling and scrubbing the off gases from the furnaces. Two methods which are employed and can result in an aqueous discharge are the semiwet gas cleaning and wet gas cleaning systems as defined in Types II, III, IV and V on Figures 17 to 20, inclusive.

The two semiwet systems surveyed had different types of waste water treatment systems. The first system was composed of a drag link conveyor, settling tank, chemical flocculation and complete recycle pump system to return the clarified treated effluent to the gas cleaning system. Make-up water was added to compensate for the evaporative water loss and the system had zero (0) aqueous discharge of blowdown. The second semiwet system was composed of a thickener with polyelectrolyte addition followed by direct discharge to the plant sewers on a "once-through" basis.

Because of the nature of these semiwet systems, direct blowdown is not required when recycle is employed. The systems are kept in equilibrium by water losses to the sludge and by entrainment carry-over into the hot gas stream. Most new wet BOF systems are designed in this manner. The BPCTCA limitations have therefore been established as "no discharge of process waste water pollutants to navigable waters" from BOF shops equipped with semiwet air pollution control systems.

The three BOF wet systems surveyed were generally of the same type and included classifiers and thickeners with recirculation of a portion of the clarified effluent. The blowdown rates were 138, 217, and 905 l/kkg (33, 52, and 217 gal/ton) of steel produced, respectively, with the latter system discharging at a blowdown rate equivalent to 65% of makeup and 25% of the recirculation rate. The first two plants were discharging at a rate equivalent to 5.2 and 11.5% of the recirculation rate. The third plant should be able to reduce the effluent to a rate equivalent to 7.5% of the recirculation rate or 271 l/kkg (65 gal/ton). The average rate of discharge of the three plants

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# TABLE 60

## BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY _Basic Oxygen Furnace (Semi-Wet Air Pollution Control Methods)_

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS Kg/KKg [1] (LB/1000 LB) | mg/1 [2] | CONTROL & TREATMENT TECHNOLOGY [3] | ESTIMATED [4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids Fluoride pH Flow | No discharge of process wastewater pollutants to navigable waters (excluding all non contact cooling water) | | Settling tank with chemical and/or magnetic flocculation; complete recycle with no aqueous blowdown - makeup water as required; wet sludge to reuse or landfill | 0.0241 | 0.0219 |

(1) Kilograms per metric ton of steel produced or pounds per 1000 pound of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only _incremental_ costs required above those facilities which are nromally existing within a plant.

FLUORIDE        22 mg/l
SUSP. SOLIDS 250 mg/l
pH              10-12
FLOW = 1793 l/kkg (430 GAL./TON)

POLY
ELECTROLYTE

PROCESS

MAKE-UP

FLUORIDE        20 mg/l
SUSP. SOLIDS  50 mg/l
pH              10-12
FLOW = 1793 l/kkg (430 GAL/TON)

SOLIDS
TO
DISPOSAL

VACUUM
FILTER

————— ——— BASE LEVEL SYSTEM
————————— BPCTCA & BATEA MODEL
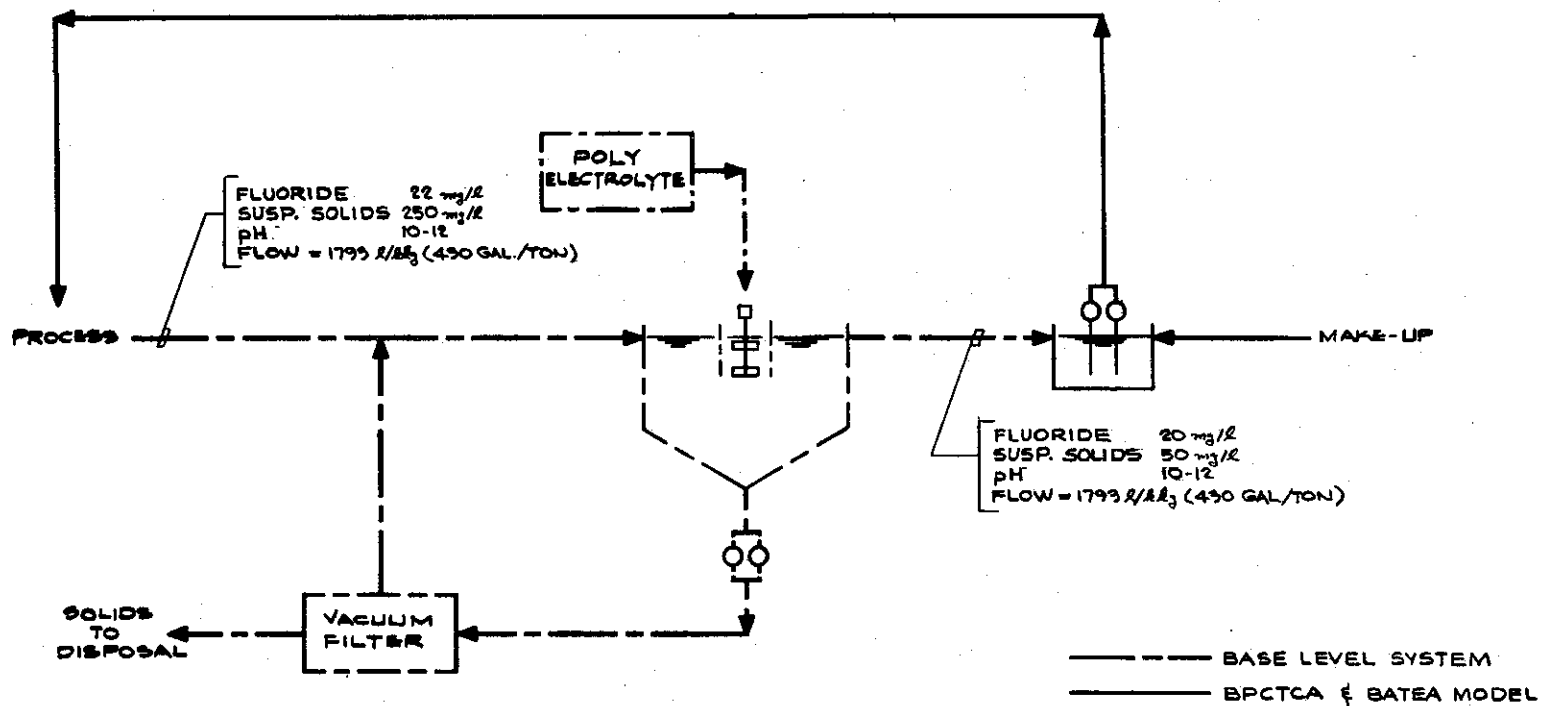
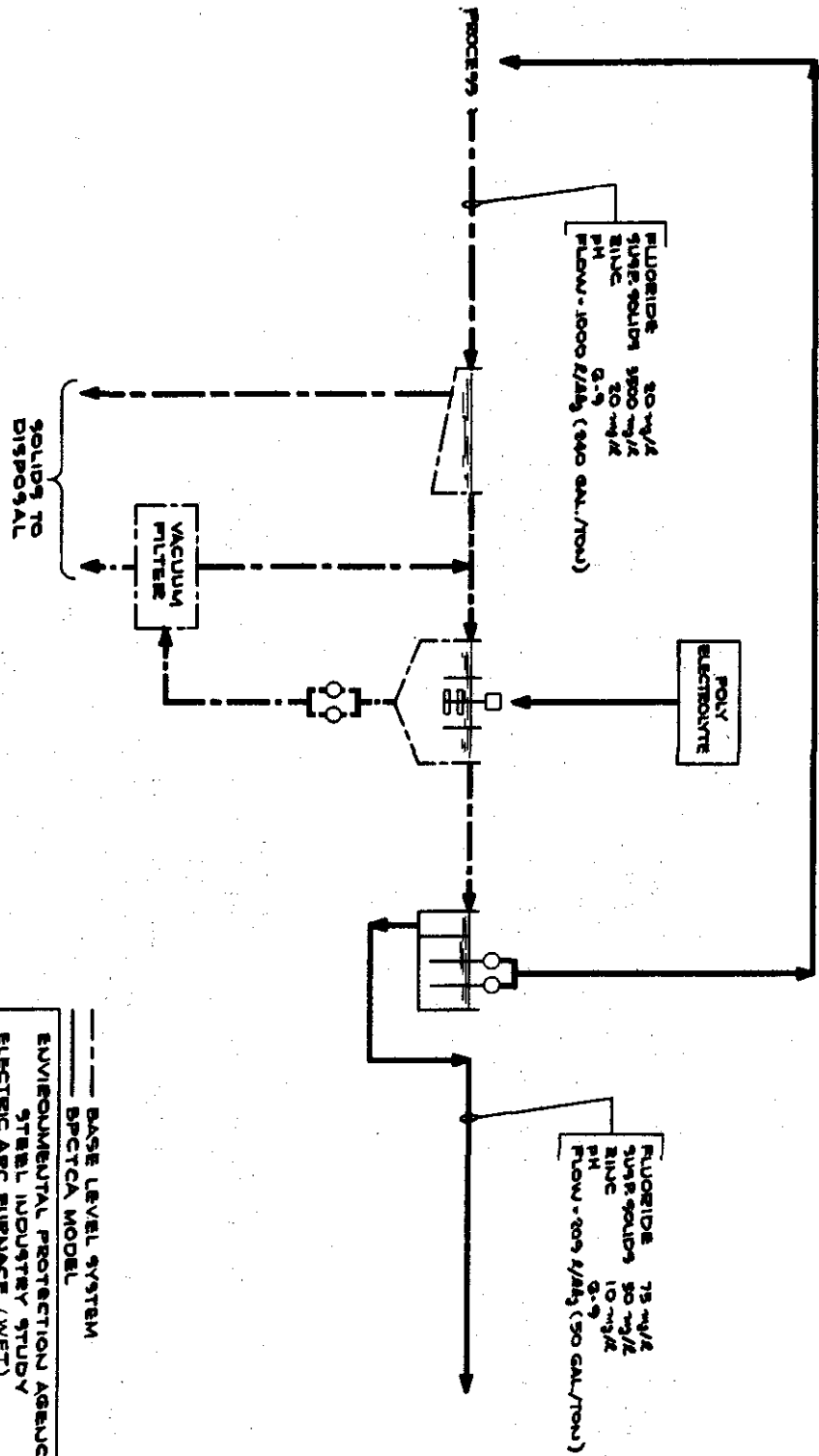| ENVIRONMENTAL PROTECTION AGENCY |
| STEEL INDUSTRY STUDY |
| BASIC OXYGEN FURNACE (SEMI-WET) |
| SUBCATEGORY |
| BPCTCA MODEL |

| 11-15-73 | FIGURE 65 |

TABLE 61

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY  Basic Oxygen Furnace (Wet Air Pollution Control Methods)

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS Kg/KKg[1] (LB/1000 LB) | mg/1[2] | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0104 | 50 | Classifier/thickener with chemical and/or magnetic flocculation; tight recycle with minimal blowdown to control cycles of concentration | 0.091 | 0.082 |
| pH | | 6.0-9.0 | Neutralization | | |
| Flow: | Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton)(excluding all non contact cooling water) | | | | |

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(1) Kilograms per metric ton of steel produced or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

FLUORIDE <50 mg/ℓ
SUSP SOLIDS <50 mg/ℓ
pH 6-9
FLOW <104 ℓ/kkg (30 GAL./TON)

ACID

MAKE-UP

POLY
ELECTROLYTE

FLUORIDE 90 mg/ℓ
SUSP SOLIDS 5000 mg/ℓ
pH 6-9
FLOW 1500 ℓ/kkg (600 GAL./TON)

VACUUM
FILTER

SOLIDS TO
DISPOSAL

PROCESS

—  —  — BASE LEVEL SYSTEM
———— BPCTCA MODEL

| ENVIRONMENTAL PROTECTION AGENCY STEEL INDUSTRY STUDY BASIC OXYGEN FURNACE (WET) SUBCATEGORY BPCTCA MODEL | |
|---|---|
| 11-14-73 | FIGURE GG |

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would then be 209 l/kkg (50 gal/ton) and this rate and the concentrations of the various pollutant parameters achievable by the indicated treatment technologies have been established as the basis for the BPCTCA limitations . A review of the data collected from the survey resulted in the following effluent guidelines:

## Suspended Solids

The effluent suspended solids were 22, 40, and 70 mg/l, respectively, for the three plants surveyed. The clarifier at the latter plant was not equipped with skimming devices and a hose was being used to agitate the surface to break up the foam, thus contributing to a high suspended solids content in the effluent. Even when including this plant the average suspended solids concentration of the three effluents is less than 50 mg/l. As indicated under discussion of blast furnaces, the technology is well established for reducing iron-laden suspended solids to less than 50 mg/l with the use of adequately designed and operated clarifiers and/or chemical and/or magnetic flocculation. Therefore, the BPCTCA limitation for suspended solids has been established on the basis of 50 mg/l at 50 gal/ton based on (1) known technology for achieving same in a cost effective manner and (2) the fact that two of the plants surveyed are currently achieving less than this effluent load.

## pH

The pH of the three plants surveyed varied from 6.4 to 9.4. As with previous subcategories, the BPCTCA permissible range for pH is set at 6.0 to 9.0, which can be readily accomplished by using appropriate neutralization techniques.

## Open Hearth Furnace Operation

As with the BOF furnaces, only contact process waters were surveyed, sampled and analyzed. Again the only contact process water in the open hearth is the water used for cooling and scrubbing the waste gases from the furnaces. As a general rule, open hearths have dry precipitator systems rather than scrubbers. Therefore, only two open hearth shops were surveyed and each had a wet high energy venturi scrubber system as defined in Types I, II, III shown on Figures 21, 22 and 23, respectively. There are no semiwet systems for open hearths.

Each plant had similar wastewater treatment systems composed of classifiers, with thickeners with recirculation of a portion of the thickener overflow. One system utilized vacuum filters for thickener underflow while the other system used slurry pumps and pumped the thickener wastes to tank trucks for disposal. The blowdown rates for the two plants were 213 l/kkg (51 gal/ton) and 492 l/kkg (118 gal/ton) which were equivalent to 9.3% and 17.5% of the recycle rates, respectively. These systems can be tightened as was indicated for the BOF and therefore the BPCTCA limitations were established on the basis of effluent volumes of

TABLE 62

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY  Open Hearth Furnace

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS Kg/KKg[1] (LB/1000 LB) | mg/1[2] | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0104 | 50 | Classifier/thickener with chemical and/or magnetic flocculation; tight recycle with minimal blow-down to control cycles of concentrations | 0.0608 | 0.0552 |
| pH | 6.0-9.0 | | Neutralization | | |
| Flow | Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton)(excluding all non contact cooling water) | | | | |

350

(1) Kilograms per metric ton of steel produced or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may very some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

FLUORIDES    20 mg/l
SUSP. SOLIDS 2000 mg/l
ZINC         400 mg/l
pH           3-7
FLOW         2500 l/kg (600 GAL/TON)

FLUORIDES    100 mg/l
SUSP. SOLIDS 50 mg/l
ZINC         25 mg/l
pH           6-9
FLOW         209 l/kg (50 GAL/TON)

MAKE-UP WATER

POLY ELECTROLYTE

LIME

VACUUM FILTER

SOLIDS TO DISPOSAL

PROCESS

———— BASE LEVEL SYSTEM
— — — BPCTCA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
OPEN HEARTH FURNACE SUBCATEGORY
BPCTCA MODEL

| 11-14-73 | FIGURE G7 |

209 l/kkg (50 gal/ton) of product and the concentrations of the process pollutant parameters achievable by the indicated treatment technologies. This effluent volume is equivalent to the average of the values that would be achieved by reducing blowdowns to 7.5% of the recycle rates.

A review of the data collected resulted in the following effluent guidelines:

Suspended solids

For the two plants surveyed, the effluent suspended solids were 80 and 52 mg/l. As with one of the BOF wet recycle systems surveyed, the clarifier at the former plant was not equipped with skimming devices and a hose was being used to agitate the surface to break up the foam, thus contributing to a high solids content in the effluent. Since suspended solids concentrations of 50 mg/l or less can readily be achieved by the use of adequately designed and operated clarifiers, and/or chemical and/or magnetic flocculation, the BPCTCA limitation for suspended solids has been established on the basis of 50 mg/l at 209 l/kkg (50 gal/ton). The technologies for achieving this effluent load are shown in Table 62.

pH

The pH was found to be 6.1 and 1.8-3.4, respectively, for the two plants surveyed, with the latter plant being judged inadequate with respect to proper control of pH. The pH range for BPCTCA limitations has been set at 6.0 to 9.0. This range is readily attainable through the use of neturalization techniques as previously discussed.

Electric Arc Furnace Operation

The electric arc furnace waste gas cleaning systems are similar in nature to the BOF, i.e., they may be dry, semiwet or wet systems as defined in Types I, II, III, and IV shown on Figures 24 through 27, respectively. Four plants were surveyed, two semiwet and two wet systems.

The two semiwet systems had similar wastewater treatment systems composed of a settling tank with drag link conveyor; one system was recycled with no aqueous blowdown while the other system had closely regulated the furnace gas cooling water spray system so that only a wetted sludge was discharged to the drag tank for subsequent disposal. The BPCTCA limitation for semiwet systems is therefore "no discharge of process waste water pollutants to navigable waters." Both plants surveyed are currently achieving this limitation.

The two wet systems surveyed had similar wastewater treatment systems. These plants were recycling untreated wastes at the rates of 12,906 and 12,010 l/kkg (3,095 and 2,880 gal/ton) of product respectively. The two plants were treating their

TABLE 63

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Electric Arc Furnace (Semi-Wet Air Pollution Control Methods)

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS Kg/KKg [1] (LB/1000 LB) | mg/1 [2] | CONTROL & TREATMENT TECHNOLOGY [3] | ESTIMATED [4] TOTAL COST $/KKg    $/TON |
|---|---|---|---|---|
| Suspended Solids<br>Fluoride<br>Zinc<br>pH<br>Flow | No discharge of process wastewater pollutants to navigable waters (excluding all non contact cooling water) | | Settling tank with chemical and/or magnetic flocculation; complete recycle with no aqueous blowdown - makeup water as required; or controlled wetting of gases to form sludge only - no recycle or blowdown; wet sludge to reuse or landfill | Zero (0) |

353

(1) Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

FLUORIDE 25 mg/l
SUSP. SOLIDS 50 mg/l
pH G-9
FLOW = 417 l/kg (100 GAL./TON)

MAKE-UP

POLY ELECTROLYTE

VACUUM FILTER

FLUORIDE 25 mg/l
SUSP. SOLIDS 2000 mg/l
pH G-9
FLOW = 417 l/kg (100 GAL./TON)

SOLIDS TO DISPOSAL

PROCESS

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC ARC FURNACE (SEMI-WET)
SUBCATEGORY
BPCTCA MODEL

11-15-73      FIGURE 66

— — — BASE LEVEL ¢ BPCTCA MODEL

354

TABLE 64

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Electric Arc Furnace (Wet Air Pollution Control Methods)

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS Kg/KKg[1] (LB/1000 LB) | mg/1[2] | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0104 | 50 | Classifier/thickener with chemical and/or magnetic flocculation; tight recycle with minimal blowdown to control cycles of concentration | 0.083 | .0753 |
| pH | 6.0-9.0 | | Neutralization | | |
| Flow | Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton)(excluding all non contact cooling water) | | | | |

355

(1) Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC ARC FURNACE (WET)
SUBCATEGORY
BPCTCA MODEL

11-15-79

FIGURE 09

blowdown streams which were being discharged at the rates of 1,268 and 659 l/kkg (304 and 158 gal/ton), respectively. The recycle rates are inadequate, i.e., excessive, in that the electric arc furnace wet gas cleaning system should be able to operate on the same recycle flows as the BOF and open hearth furnace systems. The average recycle rate on the five BOF (wet) and open hearth furnaces surveyed was found to be 2,756 l/kkg (661 gal/ton). Further the systems should be able to achieve blowdown rates equivalent to 7.5% of this recycle rate or 209 l/kkg (50 gal/ton). Since these systems can be made essentially identical to the BOF and open hearth recycle systems for gas scrubbing, the BPCTCA limitations were established on the basis of effluent flows of 209 l/kkg (50 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. A review of the data collected from the survey resulted in the following effluent guidelines:

Suspended Solids

The two plants surveyed were achieving suspended solids concentrations of 58 and 23 mg/l in the treated blowdowns. Since the use of properly designed and operated clarifiers, and/or chemical, and/or magnetic flocculation can readily achieve suspended solids concentrations on this type of waste of less than 50 mg/l, the BPCTCA limitation for suspended solids has been established on the basis of 50 mg/l in an effluent flow of 209 l/kkg· (50 gal/ton). The two surveyed plants are currently achieving lower concentrations on the average, although the limitation load is being exceeded due to the excessive blowdown rates.

pH

The two plants surveyed were both discharging effluents at a pH of 7.9. This is well within the BPCTCA permissible pH range of 6.0 to 9.0.

Vacuum Degassing Subcategory

The direct contact process water used in vacuum degassing is the cooling water used for the steam-jet ejector barometric condensers. All vacuum systems draw their vacuum through the use of steam ejectors. As the water rate depends upon the steaming rate and the number of stages used in the steam ejector, the process flow rates can vary considerably. Two degassing plants were surveyed and each had a waste water treatment system which treated other steelmaking operation process waste waters as well, i.e., one with a continuous casting water treatment system and the other with BOF discharges. The water systems were recirculating with blowdown. The blowdown rates varied from 58 to 67 l/kkg (14 to 16 gal/ton) and represented from 2% to 5% of the process recycle rate, respectively. The BPCTCA limitations were established on the basis of an effluent flow of 104 l/kkg (25 gal/ton) of product and concentrations of the various

TABLE 65

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY  Vacuum Degassing

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS Kg/KKg [1] (LB/1000 LB) | mg/l [2] | CONTROL & TREATMENT TECHNOLOGY [3] | ESTIMATED [4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0052 | 50 | Settling via classifier;  tight recycle with minimal blowdown;  cooling over a cooling tower for entire recycle flow | 0.568 | 0.516 |
| pH | 6.0-9.0 | | | | |
| Flow | Most probable value for tight system is 104 liters effluent per kkg of steel degassed (25 gal/ton)(excluding all non contact cooling water) | | | | |

358

(1) Kilograms per metric ton of steel degassed or pounds per 1000 pounds of steel degassed.
(2) Milligrams per liter based on 104 liters effluent per kkg of steel degassed (25 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary  some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

LEAD  
MANGANESE  
SUSP. SOLIDS  
ZINC  
PH  
FLOW

30   mg/l  
10   mg/l  
800  mg/l  
30   mg/l  
3-10  
6.995  l/kkg  
(360 GAL./TON)

PROCESS

SOLIDS TO  
DISPOSAL

COOLING  
TOWER

MAKE-UP  
WATER

LEAD  
MANGANESE  
SUSP. SOLIDS  
ZINC  
PH  
FLOW=

2.0 mg/l  
10   mg/l  
50   mg/l  
15   mg/l  
6-9  
104  l/kkg (25 GAL./TON)

BASE LEVEL SYSTEM  
BPCTCA MODEL

| ENVIRONMENTAL PROTECTION AGENCY | | |
| STEEL INDUSTRY STUDY | | |
| VACUUM DEGASSING OPERATION | | |
| BPCTCA MODEL | | |
| 11-14-73 | | FIGURE 70 |

pollutant parameters achievable by the indicated treatment technologies. The value of 104 l/kkg (25 gal/ton) has been set slightly above the measured values to provide a margin of safety in the interpretation of the data from the two rather complex joint treatment facilities studied.

A review of the data collected resulted in the following effluent guidelines:

## Suspended Solids

For the two plants surveyed, the suspended solids in the final effluent were found to be 37 and 1077 mg/l, respectively. The latter plant was judged inadequate with respect to the application of cost effective treatment technology for suspended solids removal, since the waste waters were being recycled without treatment and the blowdown was being discharged without treatment. The plant achieving the suspended solids level of 37 mg/l was using high rate pressure sand filtration on the final effluent prior to discharge. The BPCTCA limitation for suspended solids is based on 50 mg/l in 104 l/kkg (25 gal/ton) of product. An alternate technology for removal of these critical parameters to the indicated levels would be coagulation techniques. Table 65 is referred to for a summary of indicated BPCTCA limitations and suggested technologies.

## pH

The pH of the two plants surveyed was found to vary between 6.2 and 7.7 which is within the BPCTCA permissible range for pH of 6.0 to 9.0.

## Continuous Casting Subcategory

The only process waters used in the continuous casting operation are direct contact cooling water sprays which cool the cast product as it emerges from the molds. The water treatment methods used are either recycle flat bed filtration for removal of suspended solids and oils or scale pits with recirculating pumps. Both systems require blowdown. The flat bed filters remove oil and suspended solids whereas the scale pits may require ancilliary oil removal devices.

Two continuous casting plants were surveyed. One plant had a scale pit with sand filters with blowdown while the other plant had flat bed filters with blowdown. Both had cooling towers for cooling the spray water before recycling to the caster. The blowdown varied between 342 and 463 l/kkg (82 and 111 gal/ton). The BPCTCA limitations were therefore established on the basis of an effluent flow of 521 l/kkg (125 gal/ton) of product and the concentrations of the various pollutant parameters achievable by the indicated treatment technologies. A review of the data collected from the survey resulted in the following effluent guidelines:

TABLE 66

BPCTCA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Continuous Casting

| CRITICAL PARAMETERS | BPCTCA LIMITATIONS Kg/KKg [1] (LB/1000 LB) | mg/l [2] | CONTROL & TREATMENT TECHNOLOGY [3] | ESTIMATED [4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0260 | 50 | Scale pit with dragout conveyor | | |
| Oil and Grease | 0.0078 | 15 | Oil skimmer | | |
| | | | Flatbed filtration | Zero (0) | |
| | | | Recycle loop with blowdown and cooling tower | | |
| pH | 6.0-9.0 | | | | |
| Flow | Most probable value for tight system is 522 liters effluent per kkg of steel cast (125 gal/ton) (excluding all non contact cooling water) | | | | |

(1) Kilograms per metric ton of steel cast, or pounds per 1000 pounds of steel cast.
(2) Milligrams per liter based on 522 liters effluent per kkg of steel cast (125 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant.

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--- · --- BASE LEVEL SYSTEM

| | |
|---|---|
| 11-13-73 | FIGURE 71 |

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
CONTINUOUS CASTING SUBCATEGORY
BPCTCA MODEL

OIL & GREASE 15 mg/l
SUSP SOLIDS 50 mg/l
pH 6-9
FLOW 521 $l/kkg$ (125 GAL/TON)

OIL

OIL & GREASE 30 mg/l
SUSP SOLIDS 50 mg/l
pH 6-9
FLOW (AVG) 17500 $l/kkg$ (4200 GAL/TON)

FLATBED FILTER

PROCESS

12,500 $l/kkg$ (2990 GAL/TON) NORM.
22,300 $l/kkg$ (5350 GAL/TON) MAX.

COOLING TOWER

MAKE-UP WATER

21,900 $l/kkg$ (5250 GAL/TON) MAX 11,150 $l/kkg$ (2675 GAL/TON) NORMAL

## Suspended Solids

The plant employing the flat bed filter system was achieving 4.4 mg/l suspended solids in the treated effluent, whereas the plant utilizing the pressure sand filters was obtaining only 37 mg/l in the final treated effluent. An apparent anomaly existed here, since deep bed sand filters normally achieve higher quality effluents than flat bed filters. It was later discovered that the plant using the pressure sand filters was continually back-washing one of the dirty filters into the final treated effluent. This plant was judged inadequate with respect to applying good engineering design to alleviate the problem of contaminating the treated effluent with filter backwash. By correcting this problem, this plant should have no trouble obtaining low concentrations of suspended solids in the filtrate. To be consistent with the BPCTCA limitations for suspended solids which have been established for most of the other subcategories, however, the BPCTCA limitation for suspended solids has been established on the basis of 50 mg/l at 521 l/kkg (125 gal/ton). Both plants surveyed are currently operating well within this load limitation.

## Oil and Grease

The two plants surveyed were achieving excellent reductions in oil and grease as an apparent result of removal in the filtering devices. The two plants combined averaged less than 2.4 mg/l oil in the final effluent. However, to be consistent with the reasoning presented under By-Product Coke Operation, BPCTCA limitation for oil and grease has been established on the basis of 15 mg/l at 521 l/kkg (125 gal/ton). Table 66 summarizes the indicated technology.

## pH

The pH for the two plants surveyed varied bewteen 6.8 and 7.7 which is well within the BPCTCA permissible range for pH of 6.0 to 9.0.

## Treatment Models

Treatment models of systems to achieve the effluent quality for each subcategory have been developed. Sketches of the BPCTCA models are presented in Figures 60 through 72A1. The development included not only a determination that a treatment facility of the type developed for each subcategory could achieve the effluent quality proposed but it included a determination of the capital investment and the total annual operating costs for the average size facility. In all subcategories these models are based on the combination of unit (waste treatment) operations in an "add-on" fashion as required to control the significant waste parameters. The unit operations were each selected as the least expensive means to accomplish their particular function and thus their combination into a treatment model presents the least expensive method of control for a given subcategory.

Alternate treatment methods could be only insignificantly more effective and would be more expensive. In only one subcategory, the By-Product Coke Subcategory, was an alternate developed to provide an option for a high capital investment and high operating cost biological system (as compared to the low capital investment and low operating cost physical-chemical system) to achieve the BPCTCA limitation for 1977. This alternate was developed because the multistage biological system, which would be an add-on to the BPCTCA single stage biosystem, is the most economical way to achieve the BATEA limitations for 1983.

However, to achieve the BATEA limitations the alternate relies on the use of treatment technology that has been developed only to the pilot stage or as steps utilized individually, but not in the combination required in this model on this type of waste on a full scale basis. The effluent limitations have been established such that either alternate can achieve the effluent qualities on which the BPCTCA and BATEA limitations are based.

A cost analysis indicates that the limitations on by-product coke operations can most economically be achieved by applying alternate I to achieve BPCTCA and alternate II to achieve BATEA. Costs were therefore developed on the basis of depreciation of the BPCTCA system in 6 years (1977 - 1983). This not only saves enough on annual operating costs from the present to 1983 to more than offset the increased capital cost incurred in converting from one control technology to the other in 1983 (switching from physical/chemical to biological means of control), but it also minimrize the the total costs during the interim period while other possible alternates are evaluated and allows for flexibility in the event that BATEA limitations are later revised to lower values or to no discharge of process waste water pollutants to navigable waters.

## Cost Effectiveness Diagrams

Figures 72B through 83B presented in Section X show the pollutant reduction achieved by each step of the treatment models discussed in Tables 44 through 54 and the cumulative cost, including base level, to achieve that reduction. The curves are discussed in more detail in Section X.

EFFLUENT QUALITY ATTAINABLE THROUGH
THE APPLICATION OF THE BEST AVAILABLE
TECHNOLOGY ECONOMICALLY ACHIEVABLE

EFFLUENT LIMITATIONS GUIDELINES

## Introduction

The effluent limitations which must be achieved by July 1, 1983, are to specify the degree of effluent reduction attainable through the application of the best available technology economically achievable. Best available technology is not based upon an average of the best performance within an industrial category, but is to be determined by identifying the very best control and treatment technology employed by a specific point source within the industrial category or subcategory, or where it is readily transferable from one industry to another, such technology may be identified as BATEA technology. A specific finding must be made as to the availability of control measures and practices to eliminate the discharge of pollutants, taking into account the cost of such elimination.

Consideration must also be given to:

a. the size and age of equipment and facilities involved

b. the processes employed

c. nonwater quality environmental impact (including energy requirements)

d. the engineering aspects of the application of various types of control techniques

e. process changes

f. the cost of achieving the effluent reduction resulting from application of BATEA technology.

Best available technology assesses the availability in all cases of in-process changes or controls which can be applied to reduce waste loads as well as additional treatment techniques which can be applied at the end of a production process. Those plant processes and control technologies which at the pilot plant, semi-works, or other level, have demonstrated both technological performance and economic viability at a level sufficient to reasonably justify investing in such facilities, may be considered in assessing best available technology.

Best available technology is the highest degree of control technology that has been achieved or has been demonstrated to be capable of being designed for plant scale operation up to and

including "no discharge" of pollutants. This level of control is intended to be the top-of-the-line current technology subject to limitations imposed by economic and engineering feasibility. However, this level may be characterized by some technical risk with respect to performance and with respect to certainty of costs. Therefore, the BATEA limitations may necessitate some industrially sponsored development work prior to its application.

## Rationale for the Selection of BATEA

The following paragraphs summarize the factors that were considered in selecting the categorization, water use rates, level of treatment technology, effluent concentrations attainable by the technology, and hence the establishment of the effluent limitations for BATEA.

Size and Age of Facilities and Land Availability Considerations:

As discussed in Section IV, the age and size of steel industry facilities has little direct bearing on the quantity or quality of waste water generated. Thus, the ELG for a given subcategory of waste source applies equally to all plants regardless of size or age. Land availability for installation of add-on treatment facilities can influence the type of technology utilized to meet the ELG's. This is one of the considerations which can account for a range in the costs that might be incurred.

Consideration of Processes Employed:

All plants in a given subcategory use the same or similar production methods, giving similar discharges. There is no evidence that operation of any current process or subprocess will substantially affect capabilities to implement the best available control technology economically achievable. At such time that new processes, such as direct reduction, appear imminent for broad application the ELG's should be amended to cover these new sources. No process changes are envisioned for implementation of this technology for plants in any subcategory except By-Product Coke where the installation of a recycle system will be required on the barometric condenser system in order to achieve 417 1/kkg (100 gal/ton) of product on which the ELGs are based. The treatment technologies to achieve BATEA assesses the availability of in-process controls as well as control or additional treatment techniques employed at the end of a production process.

Consideration of Nonwater Quality Environmental Impact:

Impact of Proposed Limitations on Air Quantity:

The impact of BATEA limitaitons upon the nonwater elements of the environment has been considered. The increased use of recycle systems and stripping columns have the potential for increasing the loss of volatiles to the atmosphere. Recycle systems are so effective in reducing waste water volumes and hence waste loads to and from treatment systems and in reducing the size and cost

of treatment systems that a tradeoff must be accepted. Recycle systems requiring the use of cooling towers have contributed significantly to reductions of effluent loads while contributing only minimally to air pollution problems. Stripper vapors have been successfully recovered as usable by-products or can be routed to incinerators. Careful operation of either system can avoid or minimize air pollution problems.

Impact of Proposed Limitations on Solid Waste Problems:

Consideration has also been given to the solid waste aspects of water pollution controls. The processes for treating the waste waters from this industry produce considerable volumes of sludge. Much of this material is inert iron oxide which can be reused profitably. Other sludges not suitable for reuse must be disposed of in landfills since they are composed chiefly of chemical precipitates which could be little reduced by incineration. Being precipitates they are by nature relatively insoluble and nonhazardous substances requiring minimal custodial care.

Impact of Proposed Limitations due to Hazardous Materials:

In order to ensure long-term protection of the environment from harmful constituents, special consideration of disposal sites should be made. All landfill sites should be selected so as to prevent horizontal and vertical migration of these contaminants to ground or surface waters. In cases where geologic conditions may not reasonably ensure this, adequate mechanical precautions (e.g., impervious liners) should be taken to ensure long-term protection to the environment. A program of routine periodic sampling and analysis of leachates is advisable. Where appropriate the location of solid hazardous materials disposal sites, if any, should be permanently recorded in the appropriate office of legal jurisdiction.

Impact of Proposed Limitations on Energy Requirements:

The effects of water pollution control measures on energy requirements has also been determined. The additional energy required in the form of electric power to achieve the effluent limitations for BPCTCA and BATEA amounts to less than 1.5% of the electrical energy used by the steel industry in 1972.

The enhancement to water quality management provided by these effluent limitations substantially outweighs the impact on air, solid waste, and energy requirements.

Consideration of the Engineering Aspects of the Application of Various Types of Control Techniques:

This level of technology is considered to be the best available and economically achievable in that the concepts are proven and available for implementation and may be readily applied through adaptation or as add-ons to BPCTCA treatment facilities.

Consideration of Process Changes:

No process changes are envisioned for implementation of this technology for plants in any subcategory except By-Product Coke where the installation of a recycle system on the barometric condensers may be the most feasible means to achieve the 417 l/kkg (100 gal/ton) flow on which the ELGs are based. The treatment technologies to achieve BATEA assesses the availability of in-process controls as well as control or additional treatment techniques employed at the end of a production process.

Consideration of Costs of Achieving the Effluent Reduction Resulting from the Application of BATEA Technology:

The costs of implementing the BATEA limitations relative to the benefits to be derived is pertinent but is expected to be higher per unit reduction in waste load achieved as higher quality effluents are produced. The overall impact of capital and operating costs relative to the value of the products produced and gross revenues generated was considered in establishing the BATEA limitations.

The technology evaluation, treatment facility costing, and calculation of overall capital and operating costs to the industry as described in Section IX and which provided the basis for the development of the BPCTCA limitations, was also used to provide the basis for determining the BATEA limitations, the costs therefore, and the acceptability of those costs.

The initial capital investment and total annual expenditures required of the industry to achieve BATEA limitations are summarized in Table 79.

After selection of the treatment technology to be designated as one means to achieve the BATEA limitations for each subcategory was made, a sketch of each treatment model was prepared. The sketch for each subcategory is presented following the tables presenting the BATEA limitations for the subcategory.

Identification of the Best Available Technology Economically Achievable - BATEA

Based on the information contained in Sections III through VIII of this report, a determination has been made that the quality of effluent attainable through the application of the Best Available Technology Economically Achievable is as listed in Tables 67 through 78. These tables set forth the ELG's for the following subcategories of the steel industry:

I - By-Product Coke Subcategory

II - Beehive Coke Subcategory

III - Sintering Subcategory

IV - Blast Furnace (Iron) Subcategory

V - Blast Furnace (Ferromanganese) Subcategory

VI - Basic Oxygen Furnace (Semiwet Air Pollution
Control Methods) Subcategory

VII - Basic Oxygen Furnace (Wet Air Pollution
Control Methods) Subcategory

VIII - Open Hearth Furnace Subcategory

IX - Electric Arc Furnace (Semiwet Air Pollution
Control Methods) Subcategory

X - Electric Arc Furnace (Wet Air Pollution
Control Methods) Subcategory

XI - Vacuum Degassing Subcategory

XII - Continuous Casting Subcategory

ELG's have not been set for Pelletizing and Briquetting
operations because plants of this type were not found to be
operating as an integral part of any integrated steel mill.
These operations will be considered in mining regulations to be
proposed at a later date since they are normally operated in
conjunction with mining operations.

In establishing the subject guidelines, it should be noted that
the resulting limitations or standards are applicable to aqueous
waste discharges only, exclusive of non-contact cooling waters.
In the section of this report which discusses control and
treatment technology for the iron and steelmaking industry as a
whole, a qualitative reference has been given regarding "the
environmental impact other than water" for the subcategories
investigated.

The effluent guidelines established herein take into account only
those aqueous constituents considered to be major pollutants in
each of the subcategories investigated. In general, the critical
parameters were selected for each subcategory on the basis of
those waste constituents known to be generated in the specific
manufacturing process and also known to be present in sufficient
quantity to be inimical to the environment. Certain general
parameters such as suspended solids naturally include the oxides
of iron and silica; however, these later specific constituents
were not included as critical parameters, since adequate removal
of the general parameter (suspended solids) in turn provides for
adequate removal of the more specific parameters indicated. This
does not hold true when certain of the parameters are in the
dissolved state; however, in the case of iron oxides generated in
the iron and steelmaking processes, they are for the most part
insoluble in the relatively neutral effluents in which they are

contained. The absence of less important parameters from the guidelines in no way endorses unrestricted discharge of same.

The effluent limitations guidelines resulting from this study for BATEA limitations are summarized in Tables 67 to 78. These tables also list the control and treatment technology applicable or normally utilized to reach the constituent levels indicated. These effluent limitations set herein are by no means the absolutely lowest values attainable (except where no discharge of process waste water pollutants to navigable waters is recommended) by the indicated technology, but moreover they represent values which can be readily controlled around on a day by day basis.

It should be noted that these effluent limitations represent values not to be exceeded by any 30 consecutive day average. The maximum daily effluent loads per unit of production should not exceed these values by a factor of three as discussed in Section IX.


Cost vs Effluent Reduction Benefits:

Estimated total costs on a dollars per ton basis have been included for each subcategory as a whole. These costs have been based on the wastewaters emanating from a typical average size production facility for each of the subcategories investigated. In arriving at these effluent limitations guidelines, due consideration was given to keeping the costs of implementing the new technology to a minimum. Specifically, the effluent limitation guidelines were kept at values which would not result in excessive capital or operating costs to the industry. The capital and annual operating costs that would be required of the industry to achieve BATEA were determined by a six step process for each of the twelve subcategories. It was first determined what treatment processes were already in place and currently being utilized by most of the plants. Second, a hypothetical treatment system was envisioned which, as an add-on to existing facilities, would treat the effluent sufficiently to meet BATEA ELG's. Third, the average plant size was determined by dividing the total industry production by the number of operating facilities. Fourth, a quasi-detailed engineering estimate was prepared on the cost of the components and the total capital cost of the add-on facilities for the average plant. Fifth, the annual operating, maintenance, capital recovery (basis 10 years straight line depreciation) and capital use (basis 7% interest) charges were determined. And sixth, the costs developed for the average facility were multiplied by the total number of facilities to arrive at the total capital and annual costs to the industry for each subcategory. The results are summarized in Table 79.

TABLE 67

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY  By Product Coke

| CRITICAL PARAMETERS | BATEA LIMITATIONS Kg/KKg[1] (LB/1000 LB) | mg/l[2] | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| *Cyanide$_A$ | 0.00010 | 0.25 | BPCTCA plus: | | |
| Phenol | 0.00021 | 0.5 | Recycle crystallizer effluent to final cooler recycle system | | |
| Ammonia (as NH$_3$) | 0.0042 | 10 | | | |
| BOD$_5$ | 0.0083 | 20 | Sulfide oxidation (aeration) | 0.405 | 0.367 |
| Sulfide | 0.00012 | 0.3 | Clarification | | |
| | | | Abandon dephenolization | | |
| Oil and Grease | 0.0042 | 10 | | | |
| Suspended Soilids | 0.0042 | 10 | Multi-stage biological oxidation with methanol addition | | |
| pH | 6.0-9.0 | | Pressure filtration | | |

Flow    Most probable value for tight system is 417 liters effluent per kkg of coke produced (100 gal/ton) (excluding all non contact cooling water)

(1)  Kilograms per metric ton of coke produced, or pounds per 1000 pounds of coke produced.
(2)  Milligrams per liter  based on 417 liters effluent per kkg of coke produced (100 gal/ton).
(3)  Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4)  Costs may vary some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA  standards.

*Cyanides amenable to chlorination.  Reference ASTM D 2036-72 Method B.

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AMMONIA <10 mg/l
BOD5 20 mg/l
CYANIDE 0.25 mg/l
OIL&GREASE 10 mg/l
PHENOL 0.5 mg/l
SULFIDE 0.3 mg/l
SUPP SOLIDS 10 mg/l
PH 6-9
FLOW = 417 l/kkg (100 GAL/TON)

BASE LEVEL SYSTEM & BPCTCA MODEL
BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY PRODUCT COKE SUBCATEGORY
ALTERNATE Nº1
BATEA MODEL

11-13-73     FIGURE 72A1

AMMONIA 1000 mg/l
BOD5 1200 mg/l
CYANIDE 300 mg/l
OIL&GREASE 150 mg/l
PHENOL 300 mg/l
SULFIDE 400 mg/l
SUPP SOLIDS 90 mg/l
PH 8-9

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TO AMMONIUM HYDROXIDE OR AMMONIUM SULFATE PRODUCTION

WASTE AMMONIA LIQUOR 104 ℓ/kkg (25 GAL/TON)

FREE AMMONIA STILL

DEPHENOLIZER (ABANDONED)

LIME

FIXED AMMONIA STILL

PRIMARY COOLER SYSTEM

FINAL COOLER

COOLING TOWER

BEN SOL WASTE

125 ℓ/kkg (30 GAL/TON)

CRYSTALLIZER

BLOWDOWN

MAKE-UP

104 ℓ/kkg (25 GAL/TON)

BOILER TREATMENT CHEMICALS

BOILER

STEAM 83.4 ℓ/kkg (20 GAL/TON)

SOFTENER

REGENERANTS

MAKE-UP FROM SERVICE WATER

AIR BLOWER(S)

ACID

PHENOL REMOVAL

| | |
|---|---|
| AMMONIA | 100-200 mg/ℓ |
| BOD₅ | 500-1500 mg/ℓ |
| CYANIDE | 10-100 mg/ℓ |
| OIL & GREASE | 5-15 mg/ℓ |
| PHENOL | 100-500 mg/ℓ |
| SULFIDE | 5-10 mg/ℓ |
| SUSP SOLIDS | 50-100 mg/ℓ |
| PH | 10-11.5 |

SOLIDS FOR DISPOSAL

VACUUM FILTER

FIXED MEDIA ROTATING BIOLOGICAL REACTORS

CYANIDE & AMMONIA REMOVAL

AIR

STEP AERATOR

METHANOL

NITRATE REMOVAL

TOC-C

| | |
|---|---|
| AMMONIA | <10 mg/ℓ |
| BOD₅ | <20 mg/ℓ |
| CYANIDE | <0.25 mg/ℓ |
| OIL & GREASE | <10 mg/ℓ |
| PHENOL | <0.5 mg/ℓ |
| SULFIDE | <0.5 mg/ℓ |
| SUSP SOLIDS | <25 mg/ℓ |
| PH | 6-9 |
| FLOW | 417 ℓ/kkg (100 GAL/TON) |

— · — · — BASE LEVEL SYSTEM & BPCTCA MODEL
— — — — BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BY-PRODUCT COKE SUBCATEGORY
ALTERNATE NO.2
BATEA MODEL

11-13-75

FIGURE 72A-2

EFFLUENT

FIGURE 72B

MODEL COST EFFECTIVENESS DIAGRAM
BY-PRODUCT COKE SUBCATEGORY
ALTERNATE II (BIOLOGICAL)

*ANNUAL COSTS - BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
*COST BASED ON 2414 KKG/DAY (2660 TON/DAY)
COKE PLANT

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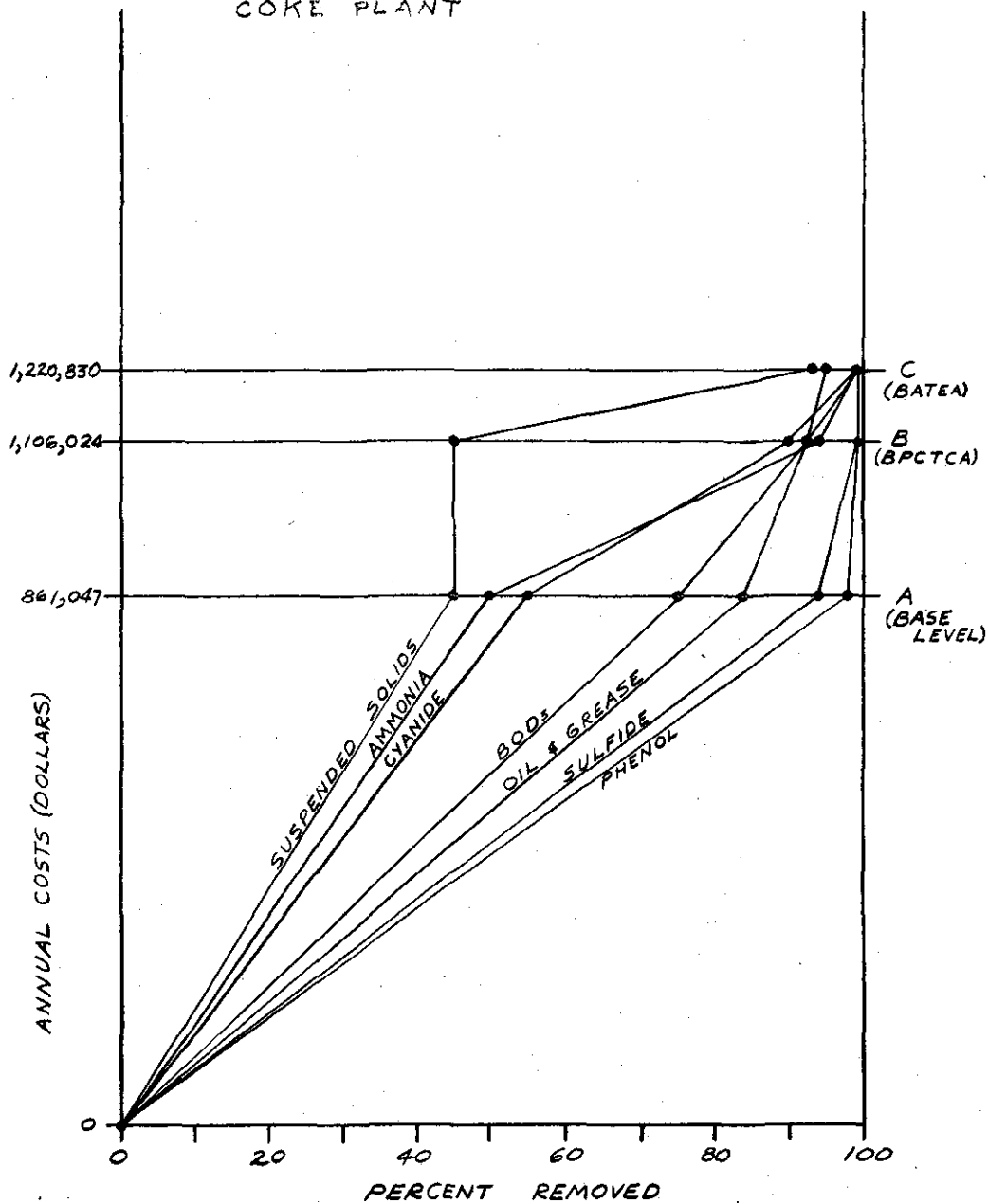
FIGURE 72 C

MODEL COST EFFECTIVENESS DIAGRAM
BY-PRODUCT COKE SUBCATEGORY
ALTERNATE I - (PHYSICAL / CHEMICAL)

* ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
    + INTEREST RATE 7%
      + OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
      + MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
  THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
* COST BASED ON 2414 KKG/DAY (2660 TOV/DAY) COKE PLANT
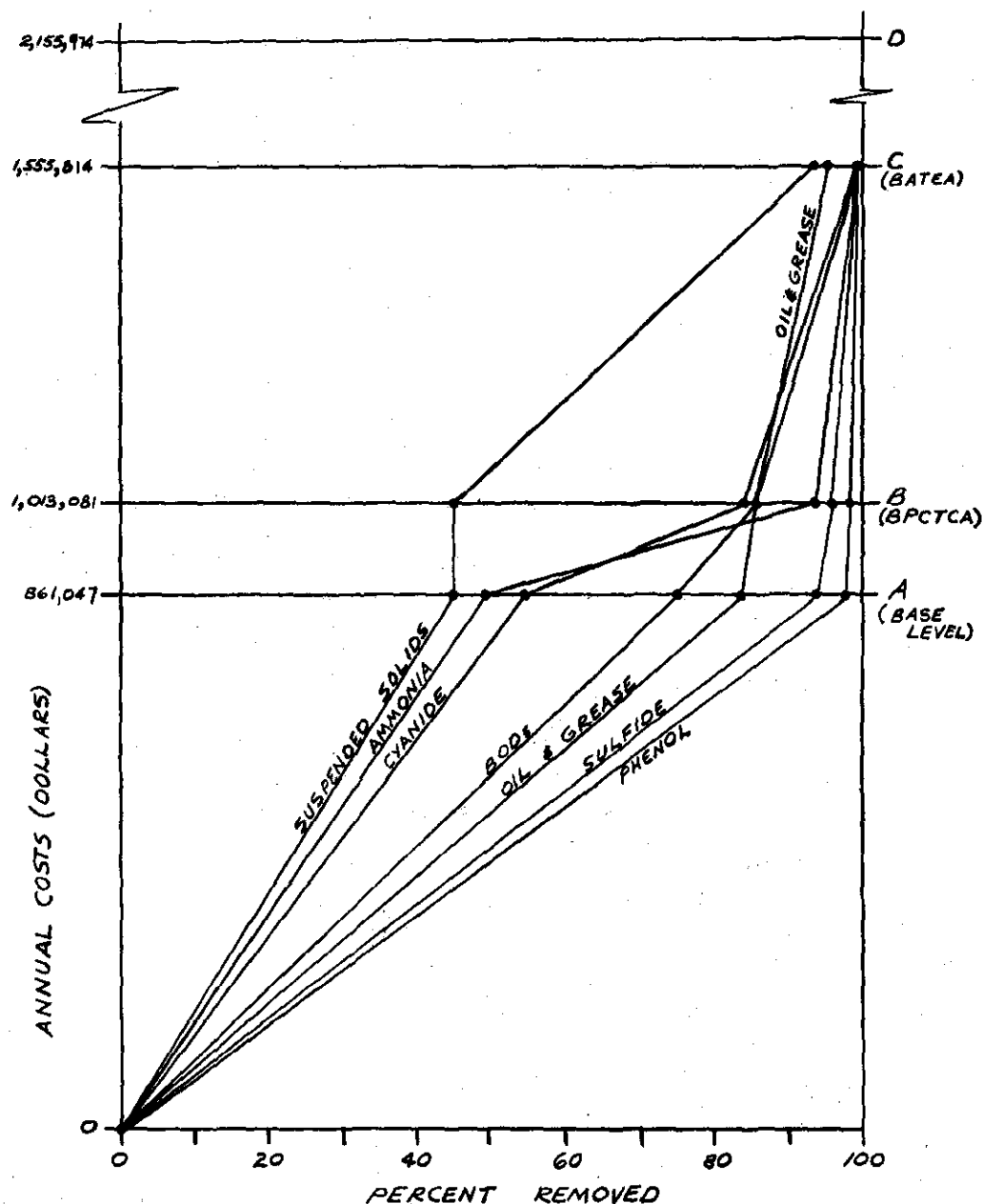
## BATEA Effluent Limitations Guidelines

The BATEA limitations have been established in accordance with the policies and definitions set forth at the beginning of this section. Further refinements of some of the technologies and the ELGs discussed in the previous Section (IX) of this study will be required. The subject BATEA limitations are summarized in Tables 67 to 78 along with their projected costs and treatment technologies.

Discussion By Subcategories:

Plants in the beehive coke and the electric arc furnace (semiwet) subcategories are presently achieving the effluent qualities that are specified herein. No plants in the other subcategories are presently achieving the total effluent quality required. However, each of the control techniques is presently employed at individual plants or in other industries and is considered to be technology that is transferable to the treatment of steel industry wastes.

The rationale used for developing BATEA effluent limitations guidelines is summarized below for each of the major subcategories. All effluent limitations guidelines are presented on a "gross" basis since for the most part, removals are relatively independent of initial concentrations of contaminants. The ELGs are in kilograms of pollutant per metric ton of product or in pounds of pollutant per thousand pounds of product and in these terms only. The ELG's are not a limitation on flow, type of technology to be utilized, or concentrations to be achieved. These items are listed only to show the basis for the ELG's and may be varied as the discharger desires so long as the ELG's per unit of production are met.

## By-Product Coke Subcategory

Following is a summary of the factors used to establish the effluent limitations guidelines applying to by-product coke making. As far as possible, the stated limits are based upon performance levels attained by the coke plants surveyed during this study. Where treatment levels can be improved by application of additional currently available control and treatment technology, the anticipated reduction of waste loads was included in the estimates. Flows at three of the four by-product coke plants surveyed together averaged 417 l/kkg (100 gal/ton) of coke produced. The fourth plant was diluting their effluent with contaminated final cooler water. Two of the four plants were disposing of a portion of their wastes in coke quenching. Even if this practice is disallowed, it can still be shown by analysis of the plants surveyed, the data presented by Black, McDermott, et el (Reference 22), and by employing internal recycle followed by minimal blowdown on such systems as the barometric condenser and final cooler waters, that the effluent can be reduced to 417 l/kkg (100 gal/ton). This is summarized as follows:

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| | | |
|---|---|---|
| Waste ammonia liquor | 104 l/kkg | 25 gal/ton |
| Steam condensate, lime slurry | 75 l/kkg | 18 gal/ton |
| Benzol plant waste | 125 l/kkg | 30 gal/ton |
| Final cooler blowdown | 84 l/kkg | 20 gal/ton |
| Barometric condenser blowdown | 29 l/kkg | 7 gal/ton |
| TOTAL | 417 l/kkg | 100 gal/ton |

The ELG's were therefore based on the total effluent flows of 417 l/kkg (100 gal/ton) of product and the concentrations of the various pollutant parameters achievable by the indicated treatment technologies.

By-products plants operating vacuum carbonate type desulfurization equipment will generate an additional 104 l/kkg (25 gal/ton) of waste water as discussed previously in Section IX, under the rationale for BPCTCA. The effluent flow from these plants would be 521 l/kkg (125 gal/ton) of coke produced, rather than the 417 l/kkg (100 gal/ton) shown above.

By-product coke plants using the indirect rather than the simidirect ammonia recovery process produce 375.4 l/kkg (90 gallons per ton) more weak ammonia liquor than the semidirect system on which the guidelines above were based. This increase in WAL volume is partially offset by reductions in other waste sources. These reductions are related to the absence of final coolers and of barometer condensers associated with the operation of crystalizers. The provision added to Section 420.12 of the regulation allows for a 30 percent increase in waste loads corresponding to an increase in waste water volume from 730 to 938 l/kkg (175 to 225 gallons per ton). The provisions added to Sections 420.13 and 420.15 allow for a 70 percent increase in waste loads corresponding to an increase in waste water volume from 417 to 709 l/kkg (100 to 170 gallons per ton). The reduction in waste volume from BPCTCA to BATEA of 730 to 417 l/kkg (175 to 100 gallons per ton) on the semidirect systems is accomplished by cooling and recycling the barometric condenser waters. Since the indirect ammonia systems use less barometric concenser water the opportunities for reduction here are less and the reduction in waste water volume from BPCTCA to BATEA is less for the indirect ammonia plants, i.e., from 938 l/kkg to 709 l/kkg (225 gallons per ton to 170 gallons per ton). Approximately 15 percent of the by-product coke plants use the indirect ammonia recovery process.

Phenol

The ELG is based on 0.5 mg/l at a 417 l/kkg (100 gal/ton) discharge flow rate. The one single-stage biological treatment system sampled was achieving 0.0639 mg/l on the average. The plant is achieving this only on the diluted wastes and some of the wastes are not treated. The dilution is required at this facility to prevent ammonia from interfering with the biological activity. If the waste were first treated in free and fixed stills for ammonia removal as recommended herein, dilution would not be required for this purpose. The routing of all plant

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process waste waters through a proposed multi-stage biological treatment facility can be expected to reduce the phenol waste load to well within the ELG recommended. Pilot plant sized multi-stage systems have been tested on by-product coke plant wastes, and additional testing and scale-up continues. Full scale operating single-stage plants have shown consistently excellent phenol removals to well within the ELG. Physical/chemical treatment methods involve alkaline chlorination, followed by carbon adsorption. Both of these techniques involve transfer of technology, the former from a full scale operating blast furnace (iron) subcategory plant within the iron and steel industry and from the metal plating industry; the latter from full-scale waste water treatment plants in the petrochemical industry. Either of the alternate treatment methods can achieve the BATEA limitations for phenols.

## Cyanide

None of the plants surveyed were intentionally practicing cyanide removal, except for some small reduction coincidental to stripping, extraction and/or biological processes employed for ammonia and phenol removals. All resulting levels of total cyanide in the final treated effluent were found to be excessive due to _uniformly inadequate_ application of treatment technology specific to cyanide removal. However, within the iron and steel industry, cyanide removal is practiced by at least one operating plant in the blast furnace (iron) subcategory, and by many plating and finishing plants which will be surveyed as part of the Phase II study of this industry. In addition, the nonferrous metals industry routinely performs treatment for cyanide destruction as part of their operations. For these reasons, the ELG for cyanides is set at 0.25 mg/l based on a total effluent flow of 413 l/kkg (100 gal/ton) of coke produced. This limit is currently achieved at operating plants outside the By-Product Coke subcategory by physical/chemical treatment methods as described in the phenol discussion above. The biological treatment of cyanides will require development to improve on currently achievable cyanide levels from operating single-stage plants. A multi-stage biological treatment system, including a cyanide removal stage, appears capable of reaching the BATEA limitation for by-product coke plant wastes by the time these limitations become effective. The technologies for accomplishing this level of treatment are shown in Table 67.

## Ammonia

Two of the four plants surveyed were practicing ammonia removal with free and fixed stills; however, the resulting effluents (without dilution) were 115 and 417 mg/l, respectively, with the latter plant judged to be _inadequate_ with respect to the capability of this technology. Furthermore, it becomes apparent that improved removals of phenol and especially cyanide by the technologies indicated above will result in reductions of ammonia in the final effluent. Therefore, because of the inter-relationships of treating for phenol and cyanide, ammonia will,

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as a side effect of these other treatments, be further reduced to less than 10 mg/l. The ELG based on 10 mg/l at 417 l/kkg (100 gal/ton) is further supported by a preponderance of bench scale and pilot studies for the treatment technologies shown in Table 67. The biological treatment alternate will require additional development of the type described in the cyanide discussion above to insure compliance with the BATEA limitation for ammonia. Most ammonia removal will occur during stripping operations prior to bio-oxidation.

## Oil and Grease

Two of the four plants surveyed were achieving less than 3 mg/l O & G; however, the one plant was doing so by dilution with contaminated final cooler water. In view of the oxidation methods which will be required for removal of the other listed pollutants, the O & G will be reduced to less than 10 mg/l in the oxidizing environment proposed. Auxiliary control technologies may be utilized to achieve this level as indicated in Table 67. The ELG for oil and grease for BATEA has been based on 10 mg/l in consideration of the testing problems discussed in Section IX.

## Sulfide

Only one of the four plants surveyed was achieving a substantial sulfide reduction to 0.26 mg/l and this was being accomplished concurrently with biological oxidation of phenols. Another plant was achieving 1.5 mg/l sulfide, but by dilution. Since sulfide represents an immediate oxygen demand upon the receiving stream, and since technology exists for effective and inexpensive oxidation of sulfides, the remaining plants surveyed were judged to be uniformly inadequate with respect to the application of treatment technology for sulfide reduction. Therefore, the ELG for sulfide was based on 0.3 mg/l at 417 l/kkg (100 gal/ton). These values are achievable by direct oxidation with air, chemicals or biological techniques. At least one of these indicated removal techniques will be employed for reduction of certain of the other listed by-product pollutants. An example of applying one of the possible transferred technology methods of sulfide reduction would be chlorination of raw sewage in transit through sewer lines which is regularly practiced to reduce sulfide to 0.3 mg/l and less. Reduction to the indicated ELG level is further substantiated by a proliferation of bench scale studies performed with the technologies indicated in Table 67.

## Suspended Solids

Only one of the plants surveyed was producing a treated effluent containing 25 mg/l of suspended solids or less. Nevertheless, there is an abundance of engineering knowhow and experience that demonstrates that suspended solids can be reduced to 25 mg/l in a cost effective manner. Therefore, the surveyed plants were judged to be uniformly inadequate with respect to the application of treatment technology for suspended solids removal. The ELG for total suspended solids was based on 25 mg/l at 417 l/kkg (100

gal/ton). Table 67 lists some of the available technologies for readily achieving this level.

## pH

Three of the four plants surveyed fall within the pH constraint range of 6.0 to 9.0 thus providing a basis for establishing this range as the BPCTCA. Any plant falling outside this range can readily remedy the situation by applying appropriate neutralization procedures to his final effluent. No further tightening of the BPCTCA pH range is recommended at this time. The ELG for BATEA remains at pH 6.0 to 9.0, and is currently achieved by operating plants in this subcategory.

## Beehive Coke Subcategory

Currently, two of the three selected beehive coke operations surveyed practice zero (0) aqueous discharge. The BATEA guidelines are therefore no discharge of process waste water pollutants to navigable waters, as previously set for BPCTCA limits in this subcategory. The control and treatment technology required would include provision for an adequate settling basin, and a complete recycle of all water collected from the process back to the process, with fresh water make-up as required. The system reaches equilibrium with respect to critical parameters, but provision must be made for periodic removal of settled solids from the basin. Actual operating costs are modest. No problems are anticipated in implementing BATEA guidelines for the Beehive Coke subcategory.

## Sintering Subcategory

The only direct contact process water used in the sintering plant is water used for cooling and scrubbing off gases from the sintering strand. As with steelmaking, there are wet and dry types of systems. The sintering strand generally has two (2) independent exhaust systems, the dedusting system at the discharge end of the machine, and the combustion and exhaust system for the sinter bed. Each one of these systems can either be wet or dry as defined in the process flow diagrams types I, II, III, shown as Figures 6, 7, and 8, respectively.

Generally the sinter bed exhaust systems are dry precipitation systems with the dedusting exhaust systems split between wet and dry.

Three sintering plants were visited, but two of the three systems were deleted from the comparison. These two systems were deleted due to the intricate wastewater treatment system which was utilized not only for the sinter plant but for the blast furnace as well, thus making separate identification of unit raw waste and unit effluent loads from the sintering operation virtually impossible.

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TABLE 68

BATEA  - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY     Beehive Coke

| CRITICAL PARAMETERS | BATEA LIMITATIONS | | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST | |
|---|---|---|---|---|---|
| | Kg/KKg[1] (LB/1000 LB) | mg/1[2] | | $/KKg | $/TON |
| *Cyanide$_A$ | | | | | |
| Phenol | No discharge of process wastewater pollutants to navigable waters (excluding all non-contact cooling water) | | Same as BPCTCA | | Zero (0) |
| Ammonia (as NH3) | | | | | |
| BOD5 | | | | | |
| Sulfide | | | | | |
| Oil and Grease | | | | | |
| Suspended Solids | | | | | |
| pH | | | | | |
| Flow | | | | | |

(1)  Kilograms per metric ton of coke produced, or pounds per 1000 pounds of coke produced.
(2)  Milligrams per liter based on 417 liters effluent per kkg of coke produced (100 gal/ton).
(3)  Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4)  Costs may vary some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA Standards.

*Cyanides amenable to chlorination.   Reference ASTM D 2036-72 Method B.

PROCESS

POND(S)

MAKE-UP

AMMONIA 0.75 mg/l
BOD 5
CYANIDE 0.004 mg/l
PHENOL 0.01 mg/l
SUSP. SOLIDS 400 mg/l
PH 6-9
FLOW = 1251 l/AA3 (300 GAL/TON)

AMMONIA 0.20 mg/l
BOD 1
CYANIDE 0.005 mg/l
PHENOL 0.005 mg/l
SUSP. SOLIDS 15 mg/l
PH 6-9
FLOW = 1251 l/AA3 (300 GAL/TON)

——— BASE LEVEL, BPCTCA & BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BEEHIVE COKE SUBCATEGORY
BATEA MODEL

| 11-13-79 | FIGURE 79A |

FIGURE 73B

MODEL COST EFFECTIVENESS DIAGRAM
BEEHIVE COKE SUBCATEGORY

* ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
  + INTEREST RATE 7%
  + OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
  + MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
  THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
* COST BASED ON 665 KKG/DAY (730 TON/DAY) COKE PLANT
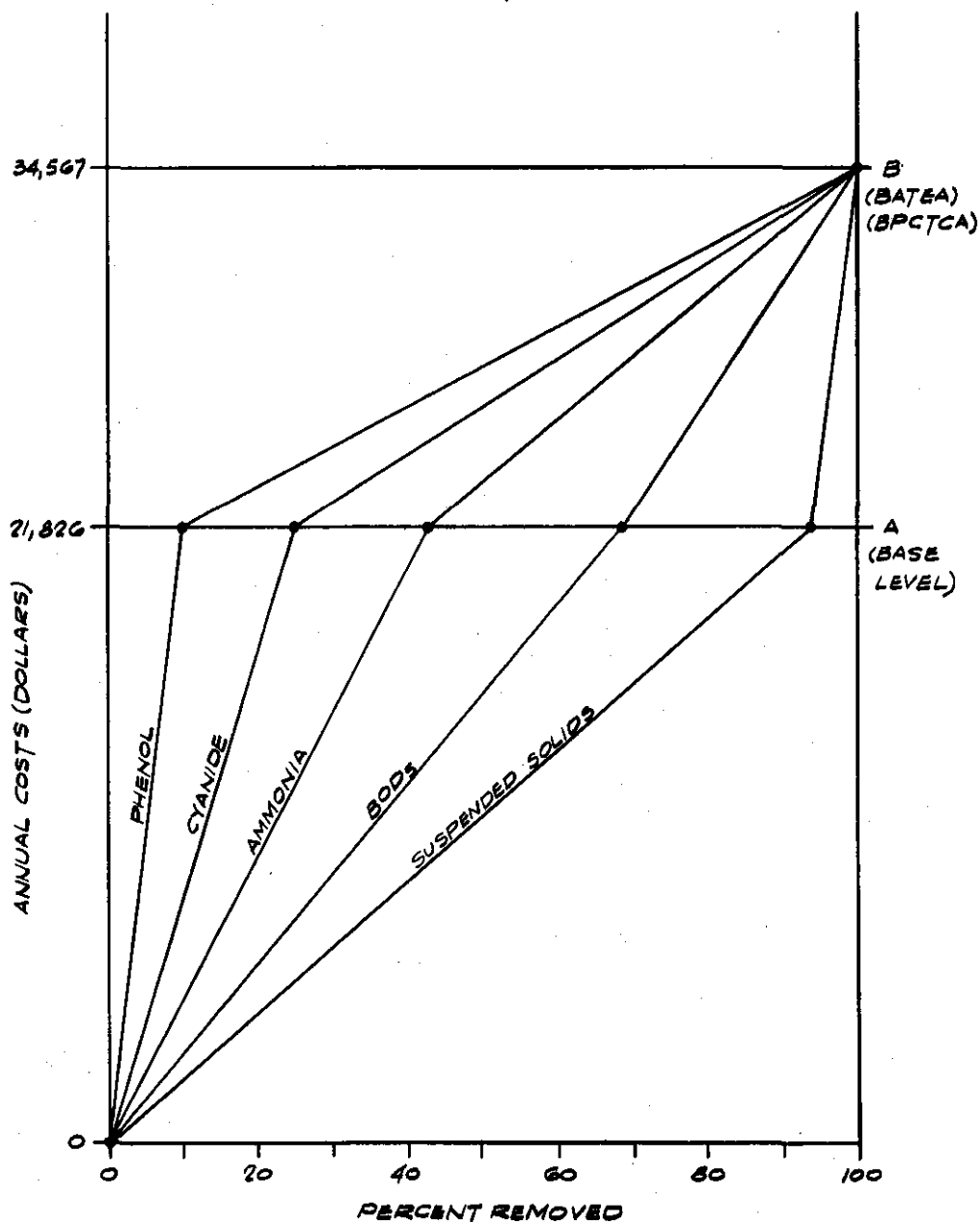
# TABLE 69

## BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Sintering

| CRITICAL PARAMETERS | BATEA LIMITATIONS Kg/KKg[1] (LB/1000 LB) | mg/1[2] | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0053 | 25 | | | |
| Oil and Grease | 0.0021 | 10 | (Implemented under BPCTCA Standards) | | |
| Sulfide | 0.00006 | 0.3 | | | |
| Fluoride | 0.0042 | 20 | Blowdown treatment using lime precipitation of fluorides | 0.0694 | 0.0630 |
| pH | 6.0-9.0 | | Neutralization | | |
| Flow | Most probable value for tight system is 209 liters effluent per kkg of sinter produced (50 gal/ton) (excluding all non contact cooling water) | | | | |

(1) Kilograms per metric ton of sinter produced, or pounds per 1000 pounds of sinter produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of sinter produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.

PROCESS

FLUORIDE 30 mg/l
OIL & GREASE 600 mg/l
SULFIDE 200 mg/l
SUSP SOLIDS 8000 mg/l
pH 8-10
FLOW (1045.8/ton) (250 Gal/Ton)

SOLIDS TO DISPOSAL

OIL

VACUUM FILTER

POLY ELECTROLYTE

MAKE-UP WATER

AIR BLOWER

LIME

SOLIDS TO DISPOSAL

VACUUM FILTER

ACID

FLUORIDE < 20 mg/l
OIL & GREASE < 10 mg/l
SULFIDE < 0.3 mg/l
SUSP SOLIDS < 25 mg/l
pH 6-9
FLOW 209.8/ton (50 Gal/Ton)

---- BASE LEVEL & BPCTCA MODEL
—— BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
SINTERING SUBCATEGORY
BATEA MODEL

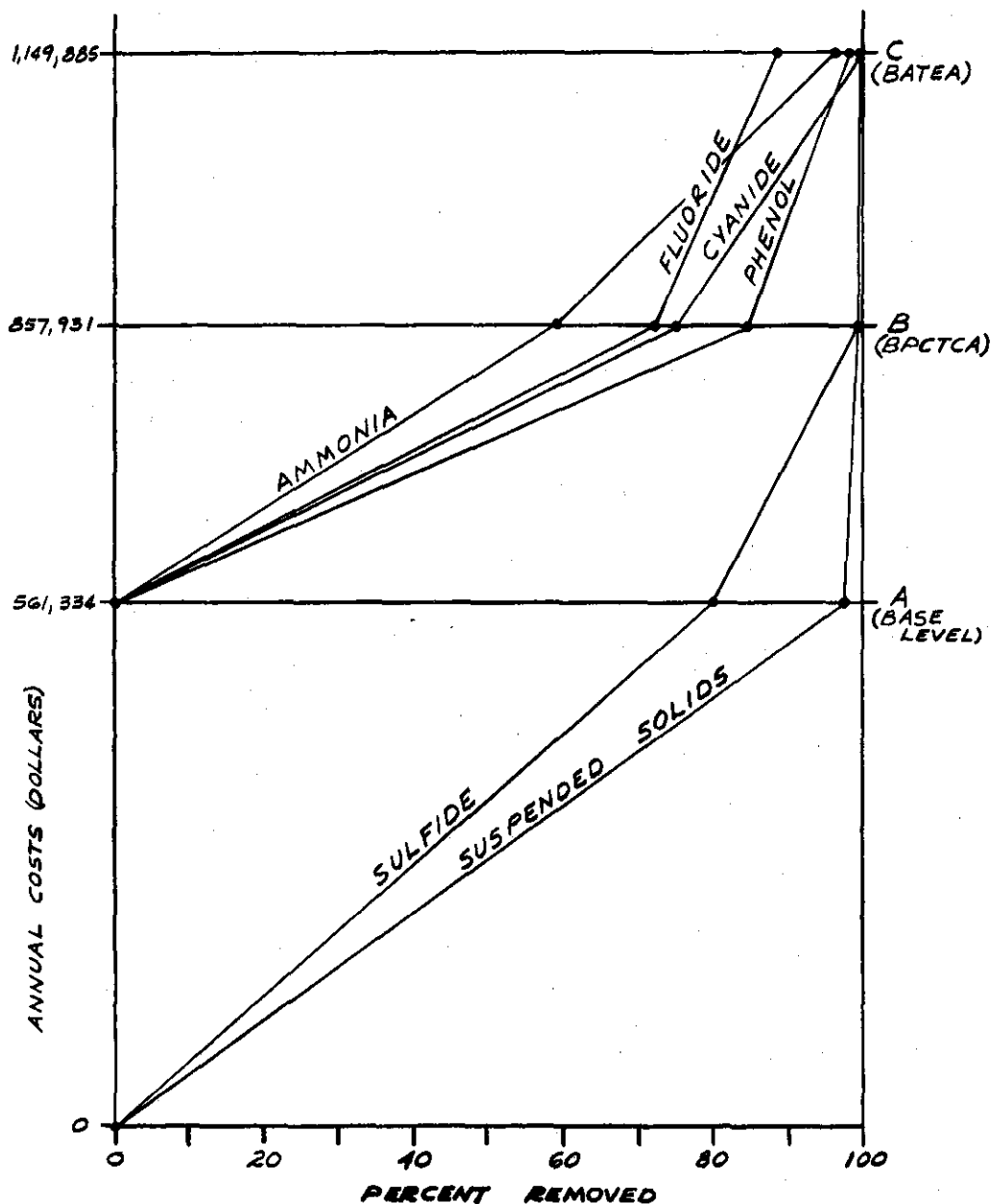| 11-14-73 | FIGURE 74A |

Figure 74B

MODEL COST EFFECTIVENESS DIAGRAM
SINTERING SUBCATEGORY

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES

*COST BASED ON 2704 kKg/DAY (2980 TON/DAY) PLANT

The last sintering plant had wet scrubber systems for both the dedusting and sinter bed exhaust systems. The wastewater treatment system was composed of a classifier and a thickener; a portion of the thickener overflow was recirculated and the rest went to blowdown. Underflow was filtered through vacuum filters.

For the one plant considered under this study, the flow was 475 l/kkg (114 gal/ton) of sinter produced. This value, however, represents a blowdown equivalent to approximately 33% of the process recycle flow of 341 gal/ton. Therefore, the magnitude of the effluent flow was considered uniformly inadequate, since simply tightening up the recycle loop can reduce the effluent discharge by more than 50 percent. In doing this, more attention may have to be paid to control of heat buildup and scaling and/or corrosive conditions in the recycle system. The ELG's were therefore based on 209 l/kkg (50 gal/ton) of product and the concentrations of the various pollutant parameters achievable by the indicated treatment technologies. This 209 l/kkg (50 gal/ton) is identical to the effluent flow limitations actually found (under this study) for the Open Hearth and BOF gas scrubber recycle systems. Thus the technology should be readily transferable to a sinter plant, since the type of recycle system and many of the aqueous contaminants are identical.

After reviewing the laboratory analyses, the critical parameters were established as suspended solids, oils and grease, sulfides, fluoride, pH and the resulting ELG's were set as follows:

## Suspended Solids

The one plant studied showed 9 mg/l total suspended solids in the final effluent, although this concentration was found in the excessive flow of 475 l/kkg (114 gal/ton) discussed above. This concentration based on a 209 l/kkg (50 gal/ton) flow would be equivalent to 21 mg/l. This excellent reduction can apparently be credited to the presence of substantial oil in the raw waste which tends to act as a mucilage on the suspended solids. Similar phenomena have long been known to be responsible for enhancing removal of fine suspended solids in deep bed sand filters. The ELG for total suspended solids was therefore based on 25 mg/l at flows of 209 l/kkg (50 gal/ton) based on measured performance values. The technologies for achieving this are as shown in Table 69.

## Oil and Grease

The one plant surveyed was discharging 1.0 mg/l oil and grease at 475 l/kkg (114 gal/ton), which is equivalent to less than 3 mg/l oil and grease on a 209 l/kkg (50 gal/ton) basis. The ELG for oil and grease for BATEA has been set at 10 mg/l based on a total effluent flow of 209 l/kkg (50 gal/ton) of sintered product. Sampling and analysis techniques currently available mitigate against lowering this standard at this time.

## Sulfide

Appreciable sulfide (11 mg/l) was found in the final effluent of the plant surveyed. No reduction was being practiced and therefore this plant was judged to be _inadequate_ with respect to the application of cost effective treatment technology available for sulfide removal. Therefore, the ELG for sulfide was based on 0.3 mg/l at 50 gal/ton based on values achievable by chemical or air oxidation techniques as described in the BATEA limitations discussed above for By-Product Coke plants.

## Fluoride

For the one plant studied, fluoride was found to be present in the final effluent at 8.5 mg/l at a flow of 475 l/kkg (114 gal/ton). This fluoride load is equivalent to 19 mg/l F based on a discharge flow of 209 l/kkg (50 gal/ton). Since substantial fluoride may enter the sintering process from the reuse of steelmaking fines, a standard should be set for the final treated effluent even though in this particular instance the fluoride level was down to values considered to be best available treatment. The BATEA guideline is based on a concentration of 20 mg/l at 209 l/kkg (50 gal/ton). These values represent the effluent quality attainable through application of treatments including lime precipitation of fluoride, followed by sedimentation for removal of suspended matter. These technologies are currently practiced in a number of raw water treating plants and are readily transferable to wastewater treatment in the steel industry.

## pH

For the one plant studied, the pH was found to be 12.7 in the final effluent, apparently due to the use of lime fluxing agents in the sintering process. Although the presence of lime in the process water enhances removal of fluorides, pH levels in this range would definitely have to be classed as detrimental. Appropriate neutralization procedures would have to be applied to attain the pH range required by BPCTCA limitations. No further tightening of the BPCTCA pH range is recommended at this time. The ELG for BATEA remains at pH 6.0 to 9.0.

## Blast Furnace (Iron) Subcategory

Waste treatment practices in blast furnace (iron) plants center primarily around removal of suspended solids from the contaminated gas scrubber waters. In past practice, little attention was paid to treatment for other aqueous pollutants in the discharge. Water conservation is practiced in many plants by employing recycle systems.

Three of the four plants surveyed were practicing tight recycle with minimum blowdown. Discharges from these three plants averaged approximately 417 l/kkg (100 gal/ton) of iron produced. The ELG's for BATEA were therefore established conservatively on the basis of 521 l/kkg (125 gal/ton) of product and the concentrations of the various pollutant parameters achievable by

# TABLE 70

## BATEA - EFFLUENT LIMITATIONS GUIDELINES

### SUBCATEGORY   Blast Furnace (Iron)

| CRITICAL PARAMETERS | BATEA LIMITATIONS Kg/KKg[1] (LB/1000 LB) | mg/l[2] | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0052 | 10 | BPCTCA plus: | | |
| *Cyanide A | 0.00013 | 0.25 | Treatment of cooling | | |
| Phenol | 0.00026 | 0.5 | Tower blowdown via: | | |
| Ammonia | 0.0052 | 10 | Alkaline chlorination | 0.267 | 0.242 |
| Sulfide | 0.00016 | 0.3 | Pressure Filtration | | |
| Fluoride | 0.0104 | 20 | Carbon adsorption. | | |
| pH | 6.0 - 9.0 | | pH neutralization | | |
| Flow | Most probable value for tight system is 522 liters effluent per kkg of coke produced (125 gal/ton) (excluding all non-contact cooling water.) | | | | |

(1)  Kilograms per metric ton of iron produced, or pounds per 1000 pounds of iron produced.
(2)  Milligrams per liter based on 522 liters effluent per kkg of iron produced (125 gal/ton).
(3)  Available technology listed in not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4)  Costs may vary some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA Standards.

*Cyanides amenable to chlorination.  Reference ASTM D 2036-72 Method B.

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PROCESS

VACUUM FILTER

MAKE-UP

COOLING TOWER

POLY ELECTROLYTE

AMMONIA        10 mg/l
CYANIDE         1.0 mg/l
FLUORIDE        5 mg/l
PHENOL          1.0 mg/l
SULFIDE         10 mg/l
SUSP. SOLIDS    1600 mg/l
pH              7-9
FLOW            10260 l/kg (2900 GAL/TON)

LIME

ACID

CITY WATER

CHLORINATOR

CHLORINE

PRESSURE FILTER

ACTIVATED CARBON

AMMONIA        =10 mg/l
CYANIDE         =0.25 mg/l
FLUORIDE        =50 mg/l
PHENOL          =0.5 mg/l
SULFIDE         =0.1 mg/l
SUSP. SOLIDS    =10 mg/l
pH              6-9
FLOW            551 l/kg (125 GAL/TON)

- - - - -  BASE LEVEL SYSTEM & BPCTCA MODEL
           BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE (IRON) SUBCATEGORY,
BATEA MODEL

11-10-75        FIGURE 75A
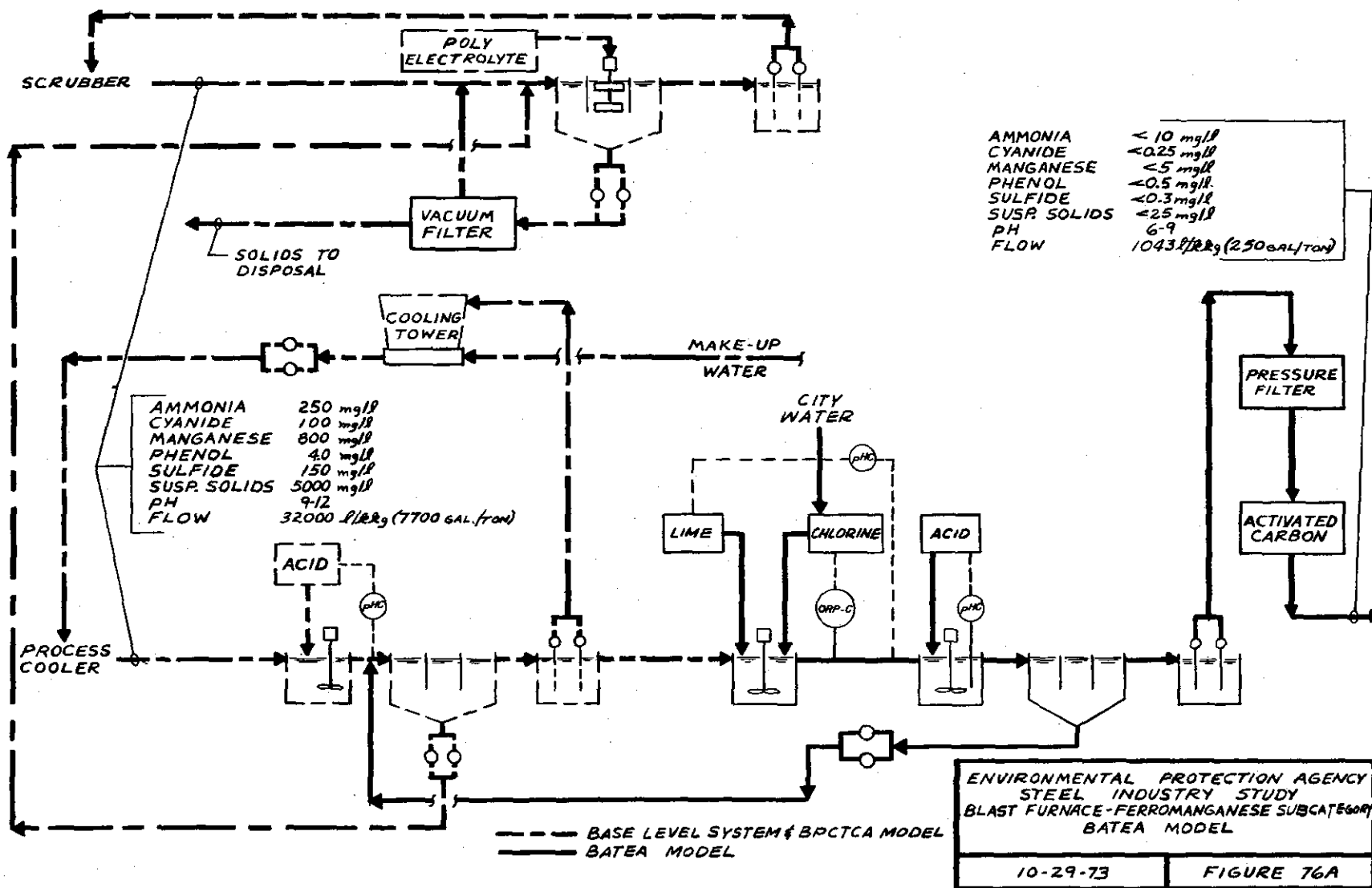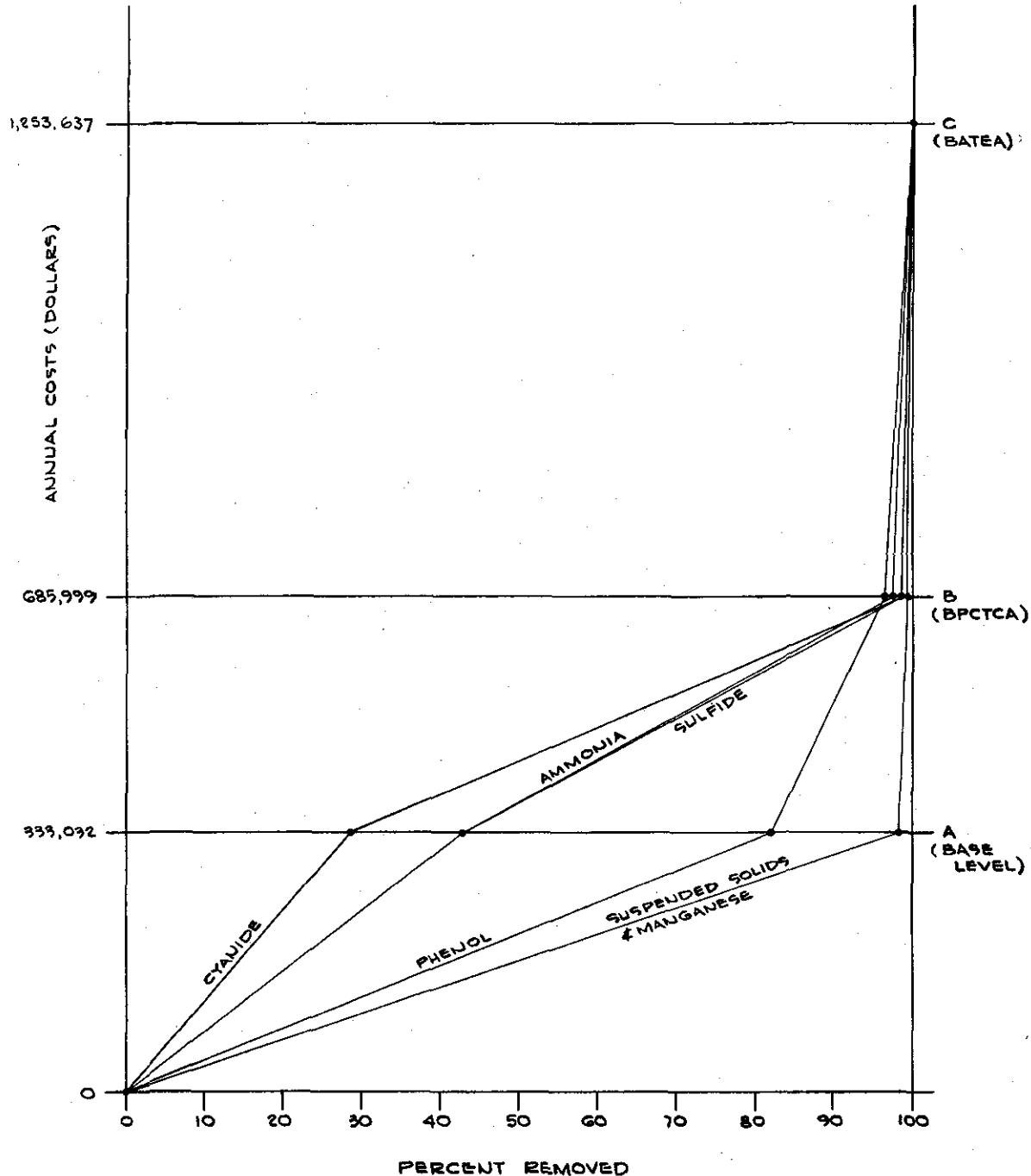
FIGURE 75B
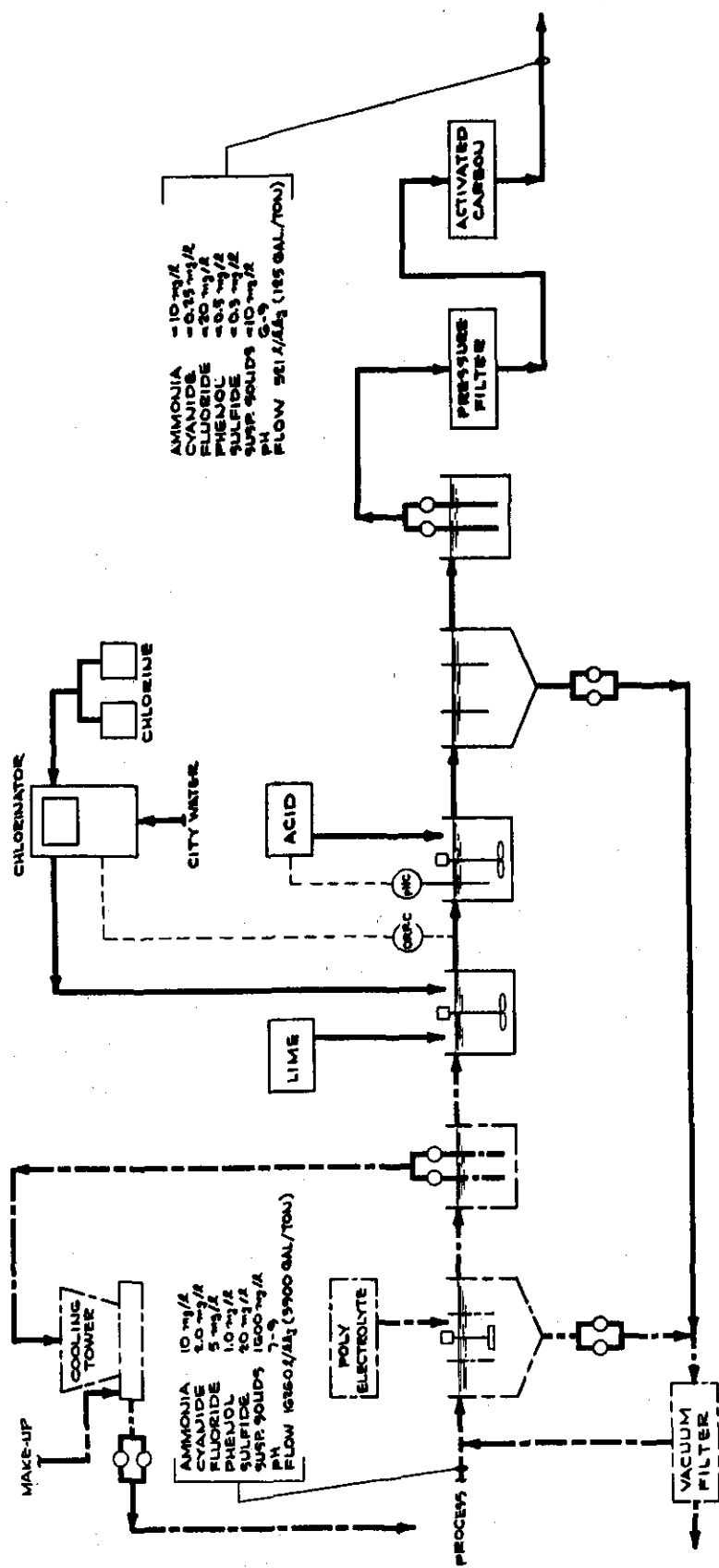
MODEL COST EFFECTIVENESS DIAGRAM
BLAST FURNACE (IRON) SUBCATEGORY

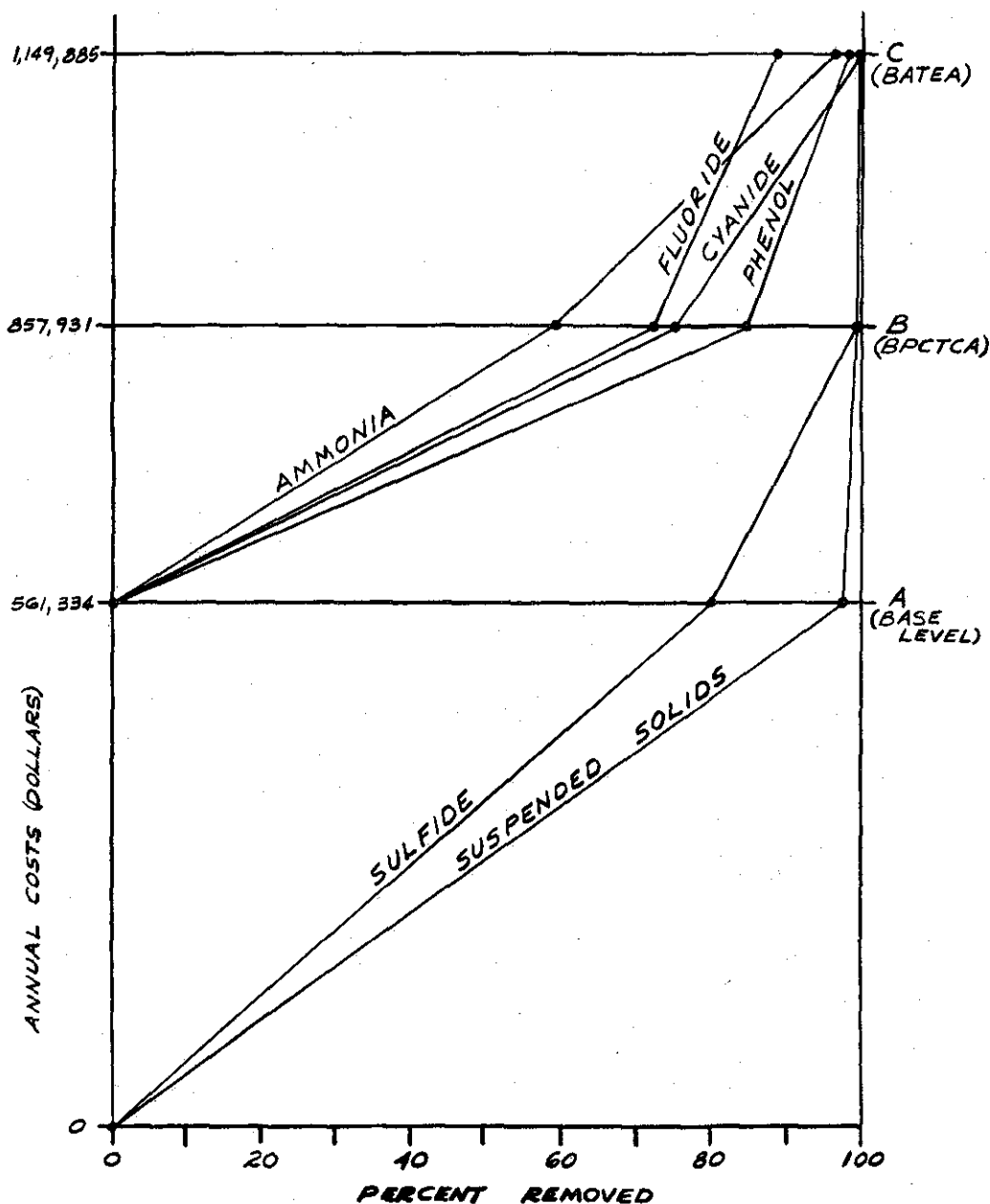* ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
* COST BASED ON 2995 KKG/DAY (3300 TON/DAY) PRODUCTION

the indicated treatment technologies. All three blast furnace
(iron) plants which practice recycle do achieve this recommended
discharge flow. The fourth plant surveyed was running close to a
once-through system and was judged _inadequate_ with respect to
water conservation, since blast furnace recycle is a well
established art.

## Cyanide

Only one of the blast furnace (iron) plants surveyed was
practicing cyanide removal; it was done by alkaline chlorination
of the total discharge flow, yielding a cyanide concentration in
the effluent of 0.005 mg/l in a flow of 22,520 l/kkg (5400
gal/ton) of iron produced. This same cyanide load estimated on a
521 l/kkg (125 gal/ton) flow from a recycle system is equivalent
to 0.216 mg/l. Therefore, the ELG for cyanide is set at 0.25
mg/l, based on a total discharge flow of 521 l/kkg (125 gal/ton)
of iron produced. Conversion of the once-through system to a
recycle system is expected to increase chances for achievement of
the BATEA limitation.

## Phenol

Two of the three blast furnace (iron) recycle systems were
attaining very low phenol concentrations in their discharge
flows, equivalent to 0.03 and 0.01 mg/l based on flows of 521
l/kkg (125 gal/ton). The once-through system was attaining an
equivalent concentration of 0.6 mg/l at 521 l/kkg (125 gal/ton).
Therefore, the ELG for phenol is set at 0.5 mg/l, based on a
total discharge flow of 521 l/kkg (125 gal/ton) of iron produced,
utilizing technology currently practiced in the blast furnace
(iron) subcategory.

## Ammonia

None of the three blast furnace (iron) recycle systems surveyed
were attaining less than 75 mg/l of ammonia in the effluent.
Only the once-through system, utilizing alkaline chlorination,
attained low ammonia levels of 0.84 mg/l in 22,520 l/kkg (5400
gal/ton), equivalent to 36 mg/l based on a flow of 521 l/kkg (125
gal/ton). This system can be upgraded by providing a recycle
loop, alkaline chlorination treatment of the blowdown,
filtration, and carbon adsorption to provide a lower final
ammonia concentration. Therefore, the ELG for ammonia is set at
10 mg/l, based on a discharge flow of 521 l/kkg (125 gal/ton) of
iron produced, utilizing technology currently practiced in the
blast furnace (iron) subcategory modified by additional
technology transferred from the petrochemical industry.

## Sulfur

None of the four plants surveyed was attaining adequate sulfide
levels, although the plant utilizing alkaline chlorination was
discharging a concentration of 0.043 mg/l in the once-through
system, equivalent to 1.86 mg/l in 521 l/kkg (125 gal/ton). The

improvements to this system described previously under Ammonia can serve to drive sulfide removals significantly further. Therefore, the ELG for sulfide is set at 0.3 mg/l based on a discharge flow of 521 l/kkg (125 gal/ton) of iron produced, utilizing the technology described above.

## Suspended Solids

Only the once-through system was achieving acceptable suspended solids concentrations in the effluent, although in terms of load, this system was discharging excessive solids. An abundance of technology exists for reducing suspended solids in a cost effective manner. For this reason, the ELG for suspended solids was based on 25 mg/l at a discharge flow of 521 l/kkg (125 gal/ton) of iron utilizing existing technology for solids removal.

## Fluoride

Since substantial quantities of fluoride may occur in certain raw materials used in blast furnace (iron) operations, a limitation on this parameter is desirable. All four operating plants surveyed showed equivalent concentrations of fluoride ranging between 8.4 and 22.6 mg/l based on discharge flows of 521 l/kkg (125 gal/ton). Even though these plants show fluoride levels approaching BATEA, an ELG is set at 20 mg/l based on a total discharge flow of 521 l/kkg (125 gal/ton) of iron produced to provide control over plants which may show higher raw waste fluoride concentrations. The lime precipitation and sedimentation treatment referred to above in discussing sintering plants is the treatment technology of choice.

## pH

All four plants surveyed discharge effluents well within the BATEA pH range noted elsewhere. In the event that lime precipitation of fluorides is required, the effluent pH may have to be adjusted with acid addition to remain within the desired 6.0 to 9.0 pH range.

## Blast Furnace (Ferromanganese) Subcategory

Only one operating ferro-manganese furnace was found for the survey. The one plant surveyed was operating on a close to once-through basis of 23,770 l/kkg (5700 gal/ton) of ferro-manganese produced. This flow would have to be considered uniformly inadequate since there is no reason precluding running a recycle system identical to that of the iron producing blast furnaces, except that a blowdown rate of 1043 l/kkg (250 gal/ton) is required for the reasons discussed in section IX.

BATEA limitations for the blast furnace (iron) subcategory are applicable to blast furnace (ferromanganese) plants, except that the higher flow rates do provide for discharge of twice the load from the latter. All of the treatment and control technologies

## TABLE 71

### BATEA − EFFLUENT LIMITATIONS GUIDELINES

### SUBCATEGORY   Blast Furnace (Ferromanganese)

| CRITICAL PARAMETERS | BATEA LIMITATIONS | | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST | |
|---|---|---|---|---|---|
| | Kg/KKg[1] (LB/1000 LB) | mg/1[2] | | $/KKg | $/TON |
| Suspended Solids | 0.0104 | 10 | BPCTCA plus: | | |
| *Cyanide $_A$ | 0.00026 | 0.25 | Treatment of system | | |
| Phenol | 0.00052 | 0.5 | blowdown via: | | |
| Ammonia (as $NH_3$) | 0.0104 | 10 | Alkaline chlorination. | 1.927 | 1.749 |
| Sulfide | 0.00031 | 0.3 | Pressure filtration. | | |
| Manganese | 0.0052 | 5 | Carbon adsorption. | | |
| pH | 6.0 − 9.0 | | pH neutralization | | |
| Flow: | Most probable value for tight system is 1043 liters per kkg of ferromanganese produced (250 gal/ton) (excluding all non-contact cooling water). | | | | |

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(1)  Kilograms per metric ton of ferromanganese produced or pounds per 1000 pounds of ferromanganese produced.
(2)  Milligrams per liter based on 1043 liters per kkg of ferromanganese produced (250 gal/ton).
(3)  Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4)  Costs may vary some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of pre-liminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA Standards.

*Cyanides amenable to chlorination.  Reference ASTM D 2036-72 Method B.

POLY
ELECTROLYTE

SCRUBBER

VACUUM
FILTER

SOLIDS TO
DISPOSAL

COOLING
TOWER

MAKE-UP
WATER

AMMONIA        < 10 mg/l
CYANIDE        <0.25 mg/l
MANGANESE      <5 mg/l
PHENOL         <0.5 mg/l
SULFIDE        <0.3 mg/l
SUSP. SOLIDS   <25 mg/l
PH             6-9
FLOW           1043 l/kkg (250 GAL/TON)

PRESSURE
FILTER

AMMONIA        250 mg/l
CYANIDE        100 mg/l
MANGANESE      800 mg/l
PHENOL         40 mg/l
SULFIDE        150 mg/l
SUSP. SOLIDS   5000 mg/l
PH             9-12
FLOW           32000 l/kkg (7700 GAL./TON)

CITY
WATER

ACID

LIME      CHLORINE    ACID

ORP-C

ACTIVATED
CARBON

PROCESS
COOLER

- - - - BASE LEVEL SYSTEM & BPCTCA MODEL
─────── BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE-FERROMANGANESE SUBCATEGORY
BATEA MODEL

| 10-29-73 | FIGURE 76A |

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FIGURE 7GB

MODEL COST EFFECTIVENESS DIAGRAM
BLAST FURNACE (FERROMANGANESE) SUBCATEGORY

＊ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDING LABOR, CHEMICALS, & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS

THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
＊COST BASED ON 744 KKG/DAY (820 TON/DAY) PRODUCTION

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AMMONIA =10 mg/l
CYANIDE =0.15 mg/l
FLUORIDE =30 mg/l
PHENOL =0.5 mg/l
SULFIDE =0.5 mg/l
SUSP. SOLIDS =10 mg/l
pH 6-9
FLOW 561 l/kkg (135 GAL./TON)

AMMONIA 10 mg/l
CYANIDE 1.0 mg/l
FLUORIDE 5 mg/l
PHENOL 1.0 mg/l
SULFIDE 20 mg/l
SUSP. SOLIDS 1200 mg/l
pH 7-9
FLOW 16260 l/kkg (3900 GAL./TON)

CHLORINATOR
CHLORINE
CITY WATER
ACID
LIME
ACTIVATED CARBON
PRESSURE FILTER
COOLING TOWER
MAKE-UP
POLY ELECTROLYTE
PROCESS
VACUUM FILTER

BASE LEVEL SYSTEM + BPCTCA MODEL
BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BLAST FURNACE (IRON) SUBCATEGORY
BATEA MODEL

11-10-75          FIGURE 75A

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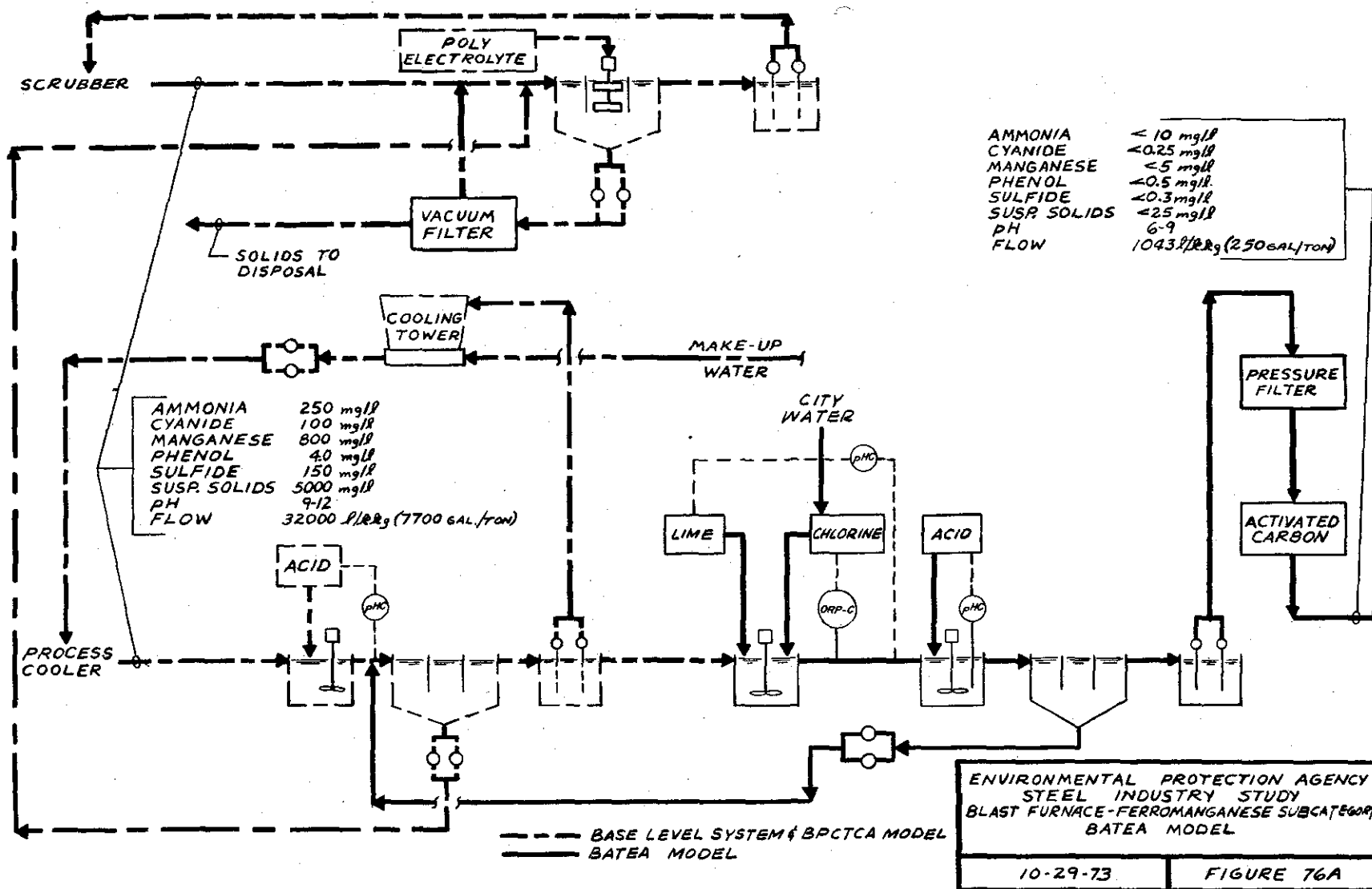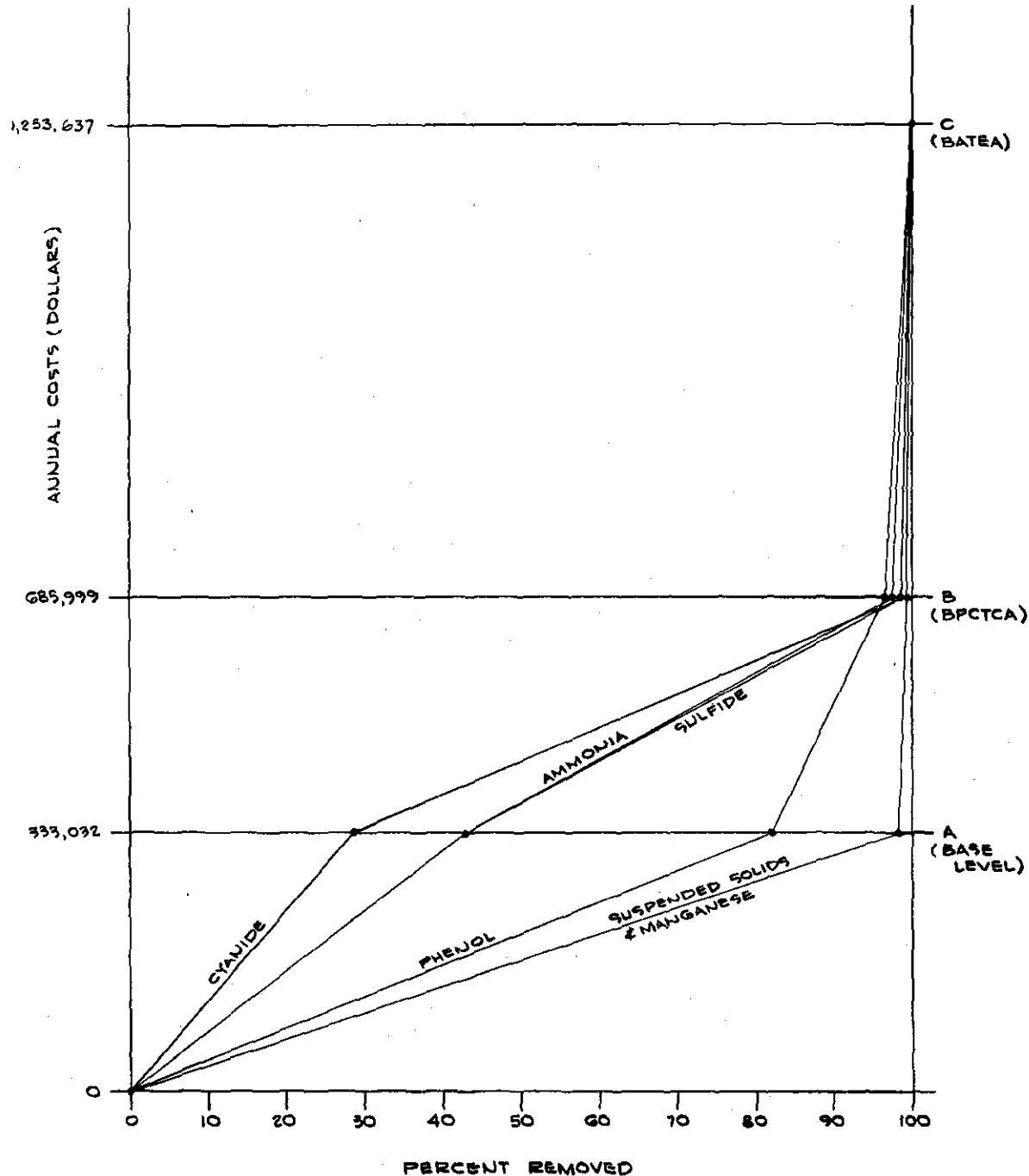
FIGURE 75B

MODEL COST EFFECTIVENESS DIAGRAM
BLAST FURNACE (IRON) SUBCATEGORY

*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
        + INTEREST RATE 7%
        + OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
        + MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
    THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
* COST BASED ON 2995 KKG/DAY (3300 TON/DAY) PRODUCTION

the indicated treatment technologies. All three blast furnace (iron) plants which practice recycle do achieve this recommended discharge flow. The fourth plant surveyed was running close to a once-through system and was judged inadequate with respect to water conservation, since blast furnace recycle is a well established art.

## Cyanide

Only one of the blast furnace (iron) plants surveyed was practicing cyanide removal; it was done by alkaline chlorination of the total discharge flow, yielding a cyanide concentration in the effluent of 0.005 mg/l in a flow of 22,520 l/kkg (5400 gal/ton) of iron produced. This same cyanide load estimated on a 521 l/kkg (125 gal/ton) flow from a recycle system is equivalent to 0.216 mg/l. Therefore, the ELG for cyanide is set at 0.25 mg/l, based on a total discharge flow of 521 l/kkg (125 gal/ton) of iron produced. Conversion of the once-through system to a recycle system is expected to increase chances for achievement of the BATEA limitation.

## Phenol

Two of the three blast furnace (iron) recycle systems were attaining very low phenol concentrations in their discharge flows, equivalent to 0.03 and 0.01 mg/l based on flows of 521 l/kkg (125 gal/ton). The once-through system was attaining an equivalent concentration of 0.6 mg/l at 521 l/kkg (125 gal/ton). Therefore, the ELG for phenol is set at 0.5 mg/l, based on a total discharge flow of 521 l/kkg (125 gal/ton) of iron produced, utilizing technology currently practiced in the blast furnace (iron) subcategory.

## Ammonia

None of the three blast furnace (iron) recycle systems surveyed were attaining less than 75 mg/l of ammonia in the effluent. Only the once-through system, utilizing alkaline chlorination, attained low ammonia levels of 0.84 mg/l in 22,520 l/kkg (5400 gal/ton), equivalent to 36 mg/l based on a flow of 521 l/kkg (125 gal/ton). This system can be upgraded by providing a recycle loop, alkaline chlorination treatment of the blowdown, filtration, and carbon adsorption to provide a lower final ammonia concentration. Therefore, the ELG for ammonia is set at 10 mg/l, based on a discharge flow of 521 l/kkg (125 gal/ton) of iron produced, utilizing technology currently practiced in the blast furnace (iron) subcategory modified by additional technology transferred from the petrochemical industry.

## Sulfur

None of the four plants surveyed was attaining adequate sulfide levels, although the plant utilizing alkaline chlorination was discharging a concentration of 0.043 mg/l in the once-through system, equivalent to 1.86 mg/l in 521 l/kkg (125 gal/ton). The

improvements to this system described previously under Ammonia can serve to drive sulfide removals significantly further. Therefore, the ELG for sulfide is set at 0.3 mg/l based on a discharge flow of 521 l/kkg (125 gal/ton) of iron produced, utilizing the technology described above.

## Suspended Solids

Only the once-through system was achieving acceptable suspended solids concentrations in the effluent, although in terms of load, this system was discharging excessive solids. An abundance of technology exists for reducing suspended solids in a cost effective manner. For this reason, the ELG for suspended solids was based on 25 mg/l at a discharge flow of 521 l/kkg (125 gal/ton) of iron utilizing existing technology for solids removal.

## Fluoride

Since substantial quantities of fluoride may occur in certain raw materials used in blast furnace (iron) operations, a limitation on this parameter is desirable. All four operating plants surveyed showed equivalent concentrations of fluoride ranging between 8.4 and 22.6 mg/l based on discharge flows of 521 l/kkg (125 gal/ton). Even though these plants show fluoride levels approaching BATEA, an ELG is set at 20 mg/l based on a total discharge flow of 521 l/kkg (125 gal/ton) of iron produced to provide control over plants which may show higher raw waste fluoride concentrations. The lime precipitation and sedimentation treatment referred to above in discussing sintering plants is the treatment technology of choice.

## pH

All four plants surveyed discharge effluents well within the BATEA pH range noted elsewhere. In the event that lime precipitation of fluorides is required, the effluent pH may have to be adjusted with acid addition to remain within the desired 6.0 to 9.0 pH range.

## Blast Furnace (Ferromanganese) Subcategory

Only one operating ferro-manganese furnace was found for the survey. The one plant surveyed was operating on a close to once-through basis of 23,770 l/kkg (5700 gal/ton) of ferro-manganese produced. This flow would have to be considered uniformly inadequate since there is no reason precluding running a recycle system identical to that of the iron producing blast furnaces, except that a blowdown rate of 1043 l/kkg (250 gal/ton) is required for the reasons discussed in section IX.

BATEA limitations for the blast furnace (iron) subcategory are applicable to blast furnace (ferromanganese) plants, except that the higher flow rates do provide for discharge of twice the load from the latter. All of the treatment and control technologies

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TABLE 71

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY  Blast Furnace (Ferromanganese)

| CRITICAL PARAMETERS | BATEA LIMITATIONS Kg/KKg[1] (LB/1000 LB) | mg/l[2] | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0104 | 10 | BPCTCA plus: | | |
| *Cyanide A | 0.00026 | 0.25 | Treatment of system | | |
| Phenol | 0.00052 | 0.5 | blowdown via: | | |
| Ammonia (as NH3) | 0.0104 | 10 | Alkaline chlorination. | 1.927 | 1.749 |
| Sulfide | 0.00031 | 0.3 | Pressure filtration. | | |
| Manganese | 0.0052 | 5 | Carbon adsorption. | | |
| pH | 6.0 - 9.0 | | pH neutralization | | |
| Flow: | Most probable value for tight system is 1043 liters per kkg of ferromanganese produced (250 gal/ton) (excluding all non-contact cooling water). | | | | |

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(1)  Kilograms per metric ton of ferromanganese produced or pounds per 1000 pounds of ferromanganese produced.
(2)  Milligrams per liter based on 1043 liters per kkg of ferromanganese produced (250 gal/ton).
(3)  Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4)  Costs may vary some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA Standards.

*Cyanides amenable to chlorination.  Reference ASTM D 2036-72 Method B.

SCRUBBER

POLY
ELECTROLYTE

VACUUM
FILTER

SOLIDS TO
DISPOSAL

AMMONIA          < 10 mg/l
CYANIDE          <0.25 mg/l
MANGANESE        <5 mg/l
PHENOL           <0.5 mg/l
SULFIDE          <0.3 mg/l
SUSP. SOLIDS     <25 mg/l
pH               6-9
FLOW             1043 l/kkg (250 GAL/TON)

COOLING
TOWER

MAKE-UP
WATER

395

AMMONIA          250 mg/l
CYANIDE          100 mg/l
MANGANESE        800 mg/l
PHENOL           40 mg/l
SULFIDE          150 mg/l
SUSP. SOLIDS     5000 mg/l
pH               9-12
FLOW             32000 l/kkg (7700 GAL./TON)

CITY
WATER

PRESSURE
FILTER

ACID

LIME

CHLORINE

ACID

ACTIVATED
CARBON

PROCESS
COOLER

ORP-C

ENVIRONMENTAL  PROTECTION  AGENCY
STEEL  INDUSTRY  STUDY
BLAST FURNACE-FERROMANGANESE SUBCATEGORY
BATEA  MODEL

— — —   BASE LEVEL SYSTEM & BPCTCA MODEL
————   BATEA  MODEL

| 10-29-73 | FIGURE  76A |

FIGURE 7GB

MODEL COST EFFECTIVENESS DIAGRAM
BLAST FURNACE (FERROMANGANESE) SUBCATEGORY

*ANNUAL COSTS - BASED ON TEN YEAR CAPITAL RECOVERY
         + INTEREST RATE 7%
         + OPERATING COSTS INCLUDING LABOR, CHEMICALS, +UTILITIES
         + MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS

    THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
*COST BASED ON 744 KKG/DAY (820 TON/DAY) PRODUCTION

described above for achieving blast furnace (iron) BATEA limitations are applicable to blast furnace (ferromanganese) plants, with one exception. Raw waste loads for ferromanganese operations indicate that fluoride loads are relatively minor, and therefore do not require control. However, a high load of manganese results from this process, and must be controlled by the treatment technology. Since most of the manganese is in the suspended solid form, it is effectively removed with the suspended solids, as described above.

The ELG for all parameters to be controlled by application of BATEA for blast furnace (ferromanganese) plants is summarized as follows: cyanide 0.25 mg/l; phenol 0.5 mg/l; ammonia 10 mg/l; sulfide 0.3 mg/l; suspended solids 25 mg/l; and manganese 5 mg/l. All concentrations are based on a total effluent flow of 1,043 l/kkg (250 gal/ton).

## Basic Oxygen Furnace Operation

The only direct contact process water used in the BOF plant is the water used for cooling and scrubbing the off-gases from the furnaces. Two methods which are employed and can result in an aqueous discharge are the semiwet gas cleaning and wet gas cleaning systems as defined in Types II, III, IV and V on Figures 17 through 20, inclusive.

## Basic Oxygen Furnace (Semiwet Air Pollution Control Methods) Subcategory

The two semiwet systems surveyed had different types of wastewater treatment systems. The first system was composed of a drag link conveyor, settling tank, chemical flocculation and complete recycle pump system to return the clarified treated effluent to the gas cleaning system. Make-up water was added to compensate for the evaporative water loss and the system had zero (0) aqueous discharge of blowdown. The second semiwet system was composed of a thickener with polyelectrolyte addition followed by direct discharge to the plant sewers on a "once-through" basis.

Because of the nature of these semiwet systems, direct blowdown is not required when recycle is employed. The systems are kept in equilibrium by water losses to the sludge and to entrainment carry-over into the hot gas stream. Most new wet BOF systems are designed in this manner. Therefore, the BATEA for this operation has been established as no discharge of process wastewater pollutants to navigable waters. This requirement had previously been set as BPCTCA limitations for this subcategory.

## Basic Oxygen Furnace (Wet Air Pollution Control Methods) Subcategory

The three BOF wet systems surveyed were generally of the same type and included classifiers and thickeners with recirculation of a portion of the clarifier effluent. The blowdown rates were 33, 52, and 217 gallons per ton of steel produced, respectively,

FIGURE 77B

MODEL COST EFFECTIVENESS DIAGRAM
BASIC OXYGEN FURNACE
(SEMI-WET AIR POLLUTION CONTROL METHODS) SUB-CATEGORY
* ANNUAL COSTS - BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDING LABOR, CHEMICALS, & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5 % OF CAPITAL COSTS

* THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
* COST BASED ON 4429 KKG/DAY (4880 TON/DAY) BOF SHOP
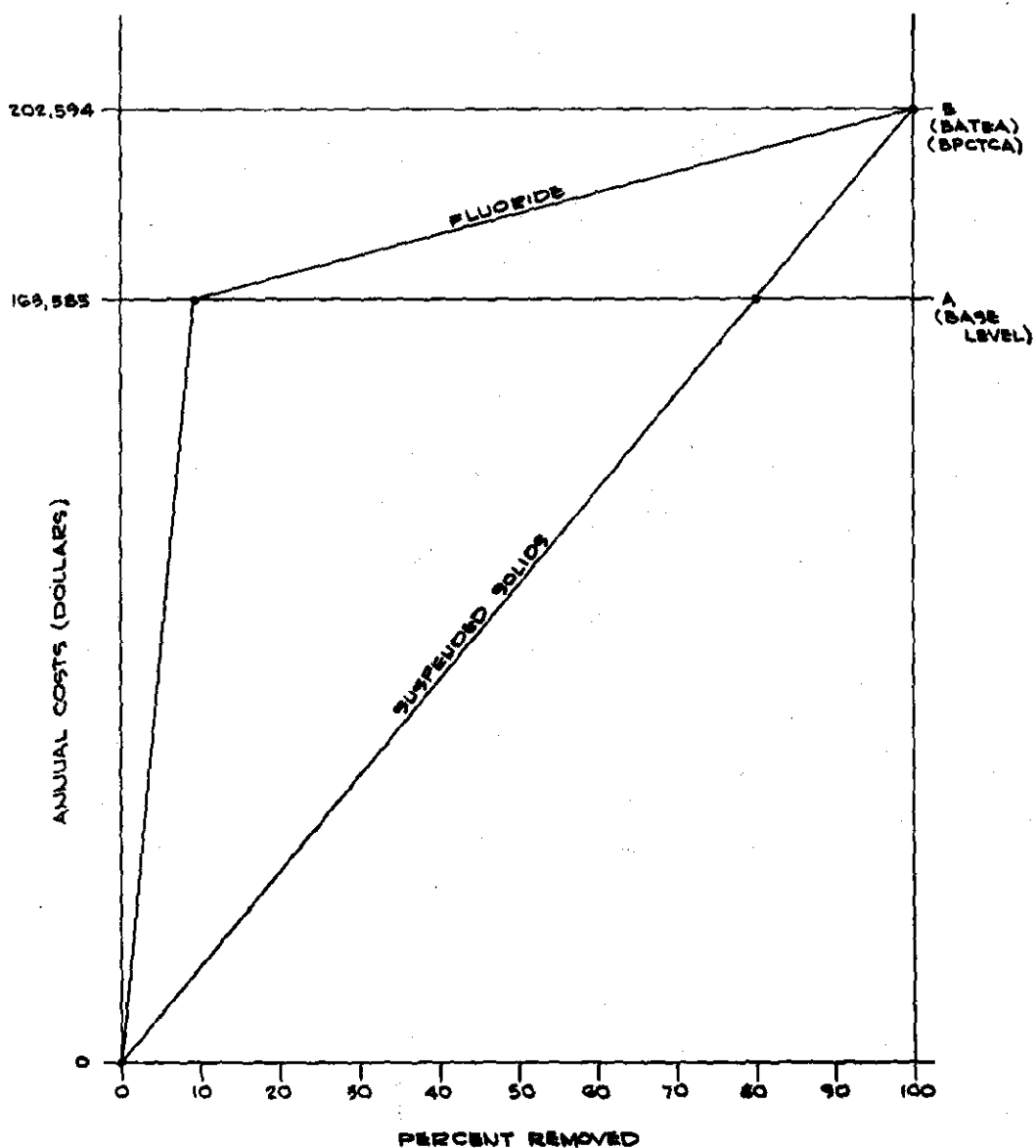
TABLE 73

BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY Basic Oxygen Furnace (Wet Air Pollution Control Methods)

| CRITICAL PARAMETERS | BATEA LIMITATIONS | | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST | |
|---|---|---|---|---|---|
| | Kg/KKg[1] (LB/1000 LB) | mg/1 [2] | | $/KKg | $/TON |
| Suspended Solids | 0.0052 | 25 | Blowdown treatment with sand filtration or improved settling with coagulation | | |
| Fluoride | 0.0042 | 20 | Blowdown treatment using lime precipitation of fluorides. | 0.0328 | 0.0298 |
| pH | 6.0 - 9.0 | | Neutralization | | |
| Flow | Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton) (excluding all non-contact cooling water). | | | | |

(1) Kilograms per metric ton of steel produced or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of pre-liminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.

FLUORIDE 20 mg/l
SUSP. SOLIDS 25 mg/l
pH 6-9
FLOW 209 l/kkg (50 GAL./TON)

ACID

LIME

MAKE-UP

VACUUM FILTER

SOLIDS TO DISPOSAL

POLY ELECTROLYTE

VACUUM FILTER

SOLIDS TO DISPOSAL

FLUORIDE 30 mg/l
SUSP. SOLIDS 5000 mg/l
pH 6-9
FLOW 6800 l/kkg (800 GAL./TON)

PROCESS

--- BASE LEVEL & BPCTCA MODEL
BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
BASIC OXYGEN FURNACE (WET)
SUBCATEGORY
BATEA MODEL

11-15-73    FIGURE 78A

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FIGURE 78B

MODEL COST EFFECTIVENESS DIAGRAM
BASIC OXYGEN FURNACE
(WET AIR POLLUTION CONTROL METHODS) SUBCATEGORY
*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
*COST BASED ON 6888 KKG/DAY (7590 TON/DAY) BOF SHOP
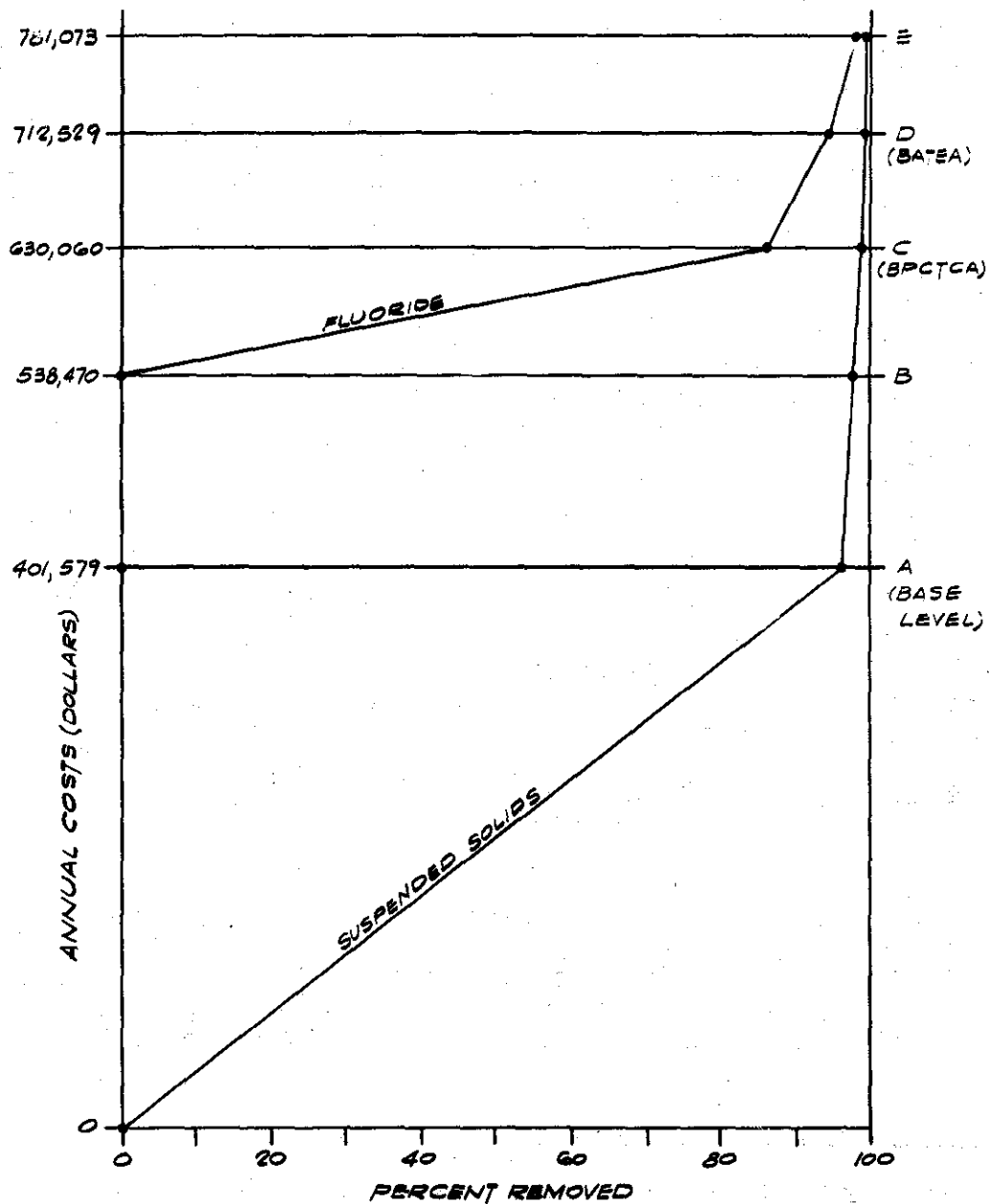
with the latter system discharging in excess of the blowdown normally required for recycle systems of this type. The ELG's were therefore established on the basis of discharge flows of 209 l/kkg (50 gal/ton) of product and the concentrations of the various pollutant parameters achievable by the indicated treatment technologies. A review of the data collected from the survey resulted in the following effluent guidelines:

## Suspended Solids

The effluent suspended solids were 22, 40, and 71 mg/l, respectively, for the three plants surveyed. The first two of these concentrations are equivalent to 23 and 26 mg/l at the recommended flow of 209 l/kkg (50 gal/ton), so the ELG for suspended solids is set at 25 mg/l based on a total discharge flow of 209 l/kkg (50 gal/ton). As indicated under discussion of blast furnaces, the technology is well established for reducing iron-laden suspended solids to less than 25 mg/l with the use of chemical and/ or magnetic flocculation. This technology is currently utilized within this subcategory.

## Fluoride

Fluoride was only measured at one of the three BOF wet systems surveyed and was found to be 14 mg/l, equivalent to 63 mg/l based on a total discharge flow of 209 l/kkg (50 gal/ton). As discussed under sinter plants, fluoride is a normal by-product of steelmaking where fluoride-containing fluxes are employed and as a result shows up in the sinter plant effluent and blast furnace effluent due to the recycle and reuse of steelmaking fines. The BATEA guideline for fluoride has been based on 20 mg/l at 209 l/kkg (50 gal/ton) for the reasons discussed above in the sintering subcategory. This value represents the effluent quality attainable by the application of the best available method of treatment for removal of fluorides, i.e., lime precipitation followed by sedimentation for particulate removal. This technology is currently practiced in a number of raw water treating plants and is readily transferable to wastewater treatment in the steel industry.

## pH

The pH of the three plants surveyed varied from 6.4 to 9.4. As with previous subcategories, the BATEA standards for pH are the same as BPCTCA limits for this parameter. If excess lime is used in the fluoride precipitation step, the effluent pH may have to be adjusted with acid to remain in the desired 6.0 to 9.0 pH range.

## Open Hearth Furnace Subcategory

As with the BOF furnaces, only contact process waters were surveyed, sampled and analyzed. Again the only contact process water in the open hearth is the water used for cooling and scrubbing the waste gases from the furnaces. As a general rule,

open hearths have dry precipitator systems rather than scrubbers. Therefore, only two open hearth shops were surveyed and each had a wet high energy venturi scrubber system as defined in Types I, II, III shown on Figures 21, 22, and 23, respectively. There are no semiwet systems for open hearths.

Each plant had a similar wastewater treatment system composed of classifiers and thickeners; a portion of the thickener overflow was recirculated. One system utilized vacuum filters for thickener underflow while the other system used slurry pumps and pumped the thickener wastes to tank trucks for disposal. The blowdown rates varied between 213 l/kkg (51 gal/ton), and 492 l/kkg (118 gal/ton) but the latter represented a 22% blowdown and the former about 9%.

These systems can be tightened as was indicated for the BOF and therefore the ELG's were established on the basis of 209 l/kkg (50 gal/ton) of product and the concentrations of the process pollutant parameters achievable by the indicated treatment technologies.

A review of the data collected resulted in the following effluent guidelines:

## Suspended Solids

For the two plants surveyed, the effluent suspended solids were 80 and 52 mg/l. As with the similarly operated BOF wet recycle systems, less than 25 mg/l suspended solids can readily be achieved and therefore the two open hearth plants surveyed were judged _uniformly inadequate_ with respect to achieving this level.

Similar to the BOF wet system, the BATEA ELG for suspended solids has been based on 25 mg/l at 209 l/kkg (50 gal/ton) based on the use of conventionally available coagulation and/or filtration techniques as indicated in Table 84. This technology is currently utilized in other iron and steel industry subcategories for attaining the BATEA limitations, and should achieve similar results in the open hearth subcategory.

## Fluoride

The two plants surveyed showed fluoride levels in their final effluents of 65 and 148 mg/l. No reduction was being practiced and the plants were judged _uniformly inadequate_ with respect to the application of cost effective treatment technology available for fluoride removal. The ELG for fluoride is based on 20 mg/l at 209 l/kkg (50 gal/ton) for the reasons discussed above in the sintering subcategory. This value represents the best available method of treatment for removal of fluorides. The technology for achieving this is shown in Table 74.

## Nitrate

# TABLE 74

## BATEA - EFFLUENT LIMITATIONS GUIDELINES

### SUBCATEGORY Open Hearth Furnace

| CRITICAL PARAMETERS | BATEA LIMITATIONS Kg/KKg[1] (LB/1000 LB) | mg/l[2] | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0052 | 25 | Blowdown treatment with sand filtration or improved settling with coagulation | | |
| Fluoride | 0.0042 | 20 | Blowdown treatment using lime precipitation of fluorides | 0.126 | 0.114 |
| Nitrate (as $NO_3$) | 0.0094 | 45 | Anaerobic denitrification | | |
| Zinc | 0.0010 | 5 | Reduction occurs as a result of improved suspended solids removal | | |
| pH | 6.0 - 9.0 | | Neutralization | | |
| Flow | Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton)(excluding all non-contact cooling water). | | | | |

(1)  Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2)  Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3)  Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4)  Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.

STEP
AERATOR

METHANOL

TOC-C

FLUORIDE
NITRATE
SUSP. SOLIDS
ZINC
pH
FLOW:

20 mg/l
45 mg/l
25 mg/l
5 mg/l
6-9
209 l/Δz₃
(50 GAL/TON)

VACUUM
FILTER

pH &F-C
CONTROLLER

ACID

LIME

MAKE-UP

POLY
ELECTROLYTE

LIME

FLUORIDE
NITRATE
SUSP. SOLIDS
ZINC
pH
FLOW:

20 mg/l
35 mg/l
2000 mg/l
400 mg/l
3-7
2500 l/Δz₃ (600 GAL/TON)

VACUUM
FILTER

SOLIDS TO
DISPOSAL

PROCESS H₂O

SOLIDS TO
DISPOSAL

| | |
|---|---|
| — — — | BASE LEVEL & BPCTCA MODEL |
| ———— | BATEA MODEL |

| ENVIRONMENTAL PROTECTION AGENCY |
|---|
| STEEL INDUSTRY STUDY |
| OPEN HEARTH FURNACE SUBCATEGORY |
| BATEA MODEL |

| 11-14-73 | FIGURE 79A |
|---|---|

FIGURE 79B

MODEL COST EFFECTIVENESS DIAGRAM
OPEN HEARTH FURNACE SUBCATEGORY

*ANNUAL COSTS • BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 2.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
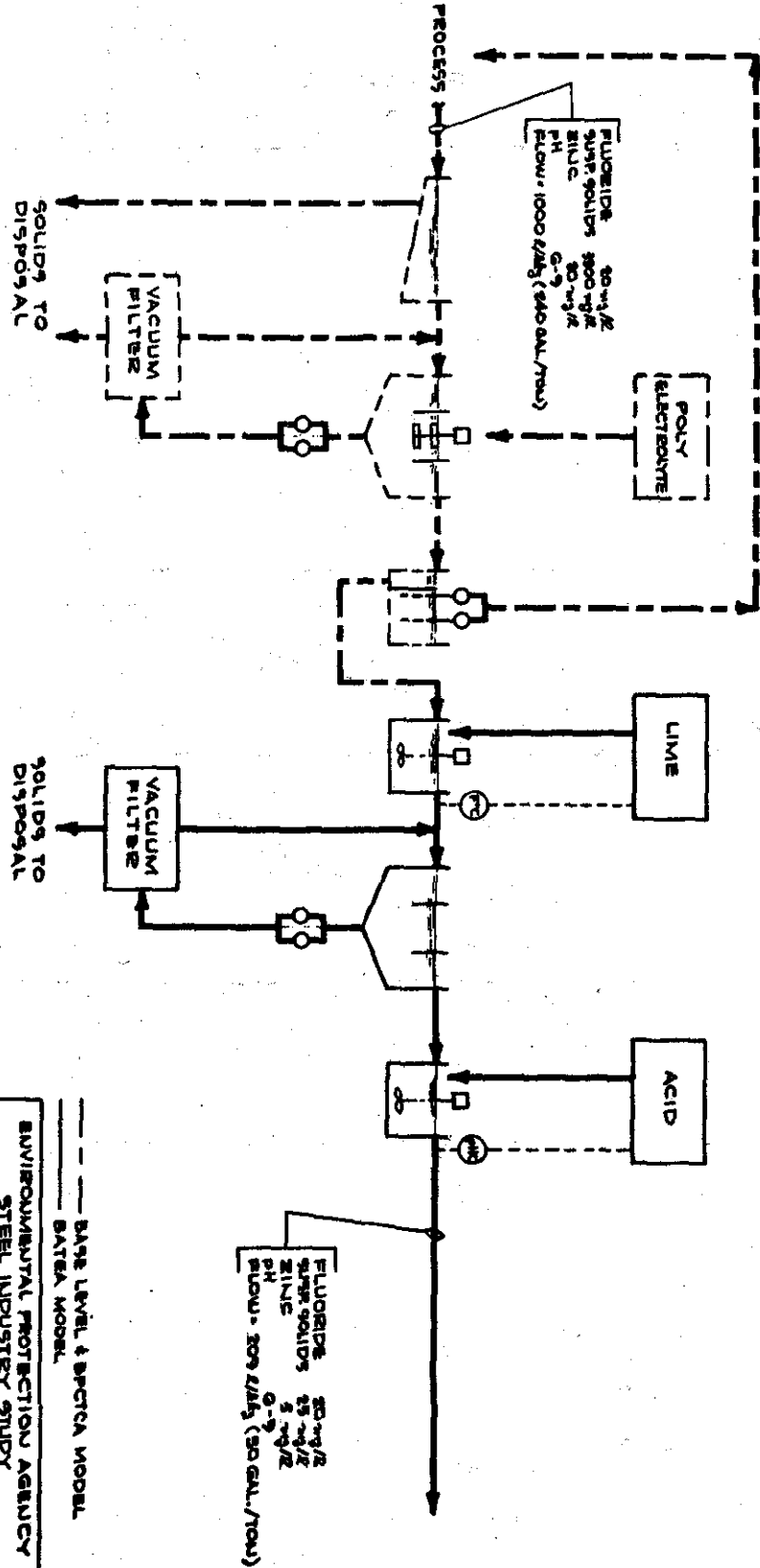* COST BASED ON 6716 KKG (7400 TON/DAY) OH SHOP
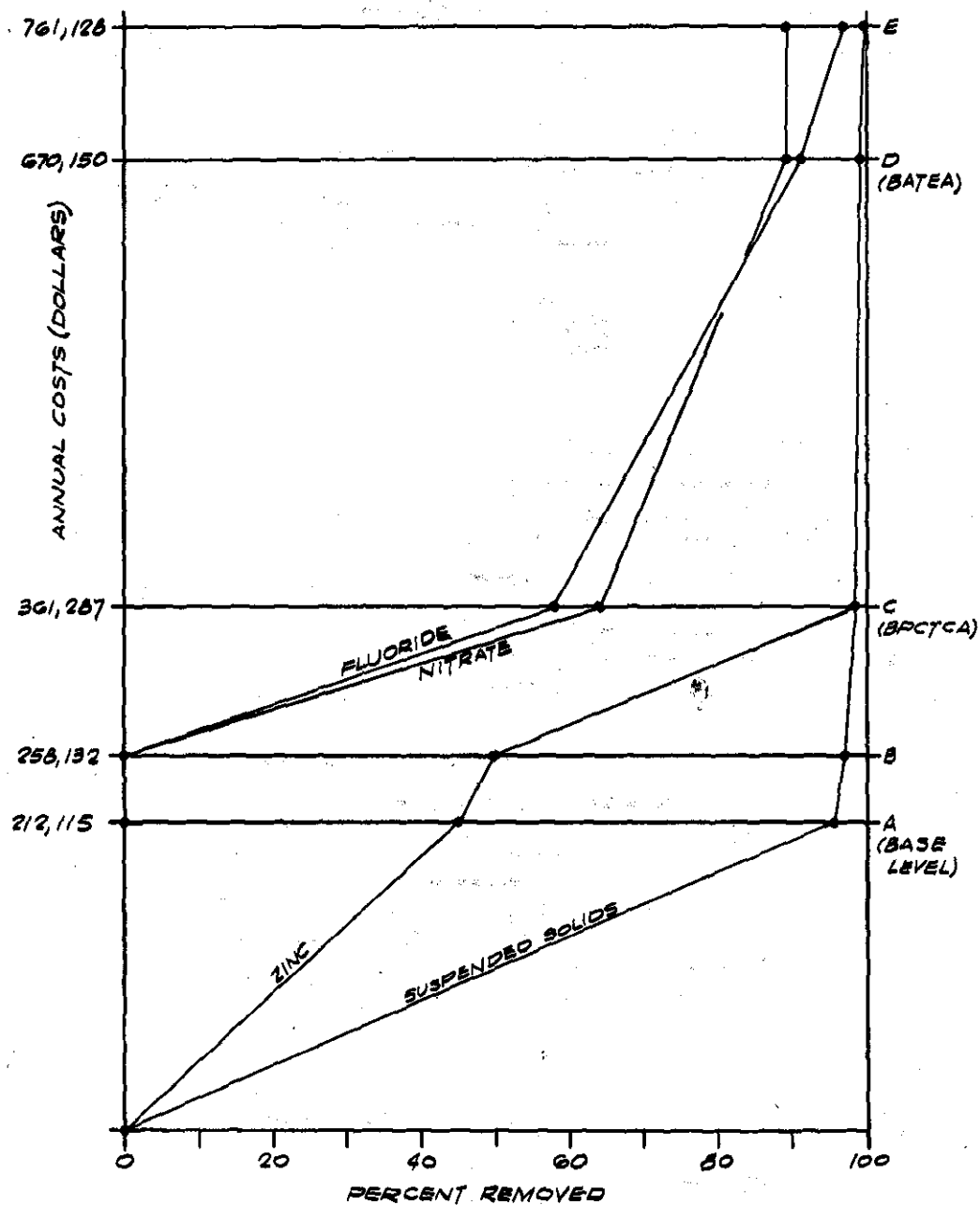
For the two plants surveyed, nitrate was found to be 22 and 303 mg/l in the respective final effluents. The latter plant was judged to be <u>inadequate</u> with respect to employing treatment techniques for removal of the gross level of nitrate measured. This high level can probably be attributed to the type and quantity of combustion fuel used in the burners. The BATEA guideline for nitrate has been based on 45 mg/l at 209 l/kkg (50 gal/ton). The technology employed for nitrate removal usually encompasses anaerobic denitrification and since the removal efficiency of this technique is highly temperature-dependent, the rather liberal ELG of 45 mg/l was selected to provide sufficient flexibility for seasonal temperature changes. Anerobic denitrification to less than this level has been recently practiced in treatment of domestic sewage where regulatory agencies have required it. Lower nitrate values could be achieved for these BATEA guidelines; however, the costs for obtaining same would not be cost effective in relation to the minor improvements gained.

## Zinc

For the two plants surveyed, the effluent zinc concentrations were measured at 26 and 1210 mg/l. No reduction was being practiced and the plants were judged <u>uniformly inadequate</u> with respect to the application of cost effective treatment technology available for zinc removal. These high levels can probably be attributed to the type and amount of scrap charged to the furnaces. The BATEA guideline for zinc is based on 5 mg/l at 209 l/kkg (50 gal/ton). This limit is based upon best available technology, as extensively practiced by the metal finishing industry for zinc removal. More effective removal of particulate matter consistent with the required reduction in suspended solids should effect the further reduction in this parameter to the 5 mg/l concentration on which the BATEA ELG is based.

## pH

The pH was found to be 6.1 and 1.8-3.4, respectively, for the two plants surveyed, with the latter plant being judged <u>inadequate</u> with respect to proper control of pH. The pH range for BATEA has been set at 6.0 to 9.0. The ranges are readily attainable through the use of suitable chemicals and closer control of neutralization techniques as previously discussed.

## Other

Although significant levels of sulfides did not appear in the effluent analyses, these effluents should be monitored to determine if a sulfide limitation should be applied, i.e., 0.3 mg/l in 209 l/kkg (50 gal/ton) due to the many high sulfur fuels such as No. 6 fuel oil that may be used for firing open hearth furnaces.

## Electric Arc Furnace Operation

The electric arc furnace waste gas cleaning systems are similar in nature to the BOF, i.e., they may be dry, semiwet or wet systems as defined in Types I, II, III, and IV shown on Figures 24 through 27. Four plants were surveyed, two semiwet and two wet systems.

## Electric Arc Furnace (Semiwet Air Pollution Control Methods) Subcategory

The two semiwet systems had similar wastewater treatment systems composed of a settling tank with drag link conveyor; one system was recycled with no aqueous blowdown while the other system had closely regulated the furnace gas cooling water spray system so that only a wetted sludge was discharged to the drag tank for subsequent disposal. Therefore, the BATEA for semiwet systems has been establised as "no discharge of process wastewater pollutants to navigable waters", as previously set for BPCTCA limitations in this subcategory.

## Electric Arc Furnace (Wet Air Pollution Control Methods) Subcategory

The two wet systems surveyed had similar wastewater treatment systems. Both plants were recirculating waste waters without treatment at the rate of 12,500 l/kkg (3000 gal/ton) and treating blowdowns of 6 and 10%, respectively. Since these systems can be made essentially identical to the BOF and open hearth recycle systems for gas scrubbing, the ELG's were established on the basis of 209 l/kkg (50 gal/ton) of product and the concentrations of the various pollutants parameters achievable by the indicated treatment technologies. A review of the data collected from the survey resulted in the following effluent guidelines:

## Suspended Solids, Fluoride, Zinc, and pH

All of the above indicated critical parameters are likewise found in the open hearth subcategory. Since the treatment technology for their reduction is the same, the ELG's for these parameters have been based on the same values established for the open hearth. These limitations and the corresponding technologies for achieving same are given in Table 76.

Although the effluent analyses from the two plants surveyed indicated no significant amount of zinc present, an effluent guideline similar to that established for the open hearth has been required since galvanized scrap can be an even greater proportion of the charge to an electric furnace than of that to an open hearth furnace.

## Vacuum Degassing Subcategory

The direct contact process water used in vacuum degassing is the cooling water used for the steam-jet ejector barometric condensers. All vacuum systems draw their vacuum through the use of steam ejectors. As the water rate depends upon the steaming

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# TABLE 75

## BATEA - EFFLUENT LIMITATIONS GUIDELINES

### SUBCATEGORY Electric Arc Furnace (Semi-wet Air Pollution Control Methods)

| CRITICAL PARAMETERS | BATEA LIMITATIONS | | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST | |
|---|---|---|---|---|---|
| | Kg/KKg[1] (LB/1000 LB) | mg/l[2] | | $/KKg | $/TON |
| Suspended Solids | No discharge of process wastewater pollutants to navigable waters (excluding all non-contact cooling water) | | Same as BPCTCA | Zero (0) | |
| Fluoride | | | | | |
| Zinc | | | | | |
| pH | | | | | |
| Flow | | | | | |

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(1) Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2) Milligrams per liter based on 209 liters effluent per kkg of steel produced (50 gal/ton).
(3) Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4) Costs may vary some depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices. Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have installed as a result of complying with BPCTCA standards.
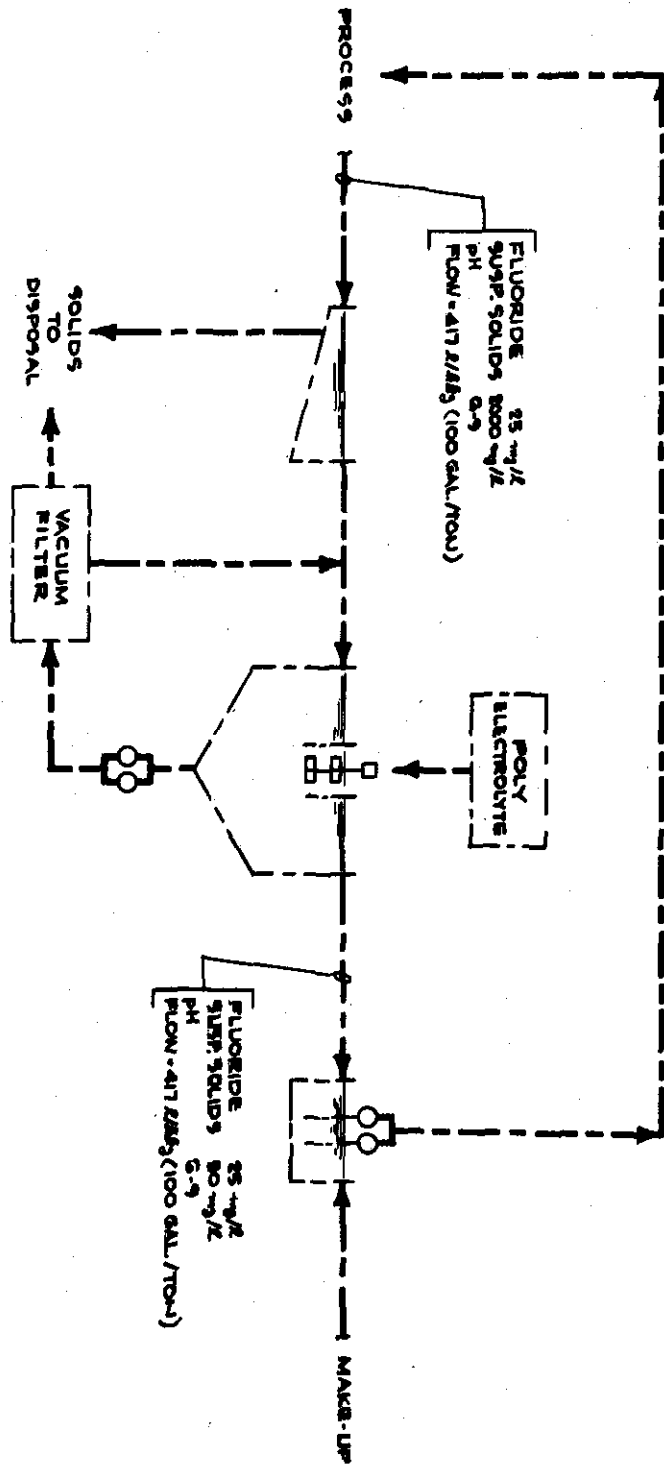
FLUORIDE          25 mg/l
SUSP. SOLIDS   5000 mg/l
pH                     0-9
FLOW = 417.2/85₅ (100 GAL./TON)

PROCESS

SOLIDS
TO
DISPOSAL

VACUUM
FILTER

POLY
ELECTROLYTE

FLUORIDE          25 mg/l
SUSP. SOLIDS   50 mg/l
pH                     0-9
FLOW = 417.2/85₅ (100 GAL./TON)

MAKE-UP

— — — — BASE LEVEL-BPCTCA & BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC ARC FURNACE (SEMI-WET)
SUBCATEGORY
BATEA MODEL

| 11-15-79 | FIGURE 80A |

FIGURE _808_

MODEL COST EFFECTIVENESS DIAGRAM
ELECTRIC ARC FURNACE
(SEMI-WET AIR POLLUTION CONTROL METHODS) SUB-CATEGORY
\* ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH _CANNOT_ BE USED FOR INTERMEDIATE VALUES
\* COST BASED ON 1488 KKG/DAY (1640 TON/DAY) EAF SHOP



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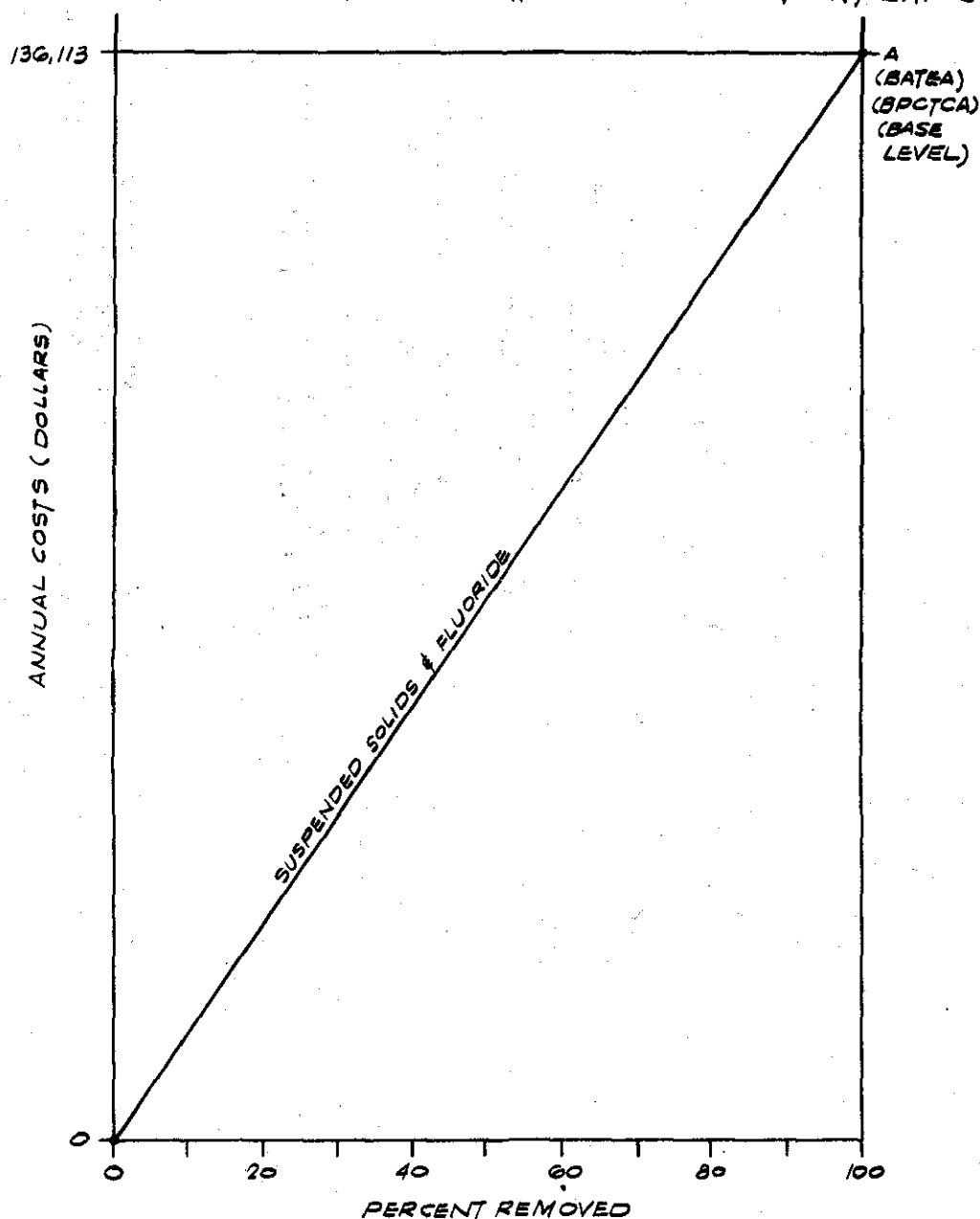
## TABLE 76

### BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY  Electric Arc Furnace (Wet Air Pollution Control Methods)

| CRITICAL PARAMETERS | BATEA LIMITATIONS | | CONTROL & TREATMENT TECHNOLOGY[3] | ESTIMATED[4] TOTAL COST | |
| | Kg/KKg [1] (LB/1000 LB) | mg/1 [2] | | $/KKg | $/TON |
| --- | --- | --- | --- | --- | --- |
| Suspended Solids | 0.0052 | 25 | Blowdown treatment with sand filtration or improved settling with coagulation | | |
| Fluoride | 0.0042 | 20 | Blowdown treatment using lime precipitation of fluorides | 0.0988 | .0897 |
| Zinc | 0.0010 | 5 | Reduction occurs as a result of improved suspended solids removal | | |
| pH. | 6.0 - 9.0 | | Neutralization | | |
| Flow | Most probable value for tight system is 209 liters effluent per kkg of steel produced (50 gal/ton)(excluding all non-contact cooling water) | | | | |

(1)  Kilograms per metric ton of steel produced, or pounds per 1000 pounds of steel produced.
(2)  Milligrams per liter based on 209 leters effluent per kkg of steel produced (50 gal/ton).
(3)  Available technology listed is not necessarily all inclusive nor does is reflect all possible combinations or permutations of treatment methods.
(4)  Costs may vary  some  depending on such factors as location, availability or land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extend of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.

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FLUORIDE        20 mg/L
SUSP. SOLIDS    2500 mg/L
ZINC            20 mg/L
pH              6-9
FLOW: 1000 L/kkg (240 GAL./TON)

POLY (ELECTROLYTE)

VACUUM FILTER

SOLIDS TO DISPOSAL

PROCESS

LIME

VACUUM FILTER

SOLIDS TO DISPOSAL

ACID

FLUORIDE        20 mg/L
SUSP. SOLIDS    25 mg/L
ZINC            5 mg/L
pH              6-9
FLOW: 209 L/kkg (50 GAL./TON)

- - - - BASE LEVEL & BPCTCA MODEL
——— BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
ELECTRIC ARC FURNACE (WET)
SUBCATEGORY
BATEA MODEL

| 11-15-75 | FIGURE 91A |

FIGURE 61B

MODEL COST EFFECTIVENESS DIAGRAM
ELECTRIC ARC FURNACE
(WET AIR POLLUTION CONTROL METHODS) SUB-CATEGORY
*ANNUAL COSTS = BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
*COST BASED ON 1652 KKG/DAY (1820 TON/DAY) EAF SHOP
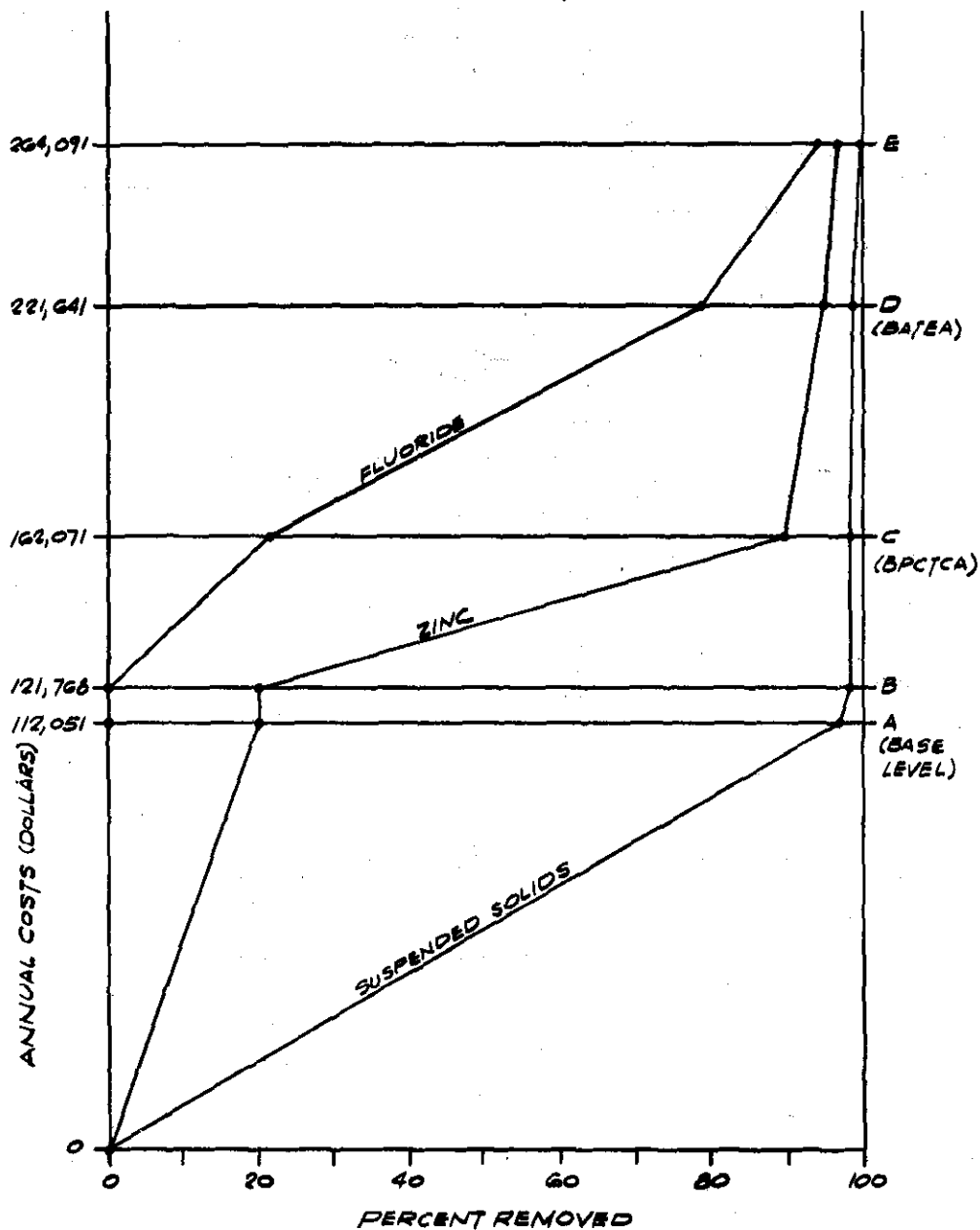
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rate and the number of stages used in the steam ejector, the process flow rates can vary considerably. Two degassing plants were surveyed and each had a water treatment system which treated other steelmaking operation proces waste waters as well, i.e., one was treating continuous casting process waters, and the other, BOF discharges. The blowdown rates varied from 45.5 1/kkg (10.9 gal/ton) to 66.7 1/kkg (16.0 gal/ton) and) and represented from 2% to 5% of the process recycle rate, respectively. The ELG's were established on the basis of 104 1/kkg (25 gal/ton) of product and concentrations of the various pollutant parameters achievable by the indicated treatment technologies. The value of 104 1/kkg (25 gal/ton) has been set somewhat higher than the measured values to compensate for the anticipated increased flows that would be achieved if the systems were joined with other steelmaking processes in which more heat is generated.

A review of the data collected resulted in the following effluent guidelines:

## Zinc

Zinc was measured at 0.9 and 416 mg/1, respectively, at the two plants surveyed. The latter plant was judged <u>inadequate</u> with respect to the application of cost effective treatment technology for zinc removal. The latter plant also displayed a very high level of effluent suspended solids (1077 mg/1) which would account for the high zinc concentration if most of the zinc is in the particulate form. As indicated under the subcategory for open hearths, the BATEA guideline is based on 5 mg/1 measured in 104 1/kkg (25 gal/ton) in this instance. Discussion of the removal techniques will be deferred to the section dealing with suspended solids.

## Manganese

For the two plants surveyed, the effluent manganese concentrations were measured at 2.8 and 340 mg/1. The latter plant was judged <u>inadequate</u> with respect to the application of cost effective treatment technology for manganese removal. The BATEA guideline for manganese is based on 5 mg/1 measured in 104 1/kkg (25 gal/ton). Discussion of the removal techniques will be deferred to the section dealing with suspended solids.

## Lead

The two plants surveyed showed lead concentrations of less than 0.1 and 32 mg/1, respectively, in their final effluents. The latter plant was judged <u>inadequate</u> with respect to the application of cost effective treatment technology for lead removal. The BATEA guideline for lead is based on 0.5 mg/1 measured in 104 1/kkg (25 gal/ton). Discussion of the removal techniques will be deferred to the section dealing with suspended solids.

## Suspended Solids

# TABLE 77

## BATEA - EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY  Vacuum Degassing

| CRITICAL PARAMETERS | BATEA LIMITATIONS Kg/KKg [1] (LB/1000 LB) | mg/l [2] | CONTROL & TREATMENT TECHNOLOGY [3] | ESTIMATED [4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0026 | 25 | Blowdown treatment with coagulation/clarification | | |
| Zinc | 0.00052 | 5 | | | |
| Manganese | 0.00052 | 5 | | | |
| Lead | 0.00005 | 0.5 | | | |
| Nitrate (as NO₃) | 0.0047 | 45 | Blowdown treatment with anaerobic denitrification, (or substitution of another gas for blanketing instead of nitrogen) | 0.492 | 0.446 |
| pH | 6.0 - 9.0 | | Neutralization | | |
| Flow | Most probable value for tight system is 104 liters effluent per kkg of steel degassed (25 gal/ton) (excluding all non-contact cooling water) | | | | |

(1)  Kilograms per metric ton of steel degassed, or pounds per 1000 pounds of steel degassed.
(2)  Milligrams per liter based on 104 liters effluent per kkg of steel degassed (25 gal/ton).
(3)  Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4)  Costs may vary some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of preliminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a plant and/or have been installed as a result of complying with BPCTCA standards.

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FIGURE 82B
MODEL COST EFFECTIVENESS DIAGRAM
VACUUM DEGASSING SUBCATEGORY
* ANNUAL COST = BASED ON TEN YEAR CAPITAL RECOVERY
        + INTEREST RATE 7%
        + OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
        + MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
    THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
* COST BASED ON 472 KKG/DAY (520 TON/DAY) VD OPERATION
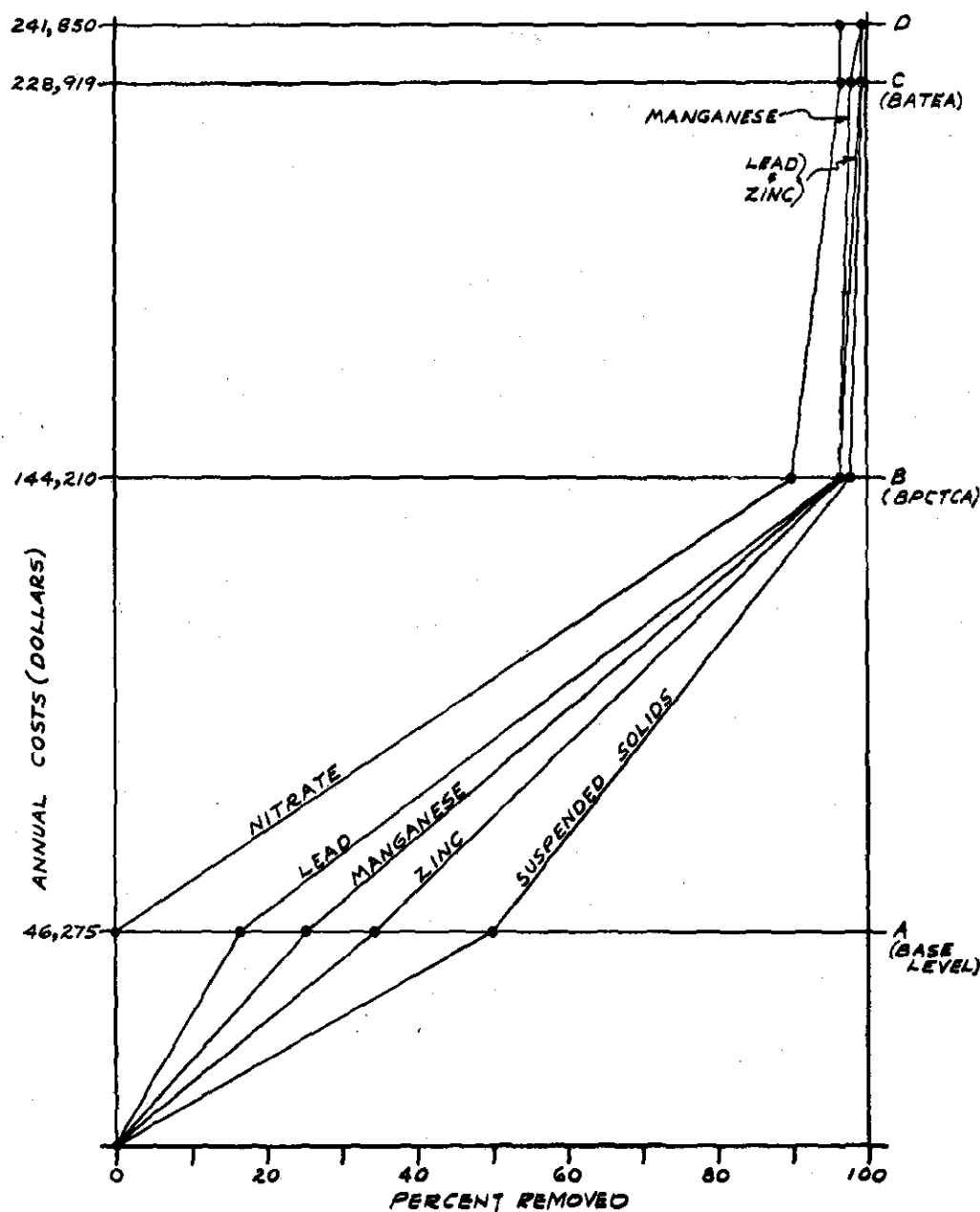
For the two plants surveyed, the suspended solids in the final effluent were found to be 37 and 1077 mg/l, respectively. The latter plant was judged inadequate with respect to the application of cost effective treatment technology for suspended solids removal. The plant achieving the suspended solids level of 37 mg/l was also the plant obtaining low values for zinc, manganese and lead at 0.9, 2.8 and 0.1, respectively. This plant was using high rate pressure sand filtration on the final effluent prior to discharge. Furthermore, the effluent from the sand filter was actually achieving 75% of all the above constituent levels reported, but these levels were adjusted upward to compensate for removal of the other process waters not related to vacuum degassing. The BATEA guidelines for suspended solids is based on 25 mg/l measured in 104 1/kkg (25 gal/ton). It should be noted that a plant using sand filtration can readily achieve these levels and furthermore this technology also removes the zinc, manganese, and lead to the BATEA guidelines required herein. An alternate technology for removal of these critical parameters to the indicated levels would be coagulation techniques. Table 77 is referred to for a summary of indicated ELG's and suggested technologies.

## Nitrate

For the two plants surveyed, nitrate was found to be 0 and 1940 mg/l, respectively. The latter plant was judged inadequate with respect to the application of cost effective treatment technology for nitrate removal. For the reasons previously established for the open hearth, the ELG for nitrate is based on 45 mg/l at 104 1/kkg (25 gal/ton) in this case. The technology for achieving this level is shown in Table 77 and is discussed in detail under the open hearth subcategory.

## pH

The pH of the two plants surveyed was found to vary between 6.2 and 7.7 which is within the required BPCTCA range of 6.0 to 9.0. The BATEA guideline for pH remains at this level, as for all other subcategories.

It should be noted that many of the aforementioned critical parameters observed in the final effluent are the apparent result of various alloying agents being added to the steel during the steelmaking process. The nitrates found may be coming from nitrogen gas which is commonly used for blanketing to insure no explosions take place.

## Continuous Casting Subcategory

The only process waters used in the continuous casting process are direct contact cooling water sprays which cool the cast product as it emerges from the molds. The water treatment methods used are either recycle flat bed filtration for removal of suspended solids and oils or scale pits with recirculating pumps. Both systems require blowdown. The flat bed filters

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## TABLE 78

### BATEA  –  EFFLUENT LIMITATIONS GUIDELINES

SUBCATEGORY    Continuous Casting

| CRITICAL PARAMETERS | BATEA LIMITATIONS Kg/KKg [1] (LB/1000 LB) | mg/1 [2] | CONTROL & TREATMENT TECHNOLOGY [3] | ESTIMATED [4] TOTAL COST $/KKg | $/TON |
|---|---|---|---|---|---|
| Suspended Solids | 0.0052 | 10 | BPCTCA plus: | | |
| Oil and Grease | 0.0052 | 10 | Filtration of blowdown. | 0.0752 | 0.0682 |
| pH | 6.0 – 9.0 | | | | |

Flow:    Most probable value for tight system is 522 liters effluent per kkg of steel cast (125 gal/ton) (excluding all non-contact cooling water).

(1)  Kilograms per metric ton of steel cast, or pounds per 1000 pounds of steel cast.
(2)  Milligrams per liter based on 522 liters effluent per kkg of steel cast (125 gal/ton)
(3)  Available technology listed is not necessarily all inclusive nor does it reflect all possible combinations or permutations of treatment methods.
(4)  Costs may vary some  depending on such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and extent of pre-liminary modifications required to accept the indicated control and treatment devices.  Estimated total costs shown are only incremental costs required above those facilities which are normally existing within a pland and/or have been installed as a result of complying with BPCTCA  Standards.

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PROCESS

12,500 ℓ/kkg (2990 GAL/TON) NORMAL
22,300 ℓ/kkg (5350 GAL/TON) MAXIMUM

OIL & GREASE   10 mg/ℓ
SUSP SOLIDS   30 mg/ℓ
PH            6-9
FLOW (AVG)    17300 ℓ/kkg (4150 GAL./TON)

OIL

FLATBED FILTER

COOLING TOWER

MAKE-UP WATER

11,150 ℓ/kkg (2675 GAL/TON) NORMAL
21,900 ℓ/kkg (5250 GAL/TON) MAXIMUM

OIL & GREASE   10 mg/ℓ
SUSP SOLIDS    10 mg/ℓ
PH             6-9
FLOW           521 ℓ/kkg (125 GAL./TON)

PRESSURE FILTER

— — — — BASE LEVEL SYSTEM & BPCTCA MODEL
———— BATEA MODEL

ENVIRONMENTAL PROTECTION AGENCY
STEEL INDUSTRY STUDY
CONTINUOUS CASTING SUBCATEGORY
BATEA MODEL

| 11-19-75 | FIGURE 83A |

FIGURE  83 B

MODEL COST EFFECTIVENESS DIAGRAM
CONTINUOUS CASTING SUBCATEGORY

*ANNUAL COSTS ≈ BASED ON TEN YEAR CAPITAL RECOVERY
+ INTEREST RATE 7%
+ OPERATING COSTS INCLUDE LABOR, CHEMICALS & UTILITIES
+ MAINTENANCE COSTS BASED ON 3.5% OF CAPITAL COSTS
THIS GRAPH CANNOT BE USED FOR INTERMEDIATE VALUES
*COST BASED ON 971 KKG/DAY (1070 TON/DAY) CC OPERATION
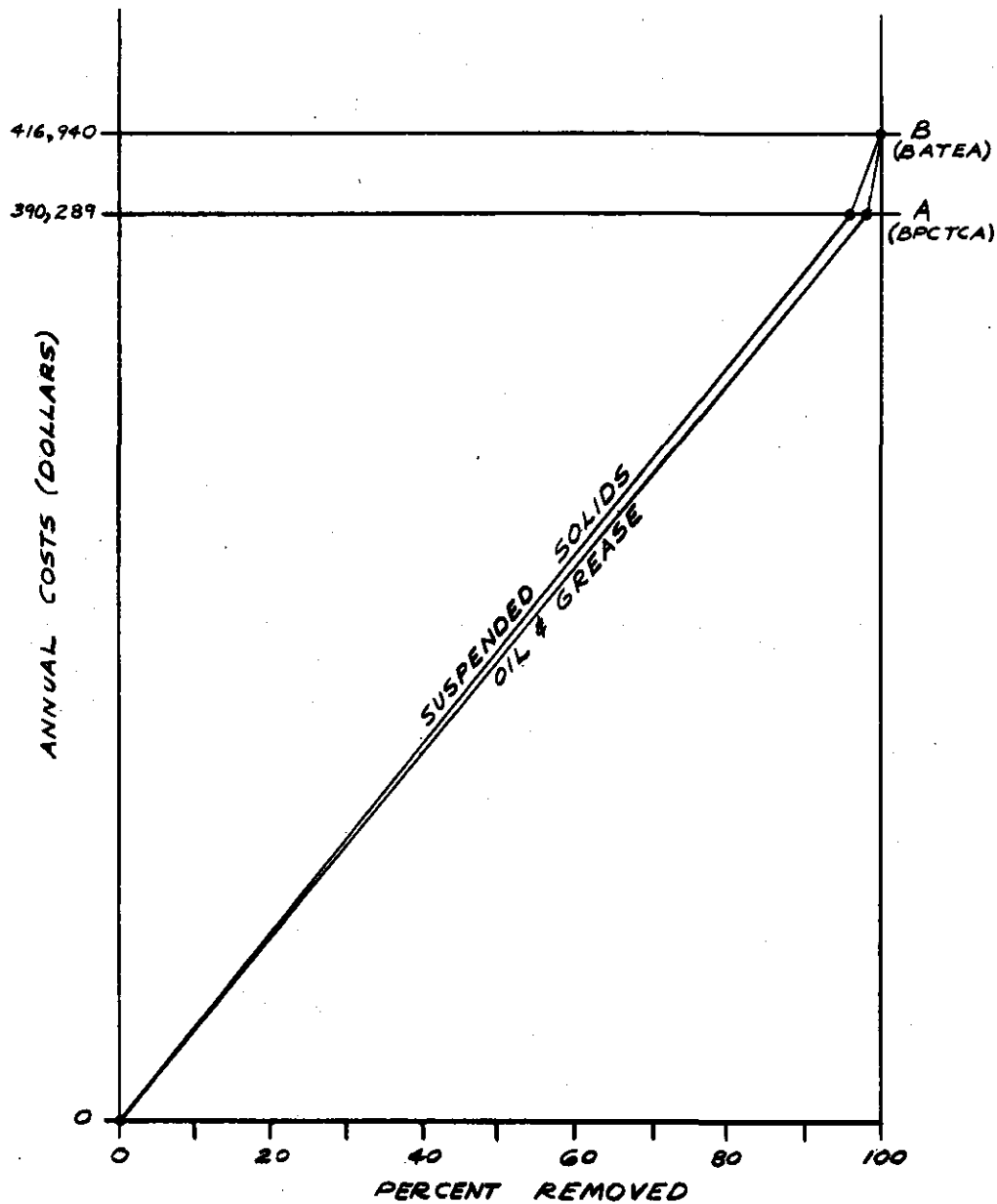
remove oil and suspended solids whereas the scale pits may require ancilliary oil removal devices.

Two continuous casting plants were surveyed. One plant had a scale pit with sand filters with blowdown while the other plant had flat bed filters with blowdown. Both had cooling towers for cooling the spray water before recycling to the caster. The blowdown varied between 342 l/kkg (82 gal/ton) and 463 l/kkg (111 gal/ton). The ELG's were therefore established on the basis of 521 l/kkg (125 gal/ton) of product and the concentrations of the various pollutant parameters achievable by the indicated treatment technologies. A review of the data collected from the survey resulted in the following effluent guidelines:

## Suspended Solids

The plant employing the flat bed filter system was achieving 4.4 mg/l suspended solids in the treated effluent; whereas the plant utilizing the pressure sand filters was obtaining only 37 mg/l in the final treated effluent. An apparent anomaly existed here, since deep bed sand filters normally achieve higher quality of effluents than flat bed filters. It was later discovered that the plant using the pressure sand filters was continually back-washing one of the dirty filters into the final treated effluent. This plant was judged inadequate with respect to applying good engineering design to alleviate the problem of contaminating the treated effluent with filter backwash. By correcting this problem, this plant should have no trouble obtaining 10 mg/l or less suspended solids in the filtrate. Since the flat bed system was already achieving less than this value, the BATEA ELG for suspended solids has been based on 10 mg/l at 521 l/kkg (125 gal/ton).

## Oil and Grease

The two plants surveyed were achieving excellent reductions in oil and grease as an apparent result of removal in the filtering devices. The two plants combined averaged less than 2.4 mg/l oil in the final effluent. However, the BATEA for oil and grease has been based on 10 mg/l at 520 l/kkg (125 gal/ton) for the reasons indicated above for the By-Product Coke subcategory. Table 78 summarizes the indicated technology.

## pH

The pH for the two plants surveyed varied between 6.8 and 7.7 which is within the range of 6.0 to 9.0 established as the BPCTCA guideline. No further tightening of the BPCTCA guideline is recommended at this time.

## Treatment Models

Treatment models of systems to achieve the effluent quality for each subcategory have been developed. Sketches of the BATEA models are presented in Figures 72A through 83A. The development

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included not only a determination that a treatment facility of the type developed for each subcategory could achieve the effluent quality required but also a determination of the capital investment and the total annual operating costs for the average size facility. In all subcategories, these models are based on the use of unit (waste treatment) operations in an "add-on" fashion as required to control the significant waste parameters. The process changes and the unit operations were each selected as the least expensive means to accomplish their particular function and thus their combination into a treatment model presents the least expensive method for control for a given subcategory.

Alternate treatment methods could be insignificantly more effective and would be more expensive. In only one subcategory, By-Product Coke , was an alternate developed to provide an option for high capital investment and low operating cost as compared to the low capital investment high operating costs that are inherent in the basic treatment model. However, the alternate relies on the use of treatment technology that has been developed only to the pilot stage or as steps utilized individually, but not in the combination required in this model on this type of waste on a full scale basis. Therefore, the effluent limitation and treatment costs have been developed via the basic treatment model rather than the alternate.

## Cost Effectiveness Diagrams

Cost effectiveness diagrams (Figures 72B through 83B) have been included to show the costs of waste reduction in relation to the percent reduction achieved by the various treatment models presented in Tables 44 through 54. These treatment models are combinations of the "least cost" process changes and unit (waste treatment) operations to achieve a given effluent quality. Alternate models could be developed and costed out but they would by definition be more costly and not significantly more effective.

The cost effectiveness diagrams must be intrepreted with caution in that they can be misleading in at least two ways. While percent reduction is plotted, the real objective is to achieve the effluent quality attainable with the application of the best practicable control technology currently available or the best available technology economically achievable. Some industrial wastes contain very high concentrations of pollutants and a treatment system which achieves a 95 percent reduction may still produce an effluent with a high concentration of the pollutant remaining, i.e. a concentration that can be further reduced at an economically acceptable cost. However, economics has dictated that the application of some treatment technologies be deferred until 1983 and that some high concentrations of pollutants, representing a low percentage of the initial load, be tolerated in the interim.

As an example of the significance of concentration rather than percent reduction as a factor to be considered in determining

whether the additional treatment costs can be justified by the added treatment achieved, Figure 76 B presents a good example. While the recycle system (Model B) reduced the effluent volume and effluent load, the effect is to concentrate the cyanides such that the cyanide concentration in the blowdown stream to discharge is 30 mg/l. This is a concentration that can readily be reduced by treatment technology in a cost effective manner. Therefore treatment of this blowdown stream has been required for BATEA.

The cost effectiveness diagrams can also be misleading in that the added cost to get from one model to the next cannot be attributed in part to each of the reductions that occur. Figure 72B is a good example. The costs to get from Model B to Model C(BATEA) is primarily associated with the chlorination to reduce the cyanide concentration and adsorption of the chlorinated organics with some small part of the cost for sulfide reduction and neutralization. However, reductions in the other parameters occur as a side effect of the treatment steps added. Though the reduction in phenol is small and may not justify further expenditures for this purpose, in actuality none of the added cost is attributable to this. The diagram shows a great percentage reduction in suspended solids but this is actually a small reduction in a parameter that is not present to a great extent to begin with. And the reduction is not primarily to achieve solids reduction for effluent quality purposes but to prevent plugging of the carbon adsorption system that follows.

The regulations herein apply only to the process waste waters of the raw steel making operations. The Phase II study of the forming and finishing operations as well as the foundry industry is underway and is expected to be completed in the spring of 1974. This phase will consider thermal limitations on the process and noncontact cooling waters of all operations in the industry.

The costs and methods for fugitive runoff controls for the raw steel making operations have already been developed but action on this has been deferred until the total water pollution control costs for all operations has been developed.

## Cost to the Iron and Steel Industry

Table 79 presents a summary of projected capital and annual operating costs to the integrated mills of the steel industry as a whole to achieve the effluent quality required herein for BPCTCA and BATEA for the steel making operations.

The Total annual costs (including amortization) for the BPCTCA and BATEA regulations herein are estimated at $82.3 million or 0.37% of the 1972 gross revenue of the steel industry. This is an addition to the $127 million annual capital amortization and operating costs, (0.56% of 1972 gross revenue) which it is estimated the industry is already spending on these

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## TABLE 79
### IRON AND STEELMAKING OPERATIONS
### PROJECT TOTAL COSTS FOR RELATED SUBCATEGORIES

COSTS TO INDUSTRY [1]

| Subcategory | 1972 Annual Production (millions of tons) | Number of Plants | BPCTCA Annual Capital and Operating Cost | BPCTCA Initial Capital Investment | BATEA Annual Capital and Operating Cost | BATEA Initial Capital Investment |
|---|---|---|---|---|---|---|
| Coke Making | | | | | | |
| By Product | 64.2 | 66 | 10,034,000 | 11,118,000 | 23,538,000 [2] | 61,732,000 |
| Beehive | 0.8 | 3 | 38,000 | 152,000 | 38,000 | 0 |
| Burden Preparation | | | | | | |
| Sintering | 6.5 | 6 | 335,000 | 1,530,000 | 746,000 | 1,765,000 |
| Iron Making | | | | | | |
| Blast Furnace - Fe | 82.1 | 68 | 20,169,000 | 100,414,000 | 40,021,000 | 28,086,000 |
| Blast Furnace - FeMn | 0.9 | 3 | 1,059,000 | 5,177,000 | 2,762,000 | 1,620,000 |
| Steelmaking | | | | | | |
| BOF (Semi-wet) | 17.8 | 10 | 390,000 | 1,875,000 | 390,000 | 0 |
| BOF (wet) | 47.1 | 17 | 3,884,000 | 7,895,000 | 5,286,000 | 6,175,000 |
| OH (wet) | 13.5 | 5 | 746,000 | 2,665,000 | 2,290,000 | 7,837,000 |
| EF (semi-wet) | 1.2 | 22 | 0 | 0 | 0 | 0 |
| EF (wet) | 5.3 | 8 | 400,000 | 1,776,000 | 877,000 | 2,289,000 |
| Degassing | 5.5 | 29 | 2,840,000 | 12,290,000 | 5,297,000 | 8,908,000 |
| Continuous Casting | 18.0 | 46 | 0 | 0 | 1,226,000 | 4,562,000 |
| TOTAL | | | 39,895,000 | 144,892,000 | 82,471,000 | 122,974,000 |

(1) Costs determined by following relationships:
    (a) Annual capital + operating = Number of plants x annual cost/facility
    (b) Initial capital investment = number of plants x 1st cost/facility

(2) Does not include the $10,034,000 for BPCTCA since BATEA is achieved by switching to a multi-stage biological treatment facility.

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operations. The total estimated costs for water pollution control will be available only after the Phase II study is completed. However, the preliminary estimate is that the additional annual costs (including amortization) for the remaining forming and finishing operations, for thermal limitations, and for fugitive runoff controls will be approximately three to four times those proposed herein for the steel making operations or $295 million per year. Total annual costs (including amortization) for water pollution controls after 1983, including operation and amortization of existing facilities, are estimated at $551 million or 2.45% of the 1972 gross revenue. Of this amount, $377 million (or 1.68%) will be incremental to the current rate of expenditures.

As presented in the table, an initial capital investment of approximately $144.9 million with annual capital and operating costs of $39.9 million would be required by the industry to achieve BPCTCA guidelines. An additional capital investment of approximately $122.3 million and a total annual capital amortization and operating cost of $82.3 million would be needed to achieve BATEA guidelines. Costs may vary depending upon such factors as location, availability of land and chemicals, flow to be treated, treatment technology selected where competing alternatives exist, and the extent of preliminary modifications required to accept the necessary control and treatment devices.

The operating costs (including amortization) for air pollution controls for the steel industry, as presented in the Council on Environmental Quality report of March, 1972 titled "Economic Impact of Pollution Control - A Summary of Recent Studies" shows costs building up to $693 million dollars per year for 1976. This is equivalent to 3.08% of the 1972 gross revenue of the industry.

The total annual costs (including amortization) for air and water pollution controls for all operations of the steel industry is thus estimated at 1.24 billion per year after 1983 or 5.54% of gross revenues for 1972. This includes the 292 million or 1.3% of gross revenues for 1972 which it is estimated that the industry is currently spending annually for air and water pollution controls.

Economic Impact

The economic impact of these BPCTCA and BATEA Limitations is discussed in a report titled Economic Analysis of the Proposed Effluent Guidelines for the Integrated Iron and Steel Industry (January 1974) which was prepared for the Environmental Protection Agency by A. T. Kearney and Company, Inc., Chicago, Illinois.

## EFFLUENT QUALITY ATTAINABLE THROUGH THE APPLICATION OF NEW SOURCE PERFORMANCE STANDARDS

## Introduction

The effluent limitations which must be achieved by new sources, i.e., any source, the construction of which is started after publication of new source performance standard regulations, are to specify the degree of effluent reduction achievable through the application of the best available demonstrated control technology (BADCT), processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants.

For purposes of developing the BPCTCA and BATEA technologies and limitations, the industry was divided into the following subcategories:

I       By-Product Coke Subcategory

II      Beehive Coke Subcategory

III     Sintering Subcategory

IV      Blast Furnace (Iron) Subcategory

V       Blast Furnace (Ferromanganese) Subcategory

VI      Basic Oxygen Furnace (Semiwet Air Pollution
          Control Methods) Subcategory

VII     Basic Oxygen Furnace (Wet Air Pollution
          Control Methods) Subcategory

VIII    Open Hearth Furnace Subcategory

IX      Electric Arc Furnace (Semiwet Air Pollution
          Control Methods) Subcategory

X       Electric Arc Furnace (Wet Air Pollution
          Control Methods) Subcategory

XI      Vacuum Degassing Subcategory

XII     Continuous Casting Subcategory

## By Product Coke Subcategory

In by-product coke making, the process wastewater resulting from the production of coke is 80 to 165 liters/kkg (19 to 40 gal/ton) of coke produced. This water is actually produced as a result of coking the coal, and represents the water present in the raw coal

which was placed in the ovens. This water leaves the ovens in the gas and is condensed out of the gas at two points in the system, the primary cooler and the final cooler. Approximately 75% of the total volume comes out in the primary cooler and is called ammonia liquor. The remaining 25% comes out into the final cooler and is generally referred to as final cooler drains.

Water in excess of this approximately 104 l/kkg (25 gal/ton) which shows up in the effluent from a coke plant is added to the system to aid in processing of the coke or the by-products. Other sources of water in coke plant wastes are coke quenching tower overflow (or blowdown), coke wharf drains, steam condensed in the ammonia stills, cooling tower, and boiler blowdowns, cooling system leaks, general washwater used in the coke plant area, and dilution water used to lower pollutant concentrations for biological treatment.

Any process which brings about the pyrolytic decomposition of coal will of necessity have 80 to 165 liters/kkg (19 to 40 gal/ton) of highly contaminated liquid to dispose of. The coke wharf and quenching water can be eliminated by dry coke quenching which is presently being practiced in other countries or simply by routing the wharf drains to the quench tower as make-up water, and not allowing any overflow from the quench tower. Operating a quench tower with no overflow may generate some heat and corrosion problems, but these can be eliminated with conventional designs.

If no liquid discharge is to be achieved from modern coke plants, a means of total disposal must be found for the 80 to 165 liters/kkg (19 to 40 gal/ton) of liquid which of necessity is produced. All of the wastes in this water, with the possible exception of suspended solids, are subject to pyrolytic de-composition. A rough estimate shows that about 126,000 kilogram calories per metric ton of coke produced would be required to dispose of this waste. This is a negligible percentage of the fuel value of the tar and gas generated in the production of a ton of coke.

However, there is reason to believe that unless very sophis-ticated means were used to pyrolytically dispose of this water, serious air pollution problems would result. The effluent gases from less than optimum incineration of this water could be expected to contain high concentrations of NOX, SOX, and some particulate matter. If a simple incinerator with a wet scrubber were used, the basic pollutants would simply be transferred back to another water stream, possibly of larger volume than the original.

Since the pollutants in the liquid stream are essentially volatile, evaporation of the liquid to dryness would result in much the same problems as incineration. In fact, examination of numerous other points of disposal of this stream within an integrated steel mill all yield the same answer. While total pyrolytic decomposition of this small stream of waste to

innocuous gases would be the most desirable method of disposal, present technology does not make this possible on a proven full-scale basis.

For the above reasons, NSPS limitations cannot be set at "no liquid discharge" until such time as technology becomes available for the total conversion of this waste stream into non-polluting substances. Therefore, the NSPS guidelines shall be the same as the BATEA guidelines for the by-product coke subcategory. Refer to Section X.

## Sintering Subcategory

Burden preparation in an integrated steel mill generally takes the form of a sinter plant. The purpose of this plant is to recover fine raw materials and to agglomerate them into larger size pieces so that they can be charged into the blast furnace. In the manufacture of coke, fines are generated which must be screened out of the coke before it can be used in the blast furnace. The fines serve as the fuel for the sinter plant. The blast furnaces and steelmaking processes generate sizable quantities of fine dust which is high in iron content. It is this dust which is agglomerated in a sinter or pellet plant so that it can be recharged to the blast furnace.

It is possible to build a sinter plant with no liquid discharge. In fact, in past years, most sinter plants had no liquid discharge. As the requirements of higher air standards took effect, it became apparent that the conventional dry dust collection methods employed in older sinter plants were not adequate. In order to meet these higher standards, wet scrubbing of the dust laden gases came into being and thus a liquid discharge was generated.

This now becomes a situation of compromise and technology advancement. In order to achieve a "no liquid discharge" level for a sinter or pellet plant, the requirements of air quality and level of technology of dry dust collection must become coincidental. So long as air quality standards are such that they can only be met by wet scrubbing methods, there will be a liquid discharge from sinter plants. To simply abandon this practice of recovering valuable fines for reuse would be both costly to the industry and wasteful of natural resources. Since BATEA guidelines discussed in Section X represent the best available technology, this level must also be set for NSPS until such time as the technology of dry dust collection advances to the point where it can be used to achieve the required air quality standards.

NSPS Discharge Standard - Refer to BATEA for the Sintering Subcategory

## Blast Furnace (Iron) and Blast Furnace (Ferromanganese) Subcategories

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The primary liquid discharge from a blast furnace is made up of two parts: non-contact cooling water, and process water from gas cleaning operations. The non-contact cooling water should contain only heat, and no other pollutants contributed by the process. The heat added to the cooling water must be rejected to the environment in order for the process to operate. It can be rejected either to local streams or lakes by a once through cooling system or to the air by means of a cooling tower. Designs to achieve either means of rejection are quite standard and do not require further discussion.

The process water which is used to clean and cool the blast furnace top gas by direct contact with the gas becomes quite contaminated with suspended solids, cyanides, phenol, ammonia, and sulfides.

Modern blast furnace practice has shown that this gas cleaning and cooling water can be recycled. Normally the water would be put through settling chambers to remove the suspended solids and over a cooling tower to remove the heat.

While much effort has been expended to close these systems up completely and thereby produce a zero liquid discharge, it has not been clearly demonstrated that these systems can operate without some blowdown. For this reason, no additional reductions in pollutant loads from those described as BATEA limitations is proposed for NSPS in either of the two blast furnace subcategories. Flows for ferromanganese operations remain at twice the recommended level for iron making furnaces. A detailed description or appropriate ELG for both subcategories is found in Section X.

NSPS Discharge Standard – Refer to BATEA for the Two Blast Furnace Subcategories

## Steelmaking Operations

As is the case with the sinter plant, the liquid discharge exclusive of non-contact cooling water for all of the conventional steelmaking processes--open hearth, basic oxygen, and electric furnace--results from gas cleaning operations. Early gas cleaning systems on steelmaking processes were of the dry type, but the need to meet higher air quality standards has resulted in a shift on newer installations to wet cleaning methods. So long as the technology of dry gas cleaning lags behind the requirements for gas cleanliness, liquid discharges from steelmaking will continue. For this reason, no additional reductions in flow or pollutant loads from any steel making subcategory is required at this time as a new source performance standard. A detailed description of appropriate ELG's for all five steel making subcategories is found in Section X. However, in consideration of the nature of the biological denitrification process, and that it has been demonstrated full scale only on municipal wastes and other types of industrial wastes, but not on

steel industry wastes, the nitrate limitation has been deleted from the NSPS for the open hearth subcategory.

NSPS Discharge Standard - Refer to BATEA for the Five Steel Making Subcategories

## Vacuum Degassing Subcategory

This relatively new steel process removes dissolved gases from the molten metal to improve its quality. Exclusive of non-contact cooling water, the liquid discharge from this process results from the condensation of steam used in the steam jet ejectors which pull the vacuum. High capacity ejectors capable of pulling a significant vacuum are used.

All of the removed gases plus any particulate matter which results from the violent boiling which occurs when the vacuum is drawn, come in contact with the water. This results in particulate and dissolved contamination of the condensate which is produced in each of the interstage condensers. Substitution of another type of vacuum producing equipment does not seem practical at this time. No further reductions in the BATEA limitations are required. However, the nitrate limitation for BATEA for vacuum degassing operations shall not apply for the NSPS for the reasons cited under "Steelmaking Operations" above.

NSPS Discharge Standard - Refer to BATEA for Vacuum Degassing Subcategory

## Continuous Casting Subcategory

The continuous casting process, in addition to non-contact cooling water, uses considerable quantities of contact cooling water. This water becomes contaminated primarily with small particles of iron oxide (suspended solids) and also picks up some small amount of oil and grease from the lubricants used on the equipment. Occasionally if there is a hydraulic leak, some hydraulic fluid will also get into this water. This contact cooling water is a basic part of this new process, and methods for materially reducing either the volume or the level of contamination are not available at this time. No further reductions in the BATEA limitations are required.

NSPS Discharge Standard - Refer to BATEA for Continuous Casting Subcategory.
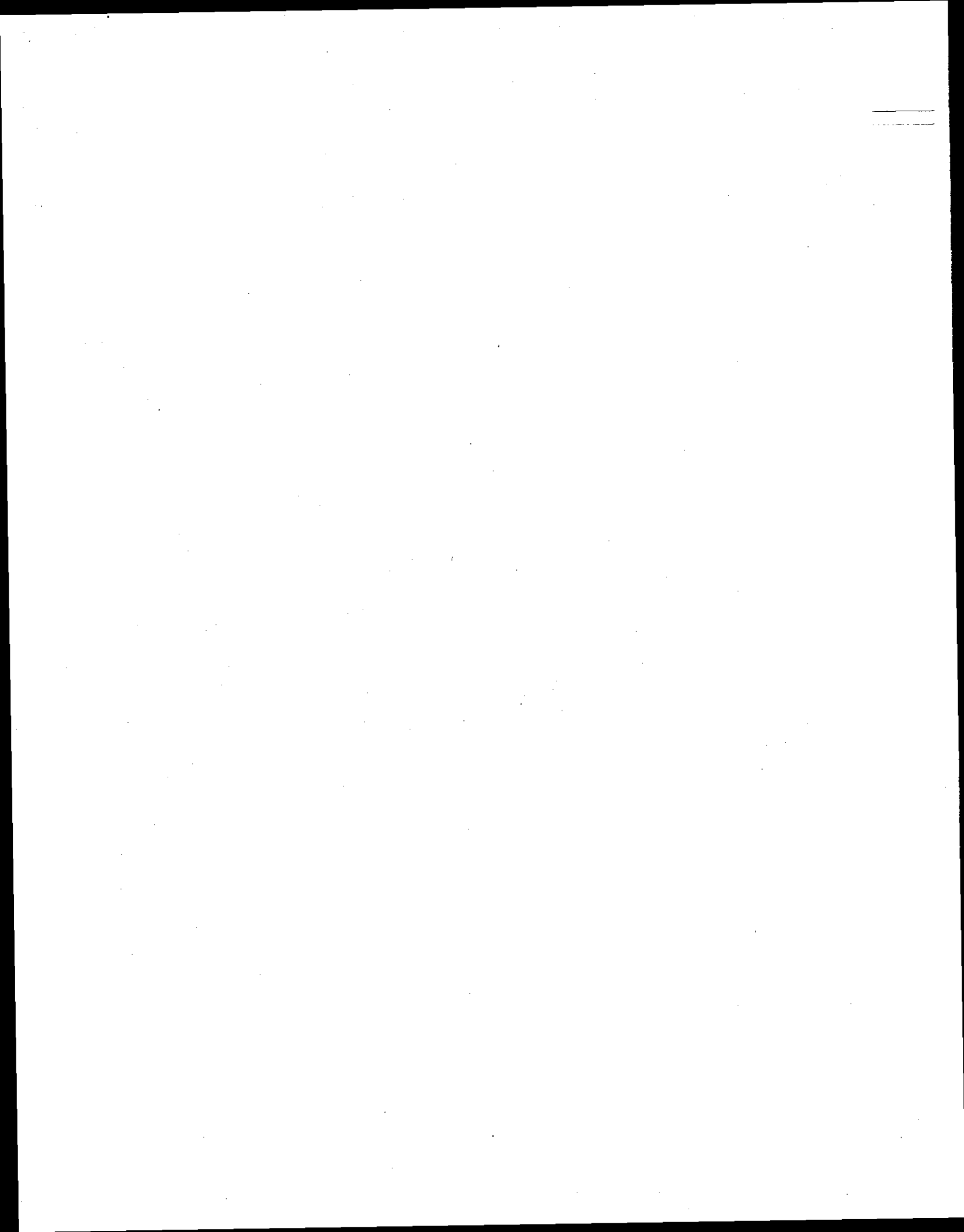
# SECTION XII

## ACKNOWLEDGEMENTS

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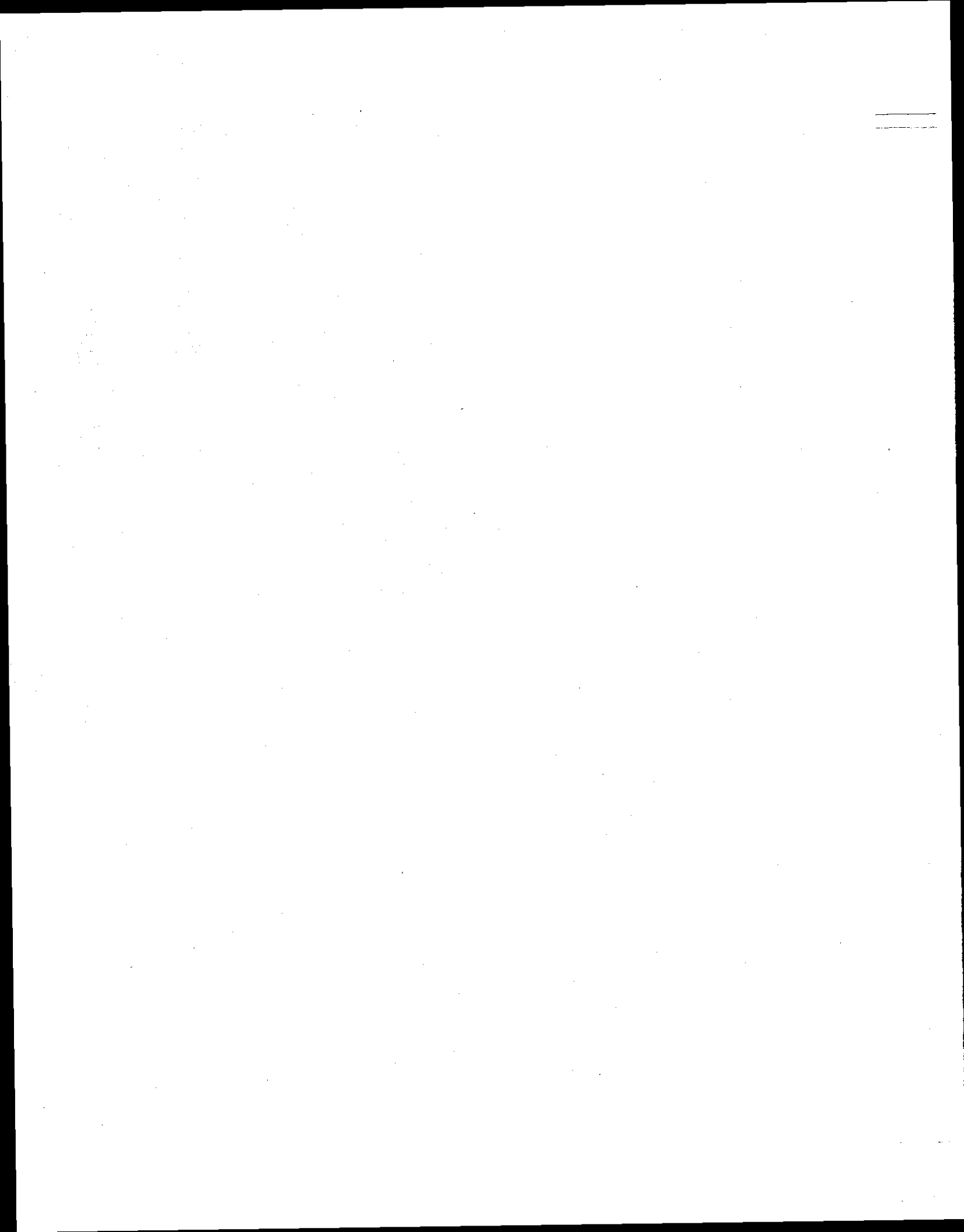
## GLOSSARY

### Acid Furnace

A furnace lined with acid brick as contrasted to one lined with basic brick. In this instance the terms acid and basic are in the same relationship as the acid anhydride and basic anhydride that are found in aqueous chemistry. The most common acid brick is silica brick or chrome brick.

### Air Cooled Slag

Slag which is cooled slowly in large pits in the ground. Light water sprays are generally used to accelerate the cooling over that which would occur in air alone. The finished slag is generally gray in color and looks like a sponge.

### Alloying Materials

Additives to steelmaking processes producing alloy steel.

### Ammonia Liquor

Primarily water condensed from the coke oven gas, an aqueous solution of ammonium salts of which there are two kinds: free and fixed. The free salts are those which are decomposed on boiling to liberate ammonia. The fixed salts are those which require boiling with an alkali such as lime to liberate the ammonia.

### Ammonia Still

The free ammonia still is simply a steam stripping operation where ammonia gas is removed from ammonia liquor. The fixed still is similar except lime is added to the liquor to force the combined ammonia out of its compounds so it can be steam stripped also.

### Ammonia Still Waste

Treated effluent from an ammonia still.

### Apron Rolls

Rolls used in the casting strand for keeping cast products aligned.

### Basic Brick

A brick made of a material which is a basic anhydride such as MgO or mixed MgO plus CaO. See acid furnace.

### Basic Furnace

A furnace in which the refractory material is composed of dolomite or magnesite.

## Basic Oxygen Steelmaking

The basic oxygen process is carried out in a basic lined furnace which is shaped like a pear. High pressure oxygen is blown vertically downward on the surface of the molten iron through a water cooled lance.

## Battery

A group of coke ovens arranged side by side.

## Blast Furnace

A large, tall, conical-shaped furnace used to reduce iron ore to iron.

## Bosh

The bottom section of a blast furnace. The section between the hearth and the stack.

## Briquette

An agglomeration of steel plant waste material of sufficient strength to be a satisfactory blast furnace charge.

## By-Product Coke Process

Process in which coal is carbonized in the absence of air to permit recovery of the volatile compounds and to produce coke.

## Burden

Solid feed stack to a blast furnace.

## Carbon Steel

Steel which owes its properties chiefly to various percentages of carbon without substantial amounts of other alloying elements. Steel is classified as carbon steel when no minimum content of elements other than carbon is specified or required to obtain a desired alloying effect.

## Charge

The minimum combination of skip or bucket loads of material which together provide the balanced complement necessary to produce hot metal of the desired specification.

## Checker

A regenerator brick chamber which is used to absorb heat and cool the waste gases to 650-750°C.

## Cinder

Another name for slag.

## Clarification

The process of removing undissolved materials from a liquid, specifically either by settling or filtration.

## Closed Hood

A system in which the hot gases from the basic oxygen furnace are not allowed to burn in the hood with outside air infiltration. These hoods cap the furnace mouth.

## Coke

The carbon residue left when the volatile matter is driven off of coal by high temperature distillation.

## Coke Breeze

Small particles of coke; these are usually used in the coke plants as boiler feed or screened for domestic trade.

## Coke Wharf

The place where coke is discharged from quench cars prior to screening.

## Cold Metal Furnace

A furnace that is usually charged with two batches of solid material.

## Continuous Casting

A new process for solidifying liquid steel in place of pouring it into ingot molds. In this process the solidified steel is in the form of cast blooms, billets, or slabs. This eliminates the need for soaking pits and primary rolling.

## Creosote

Distillate from tar.

## Cyanide

Total cyanide as determined by the test procedure specified in 40 CFR Part 136 (Federal Register Vol. 38, no. 199, October 16, 1973).

## Cyanide A

Cyanides amendable to chlorination as described in "1972 Annual Book of ASTM Standards" 1972: Standard D 2036-72, Method B, p 553.

## Dephenolizer

A facility in which phenol is removed from the ammonia liquor and recovers it as sodium phenolate; this is usually accomplished by liquid extraction and vapor recirculation.

## Double Slagging

Process in which the first oxidizing slag is removed and replaced with a white, lime-finishing slag.

## Drags

Flat bed railroad cars. A drag will generally consist of five or six coupled cars.

## Duplexing

An operation in which a lower grade of steel is produced in the basic oxygen furnace or open hearth and is then alloyed in the electric furnace.

## Dustcatcher

A part of the blast furnace through which the major portion of the dust is removed by mechanical separation.

## Electric Furnace

A furnace in which scrap iron, scrap steel, and other solid ferrous materials are melted and converted to finished steel. Liquid iron is rarely used in an electric furnace.

## Electrostatic Precipitator

A gas cleaning device using the principle of placing an electrical charge on a solid particle which is then attracted to an oppositely charged collector plate. The collector plates are intermittently rapped to discharge the collected dust to a hopper below.

## Evaporation Chamber

A method used for cooling gases to the precipitators in which an exact heat balance is maintained between water required and gas cooled; no effluent is discharged in this case as all of the water is evaporated.

## Fettling

The period of time between tap and start.

## Final Cooler

A hurdle packed tower that cools the coke oven gas by direct contact. The gas must be cooled to 30°C for recovery of light oil.

## Flushing Liquor

Water recycled in the collecting main for the purpose of cooling the gas as it leaves the ovens.

## Flux

Material added to a fusion process for the purpose of removing impurities from the hot metal.

## Fourth Hole

A fourth refractory lined hole in the roof of the electric furnace which serves as an exhaust port.

## Free Leg

A portion of the ammonia still from which ammonia, hydrogen sulfide, carbon dioxide, and hydrogen cyanide are steam distilled and returned to the gas stream.

## Fugitive Emissions

Emissions that are expelled to the atmosphere in an uncontrolled manner.

## Granulated Slag

A product made by dumping liquid blast furnace slag past a high pressure water jet and allowing it to fall into a pit of water. The material looks like light tan sand.

## Hot Blast

The heated air stream blown into the bottom of a blast furnace. Temperatures are in the range of 550°C to 1000°C, and pressures are in the range of 2 to 4.5 atmospheres.

## Hot Metal

Melted, liquid iron or steel. Generally refers to the liquid metal discharge from blast furnaces.

## Hot Metal Furnace

A furnace that is initially charged with solid materials followed by a second charge of melted liquid.

## Ingot

A large block-shaped steel casting. Ingots are intermediates from which other steel products are made. An ingot is usually the first solid form the steel takes after it is made in a furnace.

## Ingot Mold

A mold in which ingots are cast. Molds may be circular, square, or rectangular in shape, with walls of various thickness. Some molds are of larger cross section at the bottom, others are larger at the top.

## Iron

The product made by the reduction of iron ore. Iron in the steel mill sense is impure and contains up to 4% dissolved carbon along with other impurities. See steel.

## Iron Ore

The raw material from which iron is made. It is primarily iron oxide with impurities such as silica.

## Kish

A graphite formed on hot metal following tapping.

## Light Oil

A clear yellow-brown oil with a specific gravity of about 0.889. It contains varying amounts of coal-gas products with boiling points from about 40°C to 200°C and from which benzene, toluene, xylene and solvent napthas are recovered.

## Lime Boil

The turbulence created by the release of carbon dioxide in the calcination of the limestone.

## Lime Leg

The fixed leg of the ammonia still to which milk of lime is added to decompose ammonium salts; the liberated ammonia is steam distilled and returned to the gas stream.

## Meltdown

The melting of the scrap and other solid metallic elements of the charge.

## Mill Scale

The iron oxide scale which breaks off of heated steel as it passes through a rolling mill. The outside of the piece of steel is generally completely coated with scale as a result of being heated in an oxidizing atmosphere.

## Molten Metal Period

The period of time during the electric furnace steelmaking cycle when fluxes are added to furnace molten bath for forming the slag.

## Open Hearth Furnace

A furnace used for making steel. It has a large flat saucer shaped hearth to hold the melted steel. Flames play over top of the steel and melt is primarily by radiation.

## Open Plate Panel Hood

A 4.5 meter to 6 meter square, rectangular or circular cross sectional shaped conduit, open at both ends, which is used in the BOF steelmaking process for the combustion and conveyance of hot gases, fume, etc., which are generated in the basic oxygen furnace, to the waste gas collection system.

## Ore Boil

The generation of carbon monoxide by the oxidation of carbon.

## Oxidizing Slags

Fluxing agents that are used to remove certain oxides such as silicon dioxide, manganese oxide, phosphorus pentoxide and iron oxide from the hot metal.

## Pelletizing

The processing of dust from the steel furnaces into a pellet of uniform size and weight for recycle.

## Pig Iron

Impure iron cast into the form of small blocks that weigh about 30 kilograms each. The blocks are called pits.

## Pinch Rolls

Rolls used to regulate the speed of discharge of cast product from the molds.

## Pitch

Distillate from tar.

## Pouring

The transfer of molten metal from the ladle into ingot molds or other types of molds; for example, in castings.

## Quenching

A process of rapid cooling from an elevated temperature by contact with liquids, gases, or solids.

## Quench Tower

The station at which the incandescent coke in the coke car is sprayed with water to prevent combustion. Quenching of coke requires about 500 gallons of water per ton of coke.

## Reducing Slag

Used in the electric furnace following the slagging off of an oxidizing slag to minimize the loss of alloys by oxidation.

## Refining

Oxidation cycle for transforming hot metal (iron) and other metallics into steel by removing elements present such as silicon, phosphorus, manganese and carbon.

## Runner

A channel through which molten metal or slag is passed from one receptacle to another; in a casting mold, the portion of the gate assembly that connects the downgate or sprue with the casting.

## Runout

Escape of molten metal from a furnace, mold or melting crucible.

## Slag

A product resulting from the action of a flux on the nonmetallic constituents of a processed ore, or on the oxidized metallic constituents that are undesirable. Usually slags consist of combinations of acid oxides with basic oxides, and neutral oxides are added to aid fusibility.

## Spark Box

A solids and water collection zone in a basic oxygen furnace hood.

## Steel

Refined iron. Typical blast furnace iron has the following composition: Carbon - 3 to 4.5%; Silicon - 1 to 3%; Sulfur - 0.04 to 0.2%; Phosphorus - 0.1 to 1.0%; Manganese - 0.2 to 2.0%.

The refining process (steelmaking) reduces the concentration of these elements in the metal. A common steel 1020 has the following composition: Carbon - 0.18 to 0.23%; Manganese - 0.3 to 0.6%; Phosphorus - less than 0.04%; Sulfur - less than 0.05%.

## Steel Ladle

A vessel for receiving and handling liquid steel. It is made with a steel shell, lined with refractories.

## Stools

Flat cast iron plates upon which the ingot molds are seated.

## Stoves

Large refractory filled vessels in which the air to be blown into the bottom of a blast furnace is preheated.

## Strand

A term applied to each mold and its associated mechanical equipment.

## Support Rolls

Rolls used in the casting strand for keeping cast products aligned.

## Tap Hole

A hole approximately fifteen (15) centimeters in diameter located in the hearth brickwork of the furnace that permits flow of the molten steel to the ladle.

## Tapping

Transfer of hot metal from a furnace to a steel ladle.

## Tap to Tap

Period of time after a heat is poured and the other necessary cycles are performed to produce another heat for pouring.

## Tar

The organic matter separated by condensation from the gas in the collector mains. It is a black, viscous liquid, a little heavier than water. From it the following general classes of compounds may be recovered: pyrites, tar acids, naphthalene, creosote oil and pitch.

## Teeming

Casting of steel into ingots.

## Tundish

A preheated, covered, steel, refractory-lined, rectangular container with several nozzles in the bottom which is used to regulate the flow of hot steel from the teeming ladles.

## Vacuum Degassing

A process for removing dissolved gases from liquid steel by subjecting it to a vacuum.

## Venturi Scrubber

A wet type collector that uses the throat for intermixing of the dust and water particles. The intermixing is accomplished by rapid contraction and expansion of the air stream and a high degree of turbulence.

## Wash Oil

A petroleum solvent used as an extractant in the coke plant.

## Waste Heat Boiler

Boiler system which utilrize the the hot gases from the checkers as a source of heat.

## Water Tube Hood

Consists of steel tubes, four (4) to five (5) centimeters in diameter, laid parallel to each other and joined together by means of steel ribs continuously welded. This type hood is used in the basic oxygen steelmaking process for the combustion and conveyance of hot gases to the waste gas collection system.

## Wet Scrubbers

Venturi or orifice plate units used to bring water into intimate contact with dirty gas for the purpose of removing pollutants from the gas stream.

# TABLE 80

## METRIC UNITS

### CONVERSION TABLE

MULTIPLY (ENGLISH UNITS)  by   TO OBTAIN (METRIC UNITS)

| ENGLISH UNIT | ABBREVIATION | CONVERSION | ABBREVIATION | METRIC UNIT |
|---|---|---|---|---|
| acre | ac | 0.405 | ha | hectares |
| acre - feet | ac ft | 1233.5 | cu m | cubic meters |
| British Thermal Unit | BTU | 0.252 | kg cal | kilogram-calories |
| British Thermal Unit/pound | BTU/lb | 0.555 | kg cal/kg | kilogram calories/ kilogram |
| cubic feet/minute | cfm | 0.028 | cu m/min | cubic meters/minute |
| cubic feet/second | cfs | 1.7 | cu m/min | cubic meters/minute |
| cubic feet | cu ft | 0.028 | cu m | cubic meters |
| cubic feet | cu ft | 28.32 | l | liters |
| cubic inches | cu in | 16.39 | cu cm | cubic centimeters |
| degree Fahrenheit | °F | 0.555(°F-32)* | °C | degree Centigrade |
| feet | ft | 0.3048 | m | meters |
| gallon | gal | 3.785 | l | liters |
| gallon/minute | gpm | 0.0631 | l/sec | liters/second |
| horsepower | hp | 0.7457 | kw | killowatts |
| inches | in | 2.54 | cm | centimeters |
| inches of mercury | in Hg | 0.03342 | atm | atmospheres |
| pounds | lb | 0.454 | kg | kilograms |
| million gallons/day | mgd | 3,785 | cu m/day | cubic meters/day |
| mile | mi | 1.609 | km | kilometer |
| pound/square inch (gauge) | psig | (0.06805 psig +1)* | atm | atmospheres (absolute) |
| square feet | sq ft | 0.0929 | sq m | square meters |
| square inches | sq in | 6.452 | sq cm | square centimeters |
| tons (short) | ton | 0.907 | kkg | metric tons (1000 kilograms) |
| yard | yd | 0.9144 | m | meters |

* Actual conversion, not a multiplier