

SECONDARY ZINC
SMELTING 12.14
AP-42 Section 7.14
Reference Number 34

Ref. 7-11 and 7-61 (1972)

Note: This is a reference cited in AP 42, *Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources*. AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

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SECONDARY ZINC INDUSTRY EMISSION CONTROL PROBLEM DEFINITION STUDY

PART 1—TECHNICAL STUDY

ENVIRONMENTAL PROTECTION AGENCY
AIR POLLUTION CONTROL OFFICE

Final Report

on

SECONDARY ZINC INDUSTRY
EMISSION CONTROL PROBLEM DEFINITION STUDY

PART 1 - TECHNICAL STUDY

Conducted by the
AIR POLLUTION CONTROL OFFICE, EPA

in cooperation with

THE NATIONAL ASSOCIATION OF
SECONDARY MATERIAL INDUSTRIES

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Secondary Zinc Industry
Emission Control Problem Definition Study

Part 1 - Technical Study

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Secondary Zinc Industry
Emission Control Problem Definition Study

Part 1 - Technical Study

Abstract

Effluents containing particulate and gaseous emissions are exhausted from certain processes of the secondary zinc industry. Data on those emissions with related emission-control and process data were obtained from a sampling of plants. These data were evaluated to obtain the results of this study.

Process materials consumed by this industry consist principally of scrapped items that contain metallic zinc. Small amounts of chloride fluxing compounds are also consumed in some secondary zinc processes. The principal processes of the industry are sweating and distillation which are applied to recovery metallic zinc.

Sweat processing is conducted to produce finished zinc alloys; it is also a usual preliminary step to distillation, providing the crude zinc-alloy feed for the latter. Distillation processes produce zinc metal and zinc oxide, both of virtually 100% purity.

Emissions from sweat processes occur at very low rates where the processed zinc scrap contains only small amounts of impurities. However, very significant emissions of particulate and gaseous carbonaceous substances, and particulate zinc oxide and zinc chloride may occur where there are substantial amounts of impurities in the scrap. Smaller amounts of other metal oxides, metal chlorides, and ammonium chloride may also be emitted under this condition.

Emissions from distillation processes contain zinc oxide as the principal constituent. These emissions occur at significant rates, but are satisfactorily controlled using baghouses.

The results of this study indicate that emission factors for zinc sweat processes range from zero to around 32 pounds of particulate per ton of scrap material processed. The results further indicate that the emitted particulate may be composed of zero to 34% $ZnCl_2$; 40 to 100% ZnO ; and small percentages of carbonaceous substance (in one instance 10%). These values do not take into account the sweat processing of scrap containing large amounts of organic material (e.g., assemblies that contain gaskets, lubricants, etc.), where carbonaceous emissions might preponderate. Such scrap is usually subjected to preliminary sweat processing, using afterburners in some instances, that satisfactorily incinerate the organic material and resulting carbonaceous emissions.

Sweat-process emissions are alleviated by selection of processes that appear optimum for the type of scrap being processed and by application of established types of gas cleaning equipment. High collection efficiencies have been obtained in such equipment applications. However, emission control problems have not been solved for processing all types of zinc scrap material. Limitations are imposed on endurance and effectiveness of gas cleaning devices, used in this way, by the following occurrences:

- a. Corrosion of metallic fabricating materials and organic bag filter materials caused by emitted chlorides.
- b. Blinding of dry fabric filters by adhering carbonaceous particles and deliquescent $ZnCl_2$.
- c. Blinding of irrigated fabric filters by adhering carbonaceous particles.
- d. Abrasive wear of fibrous glass bag-filter material during cleaning.

- e. Limited temperature resistance of organic-fabric-filter materials.
- f. Tar-like deposits and ignition hazards associated with carbonaceous emissions.

Process model units were formulated for study of present and conceptual emission control systems.

Several emission-control concepts were developed based on findings of this study, and recommendations are made for further research and development.

CHAPTER I

Introduction

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Chapter I

Introduction

PROBLEM AREA - PROCESSES STUDIED

Gaseous exhaust effluents containing deliquescent and corrosive metal chlorides are emitted from certain processes of the secondary zinc and aluminum industries. The study reported here was conducted to define the problems of controlling emissions, so characterized, that result specifically from secondary-zinc processes.

As dealt with here, the secondary zinc industry consists of those plants that process discarded and scrapped items and materials that contain metallic zinc for the primary purpose of recovering that metal. The principal processes employed are sweating and distillation. This study does not include reduction processes applied to obtain metallic zinc from zinc oxide contained in waste materials. In present practice, most materials of that type are processed through primary smelting establishments. Also excluded from this study is the processing of zinc-process wastes, which are principally of a chemical nature, to produce chemical products - that processing usually being done in plants of the chemical and other non-metallurgical industries. (Study of processes excluded here might be taken up in "Reduction in Belgian Retorts" APEM, pp. 294-6; and "Sal Skimmings" and "Chemical Residues" Mathewson, pp. 319-21.)

SCOPE OF STUDY

The problem definition study is intended to determine a basis for research and development to improve emission control capabilities of the industry studied.

The results of the study may also be used as a source of data for additional purposes brought about by legislation, including an annual report to Congress and the setting of emission control standards required under the Clean Air Act with Amendments of 1970.

Part 1, reported here, covers the technical phase of a study to define the problems of controlling emissions of the secondary zinc industry. Part 2 of this study is planned to cover the economic phase - to show the degree of emission control that can be attained for specific process situations, the cost of attaining that control, and situations where satisfactory control cannot be attained because of cost.

APPROACH TO STUDY

The approach in conducting this study was to hold discussions between APCO and NASMI representatives; review available literature; and visit a small sampling of plants that were selected through the office of NASMI as being representative of the range of processing and resulting emissions of the industry. Data obtained through this investigation were evaluated to quantitatively define emission control problems, reveal gaps in existing emission control technology, and develop concepts, to be considered for research and development.

REFERENCES TO DATA SOURCES

Data used in this study were obtained from plants of cooperating companies and from published sources. The industrial plant sources are treated confidentially and therefore not cited within the report. Published sources are cited within the report.

EXTENT OF THE INDUSTRY AND POTENTIAL BENEFITS OF EMISSION CONTROL R&D

It is estimated that secondary production of zinc, aluminum, and copper alloys accounts for 20%, 30%, and 45%, respectively, of total consumption of those metals in the United States (NASMI Studies, p. 12; see also Minerals YB). Although the study reported here deals specifically with zinc processing, it is noted that emissions from the aforementioned three types of secondary metal processing have characteristics and constituents common to all. Deliquescent, corrosive metal chlorides are common to zinc and aluminum process emissions. Zinc oxide makes up large percentages of particulate emissions from both secondary zinc and copper-alloy processing. Carbonaceous emissions are common to all three industries processing these metals. It may, therefore, be anticipated that emission control technology, developed for secondary zinc, will be applicable at least in part to emission control efforts in the other industries. Therefore, the study reported here, while concerned specifically with the secondary zinc industry, also constitutes part of a greater effort to improve emission control capabilities of producers, which in aggregate make up a larger part of the metal-producing industries.

CHAPTER II

Process Raw Materials

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Chapter II

Process Raw Materials

Raw materials used in secondary zinc processing are zinc scrap materials, fluxes, and fuels for furnaces. These are described below.

ZINC SCRAP MATERIALS

For purposes of statistical presentation, one system of classification and nomenclature of zinc scrap materials has been developed and applied by the Bureau of Mines (Minerals YB). For purchase specification purposes, another system has been developed by NASMI and is applied within the industry (NASMI NF-66). These systems do not readily lend themselves directly for the technical analyses of this study, but are listed below to help describe the materials. For the technical analyses of this study, an additional system was formulated and is presented below. In this TECHNICAL CLASSIFICATION, zinc scrap materials are divided into two main categories and the sub-classifications as shown under that heading.

BUREAU OF MINES CLASSIFICATION:

New clippings

Old zinc

Engravers' plates

Skimmings and ashes

Sal skimmings

Die-cast skimmings

Galvanizers' dross

Diecastings

Rod and die scrap

Flue dust

Chemical residues

NASMI CLASSIFICATION:

Old zinc die cast scrap

New zinc clippings

New zinc die cast scrap

Zinc die cast slabs or pigs

New plated zinc die cast scrap

Galvanizers' slab zinc dross

Zinc die cast automotive grills

Prime zinc die cast dross

Old scrap zinc

TECHNICAL CLASSIFICATION:

A. Metallic Scrap. This scrap consists of metallic items, generally in the same shape as when manufactured or used.

1. Unplated zinc castings. Examples are reject castings, off-grade ingots, old castings, and printers plates. Castings in this classification are free of significant attachments made of other metals. They range from very clean castings to castings having relatively small amounts of oil and/or paint coatings, dirt, and other impurities.

2. Plated zinc castings. These are mainly automobile grills, having chromium platings. They are considered herein as having very little, if any, contamination with oils, paints, other organic materials, and dirt and only small amounts of higher melting-point metal attachments.

3. Zinc fabricating scrap. This scrap consists of that obtained from fabricating operations; examples are cuttings, punchings, chips, borings, turnings, and routings. They are considered here as being reasonably clean, except for coatings of oil or cutting compounds.

4. Contaminated zinc die-cast scrap. This scrap consists of assemblies containing zinc die-castings; attachments made of other metals; and materials that contain carbon compounds such as gaskets, electric insulation, and lubricants.

Examples are automobile fuel pumps, carburetors, horns, and washing machine parts. (Attachments made of metals having higher melting points than zinc may be referred to as "unmeltable attachments" or "unmeltables.")

B. Residual Scrap Materials. These are residues and impure alloys formed in the melting, fluxing, and application of molten-metal baths in galvanizing, die casting, and other processes. These materials are referred to, generally, as skimmings (or residues) and drosses. In this study, the terms skimmings and residues refer specifically to materials that form above metal bath surfaces. These materials are composed preponderantly of non-metallic substances including metal oxides and residual flux, with lesser amounts of metal contained as particles (or inclusions). They are of non-metallic appearance. The term dross, in this study, refers to materials that form within molten-metal baths, at top surfaces and at bottoms of melting vessels. They are composed mostly of metallic zinc and are metallic in appearance. As defined here, these terms are at variance with some industrial usage, as is noted below.

1. Skimmings (or residues).

a. Galvanizers' skimmings (ashes). This material is formed by oxidation of metal on galvanizing bath surfaces when no flux blanket is used. It is skimmed from above the molten metal bath surface. Skimmings are pulverulent, composed mostly of ZnO, with metallic inclusions. They are formed as galvanized items are withdrawn from baths, creating turbulence at the bath surface. Chlorine (as chlorides), derived from flux coatings on stock being galvanized, may be present in these skimmings in amounts from 0 to 12%. (The processing of "sal skimmings," formed on a galvanizing bath when a flux blanket is used, is not included in this study. See Chapter I.)

b. Die-cast skimmings. These materials are formed by accumulation of metal oxides, ZnCl and/or NH₄Cl flux, and other impurities above surfaces of zinc-alloy baths used for die-casting and are skimmed off. Skimmings are composed mostly of ZnO, with metallic inclusions making up 3 to 10%. Chlorine (as chlorides) ranges from 0 to 3% (approximately equivalent to 0 to 6% anhydrous ZnCl₂). The metallic inclusions are zinc, containing copper and aluminum, derived from die-cast alloy.

2. Dross

a. Top dross

(1) Galvanizers' top dross (also referred to as "galvanizers' top skimmings"). This material is formed by iron-aluminum compounds floating to the surface of galvanizing baths. These compounds result from reactions of aluminum with iron during certain galvanizing processes where aluminum is added to the baths to prevent a brittle layer from being formed in the coatings. They melt at a higher temperature and are lighter than zinc; therefore, they tend to separate and solidify at the bath surface. The product is skimmed from tops of baths and cast into chunks. It contains uncombined zinc and metal oxides, in addition to the aforementioned Fe-Al compounds. Top drosses contain around 90 to 95% Zn, 2 to 5% Al, are generally free of chloride flux but may contain small amounts.

(2) Die-cast dross. This material is formed at the top of die-casting process baths and is similar to galvanizers' top dross, but with different metal contents. Zinc content approximates 85%. Copper and aluminum are also present. There may be some chloride-flux content.

b. Bottom dross

(1) Galvanizers' dross. This material is formed by liquation of an iron-zinc compound to the bottom of galvanizing baths; this settling results from a higher specific gravity than zinc. In some galvanizing processes, dross may rest on a layer of molten lead. Removed from the bath with spoons and cast into chunks, the resultant product contains uncombined zinc in addition to the Fe-Zn compound. Some lead may also be present as well as chloride flux, the latter being picked up from the bath surface during dross removal.

(References: Nonferrous, pp. 63-74; Mathewson, pp. 315-21, 469)

FLUXES

The main fluxing materials used in secondary zinc processing are $ZnCl_2$ and NH_4Cl . These may be applied to the metallurgical process bath, or they may be contained in residual scrap as obtained, as noted in the foregoing description of those materials.

Other "smokeless fluxes" are in limited usage for processing relatively clean scrap. Cost is considered too high and effectiveness in emission control too limited to provide solutions to general processing and emission control problems. Application of these fluxes does not appear to fall within the problem area of this study and is therefore dismissed from further consideration in this report.

FUELS

Natural gas and fuel oil are the principal fuels used in secondary zinc processing. Based on the operations of plants visited during this study, it is believed that the fuel used most is natural gas. Oil is used in smaller facilities and as a standby fuel. Electricity is sometimes used to heat furnaces. This use of electricity appears to be unusual and limited to processing clean scrap that does not pose air pollution problems.

ERRATA FOR SECONDARY ZINC INDUSTRY EMISSION CONTROL PROBLEM
DEFINITION STUDY, PART 1 - TECHNICAL STUDY FINAL REPORT

Title Page - Insert the date "May, 1971" after the statement "Conducted by the AIR POLLUTION CONTROL OFFICE, EPA, in cooperation with THE NATIONAL ASSOCIATION OF SECONDARY MATERIAL INDUSTRIES".

Page (V-4) - At the bottom of this page, begin new paragraph by inserting the following line:

"Findings of this study indicate that there are significant carbonaceous"

Table VII-1 (Page 1 of 2) - In Column 7, the fourth item from the top, delete the decimal point that precedes the number "32".

Page (VIII-14), second line - Delete "thorough" and substitute "through".

Chapter III

Products of Processes

Products of secondary zinc plants are listed and defined as follows:

- A. Specification zinc alloys. Standard alloys, such as die-casting types, produced by sweat-processing and re-alloying zinc metallic scrap.

- B. Zinc-content metal. Zinc-containing metal produced by sweat-processing metallic and residual zinc scrap material in preparation for distillation.

- C. Distilled slab zinc. Zinc-containing metal approaching 100% Zn purity produced by distillation of metal derived from zinc scrap materials.

- D. Zinc dust. Zinc-containing metal produced by distillation of metal derived from zinc scrap materials. The distilled zinc vapor is allowed to condense under conditions which form small spherical particles.

- E. Zinc Oxide. ZnO approaching 100% purity produced by distillation of scrap-derived zinc with subsequent oxidation of vapor by atmospheric combustion.

- F. By-product residues containing ZnO (for reduction to metallic zinc by primary smelters).
 1. Sweat-process residues. These are residues that remain after metal has been extracted from metallic or residual zinc-scrap material. Some chloride flux may be retained in these residues.

2. Residues from water-wash pre-treatment of residual zinc-scrap material, applied to extract metal inclusions. These may be chemically treated and/or calcined to reduce chloride content. (See PRE-TREATMENTS, Chapter IV)

G. By-product particulates containing ZnO (for agricultural soil treatment). These are emitted particulates collected by control equipment (usually baghouses) having a maximum chloride content of 5%. Commercial usage of collected particulates has not been determined for collected particulates having over 5% chloride content.

H. By-product distillation residues containing Al and Cu (for use in aluminum alloying). These are removed from distillation furnaces.

I. Ferrous and non-ferrous unmeltable attachments to zinc base die castings.

Chapter IV

Summary of Processes, Process Effluents and Emission Points

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Chapter IV

Summary of Processes, Process Effluents and Emission Points

PRETREATMENTS

Treatments, preliminary to melting operations, are applied to some types of zinc-scrap material.

Attachments that are accessible and can be removed easily are removed from contaminated zinc die-cast scrap. Attachments and impurities that are often not removed include gaskets, sealed-in lubricants, screws, and electrical parts. Considerable organic materials and metals, other than zinc, are therefore retained in this scrap when it is charged to melting (sweating) furnaces.

Concentration of metallic zinc in skimmings is increased by ball-mill pulverizing, followed by pneumatic treatment and/or screening to remove part of the pulverulent, non-metallic constituents.

In some instances, skimmings are crushed and then treated in the following manner. The crushed skimmings are washed with water to separate non-metals as a slurry and allow zinciferous metal particles to settle out; the slurry is then treated with Na_2CO_3 to convert chlorides (mainly ZnCl_2) to NaCl , forming insoluble $\text{Zn}(\text{OH})_2$. Most of the NaCl is separated from the insoluble residues by filtration and settling; the residue is dried and calcined in a kiln to convert $\text{Zn}(\text{OH})_2$ to ZnO by driving off H_2O and vaporizing any remaining ZnCl_2 . The calcined product is mostly ZnO and is suitable for smelting. The kiln fume is collected in polyester fabric bag filters and recycled.

Emissions from the aforementioned pretreating processes were not studied in depth during this investigation, since it did not appear that there were notable difficulties in their control, there being no reports from industrial representatives indicating any problems. These emissions are therefore not dealt with further in this report.

SWEAT PROCESSES

In sweat processing, heat is applied to scrap materials, which may be of either the metallic or residual types, to melt and separate metallic zinc from metal attachments, having higher melting points, and from non-metallic residues. Any organic materials in scrap are also burned off during sweating. Sweat processing is accomplished by charging the scrap into a melting furnace. The charge may be worked, by agitation or stirring during melting; and chloride flux may be present either as residual flux, in charged residual scrap, or as flux added to the charge. Working and fluxing of the charge are done to help effect the desired metal separation. A molten-metal bath is formed from the metallic zinc (with dissolved alloy metals). Non-metallic residues, along with some platings, form above the molten-metal bath surface and are skimmed off. Unmeltable attachments settle to the bottom and are removed. The molten metal may then be (1) cast directly into blocks for subsequent further processing, or (2) fed directly to a distillation furnace, or (3) it may be sampled and analyzed, and then alloyed by adding metals to obtain specification composition, and then cast as ingots.

Types of furnaces used for sweating zinc-scrap materials are discussed in the following order:

1. Melting-kettle (or kettle) furnaces
2. Reverberatory furnaces
3. Rotary furnaces

4. Muffle furnaces

5. Electric-resistance furnaces

Of these, most usage is of the first three, which are therefore given principal attention in this chapter. Figures 4-1 and 4-2 are schematic flow diagrams that show sweat processing in kettle and reverberatory furnaces. The rotary furnace is, in effect, a mechanical modification of the reverberatory furnace, as will become apparent in the description of that furnace in a subsequent paragraph. Emission points of sweat furnaces and effluents emitted from those points are shown in Table IV-1. These furnaces, their applications, emission points, and effluents are described further in the paragraphs below.

KETTLE FURNACE

The kettle furnace consists of a melting vessel (kettle), made of cast iron in most cases, mounted over a combustion chamber. Scrap materials, which may include metallic and/or residual types, are charged into the kettle. The metallurgical-process bath is formed as zinciferous metal is melted and residues form above the molten-metal surface. Operating temperatures of kettle-process baths range from 800 to 1000^oF. Production is on a batch basis, with one process heat requiring around 6 to 8 hours to process and pour. A molten heel may be retained as finished alloy is removed from furnaces and additional scrap (process material) charged.

Normally, products of fuel combustion are exhausted separately from emissions of the metallurgical-process bath, through separate venting of the combustion chamber. Natural gas is the generally used fuel (fuel oil being used in a smaller number of cases).

As noted previously, sweat processing in a kettle furnace is shown schematically in Figure 4-1, along with emissions and emission points. Emission points and effluents emitted from these points are detailed further in Table IV-1.

REVERBERATORY FURNACE

The reverberatory furnace has a general box configuration with a sloped bottom (hearth). It is used to process both metallic and residual zinc scrap materials, which are charged into the furnace and rest on the hearth. Burners are located in the upper part of the furnace; combustion of fuel above the charge supplies heat to burn off organic substances, as well as heat to melt the zinc alloys in the charge. Furnaces are designed and burners are positioned to minimize flame impingement on the charge and to reduce oxidation and entrainment of metal oxide particles in emissions. As zinc alloys melt, they separate from unmeltables and flow downward over the hearth. Bath temperatures in reverberatory furnaces are usually around 1000°F. When comparable materials are processed, these baths are usually maintained at higher temperatures than kettle-furnace baths to increase fluidity of molten metal and thereby improve separation from unmeltables. Metal flows from the furnace as it melts; and, at intervals, unmeltables are raked out and additional process material charged.

Reverberatory furnaces may be independent units or they may be integral with distillation furnaces (Figure 205, APEM). Consideration here is limited to the independent type of unit where molten metal from the hearth flows through a spout into ladles or kettles. The metal may then be processed

further to obtain a specification alloy, or it may be fed to a distillation furnace. Integral sweating-and-distillation furnaces are discussed further in a subsequent section on distillation furnaces.

Sweat processing in a reverberatory furnace is shown schematically in Figure 4-2, along with emissions and emission points. These emission points and effluents from these points are detailed further in Table IV-1. It might be noted that the pouring spout of the reverberatory furnace is not listed as an emission point; the molten-metal temperature at this point is normally not high enough to vaporize significant amounts of zinc (APEM p. 294).

ROTARY FURNACE

The melting unit of the rotary-type furnace consists of a hollow cylinder mounted with its lengthwise axis sloped at a small angle from horizontal. During operation, this cylinder is mechanically rotated on that axis and internally heated by gas or oil burners. The principal application of the rotary furnaces at plants visited during this study was for processing contaminated die-cast scrap, without application of fluxing compounds. Scrap materials are fed into the high end of the melting cylinder. As the cylinder rotates, zinc melts and flows out through openings in the low end, usually into a kettle where residues are skimmed off. Unmeltables are separated from the bath by tumbling them out of the low end of the cylinder or by manual raking and scraping. Rotary-furnace bath temperatures are usually lower than those of kettle or reverberatory furnaces because rotation helps (1) separate molten zinc from unmeltables, (2) maintain molten zinc and alloy metals in solution, and (3) use heat more efficiently by avoiding localized high temperature zones, thereby allowing lower bath temperatures to be applied. The collected zinc-containing metal may then be transferred to a distillation furnace, or its composition may be adjusted to an alloy specification.

Observations of this study indicated no visible (or significant) emissions at the low end of the cylinder as the molten metal or unmeltables flow from or are being removed from the melting cylinder.

The only emission point noted (in Table IV-1) is therefore, the furnace flue (the high end of the melting cylinder). Emissions from this point are those contained in furnace-exhaust effluent (flue gas), which consists of the same types of constituents as those listed for furnace flue effluents from reverberatory furnaces, except that emissions derived from flux would not normally be contained in rotary-furnace effluent.

MUFFLE FURNACE

In the muffle furnace, as applied to sweating processes, combustion gases are separated from charged zinc-scrap materials by a "muffle". (The same principle is applied to distillation as shown in Figure 204 of APEM.) This design permits separation of combustion products from those emissions derived from charged zinc-scrap materials and flux. In this respect, the muffle furnace is similar to the kettle furnace. Findings of this study indicate little usage of the muffle furnace for sweating (although usage for distillation is significant). Probably this limited usage is due to low thermal efficiency. Because usage is not extensive, the muffle furnace as applied to sweat processing is not subjected to detailed analysis in this study.

ELECTRIC-RESISTANCE FURNACE

Findings of this study indicate that electric-resistance furnaces are used in a small number of plants for processing clean, scrap-derived zinc metal, and that processing such scrap does not pose significant air-pollution problems regardless of furnace type. It appears that by avoiding fuel-combustion products, application of electric-resistance furnaces might have an emission-

control advantage. However, cost of electric energy probably precludes usage of electric-resistance furnaces for sweat processing in nearly all situations (except for melting clean metal). This type of furnace is therefore not subjected to detailed analysis in this study.

DISTILLATION PROCESSES

Distillation processes are of several variations (APEM pp. 296-9; Mathewson p. 317) which can be reasonably represented by the retort furnace system and the muffle furnace system. Figures 203 and 204 of APEM show examples of distillation processing by means of these systems. Table IV-2 of this report details their emission points and the effluents emitted. Further description is provided in the paragraphs below.

RETORT FURNACE SYSTEM

The retort furnace system consists of two units: (1) a retort furnace and (2) a condenser (Figure 203, APEM). In the retort furnace, the distillation retort (which may be bottle-shaped) is mounted inside the furnace closure where fuel is burned, heating the retort and its content. The charge to the retort may consist of molten-zinc-rich metal obtained directly from a sweat furnace, cast zinc-content metal from a zinc-sweat process, or zinc dross. Zinc is vaporized in the retort, and the vapor passes through a refractory pipe to a condenser, where it may be condensed either as zinc dust or molten zinc (for casting into slabs), depending on the type of condenser used. The condenser for making zinc dust consists of a bare sheet-steel shell. Zinc vapor entering this condenser cools rapidly and therefore condenses into small particles. The condenser for making slab zinc also consists of a steel shell, but is refractory lined for thermal insulation. Zinc vapor entering this condenser cools more slowly, forming liquid metal on

internal surfaces of the refractory lining; the liquid metal flows to the bottom where it is tapped at intervals and cast into slabs.

Retort furnaces may also be used to produce zinc oxide by allowing zinc vapor, from the retort, to burn in air, and collecting the resulting ZnO product in a baghouse.

Distillation residues (mainly mixtures of aluminum and copper) are raked out of the retort immediately after each distillation heat is completed, while residues are still at a high temperature.

Fuel-combustion products are exhausted independently of any emissions from the retort charge.

Emission points in the retort-furnace system are listed, with emissions from those points, in Table IV-2 and are discussed further as follows:

A. Retort opening. During removal of distillation residues from the retort, ZnO particles are emitted as the molten zinc that remains in the residues continues to vaporize and oxidize. Ambient air composes the gaseous part of effluent formed at this point.

B. Pressure-relief valve or "speise" hole of condenser. One or the other of these devices is used to retain a positive pressure and exclude air from condensers (APEM p. 297). Emissions from the "speise" hole consist of nearly-pure ZnO. Emissions from condenser relief valves are mixtures of zinc dust and ZnO. In heats where dross is contained in the retort charge, a small amount of chloride particulates, derived from residual flux, might also be emitted at these points. Ambient air composes the gaseous part of effluents formed at these points.

MUFFLE FURNACE SYSTEM

The muffle-furnace system consists of a melting unit (reverberatory furnace) and a vaporizing unit (muffle furnace), combined in an integral structure, and includes a condenser (APEM p. 298). Materials such as contaminated zinc die-cast scrap are charged into the melting unit. As zinc alloys melt, the molten metal flows from that unit to the bottom of the vaporizing unit. Fuel combustion in the vaporizing unit takes place in the upper chamber of that unit, which is separated from the molten metal and zinc vapor (in the lower chamber) by an arched partition (muffle). Combustion gas from the upper chamber is exhausted to the melting unit, adding heat to that of melting unit burners to help melt the charged scrap material. Zinc vapor is channeled from the vaporizing unit to the condenser where it is partly condensed to liquid metal and cast as slabs. The non-condensed vapor is oxidized to ZnO, which is collected in a baghouse.

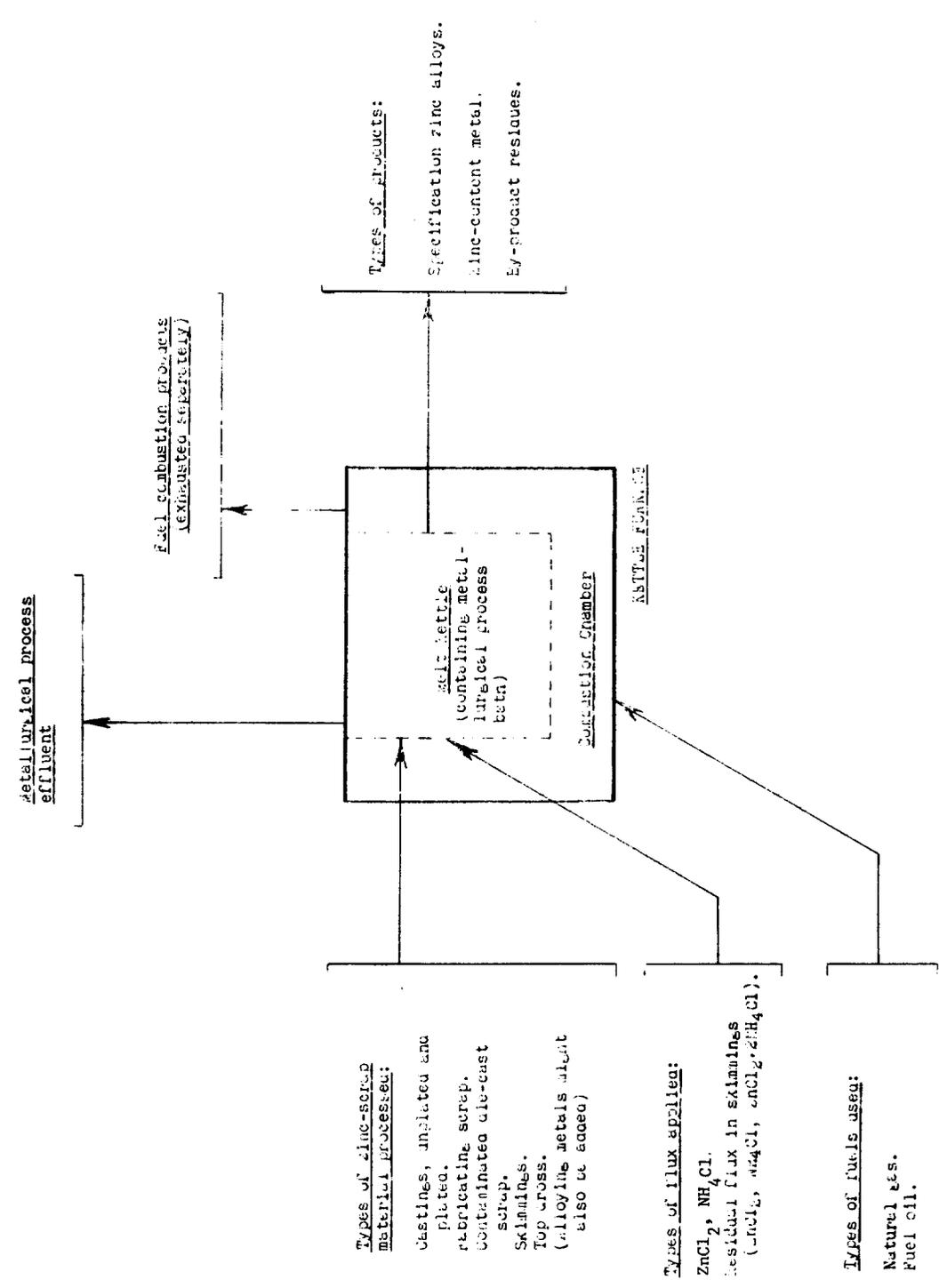
The melting unit is charged at one end; and unmeltable attachments and skimmings are removed from the other. Flux is not applied to, or contained in, the melting-unit charge.

In the melting unit incineration of organic materials in charged metallic scrap is virtually complete so as to prevent emission of carbonaceous particulates in significant amounts.

A vibrating screen is used at the discharge end of the melting unit to separate skimmings from unmeltables after removal from the unit. This device is a source of considerable amounts of particulate (mainly ZnO) emissions (APEM p. 299).

Emission points and effluents from the muffle-furnace system are detailed in Table IV-2.

Fig. 4-1 - Smet Processing of Zinc-Scrap Materials in Kettle Melting Furnace



Types of zinc-scrap material processed:

- Castings, ingots and plates.
- fabricating scrap.
- contaminated die-cast scrap.
- Skimmings.
- Top cross.
- (alloying metals might also be added)

Types of flux applied:

- ZnCl₂, NH₄Cl.
- Residual flux in skimmings (ZnCl₂, FeCl₂, SnCl₂, etc.).

Types of fuels used:

- Natural gas.
- Fuel oil.

Metalurgical process effluent

Fuel combustion products (emitted separately)

Types of products:

- Specification zinc alloys.
- zinc-content metal.
- By-product residues.

Kettle Melting (containing metalurgical process bath)

KETTLE FURNACE

Fig. 4-2 - Great Processing of Zinc-Scrap Materials in Reverberatory Melting Furnace

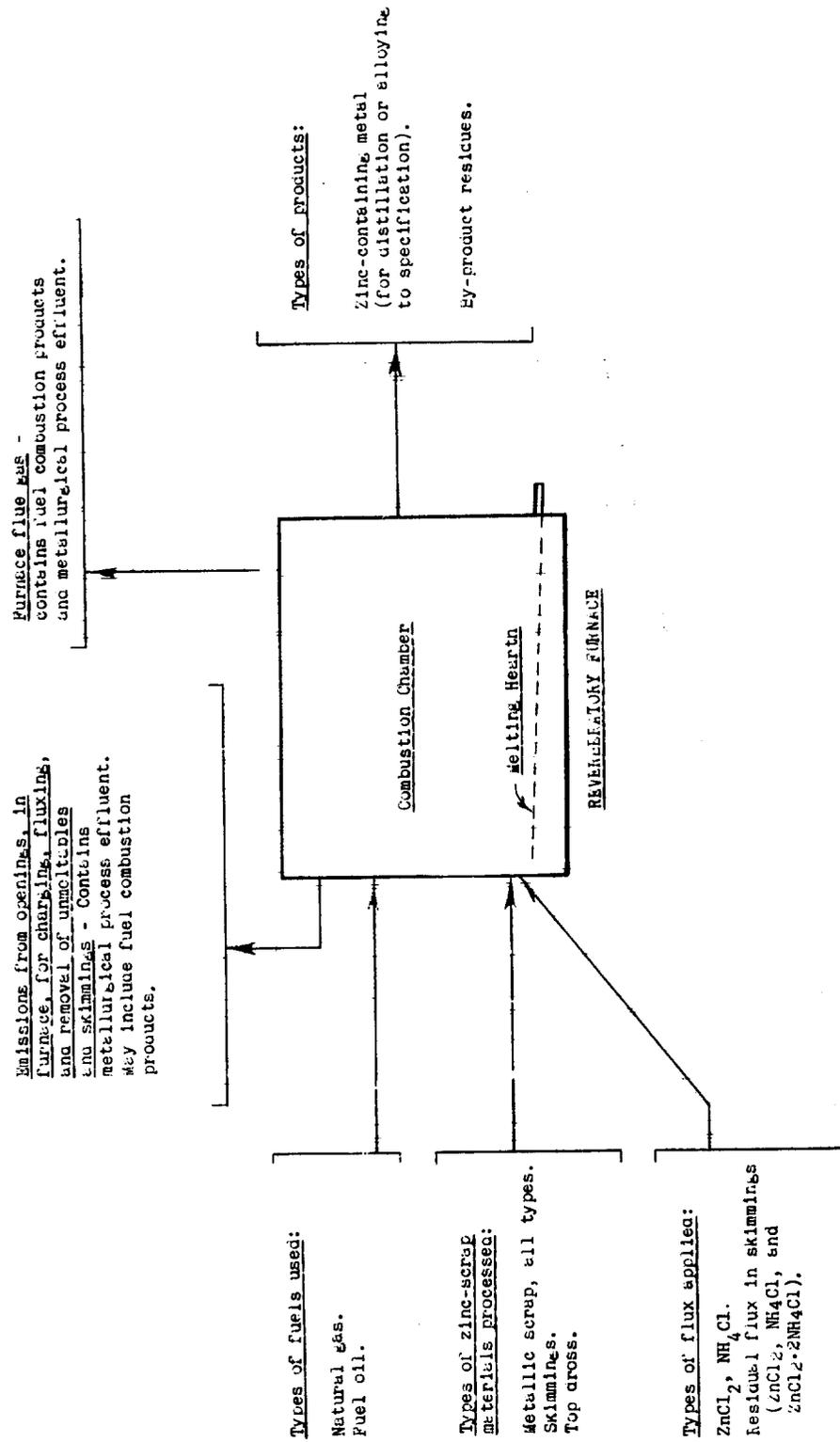


TABLE IV-1 EMISSION POINTS AND EFFLUENTS OF SECONDARY ZINC-SWEAT PROCESSES

Process (defined by type of furnace used)	Emitting Process Equipment Unit	Emission Point of Process Equipment Unit	Constituents of Effluents from Emission Points
Kettle Furnace	Melt Kettle	Top of melt kettle (or surface of metallurgical process bath, formed from charge).	<p>A. Emissions from process charge.</p> <p>1. Products of combustion or thermal decomposition of organic materials in charge.</p> <p>2. Emissions derived from metals, fluxes, and residues in metallurgical process bath, including metal oxides resulting from presence of air contacting metal.</p> <p>B. Air induced or infiltrated into exhaust effluent stream.</p>
Reverberatory Furnace	<p>Combustion chamber</p> <p>Combustion chamber, containing melting hearth. (May also be referred to as "sweating chamber").</p>	<p>Combustion chamber vent</p> <p>Furnace flue (exhausting combustion chamber).</p>	<p>A. Products of combustion of fuel (usually natural gas).</p> <p>1.-2. Emissions from process charge (same items as listed above).</p> <p>B. Air induced or infiltrated into furnace, thence into flue. (would be in excess of air consumed in combustion).</p> <p>C. Products of combustion of fuel (usually natural gas).</p>
Rotary Furnace	Rotating, cylindrical melt unit. (May also be referred to as "sweating chamber" or "combustion chamber").	Furnace flue (high end of melting cylinder).	<p>A. 1.-2.; B.; and C. -Same items as listed above for furnace flue. These effluents are formed from (1) gases escaping from the furnace; (2) emissions from the molten metal and skimmings being withdrawn from furnace with unmeltables; and (3) ambient air.</p> <p>A. 1.-2.; B.; and C. -Same as listed above for flue of reverberatory furnace, except emissions derived from flux are not normally contained in rotary furnace effluent.</p>

TABLE IV-2 (page 1 of 2) EMISSION POINTS AND EFFLUENTS OF SECONDARY ZINC-DISTILLATION PROCESSES

<u>Process (defined by furnace system used)</u>	<u>Emitting Process Equipment Unit</u>	<u>Emission Point of Process Equipment Unit</u>	<u>Constituents of Effluents from Emission Points</u>
Retort Furnace System (See Fig. 203, <u>APEM</u>)	Distillation Retort	Opening of distillation retort. (Emissions occur during removal of distillation residues. This opening may be referred to as "charging hole". It is used for applying charge to retort and removing residues).	<p>A. Emissions from distillation residues.</p> <ol style="list-style-type: none"> 1. ZnO (makes up most of emitted particulates). 2. Oxides of other metals (mainly Al_2O_3) - small amount. <p>B. Ambient air.</p>
	Combustion chamber	Combustion chamber vent.	A. Products of combustion of fuel (usually natural gas).
	Condenser	Pressure relief valve. (Used to retain positive pressure and exclude air from condenser).	<p>A. Emissions from vapors distilled from retort charge, partly oxidized by residual air in retort-and-condenser system.</p> <ol style="list-style-type: none"> 1. ZnO particulate. 2. Metallic zinc dust (particulate). 3. Chloride particulates, derived from flux. (Very small amounts may occur when dross is charged to retort). <p>B. N_2 from residual air in retort and condenser.</p>
	Condenser	"Speise" hole. (Used instead of pressure relief valve for same purpose. Zn vapor escaping from condenser thru speise hole is ignited in air, producing ZnO particulates).	<p>A. Emissions from vapors distilled from retort charge and oxidized.</p> <ol style="list-style-type: none"> 1. ZnO particulate, nearly pure. (The charge to retort is of molten metal which would not produce chloride emissions - <u>APEM</u> p. 296). <p>B. N_2 from residual air in retort and condenser.</p> <p>C. Ambient air</p>

TABLE IV-2 (page 2 of 2) EMISSION POINTS AND EFFLUENTS OF SECONDARY ZINC-DISTILLATION PROCESSES

<u>Process (defined by furnace system used)</u>	<u>Emitting Process Equipment Unit</u>	<u>Emission Point of Process Equipment Unit</u>	<u>Constituents of Effluents from Emission Points</u>
<p>Muffle Furnace System (See Fig's. 204-5, <u>APEM</u>)</p>	<p>Melt Unit (reverberatory furnace)</p>	<p>Flue of melt-unit combustion chamber.</p>	<p>A. Emissions from melt-unit charge. 1. Products of combustion or thermal decomposition of organic materials in charge. 2. Emissions derived from metals and residues (usually no flux) in metallurgical-process bath, including metal oxides resulting from presence of air. B. Air induced or infiltrated into melt unit, thence into flue. (Would be in excess of air consumed in combustion). C. Products of combustion of fuel (usually natural gas), burned in melt unit and vaporizing unit.</p>
	<p>Openings in melt unit for charging scrap material and removing unmeltables and skimmings.</p>		<p>A. 1., 2.; B.; and C. -Same items as listed above for furnace flue. These effluents are formed from (1) gases escaping from the melt unit; (2) emissions from the molten metal and skimmings being withdrawn from melt unit with unmeltables; and (3) ambient air.</p>
	<p>Vaporizing Unit (muffle furnace)</p>	<p>Tap hole of vaporizing unit. (Emissions occur during removal of distillation residue).</p>	<p>A. Emissions from distillation residues. 1. ZnO particulate, nearly pure (<u>APEM</u> p. 299) B. Ambient air.</p>

Chapter V

Analysis of Emitting Processes and Development
of Hypothesis on Emission Generation

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Chapter V

Analysis of Emitting Processes and Development of Hypothesis on Emission Generation

PROCESSES SELECTED FOR ANALYSIS

As shown in Chapter IV, chloride fluxes and organic materials are contained in charges to zinc-sweat furnaces in quantities that may be substantial. By comparison, very little if any flux and no organic materials are contained in charges to retorts or vaporizing units of distillation furnaces. Chloride emissions are derived from chloride fluxes and carbonaceous emissions from organic materials in furnace charges. Exhaust effluents from zinc-sweat processes may therefore contain substantial amounts of chlorides, as well as carbonaceous substances; very little chlorides and no carbonaceous substances are contained in emissions from distillation processes. Therefore, in this analysis, attention is confined to the operations that make up zinc-sweat processes, the materials entering into those processes, and the resulting emissions. It is noted, however, that because of zinciferous constituents common to emissions from both zinc-sweat and zinc-distillation processes, certain technological factors are common to controlling emissions from both types of processes. For this reason, distillation process emissions and their control will be discussed in later chapters. In this way, emission control technology for all secondary zinc processes will be considered together where there is common applicability.

DEFINITIONS OF TERMS EMPLOYED IN ANALYSIS

Effluent. The term "effluent" or "exhaust effluent" refers to the gas stream that flows from the region of the charge or bath being processed in a melting (sweating) furnace, and is then exhausted from the furnace. The effluent includes any particulate or gaseous emissions derived from the charge and any atmospheric air that enters the effluent stream. Fuel combustion products that are mixed into that stream also become a part of the effluent. Thus, combustion products of fuel consumed in reverberatory and rotary furnaces are part of the effluent; combustion products of fuels consumed in kettle furnaces are exhausted separately and are not part of the effluent. Fuel combustion products occurring by themselves are not within the problem area of this study, and are therefore not included in this definition or the following analysis.

Infiltrated air. The term "infiltrated air" refers to all atmospheric air that enters the effluent. It includes (1) air induced into the effluent by the furnace draft, (2) excess combustion air in reverberatory and rotary furnaces, and (3) air that mixes with emissions escaping from furnace openings used for charging, removing unmeltables, etc.

Metallurgical-process bath. The term "metallurgical-process bath" or "process bath" refers to the bath formed during zinc-sweat processing, which includes molten metal, residues, and any flux present. (Flux in the process bath is understood to fuse with residues, the fused mixture tending to float to the bath surface.)

Molten-metal bath. This term refers to the molten-metal portion of the metallurgical-process bath.

Emitting process-equipment unit. This term refers to the process-equipment unit in which emissions are generated. In the kettle-sweat furnace, this unit would be the melting kettle. In the reverberatory or rotary furnace, it would be the combustion (sweating or melting) chamber. (See figures 4-1, 2 and Table IV-1.)

PROCESS OPERATIONS THAT EFFECT EMISSIONS

For the purpose of analyzing emissions, the operations that make up all zinc-sweat processes are considered in two phases: (1) Melting the charge, and (2) Fluxing and working the metallurgical-process bath. These operations may be conducted sequentially, the first preceding the second, or partly or wholly concurrently. Each phase is briefly summarized and related to furnace applications.

Melting the Charge. To recover metallic zinc, scrap materials are heated to temperatures between 800 and 1100°F. In this temperature range, zinc is melted and alloy metals are retained in the molten-metal bath. Heat may be applied by conduction, as in kettle and electric-resistance furnaces. Heat may also be applied by a combination of convection and radiation, as in reverberatory and rotary furnaces. In the latter two furnaces, convection heating results from hot fuel combustion gases being circulated in the charge region, whereas radiant heating results from the furnace walls being heated by the same hot gases then radiating heat to the charge. Also, heat may be applied to the charge mainly by radiation, as in muffle furnaces.

Fluxing and Working the Metallurgical-Process Bath. Flux may be applied to the charge before melting (where present in residual scrap composing part or

all of the charge), or it may be applied during or after melting. The process bath may be worked by stirring or agitating to fuse and blend zinc and alloy metals into a contiguous molten-metal bath and separate the residue-flux mixture (skimmings) and unmeltables from that bath. Both fluxing and working of process baths may be done in kettle and reverberatory furnaces, in single heats. Working of baths, usually without fluxing, is done in rotary furnaces. (See Chapter IV)

MATERIALS AND FUELS APPLIED TO EMITTING PROCESS-EQUIPMENT UNITS

In the following paragraphs, materials and fuels that are applied to sweat furnaces and that might materially affect emissions are analyzed to determine their constituents and provide a basis for a hypothesis on how emissions are generated and of what they are composed.

ORGANIC CONSTITUENTS OF CHARGES

Materials made of organic compounds may be present in charged metallic scrap. Examples are gaskets, fabrics, electrical insulation, paper, and lubricants. Although these compounds are mainly of carbon, hydrogen, and oxygen, other elements could be present:

- A. Sulfur in natural rubber and polysulfide polymers.
- B. Chlorine in chloroprene and vinyl polymers.
- C. Nitrogen in nitrile rubbers, polyamide plastics, and protein binders.
- D. Fluorine in fluorocarbon plastics and fluorinated elastomers.
- E. Silicon in silicone rubbers and lubricants.

emissions from certain sweat processes. No special problems were reported or indicated involving the other elements listed (A through E). For that reason, quantities of these elements in emissions are believed to be small, and it is therefore assumed here that organic materials contained in furnace charges are essentially composed entirely of carbon-hydrogen-oxygen compounds.

METALLIC CONSTITUENTS OF CHARGES AND RESULTING
COMPOSITION OF MOLTEN METAL BATHS

In all of the types of scrap materials that are charged to zinc sweat furnaces (see Chapter II), metallic zinc is derived mainly from die-casting and galvanizing alloys with these typical compositions:

- A. Die-cast alloys - 94% Zn, 4% Al, 1% Cu, and 0.05% Mg; with restrictions to maximum of 0.1% Fe, 0.007% Pb, 0.005% Cd, and 0.005% Sn.
- B. Galvanizing alloys - Restricted to a minimum of 98.3% Zn, and maximums of 0.08% Fe and 1.6% Pb.

Die-cast alloys may be contained in both metallic and residual scrap. Galvanizing alloys are contained only in residual scrap.

Very small amounts of nickel may be present in residual scrap, probably derived from alloy cast-iron melting vessels and from platings. (Mathewson, pp. 387-8, 486,315).

The assumption is made here that chromium platings, which may be contained in charges, are essentially inert and insoluble at process bath temperatures. It is therefore considered that they do not significantly affect emissions, although traces of chromium might be emitted.

It is also assumed that unmelted attachments essentially separate from the process bath and do not significantly affect emissions. It is noted, however, that small quantities of metals in these attachments, such as copper, might dissolve in the molten metal.

Galvanizing alloys contain a higher percentage of lead than die-cast alloys. This study, however, indicated no special emission problems caused by lead. Pertaining to the possible emission of lead vapor, the boiling points of lead and zinc, 3160 and 1665°F respectively, indicate that any emission of lead vapor during zinc-sweat processes would be very small. Further, as a relatively unreactive metal, lead contained in process baths probably would not form compounds that would be emitted in significant quantity.

Findings of this study indicated that scrap materials containing die-casting alloys are more representative of materials subjected to sweat processing where charges contain significant amounts of flux than those containing galvanizing alloys. Galvanizers' skimmings are pretreated to remove residual flux, producing clean zinciferous metals particles that can be distilled directly or sweated with little or no flux being applied. Galvanizers drosses that contain little or no residual flux are either distilled directly or sweated without applying flux.

These considerations indicate that the composition shown below would be very representative of molten-metal baths obtained from sweat processing, where the charge contains significant amounts of flux:

<u>Metal</u>	<u>% by Weight of Metal Bath Formed During Sweat Processing</u>
Zn	94%
Al	4%
Cu	1%
Fe	0.1%
Mg	0.05%
Pb	Less than 0.01% each
Sn	
Ni	
Cd	
Cr	

FLUXING COMPOUNDS IN CHARGES

Fluxing compounds are considered in this study as consisting of $ZnCl_2$ and/or NH_4Cl . The double salt, zinc ammonium chloride ($ZnCl_2 \cdot 2NH_4Cl$) could be contained in residual scrap materials. This salt is assumed here as equivalent to uncombined $ZnCl_2$ and NH_4Cl , undergoing the same reactions and physical changes during zinc-sweat processing.

INORGANIC IMPURITIES IN CHARGES

As applied in this report, the term "inorganic impurities" does not include uncombined metals. It is assumed that inorganic impurities consist essentially of oxides of the metals present, particularly ZnO . This assumption is believed to approximate actual conditions. However, accumulations of dirt, residues from phosphate and chromate metal-finishing treatments, fillers and pigments of rubbers, plastics, and paints (including compounds of Si,

Ti, Sn, Cr, Ca, Cd, and Fe) could also be present.

FURNACE FUELS

Gas or oil of 100% hydrocarbon composition are considered as being used for all process fuel combustion. Sulfur content is assumed negligible.

EMISSIONS - THEIR GENERATION AND COMPOSITION

The following paragraphs present a theoretical analysis of the effects on emissions of the process operations, materials, and fuels (enumerated and described earlier in this chapter) that are applied to zinc-sweat processes. A hypothesis is developed, based on this analysis, on how emissions are generated and of what they are composed. The analysis incorporates certain assumptions, which are believed to represent actual occurrences and conditions. In a later chapter the hypothesis developed here is applied in interpreting data obtained from emission tests and thus is subjected to verification.

CONSTITUENTS THAT MAKE UP EFFLUENT

Generally, any carbonaceous emissions in effluents occur during melting operations when organic materials in the charge are burned off. Noncarbonaceous emissions occur during fluxing and working operations when vaporization, oxidation, and entrainment involving constituents of the process bath and surrounding gases take place. Emission of ZnO particulates (noncarbonaceous emissions) may also take place during melting of the charge due to vaporization and oxidation of elemental zinc taking place in kettle and reverberatory furnaces (particularly in the latter) during that phase of the process.

Considering sweat processing in kettle, reverberatory, and rotary furnaces, organic materials might be contained in charges to all of these. On the other hand, flux might be contained in charges to kettle and reverberatory but not normally in charges to rotary furnaces. It then follows that the possible combinations of constituents making up effluents from these furnaces may be listed as follows:

<u>Furnace Type</u>	<u>Constituents of which Effluents may be Formed</u>
Kettle *	Carbonaceous emissions from the charge, during melting. Noncarbonaceous emissions from (1) the charge during melting and (2) the metallurgical process bath. <u>Could include chlorides.</u> Infiltrated air.
Reverberatory	Carbonaceous emissions from the charge, during melting. Noncarbonaceous emissions from (1) the charge, during melting and (2) the metallurgical process bath. <u>Could include chlorides.</u> Infiltrated air. Fuel combustion products.
Rotary	Carbonaceous emissions from the charge, during melting. Noncarbonaceous emissions from (1) the charge, during melting and (2) the metallurgical process bath, without flux. <u>No Chlorides contained in emissions.</u> Infiltrated air. Fuel combustion products.

Detailed consideration is given below to the generation and composition of carbonaceous and noncarbonaceous emissions, and fuel combustion products, which along with infiltrated air make up effluents as shown in the above tabulation.

* Fuel combustion products from kettle furnaces are exhausted separately from the effluent that flows from the process bath, and are therefore not listed here. (See Effluent definition, page V-2)

All of the considerations below apply to sweat processing in kettle and reverberatory furnaces where chloride flux is included in charged process materials.

The considerations that pertain to noncarbonaceous emissions do not apply to rotary furnaces, since chlorides, derived from flux, are not normally emitted from those furnaces. Also, findings of this study indicate that because of lower bath temperatures and absence of flux in rotary furnaces, noncarbonaceous emissions from that type of furnace are not significant. Rotary furnace emissions are therefore considered here as being entirely carbonaceous under usual process conditions.

GENERATION OF CARBONACEOUS EMISSIONS FROM CHARGE

As material charged to furnaces is heated, metal melts and any organic compounds present undergo decomposition, oxidation, vaporization, and/or mechanical entrainment into the exhaust effluent gas stream. Carbonaceous emissions thus formed are cooled by infiltrated air and radiation of heat from ducts carrying the effluent. Where emission control equipment is used, cooling may also occur in that equipment, such as through the cooling action of a scrubbing fluid. Finally emissions may be cooled when effluent is exhausted to the atmosphere. During cooling, carbonaceous vapors condense, and viscosities of liquids increase. Resulting carbonaceous emissions may therefore be composed of combinations of carbonaceous fly ash, solid carbon particles, liquid droplets of carbon compounds having consistencies ranging from oily to tar-like, and gaseous carbon compounds. It follows, from considerations of organic constituents of charges, that these emissions would be made up essentially of inert ash and compounds of carbon, hydrogen, and oxygen.

GENERATION OF NONCARBONACEOUS EMISSIONS FROM CHARGE

As a process bath is fluxed and worked, noncarbonaceous emissions may result

from chemical reactions and physical occurrences involving the following substances:

- A. Fluxes applied to bath or contained in charged residual scrap.
- B. Metals in molten-metal bath.
- C. Residues that accumulate (fused or mixed with any flux present) at the top of the process bath above the molten metal, these residues being introduced as inorganic impurities in the charge or formed by oxidation of charged metal.
- D. Oxygen in infiltrated air. (Atmospheric nitrogen is not considered as a possible reactant because it is normally unreactive at zinc-sweat process temperatures.)

Fluxes consist of $ZnCl_2$ and/or NH_4Cl . Metals contained in the molten-metal bath are considered in the subsequent analysis as being limited to zinc and aluminum. This simplification is justified by data, shown previously, indicating that other metals would not be present in sufficient quantities to significantly affect the nature or amount of emissions. For similar reasons, metal oxides in residues are considered as consisting of ZnO and Al_2O_3 . It is immediately apparent that $AlCl_3$ might be produced within the process bath by reactions of $ZnCl_2$ with aluminum (APEM, p. 287). It follows from these considerations that the metals and compounds in process baths that may enter into chemical reactions and physical occurrences forming noncarbonaceous emissions consist essentially of Zn, Al, NH_4Cl , $ZnCl_2$, $AlCl_3$, ZnO , and Al_2O_3 . Physical properties of these materials that pertain to emissions are tabulated in Table V-1 and shown graphically in Figure 5-1.

Vapor pressures plotted in Figure 5-1 show that at the temperature of molten metal, NH_4Cl would vaporize at a high rate and that $ZnCl_2$ and metallic zinc

would also vaporize significantly. Data in Table V-1 show that ZnO and Al_2O_3 are refractory at the temperatures of the process bath. Therefore, any ZnO or Al_2O_3 in residues would not vaporize but might enter the effluent by mechanical entrainment due to the velocity of the effluent stream. Agitation and skimming of the process bath would promote vaporization of metal and flux as well as mechanical entrainment of residue particles into the effluent. Also in this temperature range, NH_4Cl decomposes to NH_3 and HCl gases, which may recombine when cooled, by infiltrated air, forming small particles of NH_4Cl fume (APEM, p. 294).

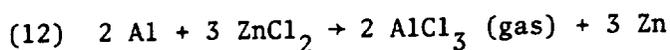
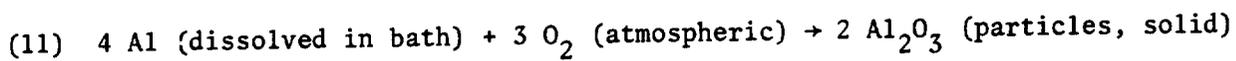
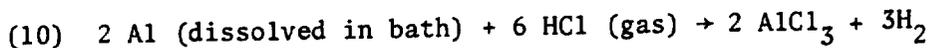
Owing to the presence of the molten metal, vapors and gases formed as noted above, the following reactions could take place in the immediate region of the molten metal bath surface:

- (1) NH_4Cl (flux) \rightarrow NH_3 (gas) + HCl (gas)
- (2) $2 \text{HCl} + \text{Zn}$ (liquid or vapor) \rightarrow ZnCl_2 (particles - liquid at process bath temp.) + H_2
- (3) 2Zn (liquid or vapor) + O_2 (atmospheric) \rightarrow 2ZnO (particles, solid)
- (4) $2 \text{H}_2 + \text{O}_2$ (atmospheric) \rightarrow $2\text{H}_2\text{O}$ (vapor)

As emitted particles cool (approaching 212°F) because of infiltrated air and radiation, further reactions could occur:

- (5) ZnCl_2 (particles, liquid) \rightarrow ZnCl_2 (particles, solid)
- (6) NH_3 (gas) + HCl (gas) \rightarrow NH_4Cl (particles, solid)
- (7) ZnCl_2 (particles) + 2HOH (from Reaction 4, atmosphere and/or fuel combustion products) \rightarrow $\text{Zn}(\text{OH})_2$ + 2HCl . (Reaction takes place in particles because of deliquescence of ZnCl_2 .)
- (8) HCl (contained in particles from Reaction 7) + NH_3 (from Reaction 1) \rightarrow NH_4Cl . (Reaction takes place in particles formed in Reaction 7. Resulting particles contain NH_4Cl , ZnCl_2 , HOH, $\text{Zn}(\text{OH})_2$, and HCl.)
- (9) Zn (vapor) \rightarrow Zn (particles, solid)

Pertaining to aluminum, further reactions could occur in the immediate region of bath surface:



In view of these reactions, it appears that the small amounts of aluminum likely to be contained in molten metal baths would not significantly influence the essential characteristics or quantities of emissions. Therefore, as a simplification of this analysis, aluminum is not considered further except to note that small quantities of aluminum compounds might be present in emissions.

Data presented in Chapter VI will show that cooling of emissions within the effluent stream, resulting from dilution with infiltrated air and radiation from ducts carrying effluent, reduces temperatures of effluents below the melting points of metallic zinc and ZnCl_2 and the sublimation (decomposition) point of NH_4Cl .

The generation of noncarbonaceous emissions from the process bath, as they exist in the effluent stream at the point of either being exhausted from the stack or entering a gas cleaning device, may then be summarized as follows:

A. ZnCl_2 particulate (solid) result from the following occurrences:

1. ZnCl_2 vapor is formed as ZnCl_2 flux vaporizes and as HCl (derived from NH_4Cl) reacts with elemental zinc vapor.

2. ZnCl_2 liquid particles are formed as ZnCl_2 vapor condenses, during cooling from the bath temperature range (800 to 1,100°F) to temperatures just above the melting point of ZnCl_2 (689°F).

3. ZnCl_2 solid particles are formed as the ZnCl_2 liquid particles solidify

on cooling to temperatures below the ZnCl_2 melting point (689°F).

B. ZnO particulate (solid) result from vaporization of metallic zinc followed by atmospheric oxidation of zinc vapor.

C. NH_4Cl particulate (solid) result from the following occurrences:

1. NH_3 and HCl gases are formed as NH_4Cl decomposes at temperatures above 662°F .

2. NH_4Cl solid particles are formed directly as NH_3 and HCl gases recombine on cooling to 662°F .

D. Particulate containing ZnCl_2 , $\text{Zn}(\text{OH})_2$, HCl , NH_4Cl , and HOH are formed as a result of the deliquescent adsorption of water by ZnCl_2 particles, as emissions cool to temperatures around 212°F and below. NH_3 gas (formed in Reaction 1) that does not recombine with gaseous HCl is probably adsorbed mostly into these particulates, forming NH_4Cl as in Reaction 8.

E. Metallic zinc particulate could be emitted through condensation of zinc vapor if a sufficiently reducing atmosphere in the furnace is obtained.

F. Particulate containing combinations of ZnCl_2 , ZnO , and NH_4Cl are emitted as a result of mechanical entrainment of the residue-flux mixture into the effluent. ZnCl_2 in these particulates would be subject to the reactions with HOH and NH_3 noted previously.

G. NH_3 gas that does not recombine with gaseous HCl and is not adsorbed into partially-hydrolyzed particles, as described in D above, remains in the effluent gas stream as a gaseous emission.

For further consideration of the possible emission constituents several additional assumptions are believed justifiable:

1. Particles of $ZnCl_2$ and ZnO are formed generally separate from each other (not as particles containing mixtures of large percentage of both compounds), as $ZnCl_2$ vapor condenses to droplets that solidify on further cooling and as zinc vapor oxidizes directly to solid ZnO particles. This assumption is based on considerations of (1) the cyclic nature of the processes where flux or flux-containing residual scrap is manually applied at intervals, $ZnCl_2$ vaporization occurring in highest concentration immediately after flux application, and (2) the difference in vapor pressures of $ZnCl_2$ and elemental zinc tending to increase the ratio of $ZnCl_2/ZnO$ emitted, at lower temperatures, the converse occurring at higher temperatures. Since ZnO particles would instantaneously result from zinc vapor oxidation those particles could act as nuclei on which $ZnCl_2$ vapor could condense. Some mixing might take place in this way.

2. Metallic zinc particles in the effluent are of negligible content because an oxidizing atmosphere in the effluent would normally be maintained by infiltrated air.

3. Gaseous NH_3 in the effluent is of negligible content because most NH_3 would either recombine with gaseous HCl or be adsorbed into $ZnCl_2$ particles as these particles adsorb moisture and hydrolyze to HCl and $Zn(OH)_2$.

The foregoing considerations therefore lead to the hypothesis that non-carbonaceous emissions resulting from melting, fluxing and working zinc-sweat process baths (at points in effluent streams where equilibrium mixtures are approached) consist mostly of combinations of particulate formed

as shown in Items A, B, C, D, and F above (E and G omitted). These emissions may then be summarized as follows:

(1) ZnCl_2 particulate (solid)

(2) ZnO particulate (solid)

(3) NH_4Cl particulate (solid)

(4) Particulate containing ZnCl_2 , $\text{Zn}(\text{OH})_2$, HCl , NH_4Cl , and HOH (resulting from vaporization of molten zinc and flux, followed by oxidation, condensation, other chemical reactions and physical occurrences).

(5) Particulate containing combinations of ZnCl_2 , ZnO , and NH_4Cl (resulting from entrainment from residue-flux mixture). Could include products of hydrolysis and other reactions of ZnCl_2 .

Pertaining to particle size, it follows from the assumption listed as number one (above) that size of ZnCl_2 particles would depend on the time particles are maintained in the liquid state (above the melting point temperature of ZnCl_2), in which particle growth and agglomeration would most readily occur. High effluent flow rates and large volumes of infiltrated air impose rapid cooling and would therefore produce small particles. ZnO particles formed from oxidation of zinc vapor would be small because their formation in the solid phase would be instantaneous at the temperatures involved, with infinitesimal time available for particle growth.

FUEL COMBUSTION PRODUCTS

Mixing of air with fuel at burners is assumed satisfactory to effect complete combustion. It then follows that fuel combustion products consist essentially of CO_2 , H_2O , and the residual N_2 that would remain after atmospheric O_2 is consumed in combustion. The content of nitrogen oxides and the possible presence of sulfur oxides and carbon monoxide in combustion products are not considered here. Those emissions do not appear significant to the problem area of this study. In any future work where it is desired to consider their affect on secondary zinc industrial emissions, results of studies specifically covering those gases should provide sufficient data.

(Duprey, pp. 6-7)

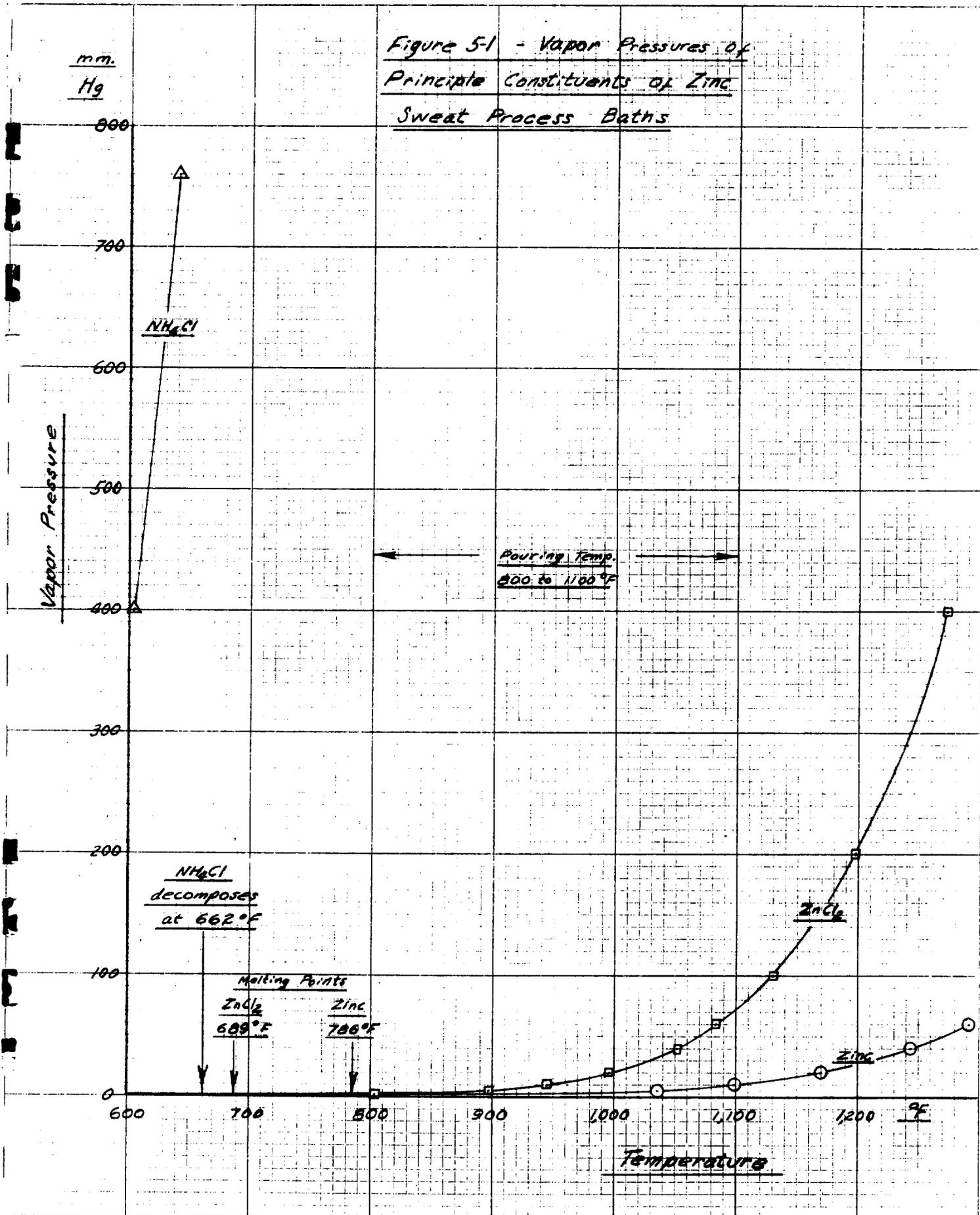
TABLE V-1 - DATA PERTAINING TO MELTING, VAPORIZING, AND CONDENSATION OF ZINC-SWEAT PROCESS MATERIALS

<u>Process Material Constituent</u>	<u>Melting Point</u>		<u>Boiling Point</u>		<u>Vapor Pressure at Pouring Temperature mm. Hg. *</u>
	<u>°C</u>	<u>°F</u>	<u>°C</u>	<u>°F</u>	
Zinc	419**	786	907	1,665	< 1 to 15.2
NH ₄ Cl	dec. 350	dec. 662	---	-----	> 760
ZnCl ₂	365	689	732	1,350	1 to 74
ZnO	>1800	> 3272	---	-----	0
Aluminum	660	1,220	2,056	3,734	< 1
AlCl ₃ (or Al ₂ Cl ₆)	---	-----	subl. 178	subl. 352	>760
Al ₂ O ₃	2,000	3,630	2,210	4,010	0

* Pouring temperature of zinc sweat-process baths (APEM, p 293) : 800 to 1,100°F

** All data in this table is from Perry.

Figure 5-1 - Vapor Pressures of
 Principle Constituents of Zinc
 Sweat Process Baths



AIR POLLUTION EMISSION TEST

AMERICAN SMELTING AND
REFINING COMPANY

(PLANT NAME)

GLOVER PLANT

P.O. BOX 7

(PLANT ADDRESS)

GLOVER, MISSOURI 63646



U. S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Water Programs
Office of Air Quality Planning and Standards
Emission Standards and Engineering Division
Emission Measurement Branch
Research Triangle Park, N. C. 27711

SOURCE SAMPLING REPORT
EMB Project Report Number 73 PLD-1

Emissions from Lead Smelter

at

American Smelting and Refining Company
Glover, Missouri

17 July 1973 to 23 July 1973

by

E. P. Shea

Midwest Research Institute
Kansas City, Missouri 64110

Reviewed by: John W. Snyder and Susan R. Wyatt
Office of Air Quality Planning and Standards
Environmental Protection Agency
Research Triangle Park, North Carolina 27711

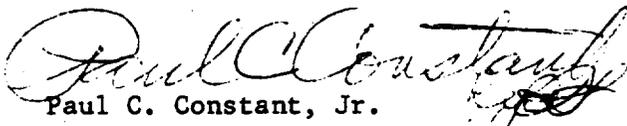
EPA Contract No. 68-02-0228, Task No. 27
(MRI Project No. 3585-C)

PREFACE

The work reported herein was conducted by Midwest Research Institute (MRI), pursuant to a Task Order issued by the Environmental Protection Agency (EPA) under the terms of EPA Contract No. 68-02-0228. Mr. E. P. Shea served as the Project Chief and directed the MRI Field Team consisting of: Messrs. Henry Moloney, Douglas Weatherman, Harold Branine, Frank Hanis, Jeff Sprinkle, Kevin Cline, Bill Maxwell, Bob Swartz, Bill Cunningham, Dick Cobb, Mike Bechtold, and Dave Hardin. Dr. J. Spigarelli assisted by Mrs. Carol Green performed the pollutant analyses at the MRI laboratories. Ms. Christine Guenther coded the data for the computer calculations. Ms. Susan Wyatt, EPA, was the Process Engineer. Mr. E. P. Shea prepared this final report.

Approved for:

MIDWEST RESEARCH INSTITUTE


Paul C. Constant, Jr.
Program Manager

9 August 1974

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II. INTRODUCTION

This emission test is a part of a comprehensive study to determine a control strategy for lead emissions from stationary sources. The entire project is referred to as the preferred standards path analysis on lead. The purpose of this preferred standards path analysis is to recommend a statutory and regulatory course of action for the control of stationary sources of lead emissions. The recommendations must be based on a thorough assessment of the pollutant effects and emissions as related to the Clean Air Act of 1970, as amended. If it is decided that a regulatory program is desirable, there are three available options for developing standards: Section 109-110 - Ambient Air Quality Standards, Section 111 - New Source Performance Standards accompanied by state standards for existing sources, and Section 112 - Hazardous Pollutant Standards.

A well defined emission inventory, which is not at this time available, is vital to the development of a regulatory strategy for lead. Such an inventory will define the extent of the problem by identifying the major lead emitters, quantifying the emissions from these sources and determining the extent and effectiveness of presently employed general particulate control technology for lead.

A preliminary emission inventory of lead sources was developed through an EPA contract to determine, from the literature and plant data, the nature, magnitude and extent of industrial lead emissions to the atmosphere in the United States in 1970. However, only a small amount of the

data was supported by emission testing. A listing of industries for emission testing has been compiled by EPA, based on information supplied by the emissions inventory. The emission data gathered during the testing programs will be used to determine the nature and extent of lead emissions from stationary sources, i.e., whether a problem exists in the industry, and if so the nature and extent of the problem. The data will also be used to help determine the degree to which particulate standards are effective in controlling lead emissions. Finally, emission data can be used in conjunction with other information on number and location of plants, trends in lead usage, growth rates, and affected populations to determine which industries are of highest priority for regulation.

Several lead smelters were surveyed for the purpose of conducting emission testing. None of the smelters were completely satisfactory for emission testing, and at some of them, emission testing was not considered to be economically feasible. The ASARCO Lead Smelter at Glover was considered to be the best of the lot.

This report presents the results of the emission testing and particle sizing which was performed by Midwest Research Institute at the American Smelting and Refining Company (ASARCO) sinter plant and blast furnace in Glover, Missouri. The particulate emission tests were 2-hr tests using the RAC* Staksampler equipment conforming with the Federal Register, 36, No. 159, 17 August 1971. The particle size testing was conducted using an Andersen eight plate impactor; the tests were conducted

* Mention of a company name does not imply endorsement by EPA.

for 1 hr, 2 hr and 1-1/2 hr. The sinter baghouse was not tested using the EPA method 5 train, because there were no ports in the stack and not enough room in the breeching to conduct isokinetic testing. For convenience and in order to have some emission data from this plant, we utilized the "Askania" sampler which was installed by ASARCO in the breeching between the baghouse and the stack.

At the ASARCO smelter domestic ore containing about 70% lead is sintered to prepare a concentrate for blast furnace feed. The ore is mixed with coke, recycled clay, and baghouse dust, ignited and the sulfur burned off. The sinter cake is disintegrated, mixed with coke, baghouse dust, scrap iron, and dross, and fed to the blast furnace. The lead bullion from the blast furnace goes to the refinery on site for production of refined lead. The control system for the sinter plant consists of a humidifying chamber, fresh air intake, fan and baghouse. The blast furnace control system has a humidifying chamber, fresh air inlet, lime addition and baghouse. Measured emissions from the sinter plant and blast furnace operation consisted of particulates. Carbon dioxide, carbon monoxide and oxygen were measured by Orsat Analysis. Another emission, sulfur dioxide, was estimated by Dräger tube readings only for the purpose of calculating carrier gas molecular weight. All particulate samples collected in this test program were analyzed for lead content.

The two inlet ducts and the baghouse outlet sampling point for the sinter plant are shown in Figure 1. The sampling points for the blast furnace are shown in Figure 2.

The following sections of the report treat (1) the summary and discussion of results, (2) the description and operation of the process, and (3) sampling and analytical procedures.

III. SUMMARY AND DISCUSSION OF RESULTS

Tables I, IA, II, IIA, III, IIIA, IV, IVA, V and VA present a summary of particulate and lead results from the emission testing on the sinter plant. Total particulate emissions were sampled and all samples analyzed for lead content. Table I contains an average of the controlled and uncontrolled emissions from the sinter plant (see Figure 1); Table IA presents the calculated data in metric units. The operation of the sinter plant, during the test period, was not constant and in the opinion of the writer was atypical. The baghouse particulate emission rate was 4.94 lb/hr, and the lead emission rate, 0.624 lb/hr; the calculated feed rate for the sinter machine during the "Askania" baghouse sampling period was 52.2 tons/hr. The baghouse emission rate based on this feed rate was: particulate - 0.0946 lb/ton; lead - 0.0119 lb/ton. The average feed rate for the sinter machine during particulate testing was 55.1 tons/hr. The average sinter plant uncontrolled emissions based on the above feed rate were: particulate front half catch (probe tip, probe, cyclone and filter) - 55.0 lb/ton; particulate total catch - 58.2 lb/ton; lead front half and total catch 5.95 lb/ton.

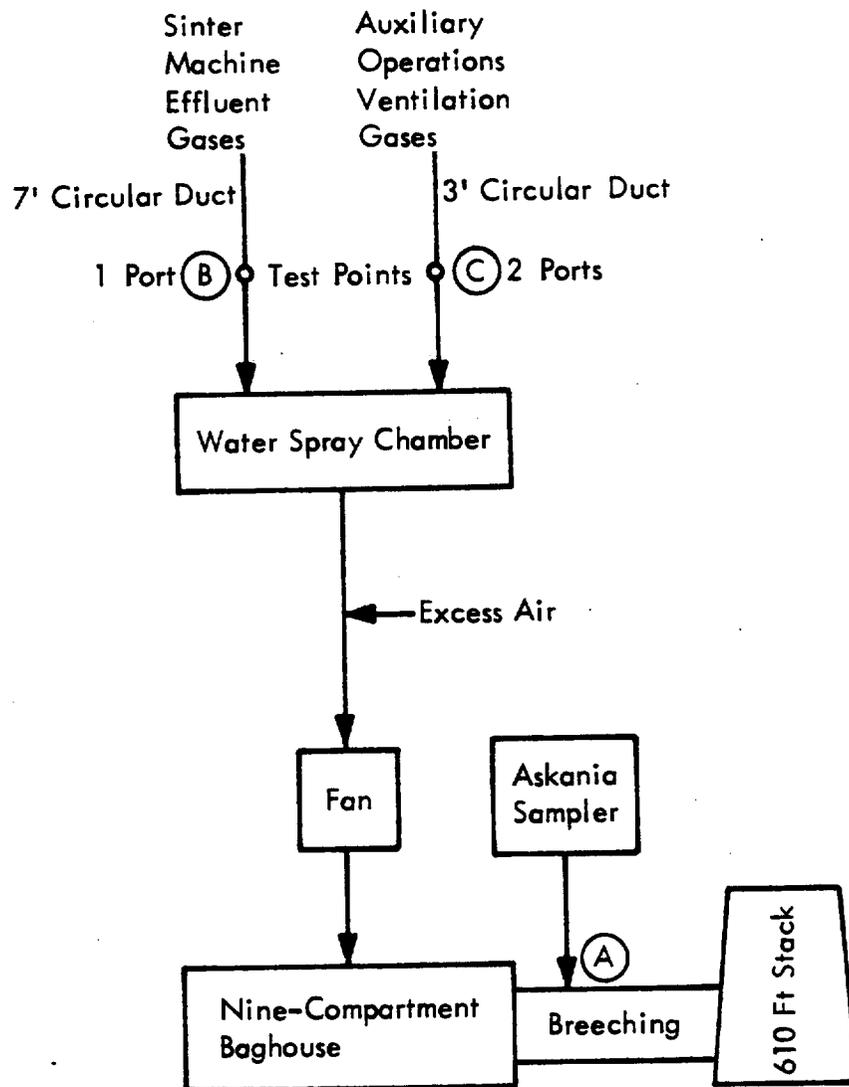


Figure 1 - Sinter Plant Sampling Points

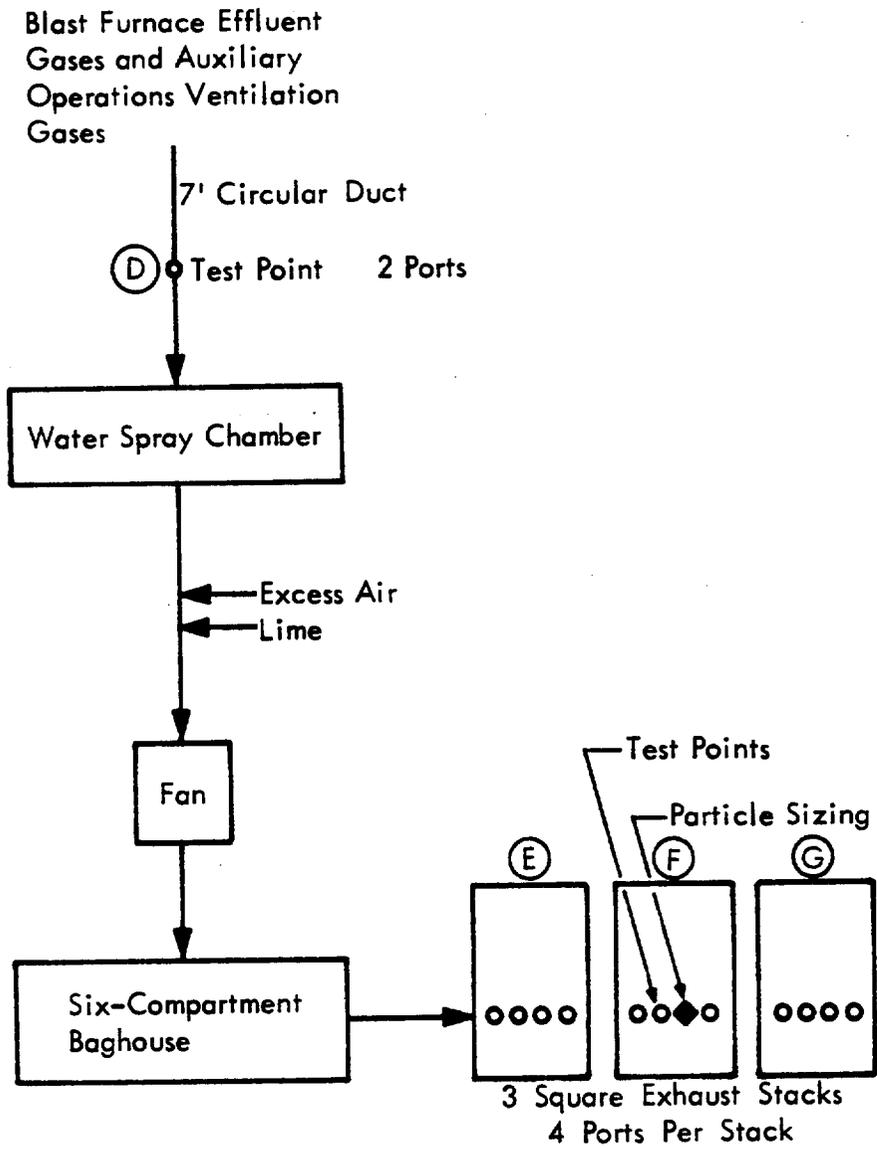


Figure 2 - Blast Furnace Sampling Points

TABLE I

AVERAGE CONTROLLED AND UNCONTROLLED EMISSIONS FROM
SINTER MACHINE AND ASSOCIATED OPERATIONS

<u>Description</u>	<u>Units</u>	<u>Sampling Point</u>	
		<u>Sinter Machine and Associated Operations (uncontrolled)</u>	<u>Baghouse (controlled)^{a/}</u>
Particulate Emissions - Partial (Probe Tip, Probe, Cyclone Filter)	lb/hr gr/DSCF	3,031 2.94 ^{b/}	-- --
Particulate Emissions - Total (Probe, Tip Probe, Cyclone, Filter and Impingers)	lb/hr gr/DSCF	3,207 3.47 ^{b/}	4.94 0.00271
Lead Emissions - Partial	lb/hr gr/DSCF	328 0.352 ^{b/}	-- --
Lead Emissions - Total	lb/hr gr/DSCF	328 0.352 ^{b/}	0.624 0.000341
Feed Rate	tons/hr	55.1	52.2
Particulate Emissions - Partial	lb/ton	55.0	--
Particulate Emissions - Total	lb/ton	58.2	0.0946
Lead Emissions - Partial	lb/ton	5.95	--
Lead Emissions - Total	lb/ton	5.95	0.0119
% Lead - Partial		10.8	--
% Lead - Total		10.2	12.6

^{a/} This sample was not taken with the EPA Method 5 sampling train. It was taken with an "Askania" sampler installed by ASARCO. It is not equivalent to EPA Method 5, but was used as it was the only method available for sampling at this location.

^{b/} Since this baghouse has two inlet ducts, the average concentrations are calculated from weighted averages based on duct flowrate for each run pair. Runs B-6 and C-1, although not simultaneous, were used as a run pair because the process feed rates differed by only 2%.

TABLE IA

AVERAGE CONTROLLED AND UNCONTROLLED EMISSIONS FROM
SINTER MACHINE AND ASSOCIATED OPERATIONS

<u>Description</u>	<u>Units</u>	<u>Sampling Point</u>	
		<u>Sinter Machine and Associated Operations (uncontrolled)</u>	<u>Baghouse (controlled)^{a/}</u>
Particulate Emissions - Partial (Probe Tip, Probe, Cyclone and Filter)	Kg/hr Mg/NM3	1,376 6,732 ^{b/}	-- --
Particulate Emissions - Total (Probe Tip, Probe, Cyclone, Filter and Impingers)	Kg/hr Mg/NM3	1,456 7,945 ^{b/}	2.24 6.205
Lead Emissions - Partial	Kg/hr Mg/NM3	149 806 ^{b/}	-- --
Lead Emissions - Total	Kg/hr Mg/NM3	149 806 ^{b/}	0.283 0.781
Feed Rate	MT/hr	50.0	47.3
Particulate Emissions - Partial	Kg/MT	27.6	--
Particulate Emissions - Total	Kg/MT	29.2	0.0473
Lead Emissions - Partial	Kg/MT	2.98	--
Lead Emissions - Total	Kg/MT	2.98	0.00596
% Lead - Partial		10.8	--
% Lead - Total		10.2	12.6

^{a/} This sample was not taken with the EPA Method 5 sampling train. It was taken with an "Askania" sampler installed by ASARCO. It is not equivalent to EPA Method 5, but was used as it was the only method available for sampling at this location.

^{b/} Since this baghouse has two inlet ducts, the average concentrations are calculated from weighted averages based on duct flowrate for each run pair. Runs B-6 and C-1, although not simultaneous, were used as a run pair because the process feed rates differed by only 2%.

TABLE II

POUND PARTICULATE/TON SINTER PRODUCED

<u>Run No.</u>	<u>Total Particulate Emission Rate (lb/hr)</u>	<u>Rate of Sinter Produced^{a/} (tons/hr)</u>	<u>Lb/Hr ÷ Tons/Hr = Lb/Ton</u>
<u>Controlled</u>			
A	4.94	48.5	0.102
<u>Uncontrolled - Sinter Machine</u>			
B-2	2,060	44.3	46.5
B-5	1,810	53.5	33.8
B-6	<u>2,450</u>	<u>56.5</u>	<u>43.4</u>
Average	2,107	51.4	41.2
<u>Uncontrolled - Sinter - Associated Operations</u>			
C-1	1,360	55.4	24.5
C-2	1,090	44.3	24.6
C-5	<u>852</u>	<u>53.5</u>	<u>15.9</u>
Average	1,101	51.1	21.7

a/ Estimated from:

$$\begin{array}{r} \text{Rate of sinter produced} \\ \text{(tons/hr)} \end{array} = \begin{array}{r} \text{Rate of sintering} \\ \text{feed material} \\ \text{(tons/hr)} \end{array} \times 0.93$$

TABLE IIA

Kg PARTICULATE/MTON SINTER PRODUCED

<u>Run No.</u>	<u>Total Particulate Emission Rate (kg/hr)</u>	<u>Rate of Sinter Produced^{a/} (Mton/hr)</u>	<u>Kg/Hr ÷ Mton/Hr = Kg/Mton</u>
<u>Controlled</u>			
A	2.24	44.0	0.0509
<u>Uncontrolled - Sinter Machine</u>			
B-2	935	40.2	23.3
B-5	822	48.5	16.9
B-6	<u>1,110</u>	<u>51.2</u>	<u>21.7</u>
Average	956	46.6	20.6
<u>Uncontrolled - Sinter - Associated Operations</u>			
C-1	617	50.2	12.3
C-2	495	40.2	12.3
C-5	<u>387</u>	<u>48.5</u>	<u>7.98</u>
Average	500	46.3	10.9

a/ Estimated from:

$$\begin{array}{l} \text{Rate of sinter produced} \\ \text{(Mton/hr)} \end{array} = \begin{array}{l} \text{Rate of sintering} \\ \text{feed material} \\ \text{(Mton/hr)} \end{array} \times 0.93$$

TABLE III

POUND LEAD/TON OF LEAD IN THE SINTER PRODUCED (ESTIMATED)

<u>Run No.</u>	<u>Total Lead Emission Rate (lb/hr)</u>	<u>Percent Lead in Sinter</u>	<u>Rate of Lead in Sinter (tons/hr)^{a/}</u>	<u>Lb/Hr ÷ Tons/Hr = Lb/Ton</u>
<u>Controlled</u>				
A	0.624	45.4	22.5	0.0277
<u>Uncontrolled - Sinter Machine</u>				
B-2	368	47.6	21.1	17.4
B-5	113	47.1	25.2	4.48
B-6	<u>175</u>	<u>47.1</u>	<u>26.7</u>	<u>6.55</u>
Average	219	47.3	24.3	9.48
<u>Uncontrolled - Sinter-Associated Operations</u>				
C-1	178	46.6	25.8	6.90
C-2	73.6	47.6	21.1	3.49
C-5	<u>76.9</u>	<u>47.1</u>	<u>25.2</u>	<u>3.05</u>
Average	110	47.1	24.0	4.48

a/ Estimated from:

$$\begin{array}{l} \text{Rate of lead in} \\ \text{sinter produced} \\ \text{(tons/hr)} \end{array} = \begin{array}{l} \text{Rate of sintering} \\ \text{feed material} \\ \text{(tons/hr)} \end{array} \times \begin{array}{l} \text{Percent Lead in} \\ \text{feed to sinter} \times 0.93 \\ \text{machine} \end{array}$$

TABLE IIIA

KILOGRAM LEAD/MTON OF LEAD IN SINTER PRODUCED (ESTIMATED)

<u>Run No.</u>	<u>Total Lead Emission Rate (kg/hr)</u>	<u>Percent Lead in Sinter</u>	<u>Rate of Lead in Sinter (Mton/hr)^{a/}</u>	<u>Kg/Hr ÷ Mton/Hr = Kg/Mton</u>
<u>Controlled</u>				
A	0.283	45.4	20.4	0.0139
<u>Uncontrolled - Sinter Machine</u>				
B-2	167	47.6	19.1	8.74
B-5	51.3	47.1	22.9	2.24
B-6	<u>79.4</u>	<u>47.1</u>	<u>24.2</u>	<u>3.28</u>
Average	99.2	47.3	22.1	4.75
<u>Uncontrolled - Sinter-Associated Operations</u>				
C-1	80.8	46.6	23.4	3.45
C-2	33.4	47.6	19.1	1.75
C-5	<u>34.9</u>	<u>47.1</u>	<u>22.9</u>	<u>1.52</u>
Average	49.7	47.1	21.8	2.24

a/ Estimated from:

$$\text{Rate of lead in sinter produced (Mton/hr)} = \text{Rate of sintering feed material (Mton/hr)} \times \text{Percent Lead in feed to sinter machine} \times 0.93$$

TABLE IV

SUMMARY OF UNCONTROLLED SINTER MACHINE EMISSIONS

<u>Name</u>	<u>Description</u> <u>Date of Run</u>	<u>Units</u>	<u>B-2</u>	<u>B-5</u>	<u>B-6</u>
			<u>07-18-73</u>	<u>07-21-73</u>	<u>07-21-73</u>
VMSTD	Vol Dry Gas-Std Cond	DSCF	25.98	22.50	23.15
PMOS	Percent Moisture by Vol		2.2	7.8	10.2
TS	Avg Stack Temperature	DEG.F	492.7	427.8	484.5
QS	Stk Flowrate, Dry, Std Cn	DSCFM	92394	83958	85046
QA	Actual Stack Flowrate	ACFM	173882	157652	174612
PERI	Percent Isokinetic		116.0 ^{a/}	107.2	108.9

PARTICULATES -- PARTIAL CATCH^{b/}

MF	Particulate Wt-Partial ^{a/}	MG	3766.90	3402.40	4818.60
CAN	Part Load-Ptl, Std Cn	GR/DSCF	2.23	2.33	3.20
CAT	Part Load-Ptl, Stk Cn	GR/ACF	1.19	1.24	1.56
CAW	Partic Emis-Partial	LB/HR	1770	1680	2340

PARTICULATES -- TOTAL CATCH^{c/}

MT	Particulate Wt-Total ^{b/}	MG	4391.00	3685.30	5048.00
CAO	Part Load-Ttl, Std Cn	GR/DSCF	2.60	2.52	3.36
CAU	Part Load-Ttl, Stk Cn	GR/ACF	1.38	1.34	1.64
CAX	Partic Emis-Total	LB/HR	2060	1810	2450
IC	Perc Impinger Catch		14.20	7.68	4.54

LEAD -- PARTIAL CATCH^{b/}

MF	Wt-Partial ^{a/}	MG	784.06	229.64	360.12
CAN	Load-Ptl, Std Cn	GR/DSCF	0.465	0.157	0.240
CAT	Load-Ptl, Stk Cn	GR/ACF	0.247	0.0837	0.117
CAW	Emis-Partial	LB/HR	368	113	175

LEAD -- TOTAL CATCH^{c/}

MT	Wt-Total ^{b/}	MG	784.16	229.75	360.30
CAO	Load-Ttl, Std Cn	GR/DSCF	0.465	0.157	0.240
CAU	Load-Ttl, Stk Cn	GR/ACF	0.247	0.0838	0.117
CAX	Emis-Total	LB/HR	368	113	175
IC	Perc Impinger Catch		0.01	0.05	0.05
	Feedrate	T/HR	47.6	57.5	60.8
	Part Emission Total	LB/T	43.3	31.5	40.3
	Lead Emissions Total	LB/T	7.73	1.97	2.88
	Perc Lead Ptl	%	20.8	6.73	7.48
	Perc Lead Ttl	%	17.9	6.24	7.15
	Avg Perc Lead Ptl	%		11.7	
	Avg Perc Lead Ttl	%		10.4	

^{a/} This value is six over the upper limit of the acceptable isokinetic range of 90-110%. This difference has no significant effect on other results. The high value is unexplainable. A portion of the value may be due to an error in stack temperature readings. The thermocouple was replaced after the run.

^{b/} Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

^{c/} Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

TABLE IVA

SUMMARY OF UNCONTROLLED SINTER MACHINE EMISSIONS
(Metric Units)

<u>Name</u>	<u>Description</u> <u>Date of Run</u>	<u>Units</u>	<u>B-2</u>	<u>B-5</u>	<u>B-6</u>
			<u>07-18-73</u>	<u>07-21-73</u>	<u>07-21-73</u>
VNSTM	Vol Dry Gas-Std Cond	NCM	0.735	0.637	0.655
PMOS	Percent Moisture by Vol		2.2	7.8	10.2
TSM	Avg Stack Temperature	DEG.C	255.9	219.9	251.3
QSM	Stk Flowrate, Dry, Std Cn	NM3/MIN	2616.3	2377.4	2408.3
QAM	Actual Stack Flowrate	M3/MIN	4923.8	4464.2	4944.5
PERI	Percent Isokinetic		116.0 ^{a/}	107.2	108.9
<u>PARTICULATES -- PARTIAL CATCH^{b/}</u>					
MF	Particulate Wt-Partial ^{a/}	MG	3766.90	3402.40	4818.60
CANM	Part Load-Ptl, Std Cn	MG/NM3	5109.98	5329.00	7334.09
CATM	Part Load-Ptl, Stk Cn	MG/M3	2715.26	2837.99	3572.15
CAWM	Partic Emis-Partial ^{a/}	KG/HR	802.03	760.03	1059.56
<u>PARTICULATES -- TOTAL CATCH^{c/}</u>					
MT	Particulate Wt-Total ^{b/}	MG	4391.00	3685.30	5048.00
CAOM	Part Load-Ttl, Std Cn	MG/NM3	5956.60	5772.09	7683.24
CAUM	Part Load-Ttl, Stk Cn	MG/M3	3165.12	3073.96	3742.20
CAXM	Partic Emis-Total ^{b/}	KG/HR	934.91	823.23	1110.00
IC	Perc Impinger Catch		14.21	7.68	4.54
<u>LEAD -- PARTIAL CATCH^{b/}</u>					
MF	Wt-Partial ^{a/}	MG	784.06	229.64	360.12
CANM	Load-Ptl, Std Cn	MG/NM3	1063.62	359.67	548.12
CATM	Load-Ptl, Stk Cn	MG/M3	565.17	191.55	266.97
CAWM	Emis-Partial ^{a/}	KG/HR	166.937	51.297	79.187
<u>LEAD -- TOTAL CATCH^{c/}</u>					
MT	Wt-Total ^{b/}	MG	784.16	229.75	360.30
CAOM	Load-Ttl, Std Cn	MG/NM3	1063.75	359.85	548.39
CAUM	Load-Ttl, Stk Cn	MG/M3	565.24	191.64	267.10
CAXM	Emis-Total ^{b/}	KG/HR	166.959	51.322	79.226
IC	Perc Impinger Catch		0.01	0.05	0.05
	Feedrate	MTON/HR	43.2	52.2	55.1
	Part Emission Total	KG/MTON	21.6	15.8	20.1
	Lead Emission Total	KG/MTON	3.87	0.983	1.44
	Perc Lead Ptl	%	20.8	6.73	7.48
	Perc Lead Ttl	%	17.9	6.24	7.15
	Avg Perc Lead Ptl	%		11.7	
	Avg Perc Lead Ttl	%		10.4	

^{a/} This value is six over the upper limit of the acceptable isokinetic range of 90-110%. This difference has no significant effect on other results. The high value is unexplainable. A portion of the value may be due to an error in stack temperature readings. The thermocouple was replaced after the run.

^{b/} Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

^{c/} Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

TABLE V

SUMMARY OF UNCONTROLLED EMISSIONS FROM SINTERING-ASSOCIATED OPERATIONS

<u>Name</u>	<u>Description</u> <u>Date of Run</u>	<u>Units</u>	<u>C-1</u>	<u>C-2</u>	<u>C-5</u>
			<u>07-17-73</u>	<u>07-18-73</u>	<u>07-21-73</u>
VMSTD	Vol Dry Gas-Std Cond	DSCF	103.30	93.29	87.25
PMOS	Percent Moisture by Vol		1.4	0.9	2.6
TS	Avg Stack Temperature	DEG.F	98.0	102.5	112.6
QS	Stk Flowrate, Dry, Std Cn	DSCFM	21732	21055	19017
QA	Actual Stack Flowrate	ACFM	23900	23156	21901
PERI	Percent Isokinetic		91.6	92.5	95.8

PARTICULATES -- PARTIAL CATCH^{a/}

MF	Particulate Wt-Partial ^{a/}	MG	48843.80	36533.30	29616.30
CAN	Part Load-Ptl, Std Cn	GR/DSCF	7.28	6.03	5.23
CAT	Part Load-Ptl, Stk Cn	GR/ACF	6.62	5.48	4.54
CAW	Partic Emis-Partial ^{a/}	LB/HR	1360	1090	852

PARTICULATES -- TOTAL CATCH^{b/}

MT	Particulate Wt-Total ^{b/}	MG	48863.10	36549.50	29646.30
CAO	Part Load-Ttl, Std Cn	GR/DSCF	7.28	6.03	5.23
CAU	Part Load-Ttl, Stk Cn	GR/ACF	6.62	5.49	4.54
CAX	Partic Emis-Total ^{b/}	LB/HR	1360	1090	852
IC	Perc Impinger Catch		0.04	0.04	0.10

LEAD -- PARTIAL CATCH^{a/}

MF	Wt-Partial ^{a/}	MG	6399.85	2469.70	2672.50
CAN	Load-Ptl, Std Cn	GR/DSCF	0.954	0.408	0.472
CAT	Load-Ptl, Stk Cn	GR/ACF	0.868	0.371	0.410
CAW	Emis-Partial ^{a/}	LB/HR	178	73.6	76.9

LEAD -- TOTAL CATCH^{b/}

MT	Wt-Total ^{b/}	MG	6399.94	2469.84	2672.63
CAO	Load-Ttl, Std Cn	GR/DSCF	0.954	0.408	0.472
CAU	Load-Ttl, Stk Cn	GR/ACF	0.868	0.371	0.410
CAX	Emis-Total ^{b/}	LB/HR	178	73.6	76.9
	Feedrate	TON/HR	59.6	47.6	57.5
	Part Emis-Ttl	LB/TON	22.8	22.9	14.8
	Lead Emis-Ttl	LB/TON	2.99	1.55	1.34
	Perc Lead Ptl	%	13.1	6.77	9.02
	Perc Lead Ttl	%	13.1	6.77	9.02
	Ave Perc Lead Ptl	%		9.63	
	Ave Perc Lead Ttl	%		9.63	

a/ Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

b/ Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

TABLE VA

SUMMARY OF UNCONTROLLED EMISSIONS FROM SINTERING-ASSOCIATED OPERATIONS
(Metric Units)

<u>Name</u>	<u>Description</u> <u>Date of Run</u>	<u>Units</u>	<u>C-1</u>	<u>C-2</u>	<u>C-5</u>
			<u>07-17-73</u>	<u>07-18-73</u>	<u>07-21-73</u>
VMSTM	Vol Dry Gas-Std Cond	NCM	2.92	2.64	2.47
PMOS	Percent Moisture by Vol		1.4	0.9	2.6
TSM	Avg Stack Temperature	DEG.C	36.7	39.2	44.8
QSM	Stk Flowrate, Dry, Std Cn	NM3/MIN	615.4	596.2	538.5
QAM	Actual Stack Flowrate	N3/MIN	676.8	655.7	620.2
PERI	Percent Isokinetic		91.6	92.5	95.8
<u>PARTICULATES -- PARTIAL CATCH^{a/}</u>					
MF	Particulate Wt-Partial ^{a/}	MG	48843.80	36533.30	29616.30
CANM	Part Load-Ptl, Std Cn	MG/NM3	16662.42	13800.73	11961.88
CATM	Part Load-Ptl, Stk Cn	MG/M3	15151.44	12548.18	10387.02
CAWM	Partic Emis-Partial ^{a/}	KG/HR	615.13	493.60	386.43
<u>PARTICULATES -- TOTAL CATCH^{b/}</u>					
MT	Particulate Wt-Total ^{b/}	MG	48863.10	36549.50	29646.30
CAOM	Part Load-Ttl, Std Cn	MG/NM3	16669.01	13806.85	11974.00
CAUM	Part Load-Ttl, Stk Cn	MG/M3	15157.43	12553.75	10397.54
CAXM	Partic Emis-Total ^{b/}	KG/HR	615.38	493.82	386.82
IC	Perc Impinger Catch		0.04	0.04	0.10
<u>LEAD -- PARTIAL CATCH^{a/}</u>					
MF	Wt-Partial ^{a/}	MG	6399.85	2469.70	2672.50
CANM	Load-Ptl, Std Cn	MG/NM3	2183.22	932.95	1079.41
CATM	Load-Ptl, Stk Cn	MG/M3	1985.25	848.27	937.30
CAWM	Emis-Partial ^{a/}	KG/HR	80.599	33.368	34.87
<u>LEAD -- TOTAL CATCH^{b/}</u>					
MT	Wt-Total	MG	6399.94	2469.84	2672.63
CAOM	Load-Ttl, Std Cn	MG/NM3	2183.26	933.00	1079.46
CAUM	Load-Ttl, Stk Cn	MG/M3	1985.27	848.32	937.34
CAXM	Emis-Total	KG/HR	80.60	33.37	34.872
IC	Perc Impinger Catch		0.00	0.01	0.00
	Feedrate	MTON/HR	54.1	43.2	52.2
	Part Emis Ttl	KG/MTON	11.4	11.4	7.41
	Lead Emis Ttl	KG/MTON	1.49	.773	.668
	Perc Lead Ptl	%	13.1	6.77	9.02
	Perc Lead Ttl	%	13.1	6.77	9.02
	Ave Perc Lead Ptl	%		9.63	
	Ave Perc Lead Ttl	%		9.63	

^{a/} Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

^{b/} Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

Table II contains the average of the controlled and uncontrolled particulate data from the emission tests, in pounds of particulate per ton of sinter produced. Table IIA contains the same data reported in metric units. The controlled particulate emission rate is 0.102 lb particulate/ton sinter produced. The uncontrolled emission rate averaged 41.2 and 21.7 lb particulate/ton sinter produced for the sinter machine and sinter-associated operations, respectively.

Table III presents the emission rates for lead per ton of lead in the sinter produced for both the controlled and uncontrolled emissions; Table IIIA shows the data in metric units. The controlled lead emission rate is 0.0277 lb Pb/ton. The average uncontrolled lead emission rate is 9.48 and 4.48 lb Pb/ton for the sinter machine and sinter-associated operations, respectively.

Table IV contains the summary of the particulate and lead data from the emission tests at Point "B," the 7-ft diameter main exhaust duct from the sinter furnace to the inlet of the control system. Table IVA contains the same data reported in metric units. In figuring the gas molecular weight the percent SO₂ estimated from Dräger tube readings was subtracted from the CO₂ value found in the Orsat analysis, and the SO₂ value was then used in the molecular weight calculation. The average values for particulate and lead are: particulate in the front half catch - 1,930 lb/hr; particulate in the total catch - 2,110 lb/hr; front half catch and total

catch lead - 219 lb/hr. The wide variation in loading from B stack can be attributed to the variance in the continuity of operation of the sinter plant. Run No. 2 shows the highest lead emission values and the plant was shut down more times during this run than in any other run.

Table V presents the particulate and lead data from the "C" duct, the 3-ft diameter hygienic duct (collection duct for sintering-associated operations), which also is a feed duct for the pollution control system. Table VA contains the metric conversion for Table V. There was less than 200 ppm SO₂ in the duct as shown in Dräger tube analysis, and therefore the SO₂ was not used in calculating carrier gas molecular weight for the hygienic duct.

The average values for particulate emissions and lead analytical values for all three runs are: particulate front half catch and particulate total catch - 1,100 lb/hr; and lead front half and total catch - 110 lb/hr. The wide variations in loading on "C" duct can also be attributed to the manner of operation of the sinter plant.

Tables VI, VIA, VII, VIIA, VIII, VIIIA, IX, IXA, X, XA, XI, XIA, XII, XIIA, XIII, XIII A, XIV, XIVA, XV and XVA contain the results of the emission testing on the uncontrolled and controlled emissions from the blast furnace and associated operations. Table VI is a summary table that shows the average uncontrolled and controlled emissions from the blast furnace operation for all three tests combined.

TABLE VI

AVERAGE OF EMISSIONS FROM BLAST FURNACE AND BAGHOUSE

<u>Description</u>	<u>Units</u>	<u>Sampling Point</u>	
		<u>Inlet to Control System</u>	<u>Total Baghouse Emissions</u>
Particulate Emissions - Partial (Probe Tip, Probe, Cyclone and Filter)	lb/hr gr/DSCF	2370 3.11	17.7 0.0142 ^{a/}
Particulate Emissions - Total (Probe Tip, Probe, Cyclone, Fil- ter and Impingers)	lb/hr gr/DSCF	2400 3.16	34.2 0.0275 ^{a/}
Lead Emissions - Partial	lb/hr gr/DSCF	307 0.403	5.97 0.00482 ^{a/}
Lead Emissions - Total	lb/hr gr/DSCF	307 0.403	6.01 0.00485 ^{a/}
Production Rate	tons/hr	13.8	13.8
Particulate Emissions - Partial	lb/ton	172	1.28
Particulate Emissions - Total	lb/ton	174	2.47
Lead Emissions - Partial	lb/ton	22.2	0.433
Lead Emissions - Total	lb/ton	22.2	0.450
% Lead - Partial		12.9	33.7
% Lead - Total		12.8	17.6
Collection Efficiency			
Particulate - Partial			99.25%
Particulate - Total			98.57%
Lead - Partial			98.05%
Lead - Total			98.04%

^{a/} Since this baghouse has three stacks, the average concentration was calculated from the weighted averages, based on the flowrate, of the individual simultaneous sets of runs.

TABLE VIA

AVERAGE OF EMISSIONS FROM BLAST FURNACE AND BAGHOUSE
(Metric Units)

<u>Description</u>	<u>Units</u>	<u>Sampling Point</u>	
		<u>Inlet to Control System</u>	<u>Total Baghouse Emissions</u>
Particulate Emissions - Partial (Probe Tip, Cyclone and Filter)	Kg/hr Mg/NM3	1070 7110	8.01 32.5 ^{a/}
Particulate Emissions - Total (Probe Tip, Probe, Cyclone, Fil- ter and Impingers)	Kg/hr Mg/NM3	1090 7220	15.5 63.0 ^{a/}
Lead Emissions - Partial	Kg/hr Mg/NM3	139 922	2.71 11.0 ^{a/}
Lead Emissions - Total	Kg/hr Mg/NM3	139 922	2.73 11.1 ^{a/}
Production Rate	MT/hr	12.5	12.5
Particulate Emissions - Partial	Kg/MT	86.2	0.641
Particulate Emissions - Total	Kg/MT	87.2	1.23
Lead Emissions - Partial	Kg/MT	11.1	0.217
Lead Emissions - Total	Kg/MT	11.1	0.224
% Lead - Partial		12.9	33.7
% Lead - Total		12.8	17.6
Collection Efficiency			
Particulate - Partial			99.25%
Particulate - Total			98.57%
Lead - Partial			98.05%
Lead - Total			98.04%

a/ Since the baghouse has three stacks, the average concentration was calculated from the weighted averages, based on flowrate, of the individual simultaneous sets of runs.

TABLE VII

TOTAL EMISSIONS BLAST FURNACE - BAGHOUSE PER TEST

<u>Description</u>	<u>Units</u>	<u>Test 3</u>	<u>Test 4</u>	<u>Test 7</u>
Particulate Emission Blast - Partial ^{a/}	lb/hr	2,650	2,500	1,950
Particulate Emission Blast - Total ^{b/}	lb/hr	2,690	2,530	1,990
Lead Emission Blast - Partial ^{a/}	lb/hr	424	303	193
Lead Emission Blast - Total ^{b/}	lb/hr	424	303	193
Particulate Emission Baghouse - Partial	lb/hr	20.2	10.7	22.2
Particulate Emission Baghouse - Total	lb/hr	36.8	24.2	41.7
Lead Emission Baghouse - Partial	lb/hr	6.43	2.59	8.89
Lead Emission Baghouse - Total	lb/hr	6.47	2.64	8.93
Particulate Efficiency - Partial	%	99.2	99.6	98.9
Particulate Efficiency - Total	%	98.6	99.0	97.9
Lead Efficiency - Partial	%	98.5	99.1	95.4
Lead Efficiency - Total	%	98.5	99.1	95.4
Production Rate	ton/hr	13.9	13.8	13.8
Particulate Emission Blast - Partial	lb/ton	191	181	141
Particulate Emission Blast - Total	lb/ton	194	183	144
Lead Emission Blast - Partial	lb/ton	30.5	22.0	14.0
Lead Emission Blast - Total	lb/ton	30.5	22.0	14.0
Particulate Emission Baghouse - Partial	lb/ton	1.45	0.775	1.61
Particulate Emission Baghouse - Total	lb/ton	2.65	1.75	3.02
Lead Emission Baghouse - Partial	lb/ton	0.463	0.188	0.644
Lead Emission Baghouse - Total	lb/ton	0.465	0.191	0.647

^{a/} Partial refers to the material caught in the probe tip, probe, cyclone and filter.
^{b/} Total refers to the partial plus the material caught in the impingers.

TABLE VIIA

TOTAL EMISSIONS BLAST FURNACE - BAGHOUSE PER TEST
(Metric Units)

<u>Description</u>	<u>Units</u>	<u>Test 3</u>	<u>Test 4</u>	<u>Test 7</u>
Particulate Emission Blast - Partial ^{a/}	Kg/hr	1,200	1,140	883
Particulate Emission Blast - Total ^{b/}	Kg/hr	1,220	1,150	903
Lead Emission Blast - Partial	Kg/hr	192	137	87.7
Lead Emission Blast - Total	Kg/hr	192	137	87.7
Particulate Emission Baghouse - Partial	Kg/hr	9.17	4.86	10.1
Particulate Emission Baghouse - Total	Kg/hr	16.7	11.0	18.9
Lead Emission Baghouse - Partial	Kg/hr	2.92	1.18	4.03
Lead Emission Baghouse - Total	Kg/hr	2.93	1.20	4.05
Production Rate	MT/hr	12.6	12.5	12.5
Particulate Emission Blast - Partial	Kg/MT	95.2	91.2	70.6
Particulate Emission Blast - Total	Kg/MT	96.8	92.0	72.2
Lead Emission Blast - Partial	Kg/MT	15.2	11.0	7.02
Lead Emission Blast - Total	Kg/MT	15.2	11.0	7.02
Particulate Emission Baghouse - Partial	Kg/MT	0.728	0.389	0.808
Particulate Emission Baghouse - Total	Kg/MT	1.33	0.880	1.51
Lead Emission Baghouse - Partial	Kg/MT	0.232	0.0944	0.322
Lead Emission Baghouse - Total	Kg/MT	0.233	0.0960	0.324

^{a/} Partial refers to the material caught in the probe tip, probe, cyclone and filter.

^{b/} Total refers to the partial plus the material caught in the impingers.

TABLE VIII

POUND PARTICULATE/TOTAL TONS OF FEED MATERIAL INTO THE BLAST FURNACE

<u>Run No.</u>	<u>Total Particulate Emission Rate (lb/hr)</u>	<u>Rate of Feed Material^{a/} (tons/hr)</u>	<u>Lb/Hr ÷ Tons/Hr = Lb/Ton</u>
<u>Uncontrolled</u>			
D-3	2,650	35.9	74.9
D-4	2,530	34.2	74.0
D-7	<u>1,990</u>	<u>36.1</u>	<u>55.1</u>
Average	2,403	35.4	68.0
<u>Controlled</u>			
Run 3 (E, F, and G)	36.83	35.9	1.02
Run 4 (E, F, and G)	24.22	34.2	0.708
Run 7 (E, F, and G)	<u>41.65</u>	<u>36.1</u>	<u>1.15</u>
Average	34.23	35.4	0.959

a/ From Table C-II, Page 142.
Rate of feed material
into blast furnace =
(tons/hr)

Sinter smelted (tons/day)+
Coke smelted (tons/day)+
Scrap iron smelted (tons/day)+
Caustic skims smelted (tons/day)
(24 hr/day)

TABLE VIIIA

KILOGRAM PARTICULATE/MTONS OF FEED MATERIAL INTO BLAST FURNACE

<u>Run No.</u>	<u>Total Particulate Emission Rate (kg/hr)</u>	<u>Rate of Feed Material^{a/} (Mton/hr)</u>	<u>Kg/Hr ÷ Mton/Hr = Kg/Mton</u>
<u>Uncontrolled</u>			
D-3	1,220	32.6	37.5
D-4	1,150	31.0	37.1
D-7	<u>903</u>	<u>32.7</u>	<u>27.6</u>
Average	1,091	32.1	34.1
<u>Controlled</u>			
Run 3 (E, F, and G)	16.72	32.6	0.513
Run 4 (E, F, and G)	11.00	31.0	0.355
Run 7 (E, F, and G)	<u>18.91</u>	<u>32.7</u>	<u>0.578</u>
Average	15.54	32.1	0.482

a/ From Table C-II, Page 142.
Rate of feed material
into blast furnace =
(Mton/hr)

Sinter smelted (Mton/day) +
Coke smelted (Mton/day) +
Scrap iron smelted (Mton/day) +
Caustic skims smelted (Mton/day)
(24 hr/day)

TABLE IX

POUND PARTICULATE/TOTAL TONS OF LEAD PRODUCED

<u>Run No.</u>	<u>Total Particulate Emission Rate (lb/hr)</u>	<u>Lead Produced^{a/} (tons/hr)</u>	<u>Lb/hr ÷ Tons/Hr = Lb/Ton</u>
<u>Uncontrolled</u>			
D-3	2,690	13.9	194
D-4	2,530	13.8	183
D-7	<u>1,990</u>	<u>13.8</u>	<u>144</u>
Average	2,403	13.8	174
<u>Controlled</u>			
Run 3 (E, F, and G)	36.83	13.9	2.65
Run 4 (E, F, and G)	24.22	13.8	1.75
Run 7 (E, F, and G)	<u>41.65</u>	<u>13.8</u>	<u>3.02</u>
Average	34.23	13.8	2.47

a/ From Table C-II, Page 142.

$$\frac{\text{Lead Produced (tons/hr)}}{24} = \frac{\text{Bullion Produced (tons/day)}}{24 \text{ hr/day}}$$

TABLE IXA

KILOGRAM PARTICULATE/TOTAL MTONS OF LEAD PRODUCED

<u>Run No.</u>	<u>Total Particulate Emission Rate (kg/hr)</u>	<u>Lead Produced^{a/} (Mton/hr)</u>	<u>Kg/Hr ÷ Mton/Hr = Kg/Mton</u>
<u>Uncontrolled</u>			
D-3	1,220	12.6	96.8
D-4	1,150	12.5	92.0
D-7	<u>903</u>	<u>12.5</u>	<u>72.2</u>
Average	1,091	12.5	87.0
<u>Controlled</u>			
Run 3 (E, F, and G)	16.72	12.6	1.32
Run 4 (E, F, and G)	11.00	12.5	.88
Run 7 (E, F, and G)	<u>18.91</u>	<u>12.5</u>	<u>1.51</u>
Average	15.54	12.5	1.23

a/ From Table C-II, Page 142.

$$\frac{\text{Lead Produced (Mton/hr)}}{24 \text{ hr/day}} = \text{Bullion Produced (Mton/day)}$$

TABLE X

POUND LEAD/TON OF LEAD IN THE SINTER FEED
TO THE BLAST FURNACE (ESTIMATED)

<u>Run No.</u>	<u>Total Lead Emission Rate (lb/hr)</u>	<u>Percent Lead in Feed Material</u>	<u>Rate of Lead in Sinter Feed Material to Blast Furnace^{a/} (tons/hr)</u>	<u>Lb/Hr + Tons/Hr = Lb/Ton</u>
<u>Uncontrolled</u>				
D-3	424	47.0	15.1	28.1
D-4	303	45.9	14.2	21.3
D-7	<u>193</u>	<u>45.4</u>	<u>14.8</u>	<u>13.0</u>
Average	307	46.1	14.7	20.8
<u>Controlled</u>				
Run 3 (E, F, and G)	6.47	47.0	15.1	0.428
Run 4 (E, F, and G)	2.64	45.9	14.2	0.186
Run 7 (E, F, and G)	<u>8.93</u>	<u>45.4</u>	<u>14.8</u>	<u>0.603</u>
Average	6.01	46.1	14.7	0.405

a/ Estimated from Table C-II, Page 142.

$$\text{Rate of lead in sinter feed material to blast furnace (tons/hr)} = \frac{\text{Sinter smelted}}{24} \text{ (tons/hr)} \times \% \text{ Lead into blast furnace}$$

TABLE XA

KG LEAD/MTON OF LEAD IN SINTER FEED TO THE BLAST FURNACE (ESTIMATED)
(metric units)

<u>Run No.</u>	<u>Total Lead Emission Rate (Kg/hr)</u>	<u>Percent Lead in Feed Material</u>	<u>Rate of Lead in Sinter Feed Material to Blast Furnace^a (Mton/hr)</u>	<u>Kg/Hr + Mton/hr = Kg/Mton</u>
<u>Uncontrolled</u>				
D-3	192	47.0	13.7	14.0
D-4	138	45.9	12.9	10.7
D-7	<u>87.6</u>	<u>45.4</u>	<u>13.4</u>	<u>6.54</u>
Average	139	46.1	13.3	10.4
<u>Controlled</u>				
Run 3 (E, F, and G)	2.93	47.0	13.7	.214
Run 4 (E, F, and G)	1.20	45.9	12.9	.093
Run 7 (E, F, and G)	<u>3.85</u>	<u>45.4</u>	<u>13.4</u>	<u>.287</u>
Average	2.66	46.1	13.3	.198

a/ Estimated from Table C-II, Page 142.

$$\begin{array}{l} \text{Rate of lead in} \\ \text{sinter feed material} \\ \text{to blast furnace} \\ \text{(Mton/hr)} \end{array} = \begin{array}{l} \text{Sinter smelted} \\ \text{24} \\ \text{(Mton/hr)} \end{array} \times \begin{array}{l} \% \text{ Lead into} \\ \text{blast furnace} \end{array}$$

TABLE XI

POUND LEAD/TON OF LEAD PRODUCED

<u>Run No.</u>	<u>Total Lead Emission Rate (lb/hr)</u>	<u>Rate of Lead Produced by Blast Furnace (tons/hr)</u>	<u>Lb/Hr ÷ Tons/Hr = Lb/Ton</u>
<u>Uncontrolled</u>			
D-3	424	13.4	31.6
D-4	303	13.3	22.8
D-7	<u>193</u>	<u>13.3</u>	<u>14.5</u>
Average	307	13.3	23.0
<u>Controlled</u>			
Run 3 (E, F, and G)	6.47	13.4	.482
Run 4 (E, F, and G)	2.64	13.3	.198
Run 7 (E, F, and G)	<u>8.93</u>	<u>13.3</u>	<u>.671</u>
Average	6.01	13.3	.450

a/ From Table C-II, Page 142.

$$\text{Rate} = \frac{\text{Bullion produced (tons/day)}}{24 \text{ hr/day}} \times \text{percent of lead in bullion}$$

TABLE XIA

KILOGRAM LEAD/MTON OF LEAD PRODUCED

<u>Run No.</u>	<u>Total Lead Emission Rate (kg/hr)</u>	<u>Rate of Lead Produced^{a/} (Mton/hr)</u>	<u>Kg/Hr + Mton/Hr = Kg/Mton</u>
<u>Uncontrolled</u>			
D-3	192	12.2	15.7
D-4	138	12.1	11.4
D-7	<u>87.6</u>	<u>12.1</u>	<u>7.24</u>
Average	139	12.1	11.4
<u>Controlled</u>			
Run 3 (E, F, and G)	2.93	12.2	.240
Run 4 (E, F, and G)	1.20	12.1	.099
Run 7 (E, F, and G)	<u>4.05</u>	<u>12.1</u>	<u>.334</u>
Average	2.72	12.1	.224

a/ From Table C-II, Page 142.

$$\text{Rate} = \frac{\text{Bullion produced (Mton/day)}}{24 \text{ hr/day}} \times \text{percent of lead in bullion}$$

TABLE XII

SUMMARY OF UNCONTROLLED BLAST FURNACE EMISSIONS

<u>Name</u>	<u>Description</u> <u>Date of Run</u>	<u>Units</u>	<u>D-3</u>	<u>D-4</u>	<u>D-7</u>
			<u>07-19-73</u>	<u>07-20-73</u>	<u>07-23-73</u>
VMSTD	Vol Dry Gas-Std Cond	DSCF	26.03	26.73	25.85
PMOS	Percent Moisture by Vol		3.1	2.0	4.1
TS	Avg Stack Temperature	DEG.F	258.0	253.0	206.8
QS	Stk Flowrate, Dry, Std Cn	DSCFM	87582	90137	89140
QA	Actual Stack Flowrate	ACFM	125923	127423	120025
PERI	Percent Isokinetic		110.8	110.6	108.2

PARTICULATES -- PARTIAL CATCH^{a/}

MF	Particulate Wt-Partial	MG	5978.00	5626.70	4278.60
CAN	Part Load-Ptl, Std Cn	GR/DSCF	3.54	3.24	2.55
CAT	Part Load-Ptl, Stk Cn	GR/ACF	2.46	2.29	1.89
CAW	Partic Emis-Partial ^{a/}	LB/HR	2650	2500	1950

PARTICULATES -- TOTAL CATCH^{b/}

MT	Particulate Wt-Total ^{b/}	MG	6065.10	5675.40	4376.30
CAO	Part Load-Ttl, Std Cn	GR/DSCF	3.59	3.27	2.61
CAU	Part Load-Ttl, Stk Cn	GR/ACF	2.50	2.31	1.94
CAX	Partic Emis-Total ^{b/}	LB/HR	2690	2530	1990
IC	Perc Impinger Catch		1.44	0.86	2.23

LEAD -- PARTIAL CATCH^{a/}

MF	Wt-Partial ^{a/}	MG	954.57	680.71	424.83
CAN	Load-Ptl, Std Cn	GR/DSCF	0.565	0.392	0.253
CAT	Load-Ptl, Stk Cn	GR/ACF	0.393	0.277	0.188
CAW	Emis-Partial ^{a/}	LB/HR	424	303	193

LEAD -- TOTAL CATCH^{b/}

MT	Wt-Total ^{b/}	MG	955.12	680.81	424.99
CAO	Load-Ttl, Std Cn	GR/DSCF	0.565	0.392	0.253
CAU	Load-Ttl, Stk Cn	GR/ACF	0.393	0.277	0.188
CAX	Emis-Total ^{b/}	LB/HR	424	303	193
IC	Perc Impinger Catch		0.06	0.01	0.04
	Prod Rate	TON/HR	13.9	13.8	13.8
	Part Emis Ttl	LB/TON	194	183	144
	Lead Emis Ttl	LB/TON	30.5	22.0	14.0
	Perc Lead Ptl	%	16.0	12.1	9.90
	Perc Lead Ttl	%	15.8	12.0	9.70
	Ave Perc Lead Ptl	%		12.7	
	Ave Perc Lead Ttl	%		12.5	

^{a/} Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

^{b/} Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

TABLE XIIA

SUMMARY OF UNCONTROLLED BLAST FURNACE EMISSIONS
(Metric Units)

<u>Name</u>	<u>Description</u> <u>Date of Run</u>	<u>Units</u>	<u>D-3</u> <u>07-19-73</u>	<u>D-4</u> <u>07-20-73</u>	<u>D-7</u> <u>07-23-73</u>
VMSTM	Vol Dry Gas-Std Cond	NCM	0.737	0.756	0.732
PMOS	Percent Moisture by Vol		3.1	2.0	4.1
TSM	Avg Stack Temperature	DEG.C	125.5	122.8	97.1
QSM	Stk Flowrate, Dry, Std Cn	NM3/MIN	2480.1	2552.4	2524.2
QAM	Actual Stack Flowrate	N3/MIN	3565.8	3608.2	3398.8
PERI	Percent Isokinetic		110.8	110.6	108.2
<u>PARTICULATES -- PARTIAL CATCH^{a/}</u>					
MF	Particulate Wt-Partial	MG	5978.00	5626.70	4278.60
CANM	Part Load-Ptl, Std Cn	MG/NM3	8093.77	7418.02	5831.83
CATM	Part Load-Ptl, Stk Cn	MG/M3	5629.37	5247.41	4331.17
CAWM	Partic Emis-Partial	KG/HR	1204.17	1135.84	883.09
<u>PARTICULATES -- TOTAL CATCH^{b/}</u>					
MT	Particulate Wt-Total	MG	6065.10	5675.40	4376.30
CAOM	Part Load-Ttl, Std Cn	MG/NM3	8211.69	7482.23	5965.00
CAUM	Part Load-Ttl, Stk Cn	MG/M3	5711.39	5292.82	4430.07
CAXM	Partic Emis-Total	KG/HR	1221.72	1145.67	903.25
IC	Perc Impinger Catch		1.44	0.86	2.23
<u>LEAD -- PARTIAL CATCH^{a/}</u>					
MF	Wt-Partial	MG	954.57	680.71	424.83
CANM	Load-Ptl, Std Cn	MG/NM3	1292.42	897.42	579.05
CATM	Load-Ptl, Stk Cn	MG/M3	898.90	634.82	430.05
CAWM	Emis-Partial	KG/HR	192.283	137.412	87.683
<u>LEAD -- TOTAL CATCH^{b/}</u>					
MT	Wt-Total	MG	955.12	680.81	424.99
CAOM	Load-Ttl, Std Cn	MG/NM3	1293.16	897.55	579.27
CAUM	Load-Ttl, Stk Cn	MG/M3	899.42	634.92	430.21
CAXM	Emis-Total	KG/HR	192.394	137.432	87.716
IC	Perc Impinger Catch		0.06	0.01	0.04
	Prod Rate	MTON/HR	12.6	12.5	12.5
	Part Emis Ttl	KG/MTON	96.9	91.6	72.2
	Lead Emis Ttl	KG/MTON	15.2	11.0	7.02
	Perc Lead Ptl	%	16.0	12.1	9.90
	Perc Lead Ttl	%	15.8	12.0	9.70
	Ave Perc Lead Ptl	%		12.7	
	Ave Perc Lead Ttl	%		12.5	

a/ Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

b/ Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

TABLE XIII

SUMMARY OF EMISSIONS FROM BLAST FURNACE BAGHOUSE - E STACK

<u>Name</u>	<u>Description</u> <u>Date of Run</u>	<u>Units</u>	<u>E-3</u> <u>07-19-73</u>	<u>E-4</u> <u>07-20-73</u>	<u>E-7</u> <u>07-23-73</u>
VMSTD	Vol Dry Gas-Std Cond	DSCF	51.72	63.72	52.53
PNOS	Percent Moisture by Vol		3.9	5.3	4.4
TS	Avg Stack Temperature	DEG.F	141.4	126.4	131.7
QS	Stk Flowrate, Dry, Std Cn	DSCFM	55424	70367	57497
QA	Actual Stack Flowrate	ACFM	66816	84169	68474
PERI	Percent Isokinetic		102.0	99.0	99.9
<u>PARTICULATES -- PARTIAL CATCH^{a/}</u>					
MF	Particulate Wt-Partial	MG	82.50	37.80	73.80
CAN	Part Load-Ptl, Std Cn	GR/DSCF	0.0246	0.00914	0.0216
CAT	Part Load-Ptl, Stk Cn	GR/ACF	0.0204	0.00764	0.0182
CAW	Partic Emis-Partial	LB/HR	11.7	5.51	10.7
<u>PARTICULATES -- TOTAL CATCH^{b/}</u>					
MT	Particulate Wt-Total ^{b/}	MG	137.20	83.80	147.00
CAO	Part Load-Ttl, Std Cn	GR/DSCF	0.0408	0.0202	0.0431
CAU	Part Load-Ttl, Stk Cn	GR/ACF	0.0339	0.0169	0.0362
CAX	Partic Emis-Total ^{b/}	LB/HR	19.4	12.2	21.2
IC	Perc Impinger Catch		39.87	54.89	49.80
<u>LEAD -- PARTIAL CATCH^{a/}</u>					
MF	Wt-Partial ^{a/}	MG	24.85	7.75	25.47
CAN	Load-Ptl, Std Cn	GR/DSCF	0.00740	0.00187	0.00747
CAT	Load-Ptl, Stk Cn	GR/ACF	0.00614	0.00157	0.00627
CAW	Emis-Partial ^{a/}	LB/HR	3.51	1.13	3.68
<u>LEAD -- TOTAL CATCH^{b/}</u>					
MT	Wt-Total ^{b/}	MG	24.94	7.88	25.60
CAO	Load-Ttl, Std Cn	GR/DSCF	0.00743	0.00190	0.00750
CAU	Load-Ttl, Stk Cn	GR/ACF	0.00616	0.00159	0.00630
CAX	Emis-Total ^{b/}	LB/HR	3.53	1.15	3.70
IC	Perc Impinger Catch		0.36	1.65	0.51
	Prod Rate	TON/HR	13.9	13.8	13.8
	Part Emis Ttl	LB/TON	1.40	0.884	1.54
	Lead Emis Ttl	LB/TON	0.254	0.0833	0.268
	Perc Lead Emis Ptl	%	30.0	20.5	34.4
	Perc Lead Emis Ttl	%	18.2	9.43	17.4
	Avg Perc Lead Emis Ptl	%		28.3	
	Avg Perc Lead Emis Ttl	%		15.0	

^{a/} Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

^{b/} Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

TABLE XIII A

SUMMARY OF EMISSIONS FROM BLAST FURNACE BAGHOUSE - E STACK
(Metric Units)

<u>Name</u>	<u>Description</u> <u>Date of Run</u>	<u>Units</u>	<u>E-3</u>	<u>E-4</u>	<u>E-7</u>
			<u>07-19-73</u>	<u>07-20-73</u>	<u>07-23-73</u>
VMSTM	Vol Dry Gas-Std Cond	NCM	1.465	1.804	1.488
PMOS	Percent Moisture by Vol		3.9	5.3	4.4
TSM	Avg Stack Temperature	DEG.C	60.8	52.5	55.4
QSM	Stk Flowrate, Dry, Std Cn	NM3/MIN	1569.4	1992.6	1628.2
QAM	Actual Stack Flowrate	M3/MIN	1892.0	2383.4	1939.0
PERI	Percent Isokinetic		102.0	99.0	99.9
<u>PARTICULATES -- PARTIAL CATCH^{a/}</u>					
MF	Particulate Wt-Partial	MG	82.50	37.80	73.80
CANM	Part Load-Ptl, Std Cn	MG/NM3	56.21	20.91	49.51
CATM	Part Load-Ptl, Stk Cn	MG/M3	46.63	17.48	41.57
CAWM	Partic Emis-Partial	KG/HR	5.29	2.50	4.84
<u>PARTICULATES -- TOTAL CATCH^{b/}</u>					
MT	Particulate Wt-Total	MG	137.20	83.80	147.00
CAOM	Part Load-Ttl, Std Cn	MG/NM3	93.48	46.35	98.61
CAUM	Part Load-Ttl, Stk Cn	MG/M3	77.54	38.75	82.81
CAXM	Partic Emis-Total	KG/HR	8.80	5.54	9.63
IC	Perc Impinger Catch		39.87	54.89	49.80
<u>LEAD -- PARTIAL CATCH^{a/}</u>					
MF	Wt-Partial	MG	24.85	7.75	25.47
CANM	Load-Ptl, Std Cn	MG/NM3	16.93	4.29	17.09
CATM	Load-Ptl, Stk Cn	MG/M3	14.05	3.58	14.35
CAWM	Emis-Partial	KG/HR	1.594	0.512	1.669
<u>Lead -- TOTAL CATCH^{b/}</u>					
MT	Wt-Total	MG	24.94	7.88	25.60
CAOM	Load-Ttl, Std Cn	MG/NM3	16.99	4.36	17.17
CAUM	Load-Ttl, Stk Cn	MG/M3	14.10	3.64	14.42
CAXM	Emis-Total	KG/HR	1.600	0.521	1.677
IC	Perc Impinger Catch		0.36	1.65	0.51
	Prod Rate	MTON/HR	12.6	12.5	12.5
	Part Emis Ttl	KG/MTON	0.698	0.443	0.770
	Lead Emis Ttl	KG/MTON	0.127	0.0416	0.134
	Perc Lead Emis Ptl	%	30.0	20.5	34.4
	Perc Lead Emis Ttl	%	18.2	9.43	17.4
	Avg Perc Lead Emis Ptl	%		28.3	
	Avg Perc Lead Emis Ttl	%		15.0	

a/ Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

b/ Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

TABLE XIV

SUMMARY OF EMISSIONS FROM BLAST FURNACE BAGHOUSE - F STACK

Name	Description Date of Run	Units	F-3	F-4	F-7
			07-19-73	07-20-73	07-23-73
VMSTD	Vol Dry Gas-Std Cond	DSCF	76.05	74.13	73.88
PMOS	Percent Moisture by Vol		4.6	4.9	4.1
TS	AVG Stack Temperature	DEG.F	151.3	147.3	141.3
QS	Stk Flowrate, Dry, Std Cn	DSCFM	39425	38839	39256
QA	Actual Stack Flowrate	ACFM	48664	47918	47385
PERI	Percent Isokinetic		93.7	92.7	91.4

PARTICULATES -- PARTIAL CATCH^{a/}

MF	Particulate Wt-Partial	MG	38.50	52.30	64.20
CAN	Part Load-Ptl, Std Cn	GR/DSCF	0.00780	0.0109	0.0134
CAT	Part Load-Ptl, Stk Cn	GR/ACF	0.00632	0.00881	0.0111
CAW	Partic Emis-Partial	LB/HR	2.63	3.62	4.50

PARTICULATES -- TOTAL CATCH^{b/}

MT	Particulate Wt-Total	MG	111.40	101.60	123.40
CAO	Part Load-Ttl, Std Cn	GR/DSCF	0.0226	0.0211	0.0257
CAU	Part Load-Ttl, Stk Cn	GR/ACF	0.0183	0.0171	0.0213
CAX	Partic Emis-Total	LB/HR	7.62	7.03	8.65
IC	Perc Impinger Catch		65.44	48.52	47.97

LEAD -- PARTIAL CATCH^{a/}

MF	Wt-Partial	MG	8.37	15.72	27.22
CAN	Load-Ptl, Std Cn	GR/DSCF	0.00170	0.00327	0.00567
CAT	Load-Ptl, Stk Cn	GR/ACF	0.00137	0.00265	0.00470
CAW	Emis-Partial	LB/Hr	0.570	1.09	1.91

LEAD -- TOTAL CATCH^{b/}

MT	Wt-Total	MG	8.47	15.89	27.32
CAO	Load-Ttl, Std Cn	GR/DSCF	0.00172	0.00330	0.00569
CAU	Load-Ttl, Stk Cn	GR/ACF	0.00139	0.00268	0.00472
CAX	Emis-Total	LB/HR	0.580	1.10	1.92
IC	Perc Impinger Catch		1.18	1.07	0.37
	Prod Rate	TON/HR	13.9	13.8	13.8
	Part Emis Ttl	LB/TON	0.548	0.509	0.627
	Lead Emis Ttl	LB/TON	0.0417	0.0797	0.139
	Perc Lead Emis Ptl	%	21.7	30.1	42.4
	Perc Lead Emis Ttl	%	7.61	15.6	22.2
	Avg Perc Lead Ptl	%		31.4	
	Avg Perc Lead Ttl	%		15.1	

a/ Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

b/ Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

TABLE XIVA

SUMMARY OF EMISSIONS FROM BLAST FURNACE BAGHOUSE - F STACK
(Metric Units)

<u>Name</u>	<u>Description</u> <u>Date of Run</u>	<u>Units</u>	<u>F-3</u>	<u>F-4</u>	<u>F-7</u>
			<u>07-19-73</u>	<u>07-20-73</u>	<u>07-23-73</u>
VMSTM	Vol Dry Gas-Std Cond	NCM	2.154	2.099	2.092
PMOS	Percent Moisture by Vol		4.6	4.9	4.1
TSM	Avg Stack Temperature	DEG.C	66.3	64.1	60.7
QSM	Stk Flowrate, Dry, Std Cn	NM3/MIN	1116.4	1099.8	1111.6
QAM	Actual Stack Flowrate	M3/MIN	1378.0	1356.9	1341.8
PERI	Percent Isokinetic		93.7	92.7	91.4

PARTICULATES -- PARTIAL CATCH^{a/}

MF	Particulate Wt-Partial	MG	38.50	52.30	64.20
CANM	Part Load-Ptl, Std Cn	MG/NM3	17.84	24.86	30.62
CATM	Part Load-Ptl, Stk Cn	MG/M3	14.45	20.15	25.37
CAWM	Partic Emis-Partial	KG/HR	1.19	1.64	2.04

PARTICULATES -- TOTAL CATCH^{b/}

MT	Particulate Wt-Total	MG	111.40	101.60	123.40
CAOM	Part Load-Ttl, Std Cn	MG/NM3	51.62	48.30	58.86
CAUM	Part Load-Ttl, Stk Cn	MG/M3	41.82	39.15	48.76
CAXM	Partic Emis-Total	KG/HR	3.46	3.19	3.93
IC	Perc Impinger Catch		65.44	48.52	47.97

LEAD -- PARTIAL CATCH^{a/}

MF	Wt-Partial	MG	8.37	15.72	27.22
CANM	Load-Ptl, Std Cn	MG/NM3	3.88	7.47	12.98
CATM	Load-Ptl, Stk Cn	MG/M3	3.14	6.06	10.76
CAWM	Emis-Partial	KG/HR	0.260	0.493	0.866

LEAD -- TOTAL CATCH^{b/}

MT	Wt-Total	MG	8.47	15.89	27.32
CAOM	Load-Ttl, Std Cn	MG/NM3	3.93	7.55	13.03
CAUM	Load-Ttl, Stk Cn	MG/M3	3.18	6.12	10.80
CAXM	Emis-Total	KG/HR	0.263	0.498	0.869
IC	Perc Impinger Catch		1.18	1.07	0.37
	Prod Rate	MTON/HR	12.6	12.5	12.5
	Part Emis Ttl	KG/MTON	0.275	0.255	0.314
	Lead Emis Ttl	KG/MTON	0.0208	0.0398	0.0695
	Perc Lead Emis Ptl	%	21.7	30.1	42.4
	Perc Lead Emis Ttl	%	7.61	15.6	22.2
	Avg Perc Lead Emis Ptl	%		31.4	
	Avg Perc Lead Emis Ttl	%		15.1	

a/ Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

b/ Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

TABLE XV

SUMMARY OF EMISSIONS FROM BLAST FURNACE BAGHOUSE - G STACK

Name	Description Date of Run	Units	G-3	G-4	G-7
			07-19-73	07-20-73	07-23-73
VMSTD	Vol Dry Gas-Std Cond	DSCF	82.43	84.49	91.52
PMOS	Percent Moisture by Vol		4.8	5.4	4.3
TS	Avg Stack Temperature	DEG.F	150.1	138.5	154.2
QS	Stk Flowrate, Dry, Std Cn	DSCFM	43723	44762	49840
QA	Actual Stack Flowrate	ACFM	54002	54665	61612
PERI	Percent Isokinetic		91.6	91.7	89.2

PARTICULATES -- PARTIAL CATCH^{a/}

MF	Particulate Wt-Partial	MG	83.80	22.00	97.40
CAN	Part Load-Ptl, Std Cn	GR/DSCF	0.0157	0.00401	0.0164
CAT	Part Load-Ptl, Stk Cn	GR/ACF	0.0127	0.00328	0.0133
CAW	Partic Emis-Partial	LB/HR	5.87	1.54	7.00

PARTICULATES -- TOTAL CATCH^{b/}

MT	Particulate Wt-Total	MG	140.20	71.40	164.00
CAO	Part Load-Ttl, Std Cn	GR/DSCF	0.0262	0.0130	0.0276
CAU	Part Load-Ttl, Stk Cn	GR/ACF	0.0212	0.0107	0.0223
CAX	Partic Emis-Total	LB/HR	9.81	4.99	11.8
IC	Perc Impinger Catch		40.23	69.19	40.61

LEAD -- PARTIAL CATCH^{a/}

MF	Wt-Partial	MG	33.52	5.35	45.97
CAN	Load-Ptl, Std Cn	GR/DSCF	0.00626	0.000980	0.00774
CAT	Load-Ptl, Stk Cn	GR/ACF	0.00507	0.000800	0.00626
CAW	Emis-Partial	LB/HR	2.35	0.370	3.30

LEAD -- TOTAL CATCH^{b/}

MT	Wt-Total	MG	33.71	5.64	46.05
CAO	Load-Ttl, Std Cn	GR/DSCF	0.00630	0.00103	0.00775
CAU	Load-Ttl, Stk Cn	GR/ACF	0.00510	0.000840	0.00627
CAX	Emis-Total	LB/HR	2.36	0.390	3.31
IC	Perc Impinger Catch		0.56	5.14	0.17
	Prod Rate	TON/HR	13.9	13.8	13.8
	Part Emis Ttl	LB/TON	0.706	0.362	0.855
	Lead Emis Ttl	LB/TON	0.170	0.0283	0.240
	Perc Lead Emis Ptl	%	40.0	24.0	47.1
	Perc Lead Emis Ttl	%	24.0	7.82	28.1
	Avg Perc Lead Emis Ptl	%		37.0	
	Avg Perc Lead Emis Ttl	%		20.0	

a/ Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

b/ Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

TABLE XVA

SUMMARY OF EMISSIONS FROM BLAST FURNACE BAGHOUSE - G STACK
(Metric Units)

Name	Description Date of Run	Units	G-3	G-4	G-7
			07-19-73	07-20-73	07-23-73
VMSTM	Vol Dry Gas-Std Cond	NCM	2.334	2.393	2.592
PMOS	Percent Moisture by Vol		4.8	5.4	4.3
TSM	Avg Stack Temperature	DEG.C	65.6	59.2	67.9
QSM	Stk Flowrate, Dry, Std Cn	NM3/MIN	1238.1	1267.5	1411.3
QAM	Actual Stack Flowrate	M3/MIN	1529.2	1547.9	1744.7
PERI	Percent Isokinetic		91.6	91.7	89.2
<u>PARTICULATES -- PARTIAL CATCH^{a/}</u>					
MF	Particulate Wt-Partial	MG	83.80	22.00	97.40
CANM	Part Load-Ptl, Std Cn	MG/NM3	35.83	9.18	37.51
CATM	Part Load-Ptl, Stk Cn	MG/M3	29.01	7.51	30.34
CAWM	Partic Emis-Partial	KG/HR	2.66	0.700	3.18
<u>PARTICULATES -- TOTAL CATCH^{b/}</u>					
MT	Particulate Wt-Total	MG	140.20	71.40	164.00
CAOM	Part Load-Ttl, Std Cn	MG/NM3	59.94	29.78	63.15
CAUM	Part Load-Ttl, Stk Cn	MG/M3	48.53	24.38	51.08
CAXM	Partic Emis-Total	KG/HR	4.45	2.26	5.35
IC	Perc Impinger Catch		40.23	69.19	40.61
<u>LEAD -- PARTIAL CATCH^{a/}</u>					
MF	Wt-Partial	MG	33.52	5.35	45.97
CANM	Load-Ptl, Std Cn	MG/NM3	14.33	2.23	17.70
CATM	Load-Ptl, Stk Cn	MG/M3	11.60	1.83	14.32
CAWM	Emis-Partial	KG/HR	1.064	0.170	1.499
<u>LEAD -- TOTAL CATCH^{b/}</u>					
MT	Wt-Total	MG	33.71	5.64	46.05
CAOM	Load-Ttl, Std Cn	MG/NM3	14.41	2.35	17.73
CAUM	Load-Ttl, Stk Cn	MG/M3	11.67	1.93	14.34
CAXM	Emis-Total	KG/HR	1.070	0.179	1.501
IC	Perc Impinger Catch		0.56	5.14	0.17
	Prod Rate	MTON/HR	12.6	12.5	12.5
	Part Emis Ttl	KG/MTON	0.353	0.181	0.428
	Lead Emis Ttl	KG/MTON	0.0849	0.0143	0.120
	Perc Lead Emis Ptl	%	40.0	24.0	47.1
	Perc Lead Emis Ttl	%	24.0	7.82	28.1
	Avg Perc Lead Emis Ptl	%		37.0	
	Avg Perc Lead Emis Ttl	%		20.0	

a/ Partial catch refers to the particulate and lead caught in the probe tip, probe, cyclone and filter.

b/ Total catch refers to all the particulate and lead caught in the partial catch plus the impingers.

Table VIA is the same except in metric units. Since the baghouse has three stacks, the average concentrations shown are calculated from weighted averages, based on stack flowrate, for each run. The collection efficiencies for the collection system, humidifying chamber, the excess air addition, lime addition and baghouse are 98+%. The data in Table VI show that most of the lead emitted from the baghouse was caught in the front half of the collection train (i.e., the probe tip, probe, cyclone and filter), and therefore is composed of larger particles. The particles caught in the impingers (which are located after the filter) are smaller than 0.3 μ in diameter and account for only 0.04 lb/hr emission. The filters used capture all particles larger than 0.3 μ in diameter.

Table VII summarizes the data by test. Table VIIA presents the data in metric units. For Test 3, the first test on the blast furnace and pollution control system, the efficiency of the collection system was 98.5-99.2%. In Test 4, the second test on the blast furnace and its pollution control system, the efficiency of the collection system varied from 99 to 99.6%. In Test 7, the third and final test on the blast furnace and its pollution control system, the collection efficiency varied from 95.4 to 98.9%. During the first and second emission tests on the blast furnace and control system, the bagshaking was done on a very irregular schedule.

Little or no automatic bagshaking occurred during the period when samples were being collected. While Test 7 (the last test) was being conducted, the bags were manually shaken several times in addition to the so-called automatic shaking. This test shows the lowest collection efficiency for the baghouse and the highest lead and particulate emissions. Shaking the bags cleans them and allows the fine material to pass through, rather than collecting on a particulate film covering the surface of the bag. The highest visible emissions occur during bagshaking.

Table VIII shows the pounds of particulate per ton of feed to the blast furnace, and Table VIIIA has the same information in metric units. The average emission rate for the uncontrolled particulate is 68 lb/ton of feed and for the particulate from the control system 0.959 lb/ton of feed.

Table IX has the particulate emission data in pounds per ton of lead produced and Table IXA in metric units. The average uncontrolled emission rate is 174 lb/ton of lead, and the average controlled emission rate is 2.47 lb/ton of lead.

Table X presents the emission factors for pounds of lead from the blast furnace per ton of feed to the furnace, and Table XA presents the data in metric units. The average uncontrolled emission rate is 20.8 lb of lead per ton of feed, and the average controlled emission rate is 0.405 lb/ton of feed.

Table XI presents the lead emission rate for ton of lead produced by the blast furnace, and Table XIA presents the data in metric units. The average uncontrolled emission rate is 23.0 lb of lead per ton of lead produced, and the average controlled emission rate is 0.450 lb of lead per ton of lead produced.

Table XII presents a summary of results from the emission tests on the duct from the blast furnace (7-ft diameter) to the control system. Table XIIA presents the same information in metric units. The percent lead in the particulate catch is: front half of train - average 12.7%; total catch - average 12.5%.

The particulate emissions in the total catch from sample location "D" (inlet duct to blast furnace control system) varied from 1,990 lb/hr to 2,690 lb/hr, and 144 lb/ton to 194 lb/ton. The lead emissions in the total catch varied from 193 lb/hr to 424 lb/hr, and from 14.0 lb/ton to 30.5 lb/ton.

Table XIII presents the summary of results from the three tests run on the baghouse exhaust stack E (Figure 2). Table XIII A presents the data in metric units. The percent lead in the particulate catch is: front half of train - average 28.3%; total catch - average 15.0%. The particulate emissions in the total catch varied from 12.2 lb/hr to 21.2 lb/hr and 0.884 lb/ton to 1.54 lb/ton. The lead emissions in the total catch ranged from 1.15 lb/hr to 3.70 lb/hr and 0.0833 lb/ton to 0.268 lb/ton.

Table XIV contains the summary of results for the emission tests from the baghouse exhaust stack F (Figure 2). Table XIVA presents the data in metric units. The average percent lead in the particulate catch is: front half of train 31.4%; total catch - 15.1%. The particulate emissions in the total catch ranged from 7.62 lb/hr to 8.65 lb/hr and from 0.509 lb/ton to 0.627 lb/ton. The lead emissions in the total catch ranged from 0.580 lb/hr to 1.92 lb/hr and 0.0417 lb/ton to 0.139 lb/ton.

Table XV contains the summary of results from the baghouse exhaust stack G (Figure 2). In Table XVA the data are presented in metric units. The average percent lead in the particulate catch from the front half of the train is 37.0%. The average percent lead in the particulate catch from the complete train is 20.0%. The particulate emissions in the total catch ranged from 4.99 lb/hr to 11.8 lb/hr and from 0.362 lb/ton to 0.855 lb/ton. The lead emissions in the total catch ranged from 0.390 lb/hr to 3.31 lb/hr and from 0.0283 lb/ton to 0.240 lb/ton.

Figures 3, 4, 5 and 6 and Tables XVI, XVII and XVIII refer to the Andersen particle size test program conducted at the blast furnace and baghouse exhaust stack F. The Andersen tests were conducted at point 3, port 3 of this stack (see Figure 14, p. 80). There were three particle size tests; Test F3A lasted 60 min, Test F4A 120 min, and Test F7A 92 min.

The Andersen sampler was used with a backup filter to capture particles not collected on the plates. The results, not including the filter net weight, are listed in Table XVII as "without filter." The results which include the filter net weight are listed as "with filter."

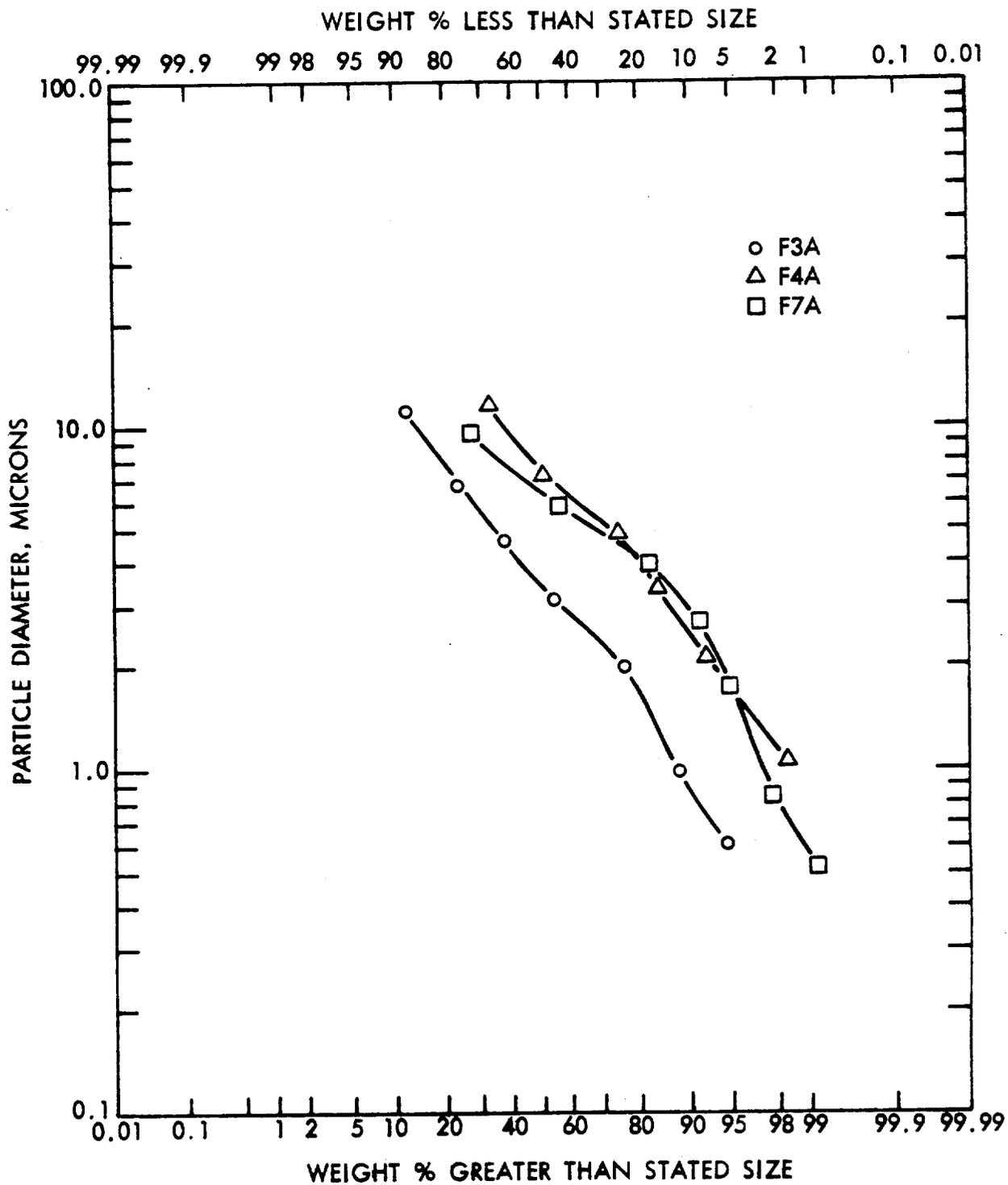


Figure 3 - Particulate Without Filter

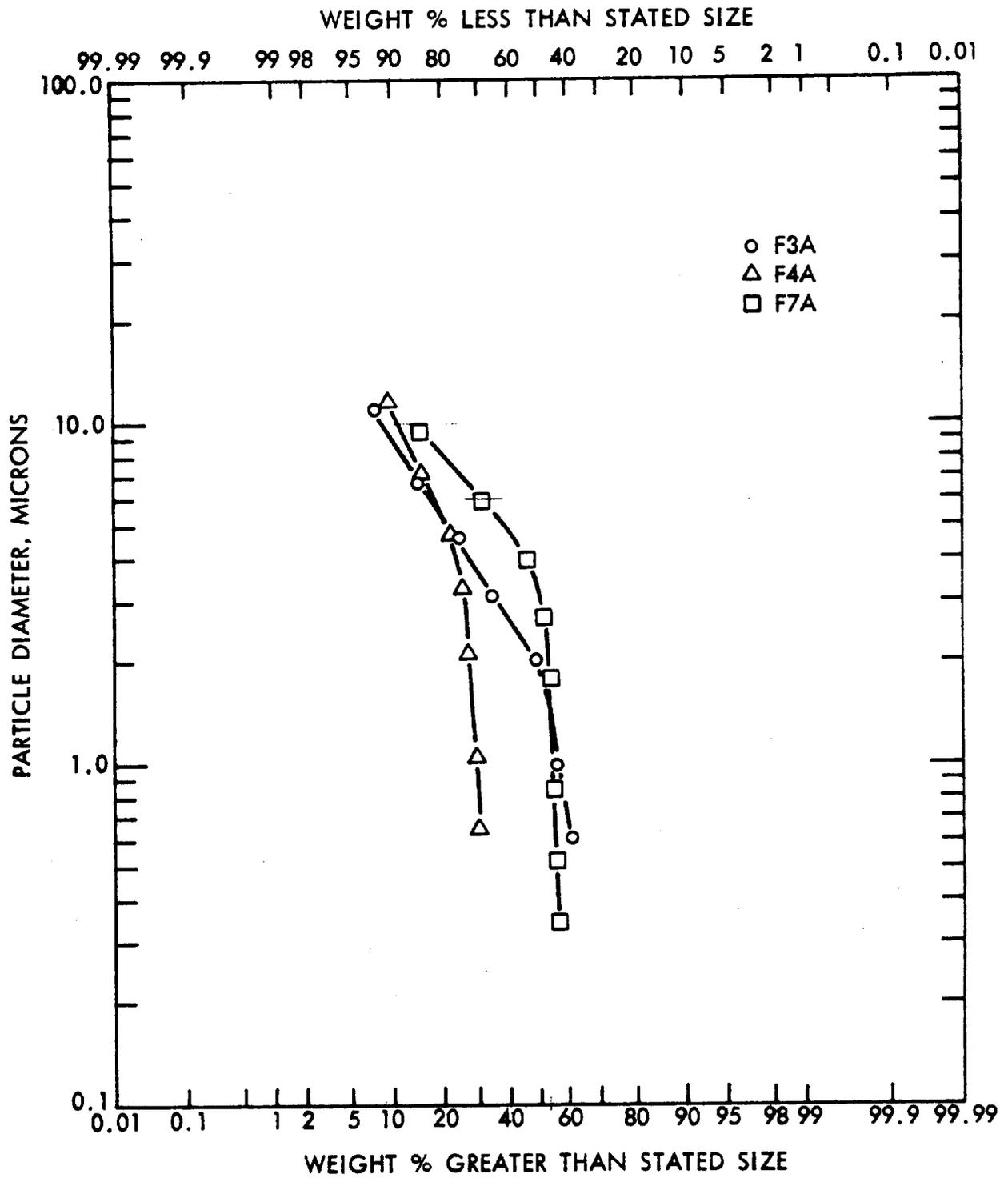


Figure 4 - Particulate With Filter

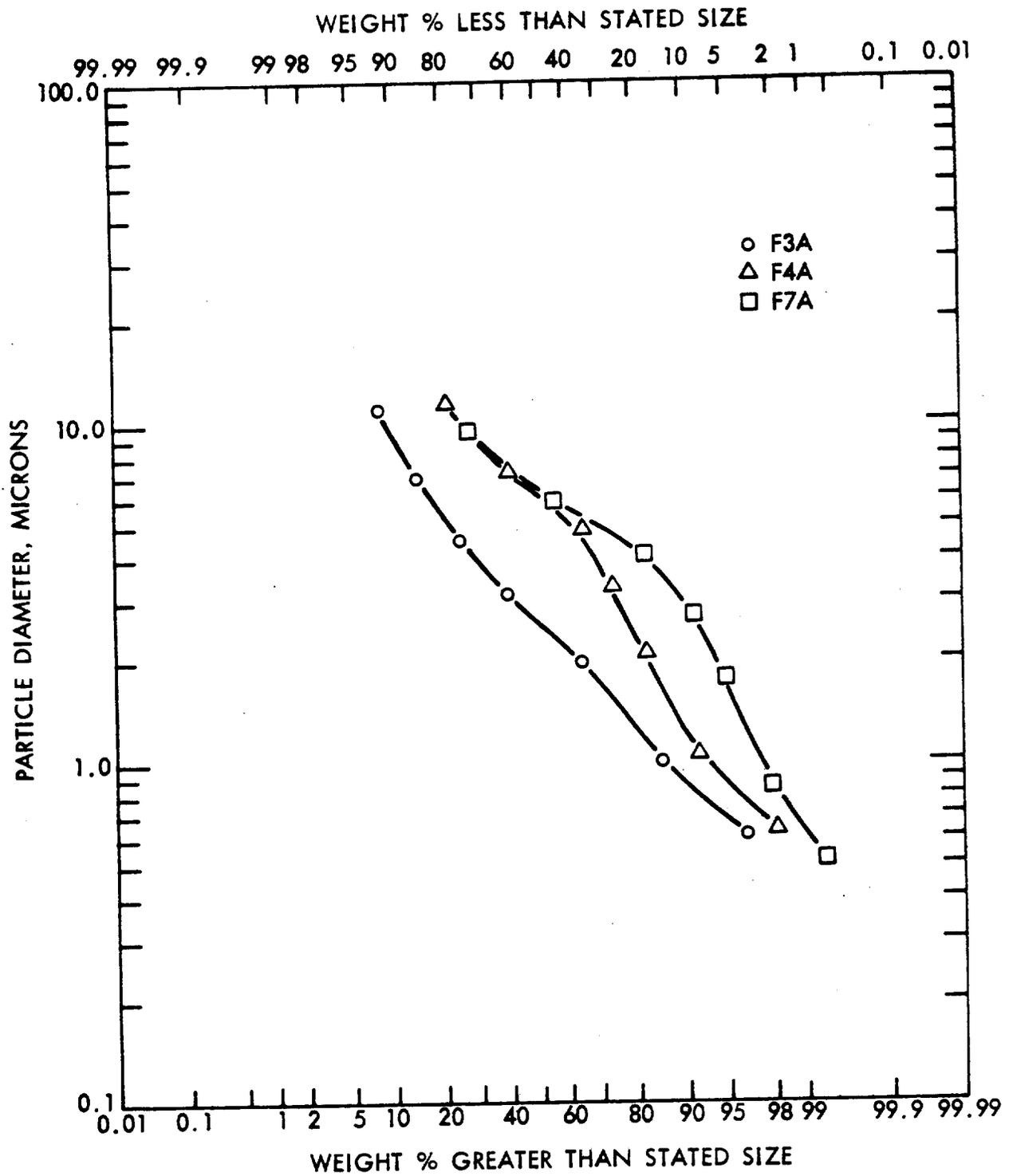


Figure 5 - Lead Without Filter

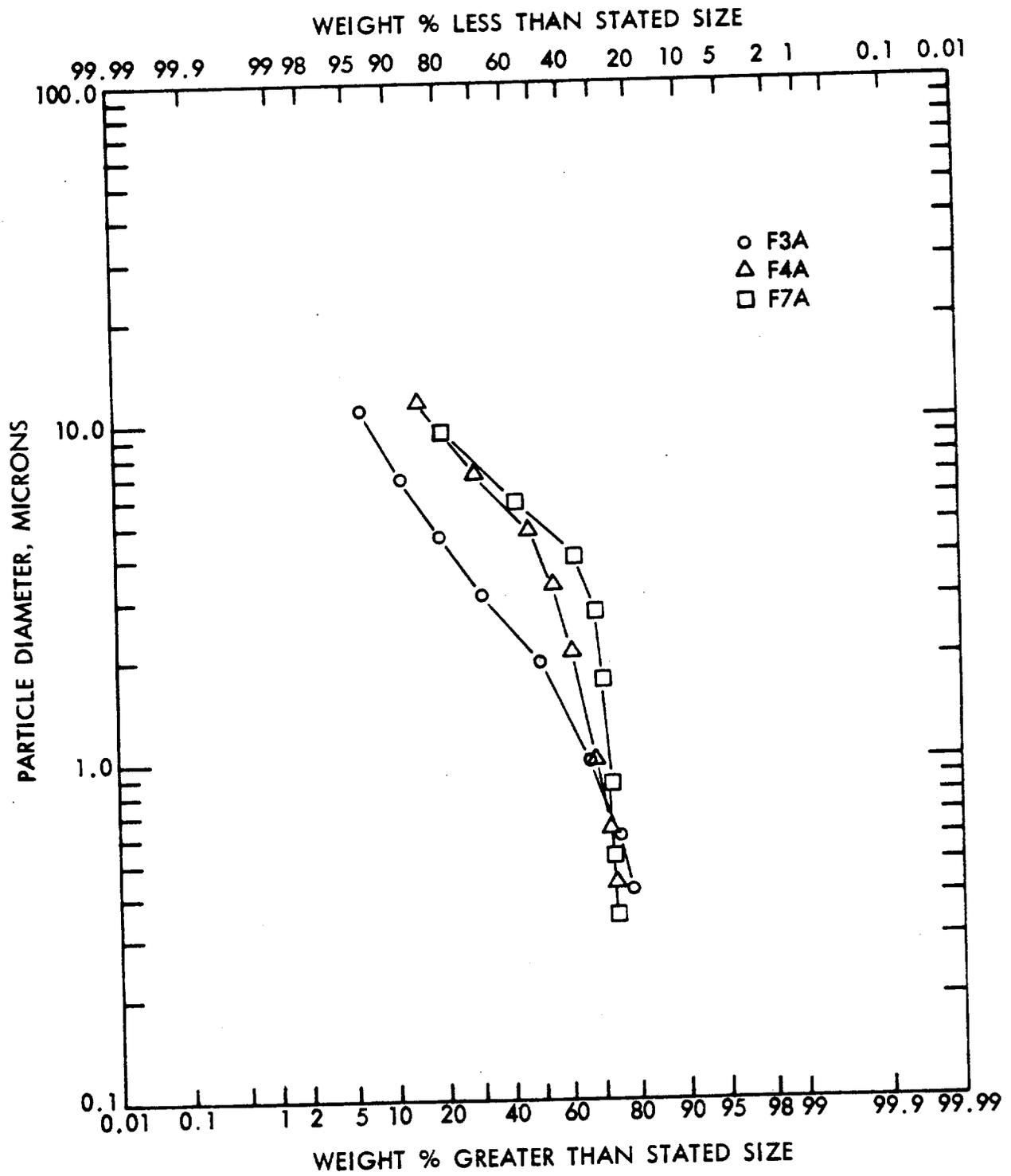


Figure 6 - Lead With Filter

TABLE XVI

PERCENT LEAD IN PARTICULATE FOR ANDERSEN TEST

<u>Plate No.</u>	<u>Wt. Part.</u> <u>(g)</u>	<u>Wt. Lead</u> <u>(mg)</u>	<u>% Lead</u>
F3A 0	0.00206	0.3515	17.1
1	0.00276	0.6765	24.5
2	0.00446	0.8265	18.5
3	0.00557	1.2765	22.9
4	0.00617	1.8265	29.6
5	0.00904	3.3265	36.8
6	0.00461	2.6015	56.4
7	0.00248	1.3415	54.1
8	0.00207	0.4365	21.1
Subtotal	0.03922	12.6635	32.3
Filter	<u>0.02370</u>	<u>3.3973</u>	<u>14.3</u>
Total	0.06292	16.0608	25.5
F4A 0	0.00105	0.4915	46.8
1	0.00084	0.3640	43.3
2	0.00110	0.7615	6.9
3	0.00142	1.0415	73.3
4	0.00057	0.3815	66.9
5	0.00045	0.3215	71.4
6	0.00035	0.3915	112.0
7	0.00010	0.2515	25.2
8	0.0	0.0	0.0
Subtotal	0.00588	4.0045	68.1
Filter	<u>0.01450</u>	<u>1.3823</u>	<u>9.5</u>
Total	0.02038	5.3868	26.4
F7A 0	0.01376	7.3265	53.0
1	0.02441	13.3515	54.7
2	0.04042	21.9765	54.4
3	0.03737	21.2265	56.8
4	0.01261	6.5265	51.8
5	0.00510	2.9265	57.3
6	0.00402	2.1265	52.9
7	0.00211	1.3265	62.9
8	0.00116	0.4915	42.4
Subtotal	0.14096	77.2785	54.8
Filter	<u>0.10490</u>	<u>25.4723</u>	<u>24.3</u>
Total	0.24586	102.7508	43.7

TABLE XVII (Continued)

ANDERSEN ANALYSIS SUMMARY

STAGE/ PLATE	RUN NUMBER DATE	F4A 072073	DENSITY= IMP.EFF.C=	1.000 .140	SAMPLING RATE =	.70920 CFM	FILTER WT= TOTAL WT=	.01360 GM .01948 GM	--WITHOUT FILTER--				--WITH FILTER--				JET VEL. (CM/S)	PARTIC. DIAM. (MICR)	
							WEIGHT PERCENT	WEIGHT PERCENT	WEIGHT PERCENT	WEIGHT PERCENT	WEIGHT PERCENT	WEIGHT PERCENT	WEIGHT PERCENT	WEIGHT PERCENT	CUM. WEIGHT PERCENT	CUM. WEIGHT PERCENT			
/0							17.86	17.86	17.86	5.39	5.39	5.39	5.39	5.39	5.39	5.39			11.54
0/1							14.29	14.29	32.14	4.31	9.60	14.29	9.60	14.29	9.60	14.29			7.20
1/2							18.71	18.71	50.85	5.65	15.35	24.15	15.35	24.15	15.35	24.15			4.88
2/3							24.15	24.15	75.00	7.29	22.64	24.15	22.64	24.15	22.64	24.15			3.32
3/4							9.69	9.69	84.69	2.93	25.56	9.69	25.56	25.56	25.56	25.56			2.13
4/5							7.65	7.65	92.35	2.31	27.87	7.65	27.87	27.87	27.87	27.87			1.06
5/6							5.95	5.95	98.30	1.80	29.67	5.95	29.67	29.67	29.67	29.67			.65
6/7							1.70	1.70	100.00	.51	30.18	1.70	30.18	30.18	30.18	30.18			.44
7/8							.00	.00	100.00	.00000	30.18	.00	30.18	30.18	30.18	30.18			.44

TABLE XVII (Concluded)

ANDERSEN ANALYSIS SUMMARY

RUN NUMBER 072373 F7A DENSITY= 1.000 SAMPLING RATE = 1.03750 CFM FILTER WT= .10490 GM
 DATE IMP.EFF.CE .140 TOTAL WT= .24586 GM

STAGE/ PLATE	SAMPLE PLATE + PAN	PAN FOR SAMPLE	TARE PLATE + PAN	PAN FOR TARE	TARE OF PLATE	SAMPLF WEIGHT (GM)	--WITHOUT FILTER--				--WITH FILTER--				PARTIC. DIAM. (MICR)
							WEIGHT PERCENT	WEIGHT PERCENT	CUM. WEIGHT PERCENT	JET VEL. (CM/S)	WEIGHT PERCENT	WEIGHT PERCENT	CUM. WEIGHT PERCENT	JET VEL. (CM/S)	
0/0	47.61919	17.33652	47.77276	17.50385	30.26891	.01376	9.76	9.76	5.60	5.60	5.60	79.88	9.52		
0/1	37.38215	17.49122	37.37055	17.50403	19.86652	.02441	17.32	27.08	15.53	15.53	15.53	148.97	5.94		
1/2	38.01382	17.34025	38.13734	17.50419	20.63315	.04042	28.67	55.75	16.44	31.97	31.97	248.54	4.02		
2/3	38.41076	17.51814	38.35971	17.50446	20.85525	.03737	26.51	82.26	15.20	47.17	47.17	410.96	1.75		
3/4	39.06809	17.33916	39.22112	17.50480	21.71632	.01261	8.95	91.21	5.13	52.29	52.29	1767.41	.86		
4/5	29.08781	17.51060	29.07705	17.50494	11.57211	.00510	3.62	94.83	2.07	54.37	54.37	3221.11	.53		
5/6	29.02014	17.34482	29.17675	17.50545	11.67130	.00402	2.85	97.68	1.64	56.00	56.00	6442.22	.35		
6/7	28.92835	17.51553	28.91633	17.50562	11.41071	.00211	1.50	99.18	.86	56.86	56.86				
7/8	37.89888	17.34322	38.06024	17.50574	20.55450	.00116	.82	100.00	.47	57.33	57.33				

2/F

6.35

TABLE XVIII

ANDERSEN ANALYSIS SUMMARY (LEAD)

	<u>mg Pb</u>	<u>gm Partic</u>	<u>mg Pb/gm Partic</u>	<u>Pb without Filter</u>		<u>Pb with Filter</u>		<u>Particle Diameter (μ)</u>
				<u>Weight (%)</u>	<u>Cum Weight (%)</u>	<u>Weight (%)</u>	<u>Cum. Weight (%)</u>	
<u>Run F3A</u>								
0	0.3515	0.00206	171	2.8	2.8	2.2	2.2	
1	0.6765	0.00276	245	5.3	8.1	4.2	6.4	10.99
2	0.8265	0.00446	185	6.5	14.6	5.1	11.5	6.86
3	1.2765	0.00557	229	10.1	24.7	7.9	19.4	4.65
4	1.8265	0.00617	296	14.4	39.1	11.4	30.8	3.16
5	3.3265	0.00904	368	26.3	65.4	20.7	51.5	2.03
6	2.6015	0.00461	564	20.5	85.9	16.2	67.7	1.01
7	1.3415	0.00248	541	10.6	96.5	8.3	76.0	0.62
8	0.4365	0.00207	211	3.5	100.0	2.7	78.7	0.42
Filter	3.3973	0.0237	143			21.3	100.0	
<u>Run F4A</u>								
0	0.4915	0.00105	468	12.0	12.0	9.0	9.0	
1	0.3640	0.00084	433	8.9	20.9	6.7	15.7	11.54
2	0.7615	0.00110	692	18.7	39.6	13.9	29.6	7.20
3	1.0415	0.00142	733	25.5	65.1	19.1	48.7	4.88
4	0.3815	0.00057	669	9.3	74.4	7.0	55.7	3.32
5	0.3215	0.00045	714	7.9	82.3	5.9	61.6	2.13
6	0.3915	0.00035	1,119	9.6	91.9	7.2	68.8	1.06
7	0.2515	0.00010	2,515	6.2	98.1	4.6	73.4	0.65
8	0.0755	0	--	1.9	100.0	1.3	74.7	0.44
Filter	1.3823	0.0145	95.3			25.3	100.0	
<u>Run F7A</u>								
0	7.3265	0.01376	532	9.5	9.5	7.1	7.1	
1	13.3515	0.02441	547	17.3	26.8	13.0	20.1	9.52
2	21.9765	0.04042	544	28.4	55.2	21.4	41.5	5.94
3	21.2265	0.03737	568	27.5	82.7	20.6	62.1	4.02
4	6.5265	0.01261	518	8.4	91.1	6.4	68.5	2.73
5	2.9265	0.00510	574	3.8	94.9	2.8	71.3	1.75
6	2.1265	0.00402	529	2.8	97.7	2.1	73.4	0.86
7	1.3265	0.00211	689	1.7	99.4	1.3	74.7	0.53
8	0.4915	0.00116	424	0.6	100.0	0.5	75.2	0.35
Filter	25.4723	0.1049	243			24.8	100.0	

Figures 3, 4 and 5 are plots of the data in Table XVII using the cumulative weight percent as the "weight % greater than stated size" and using the particle diameter in microns calculated from MRI's Andersen computer program, a development of the Ranz and Wong equation.^{1/}

Figure 3 shows the particle size distribution of the particles caught in the Andersen analyzer for all three tests. In Test F3A, 94.5% of the particles are larger than 0.62 μ , and 12% are larger than 11 μ . Test F4A shows that 98.3% of the particulates are larger than 1.1 μ , and 32% are larger than 11.5 μ . The results of Test F7A show that 99.2% are larger than 0.52 μ , and that 27% are larger than 9.6 μ .

Figure 4 presents the results of the particulate size analysis including the particles that passed through the Andersen and were caught on the filter. In Test F3A, 62% of the particles are larger than 0.62 μ , and 8% are larger than 11.1 μ . The results of Test F4A show that 30% of the particles are larger than 0.66 μ , and that 9.5% of the particles are larger than 11.15 μ . Test F7A shows that 58% of the particles are larger than 0.35 μ , and 16% are larger than 9.6 μ .

The particle size analysis of the particulate emissions shows that more than 65% of the material emitted is smaller than 3.5 μ , and about half of the particulate emission is smaller than 1 μ .

^{1/} Ranz, W. E., and J. B. Wong, "Jet Impactors for Determining the Particle Size Distribution of Aerosols," Industrial Hygiene and Occupational Medicine, Vol. 5, pp. 464-477 (1952).

The data for the Andersen particle size tests are presented in two ways. The first presentation is for the particles which are caught on the Andersen plates. This gives a particle size distribution from about 0.6 μ to 11 μ .

The data including filter are presented to spread the particle size distribution from 0.3 μ to 11 μ . The purpose of the filter is to catch small particles which pass through the Andersen without being captured.

Figure 5 shows the plot as a result of the analysis for lead of the particulate catch during the Andersen test. This does not include the material caught on the filter. The figure shows that on the average 96.0% of the lead was larger than 0.7 μ , and that half of the lead was found in particles larger than 5 μ .

Figure 6 presents the lead data for the same three runs but includes the lead caught on the filter. About 24% of the lead was smaller than 0.4 μ , and 80% of the lead was smaller than 9.0 μ .

Table XVI presents the percent lead in the particulate on each stage of the Andersen particle size analyzer as well as on the filter for each of the three tests. The percent lead in the total catch varied from 25.5 to 43.7% with Test F7A having the highest percentage lead. The difference in method and frequency of bagshaking between the first two tests when the bags were shaken very infrequently and Test 7 (D, E, F, G and FA) when the bags were shaken manually every 25 min explains the higher particulate and lead yield for Test 7. The same reasoning might explain the higher percentage lead in the total Andersen catch.

Table XVIII is a summary of the analytical data for lead on the particulate catch; in the Andersen tests the filter weights are included.

IV. PROCESS DESCRIPTION AND OPERATION

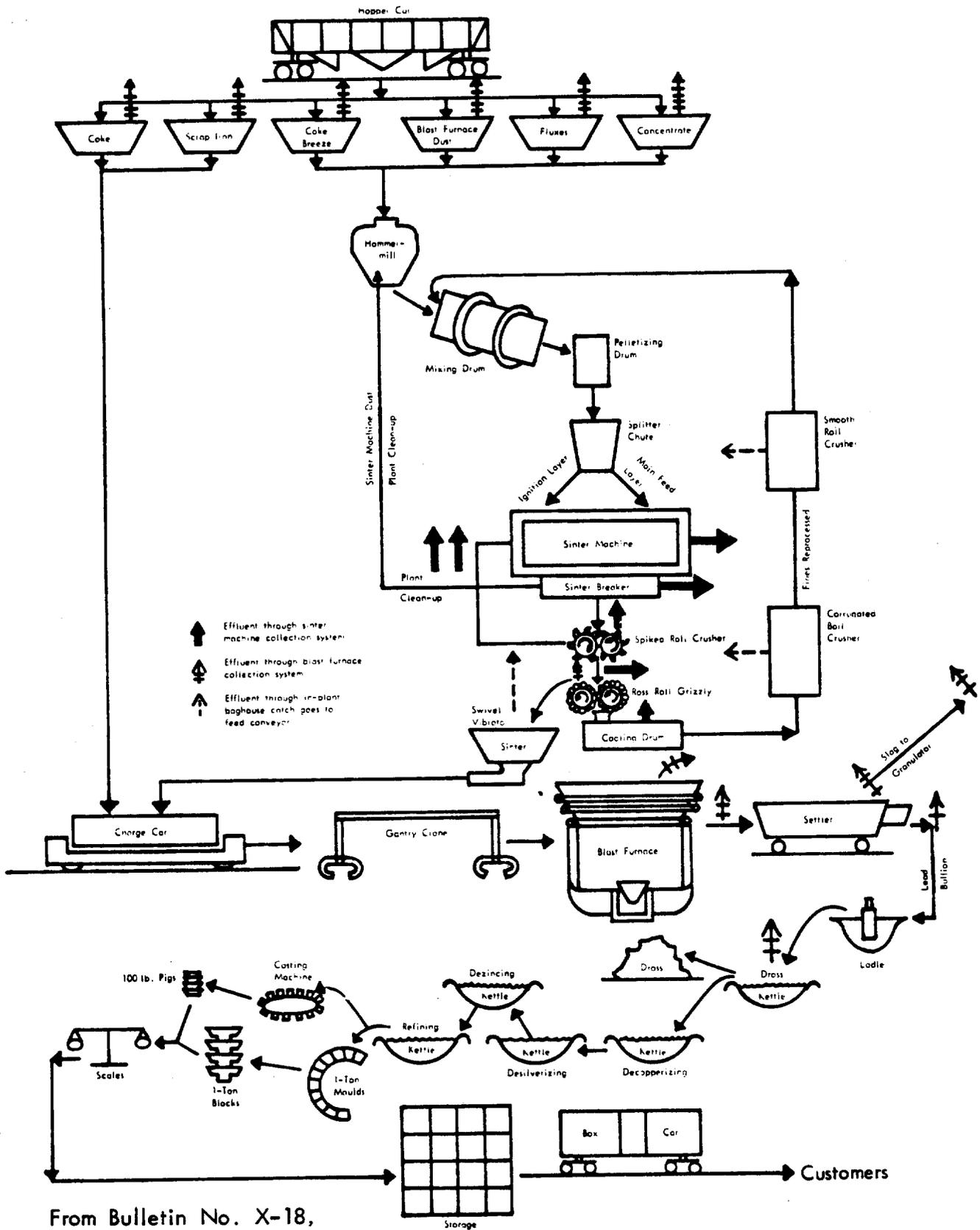
A. Process Flow^{1/}

The ASARCO smelter at Glover is a custom smelter in that all ore is purchased from other companies. It has a design capacity of 90,000 tons of lead per year and started production in 1968. The average inlet concentrate analysis is 70-75% lead, 2-1/2% zinc, and 1% copper. Figure 7 is the Glover plant flow sheet. The plant is further described in the following paragraphs.

1. Sinter machine: ASARCO's plant at Glover has a highly automated updraft sinter machine designed to handle more than 1,500 tons of material per day. Figure 8 is a photograph showing the sinter machine, mixing drum, feed conveyors and updraft fans. A lead charge which is sized, mixed, pelletized, and moistened, is fed to the sinter machine where sulfur is eliminated and the heat of the oxidizing reactions converts the charge to a fused cellular cake, known as sinter. The basic chemical reactions are as follows:

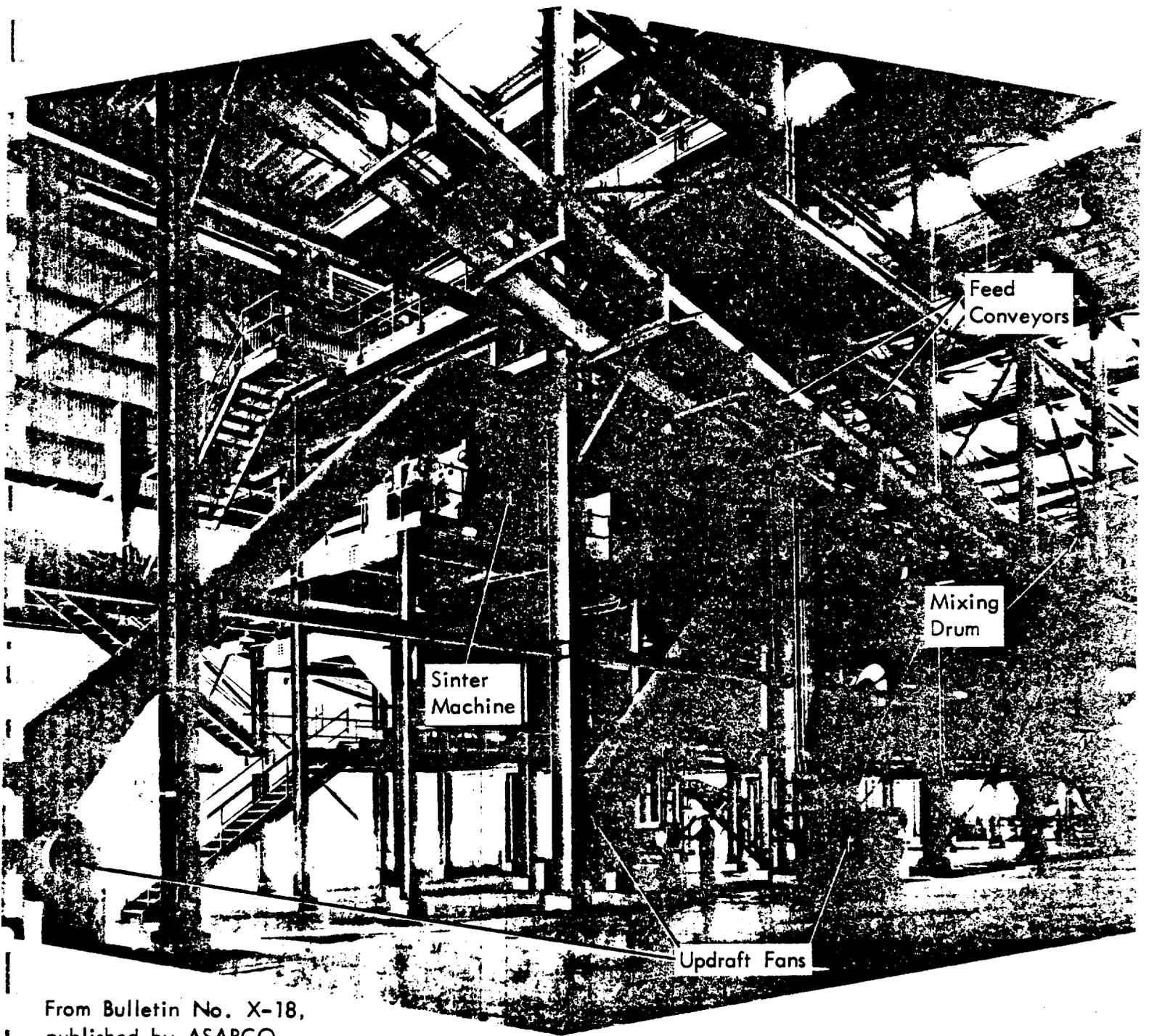
^{1/} The following process description is based on information obtained from plant personnel, Bulletin No. X-18, published by ASARCO, AIME World Symposium on Mining and Metallurgy of Lead and Zinc, Donald O. Rauski and Burt C. Auacher, Eds. AIME, New York (1970); and Lead--Progress and Prognosis: The State of the Art: Lead Recovery, A. Worcester and D. H. Beilstein, TMS, AIME, New York, Paper No. A71-87.

GLOVER PLANT FLOW SHEET



From Bulletin No. X-18,
published by ASARCO.

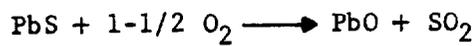
Figure 7



From Bulletin No. X-18,
published by ASARCO.

Sinter Plant

Figure 8



Charge materials to the sinter machine include lead concentrates, return sinter, blast furnace slag, and "plant clean-up" materials. The lead concentrate is conveyed from a storage bin through a Pennsylvania Impactor where six hammers break the material into smaller pieces. Return sinter, which consists of fines rejected from the final product of the sinter machine, is added to the sulfur-containing lead concentrates to dilute the total sulfur content down to a level that can be handled by the machine (5-6%). Return sinter passes through a cooling drum where it is quenched and then onto an enclosed conveyor which takes it through two crushers (corrugated rolls and smooth rolls) and finally to a storage bin.

Slag from the blast furnace which contains a minimum of 3% lead travels by conveyors to the sinter plant. Spillage from the sinter machine, sinter breaker, spiked rolls and windbox cleanings is picked up by two apion conveyors and, together with floor clean-up and baghouse dust, are conveyed to a storage bin and then through the Pennsylvania Impactor. The concentrate, return sinter, slag, and plant clean-up are fed through two 3.05-m by 9.5-m mixing drums where the feed is moistened and conditioned.

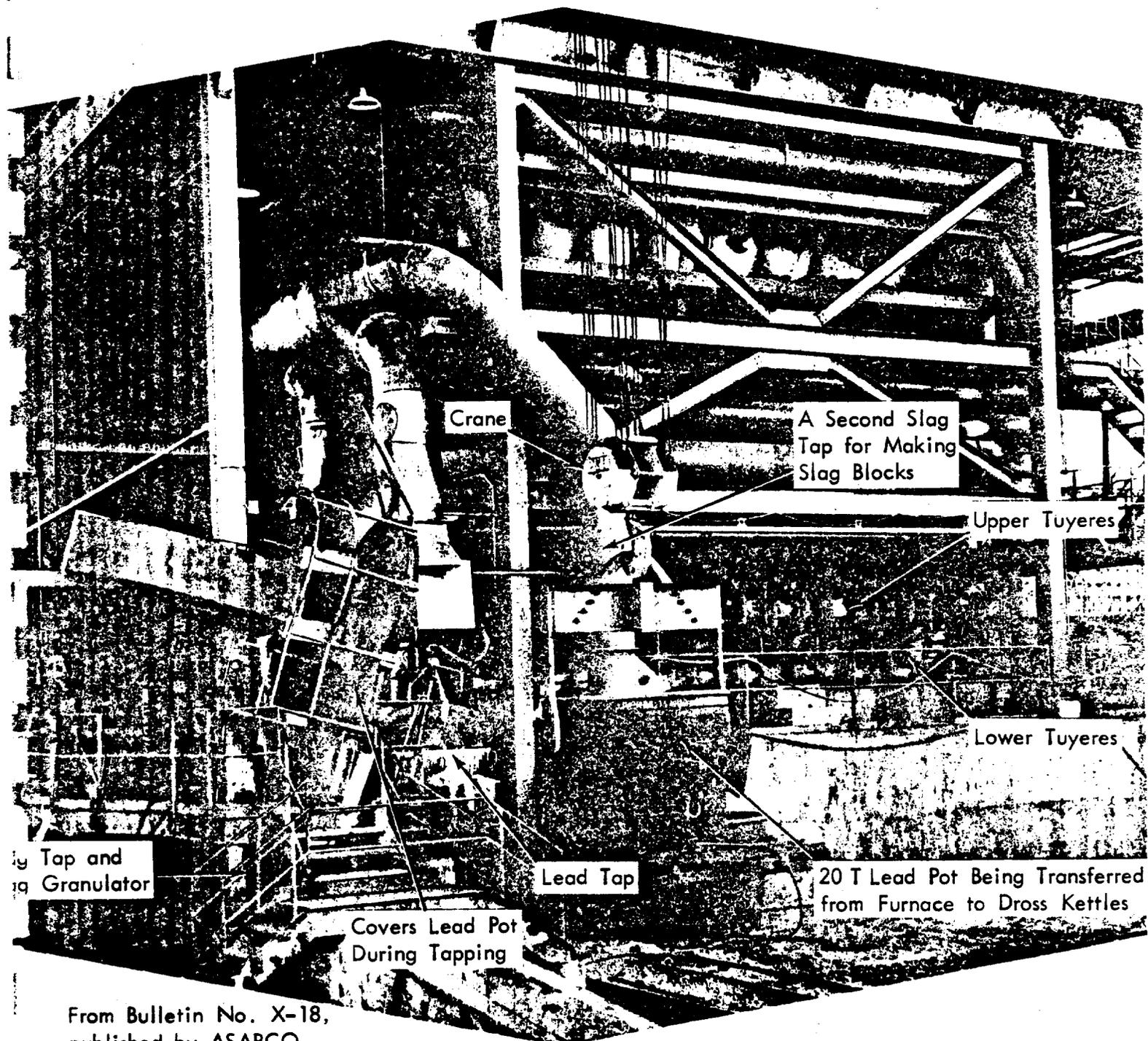
The feed is conveyed to a splitter chute where it is divided into an ignition layer and a main feed layer. A baffle diverts part of the feed into the hopper for the ignition layer, and when that demand is satisfied, the majority of the feed passes into the main feed hopper. The ignition

layer passes through a vibrating grizzly which rejects oversized material and returns it to the main feed hopper. The ignition feed is distributed evenly across the width of the machine by shuttle conveyors operated by a hydraulic system and then passes through a gas-fired ignition muffle which is over a downdraft windbox. The main feed layer is next placed on top of the ignition layer and the entire bed flows through the updraft section of the machine, which is 29 m in length and consists of 12 windboxes each 2.44 m long. In the updraft section of the machine, the airflow is reversed so that the heat from the ignition layer flows upward to ignite the main feed layer. The material burns as it travels the length of the machine. The material is cooled as it reaches the end of the machine "so that the cake will not collapse nor will metallic lead run out of the sinter to blind the pallet grate bars" (Rauski and Mauacher, p. 78). The sinter passes into the sinter breaker and then to a spiked roll, where the material is pulverized. Spillage from these pulverizers is passed onto the clean-up conveyors as part of the plant clean-up that is later recharged to the sinter machine. A pan conveyor transfers the hot sinter from the spiked roll to the Ross Classifying Rolls. The coarser sinter is pushed by the Ross Rolls into one of two sinter bins which feed the furnace. A swivel vibrator diverts the sinter into one of the two bins according to the level of material within each. The fine sinter falls through the Ross Rolls into a storage bin and then passes through the cooling drum as return sinter to the sinter machine.

Two small baghouses within the sinter plant handle ventilation air from the conveyors and crushers for the return sinter. The material collected by the baghouses is added directly to the belt carrying the sinter feed. In addition, a wet scrubber system is planned for in-plant ventilation.

Air from the sinter machine passes through a main duct to the water spray chamber and then into the sinter plant baghouse. Ventilation air from the sinter breaker, the spiked roll, the pan conveyor which carries the product sinter to the Ross Rolls, two clean-up conveyors, and the cooling drum, passes through a second, auxiliary duct to the water spray chamber and into the sinter plant baghouse. Ventilation air from the Ross Classifying Rolls and swivel vibrator (transfer of sinter to storage bin) is cleaned by the blast furnace control system.

2. Blast furnace: ASARCO has an Australian step jacket design blast furnace, with a nominal capacity of 300 tons of lead boullion per day. The furnace proper is 7.6 m long, 1.5 m wide at the lower tuyeres and 3.0 m wide at the upper tuyeres. A blower can provide up to 510 cu m of air per minute at 0.26 kg/sq cm to the furnace. This air is distributed between the lower and upper tuyeres by a proportioning controller. The lower section of the furnace, where the tuyeres are located, is tapered (see Figure 9). The top of the furnace, where charging takes place and effluent gases are ducted to the control system, is of a typical thimble top design.



Crane

A Second Slag Tap for Making Slag Blocks

Upper Tuyeres

Lower Tuyeres

Tap and Granulator

Lead Tap

20 T Lead Pot Being Transferred from Furnace to Dross Kettles

Covers Lead Pot During Tapping

From Bulletin No. X-18, published by ASARCO.

Blast Furnace

Figure 9

A large building at ASARCO houses all receiving and storage bins for the sinter machine and blast furnace. The charge materials for the furnace, consisting of coarse sinter, iron, coke, caustic skims, etc., are stored in a row of bins. The charge materials are automatically weighed as they pass through feed hoppers into a charge car. The charge car is positioned on a transfer car and moved along a track which runs past the row of feed hoppers to the side of the furnace. An automated gantry crane lifts the charge car from the transfer car and elevates it to the top of the furnace where the contents are dumped through the bottom of the car. According to the management, the charge to the furnace was a constant mixture of feed materials during the course of the test program. Charging usually takes place 17-18 times per shift.

A Roy tapper is situated at the front of the furnace, where a continuous stream of molten material flows from a 5-ft long slit in the furnace into a box-shaped settler. As the material cools in the settler, the lead settles to the bottom and the slag accumulates at the top. The lead is tapped continuously into 20 T ladles. The slag is tapped continuously into a slag granulator where two jets of water break the slag into small granules of material. The water forces the slag from the granulator underground to an elevator. The elevator transports the slag up to a pair of wooden silos for dewatering. From there the slag with a relatively high lead content (3.2 Pb - June) is transferred by conveyor to the sinter machine and the slag with a low lead content is transported by truck to a

dumping area. A second slag tap is occasionally used, if a customer specifies a need. The second slag tap, similarly to the lead tap, consists of a continuous flow of material directly from the settler into large ladles to form solid slag blocks. Ventilation gases from the front of the furnace, including the Roy tapper, the two slag taps, and the lead tap, are handled by one fan, and pass through the blast furnace water spray chamber and baghouse. Ventilation air from the slag granulator is handled by a separate fan, but is also ducted through the blast furnace control system.

When a 20 T lead ladle has been filled, the lead tap is plugged, the hooding over the ladle is lifted, and the ladle is transferred by a 27-ton crane to one of two dross kettles. The lead ladle is partially covered by a lid to minimize fuming during tapping, during transfer of the lead ladle to the dross kettle, and during pouring of the molten lead into the dross kettle.

A dome-shaped hood is used to cover the dross kettles for ventilation only during pouring of the molten lead into the dross kettles. This ventilation air passes through the blast furnace control system.

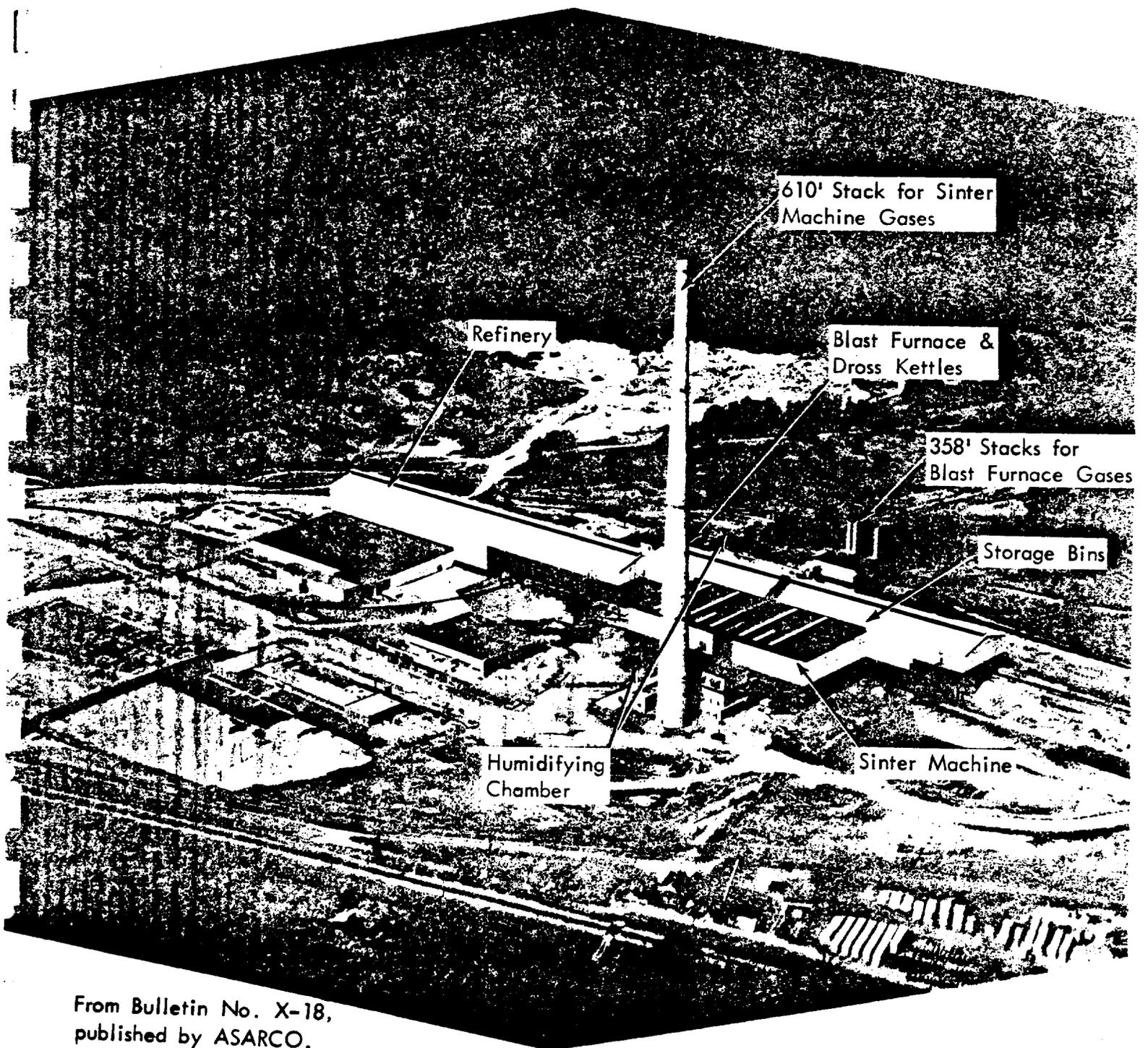
There are two dross kettles, one with a capacity of 300 tons and the other with a capacity of 250 tons. The lead is poured into one of two kettles which is maintained at 540°C. The copper solidifies and floats to the top where it is drossed off. The lead which remains is transferred to a second dross kettle which is maintained at a temperature of approximately 425°C. The copper dross from the second kettle and some drosses from the

refinery are transferred back to the first kettle to reclaim lead that may be mixed in the copper dross. In several of the lead smelters, the copper dross is treated in a reverberatory furnace to make copper matte, but at ASARCO in Glover the copper dross is transferred by rail to a separate facility for treatment. The lead from the dross kettles is transferred by crane to the refinery.

3. Refinery system: Figure 10 is an aerial photo of the smelter which shows the baghouses and the exhaust stacks as well as the general outline of the buildings, along with the humidifying chambers. The humidifiers and baghouses are the control systems. ASARCO operates a refinery at the Glover plant which removes impurities from the lead bullion and casts the metal into 100-lb pigs or 1-ton blocks for shipment. The refinery was surveyed during the course of the testing, but no emission tests were conducted at this facility.

The lead concentrate at the Glover plant contains a high percentage of lead and minimal impurities compared with the two other ASARCO plants. The lead bullion passes through a series of four kettles for decopperizing, desilverizing, and dezincing and then to a fifth kettle for refining with caustic soda and sodium nitrate before it is cast into pigs or blocks.

No visible emissions were observed within the plant. None of the refinery kettles are vented to the outside. The only two operations vented to the outside are combustion air from heating of the kettles and air from the baghouse used to collect zinc produced in a zinc-silver separating retort.



From Bulletin No. X-18,
published by ASARCO.

Aerial View

Figure 10

B. Control Systems

1. Sinter machine water spray chamber and baghouse: Effluent gases from the sinter machine, two clean-up conveyors, sinter breaker, spiked roll, pan conveyor, and the cooling drum are vented through a water spray chamber and a baghouse containing microtan synthetic bags which are resistant to the high temperature of the sintering machine exhaust. The inlet to the water spray chamber from the sinter machine is 450°-500°C. The inlet to the water spray chamber from the discharge system is 150°C.

The sinter plant baghouse was designed by ASARCO and is an enclosed concrete structure of the compartmented, pressure type with a design efficiency of 99.8%. The bags are 12-1/2 in. diameter by 20 ft long with 204 per compartment and the bags had an average age of 9 months during our test. The baghouse is inspected daily to insure proper maintenance of the bags.

In the sinter machine control system for the purpose of cooling, an undetermined quantity of air is introduced through a vent located between the water spray chamber and baghouse. The nine compartment baghouse (total cloth area 129,000 sq ft) has an inlet gas rate of 232,000 ACFM at 204°F (air-to-cloth ratio of 1.8 or 2.0 ACFM per sq ft with one compartment being cleaned). Gases from the baghouse are vented through a 12 in. thick, 610 ft tall concrete stack of 20 ft diameter. The stack has four temperature monitors which in conjunction with a ground level ambient air SO₂ monitor, are used to regulate the smelter production rate based upon weather

conditions to prevent an excess ground level concentration of SO₂. There is a sampling house on the ductwork between the baghouse and stack which has an "Askania" sampler. This bag sampler collects a continuous isokinetic sample at one point for a 3-4 day period after which the collected material is weighed.

The water used in the spray chamber is recycled continuously. The baghouse dust is burned to prevent ignition and to compact the dust. Both the water spray chamber and the baghouse are cleaned out every 3 weeks, and the collected material is recycled through the sinter machine. A grab sample from each of these systems is analyzed for lead at this time.

The baghouse compartments shake consecutively once the pressure has reached a specified point. Each compartment shakes for approximately 33 sec; a complete baghouse shake continues for 6 min 40 sec.

From 1 January 1973 through 16 July 1973 the sinter machine water spray chamber has collected on the average 19 tons of particulate per day (54.2% Pb) and the sinter machine baghouse has collected on the average 33.5 tons of particulate per day (59.7% Pb). These figures are based on measurements made when the control system is cleaned (approximately every 3 weeks).

2. Blast furnace water spray chamber and baghouse: Effluent gases from the blast furnace, swivel vibrator (transfer of sinter to storage bins), Ross Classifying Rolls, dross kettles, Roy Tapper, slag granulator, lead tap, slag taps and feed hopper drop points are cooled in a water spray chamber before going to the baghouse.

The blast furnace baghouse was designed by ASARCO and is an enclosed concrete structure of the compartmented, pressure type with a design efficiency of 99.8%. The blast furnace baghouse contains wool bags which are less flammable than synthetic bags. The bags are 12-1/2 in. diameter by 20 ft with 204 in each of six compartments and the average age of the bags was 8.2 months. The baghouse is inspected daily to insure proper maintenance of the bags. The six compartment baghouse (total cloth area 77,000 sq ft) has an inlet gas rate of 131,000 ACFM at 137°F (air-to-cloth ratio of 1.7 or 2.0 ACFM per sq ft with one compartment being cleaned). Gases from the baghouse are vented through three 58-ft stacks, each handling gases from two compartments.

An undetermined quantity of air is introduced through a vent between the water spray chamber and baghouse for cooling purposes. In the blast furnace control system, lime is also added between the water spray chamber and the baghouse to aid in collection efficiency and to retard ignition of collected dust.

The bags in each compartment are mechanically vibrated for cleaning. A damper is closed to prevent flow while vibrating and left closed for about 20 sec after vibration to allow particulate settling. Compartments are cleaned on a rotation basis when the pressure drop across the baghouse exceeds 3 in. of water. If cleaning one compartment fails to lower the pressure drop enough to satisfy the present value, the next compartment is cleaned. During the testing program, it was observed that two compartments were generally cleaned at one time.

The collected dust from the blast furnace operation usually contains a high percentage of lead and appreciable quantities of cadmium and arsenic. From 1 January 1973 through 16 July 1973, the blast furnace water spray chamber has collected on the average 10.8 tons of particulate per day (56.0% Pb), and the blast furnace baghouse has collected on the average 30 tons of particulate per day (56.0% Pb). These figures are based on measurements made when the control system chambers are cleaned out (approximately every 1-1/2 to 2 weeks).

C. Sampling Conditions

1. Sinter machine: An isokinetic sample could not be obtained with the EPA train at the outlet of the sinter machine baghouse. There is no port in the stack, and the breeching between the baghouse and the stack is not enough duct diameters long for isokinetic sampling. Outlet measurements are therefore based on results from the Askania sampler which is operated continuously by the plant. Three inlet tests were conducted upstream from the water spray chamber, thus providing information on uncontrolled emissions from the sinter machine and from auxiliary operations (crushers, conveyors, cooling drum, etc.) associated with the sinter machine. A particulate sizing test on the two inlet ducts was planned but was not completed due to sampling problems. The Askania sampler, which consists of a bag filter, collects an isokinetic sample from the single point of average velocity. For the purposes of this test, a pre-weighed clean bag was inserted in the sampler at 8:30 a.m. on 20 July and removed 23 July at 4:00 p.m.

Historically the lead companies have installed the pollution control equipment (water spray chamber and baghouse) as material recovery systems, part of their production equipment. Recovery of lead, not pollution control, was the primary reason for the installation of the baghouse. In order to more nearly complete their material balance calculations, which are made on a yearly basis, ASARCO decided that they should make an attempt to sample the outlet of the baghouse and analyze for lead. Realizing that the recognized isokinetic sampling equipment would not work, they set out to design a fixed sampler to approximate an isokinetic sampler. They installed a couple of ports in the breeching and conducted a pitot temperature traverse to determine the point of average velocity. Calculations determined the orifice size and pumping rate for drawing a proportional sample from the breeching. The sample system consists of a fixed stainless orifice with a stainless heated delivery line to a heated chamber in which a bag filter (same material as the bags in the baghouse but much tighter weave) is installed to trap the samples, and a vacuum pump calibrated to deliver fixed volume of gas from the breeching. The temperature pressure and gas flow are measured. At the end of a specified period, generally during a scheduled shutdown of the sinter machine, the bag is removed, weighed and placed on a pan in an oven for drying. After drying, the bag and pan are removed and reweighed to obtain a sample weight. This sample is then analyzed by ASARCO for lead content to determine lead losses to the atmosphere.

During the first test, the sinter machine was off during 9 min at the beginning of the test. During four of those minutes a main feed hopper was being emptied. Emissions from the main feed hopper are ventilated through the blast furnace control system, so that no operation ventilated to the sinter machine was functioning during the 9-min shutdown. The sinter machine duct was not sampled within $\pm 10\%$ of 100% isokinetic during the first run and was repeated at a later date; therefore, only the auxiliary duct measurement was affected by the sinter machine shutdown.

2. Fugitive emissions: Occasionally, fugitive emissions within the one-sided sinter machine building were observed to be fairly high. In particular, the cooling drum at some times was a source of in-plant emissions. One scrubber has been installed by the plant in the sinter machine building as a trial unit to collect fugitive dusts for the purpose of industrial hygiene. A complete scrubber system is planned to control in-plant dust. The dust released by the cooling drum has a high moisture content which would clog a baghouse, thus necessitating wet scrubber control.

3. Blast furnace: Measurements at the inlet and the outlet of the blast furnace control system were made simultaneously. The inlet test was made upstream from the water spray chamber, and the outlet test was made on all three stacks simultaneously. A lime sample was collected at the point where lime is introduced into the gas stream between the water spray chamber and baghouse to ascertain the total particulate loading to the baghouse. The lime sample was obtained by catching a sample from the

lime feeder for 1 min. The sample was weighed and lime addition rate calculated on this data. Particle sizing was planned on both the inlet and the outlet, but due to sampling problems at the inlet, only the outlet was tested for particle size.

Dynamiting of the blast furnace was a common occurrence during the course of testing. The purpose of dynamiting is to decrease the possibility of a furnace blow, when emissions would seemingly be highest. A blow occurs when the material which has built up on the sides of the furnace, forming a chimney within the furnace collapses. When a chimney forms within the furnace, the air moves directly through the furnace without maximum contact with the furnace material.

During the first test at the blast furnace (19 July 1973), the sinter machine was not operating. Therefore, ventilation air from the Ross Classifying Rolls and Swivel Vibrator was being ducted through the blast furnace baghouse. According to plant personnel, these two operations may be expected to contribute a low gas volume, but a relatively large amount of dust to the blast furnace control system. During the second test, one baghouse compartment was closed down.

During the third test at the blast furnace (23 July 1973), the baghouse compartments were manually shaken six times. Review of the control room charts indicated that the bags which usually shake when the pressure has reached 3 in. of water, had shaken on the average of 70 times/day (2.8 times per hour) between 15 June and 15 July. The maximum number of

bag shakes was 111 times-day and 4 or 5 shakes an hour was not uncommon. From our arrival on 16 July through 22 July, the bags shook on the average of only 33.7 times per day (1.4 times per hour). During Runs No. 1 and 2, the bag shakes occurred very infrequently during the actual test time. The infrequent shaking of the bags is assumed to be related to the frequent dynamiting of the furnace. When material adheres to the sides of the furnace, the air moving through the furnace has less contact with it and the emissions would seemingly be less. Because the highest visible emissions to the atmosphere have been observed to follow baghouse shakes, it was decided to manually shake the bags in order to compare the emissions with the first and second tests when the bags were shaken infrequently. The manual shaking of the bags was continued during the particle sizing test.

4. Fugitive emissions: Fugitive emissions from several operations associated with the blast furnace--dross kettles, ray tapper, slag granulator, lead tap, slag taps, and feed hopper drop points--are reduced by hooding and ventilation to the blast furnace control system. The lead tap, particularly at windy times when the lead tap was heavy, produced some fugitive emissions. At the slag tap, the hooding is not in direct contact with the receiving chamber, and did not appear to be adequate for complete collection of fumes. According to plant personnel, problems with the slag granulator fan contributed to the fuming at the slag tap. The ladles which receive the lead at the lead tap are partially covered to minimize fugitive emissions. Occasionally fuming occurs, especially when there is spillage during the transfer of lead bullion from the furnace to the dross kettles.

V. SAMPLING AND ANALYTICAL PROCEDURES

This section of the report discusses the physical layout of the sampling locations and sampling points at each location. The sampling procedures used to collect particulate samples at the smelter are presented herein. The analytical procedures are also discussed.

A. Location of Sampling Ports and Points

For the sinter plant the two sampling locations are shown in Figure 11. In the 3-ft duct which vents the operations associated with sintering, the sample ports were 25 ft, 8-1/3 pipe diameters, downstream from the elbow, and 10 ft, 3-1/3 pipe diameters, upstream from a disturbance. There were two ports 90 degrees apart in the duct. Due to the physical layout one port was located at 30 degrees from the vertical axis and the other 30 degrees below the horizontal.

The single port in the 7-ft duct was located 56 ft, 8 pipe diameters, downstream from the nearest flow obstruction, but only 7 ft, 1 pipe diameter, from the nearest upstream obstruction, a 45-degree elbow. This port was located at the center line of the duct. The port was at 90 degrees to the duct. The duct came from the fourth floor of the sinter plant to the roof of the single-story humidifying chamber at 45 degrees.

The location of the sample points in each duct is shown in Table XIX. There were 16 points in Duct B and each point was sampled twice for a total of 32 sample points per test. There were six points in each port of Duct C.

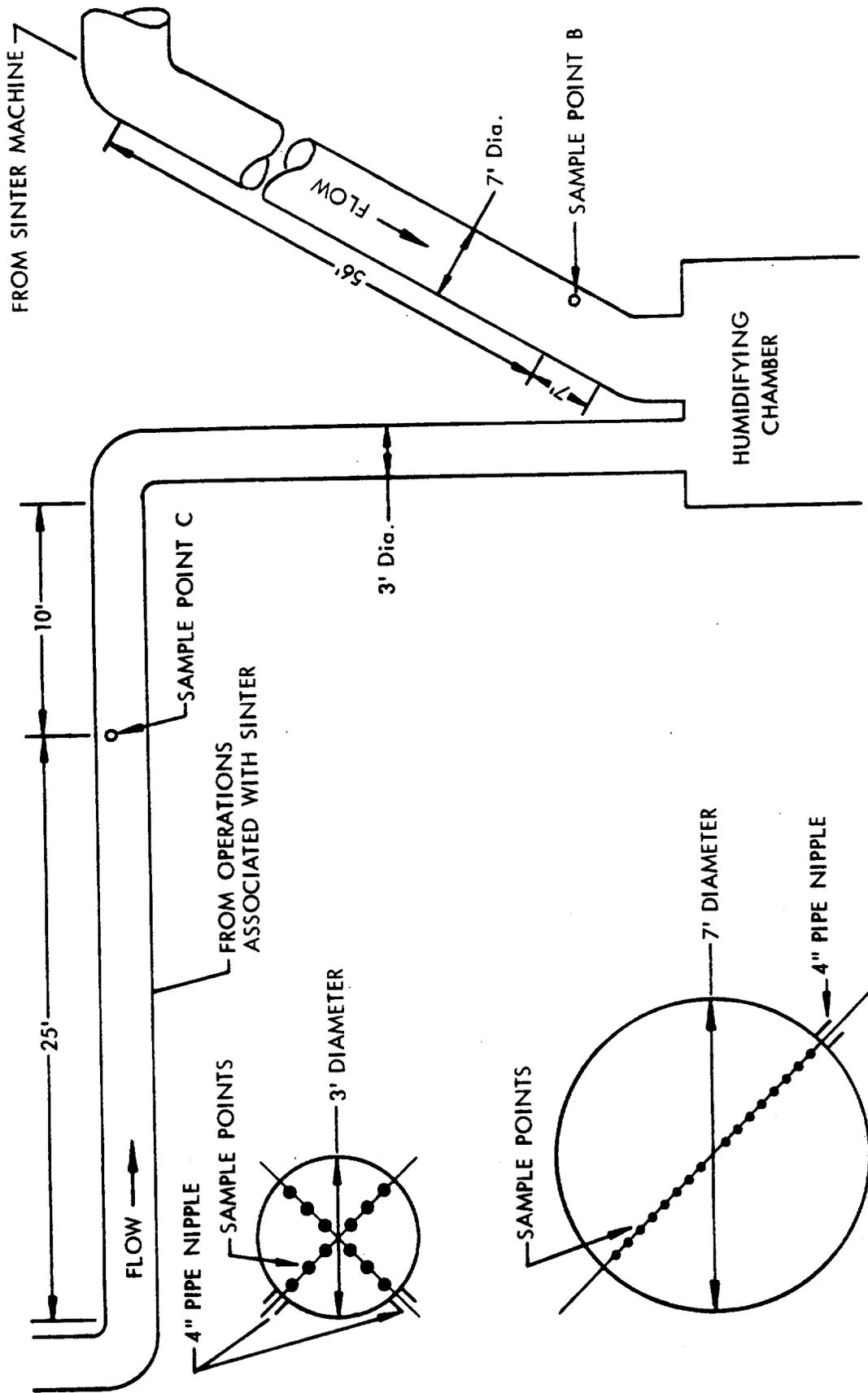


Figure 11 - Sample Ports in Sinter Plant Ducts

TABLE XIX

SAMPLING POINTS D AND C LOCATIONS
SINTER DUCTS

<u>Port</u>	<u>Point No.</u>	<u>Duct Diameter (in.)</u>	<u>%</u>	<u>Location in Duct (in.)</u>	<u>Outside Port to Inside Duct (in.)</u>	<u>Use (in.)</u>
Duct I/B	1	89-9/16	1.6	1-1/2	3-1/4	4-3/4
	2	89-9/16	4.9	4-3/8	3-1/4	7-5/8
	3	89-9/16	8.5	7-5/8	3-1/4	10-7/8
	4	89-9/16	12.5	11-1/4	3-1/4	14-1/2
	5	89-9/16	16.9	15-1/8	3-1/4	18-3/8
	6	89-9/16	22.0	17-7/8	3-1/4	21-1/8
	7	89-9/16	28.3	25-3/8	3-1/4	28-5/8
	8	89-9/16	37.5	32-3/4	3-1/4	36
	9	89-9/16	62.5	56-13/16	3-1/4	60-1/16
	10	89-9/16	71.7	64-3/16	3-1/4	67-7/16
	11	89-9/16	78.0	71-11/16	3-1/4	74-15/16
	12	89-9/16	83.1	74-7/16	3-1/4	77-11/16
	13	89-9/16	87.5	78-5/16	3-1/4	81-9/16
	14	89-9/16	91.5	81-15/16	3-1/4	85-3/16
	15	89-9/16	95.1	85-3/16	3-1/4	88-7/16
	16	89-9/16	98.4	88-1/16	3-1/4	91-5/16
Duct U/C	1	39-5/8	4.4	1-3/4	3-1/8	4-7/8
	2	39-5/8	14.7	5-7/8	3-1/8	9
	3	39-5/8	29.5	11-5/8	3-1/8	14-3/4
	4	39-5/8	70.5	28	3-1/8	31-1/8
	5	39-5/8	85.3	33-3/4	3-1/8	36-7/8
	6	39-5/8	95.6	37-7/8	3-1/8	41
Duct L/C	Same as upper port					

The sample location in the 7-ft duct from the blast furnace is shown in Figure 12. The ports were located at 45 degrees with the horizontal, one on the north axis and the other on the south. The ports were 60 ft, 8.57 pipe diameters, from the upstream 90-degree elbow and 15 ft, 2.14 pipe diameters, from the downstream 90-degree elbow. The sample point dimensions, six in each port, are in Table XX.

Figure 13 shows the configuration of the blast furnace baghouse and stacks E, F and G. Figure 14 shows the location of the ports and sample points in each of the three stacks. The ports were located 36 ft 6 in., 4-1/2 pipe diameters, above the breeching or inlet to the stack and 11 ft 6 in., 1-2/3 pipe diameters, from the outlet to the atmosphere. The sampling point calculations yielded a value of 32 sampling points, eight per port.

B. Sampling Procedures

An RAC* Model 2343 Staksampler train was used to sample for particulates. Glass-lined probes were used for all sampling. The procedures used are those in the Federal Register, 36, 159, 17 August 1971. There were two exceptions: (1) the exhaust duct from the sinter baghouse was sampled using the ASARCO's permanent continuous sampler called Askania; this sampler is supposedly an isokinetic sampler; and (2) as it was not possible to install and use two 90-degree ports in Duct B, one port was used and each of the 16 points was sampled twice.

* Mention of a specific company does not constitute endorsement by EPA.

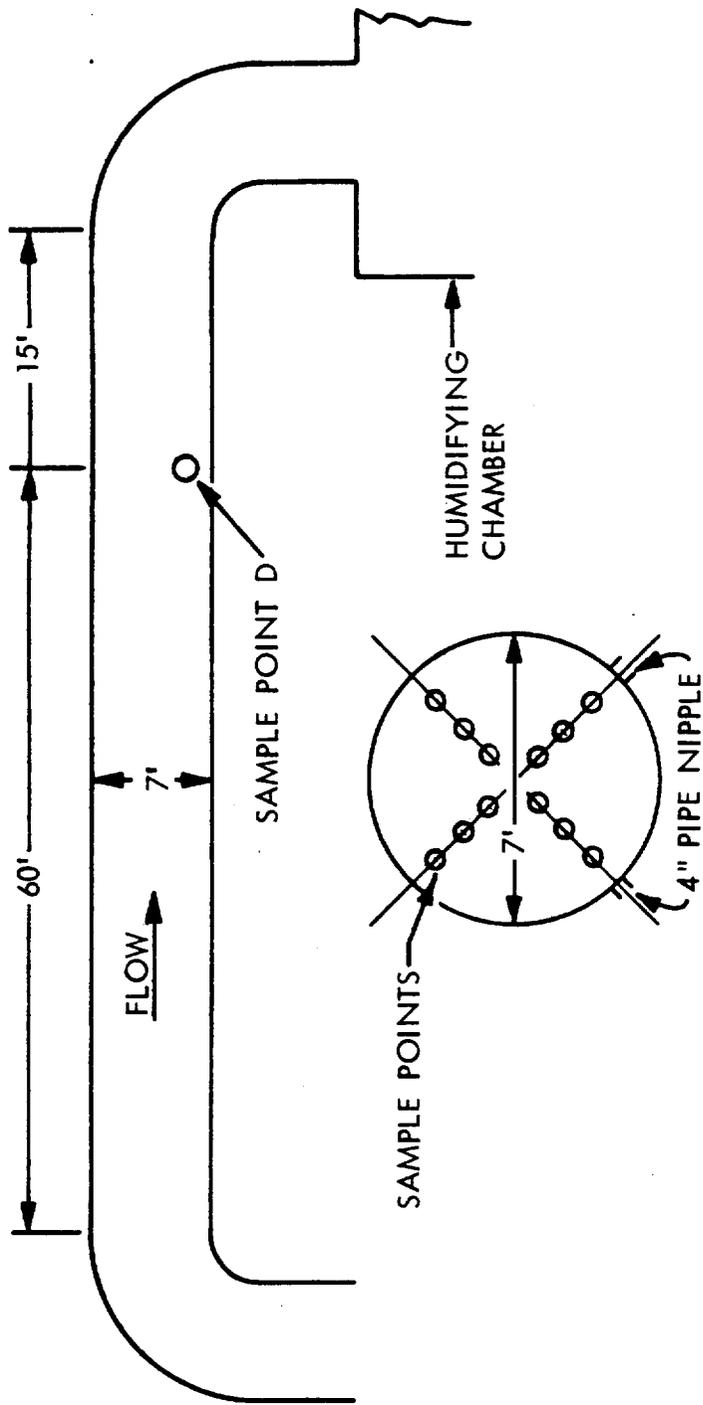


Figure 12 - Sample Ports in Blast Furnace Exhaust Duct

TABLE XX

SAMPLING POINTS IN BLAST FURNACE DUCT SAMPLING
LOCATION D

<u>Port</u>	<u>Point No.</u>	<u>Duct Diameter (in.)</u>	<u>%</u>	<u>Location in Duct (in.)</u>	<u>Outside Port to Inside Wall (in.)</u>	<u>Use (in.)</u>
Duct N/D	1	83-3/4	4.4	3-5/8	3-1/4	6-7/8
	2	83-3/4	14.7	12-1/4	3-1/4	15-1/2
	3	83-3/4	29.5	24-5/8	3-1/4	27-7/8
	4	83-3/4	70.5	59-1/8	3-1/4	62-3/8
	5	83-3/4	85.3	71-1/2	3-1/4	74-3/4
	6	83-3/4	95.6	80-1/8	3-1/4	83-3/8

Duct S/D Same as North Port

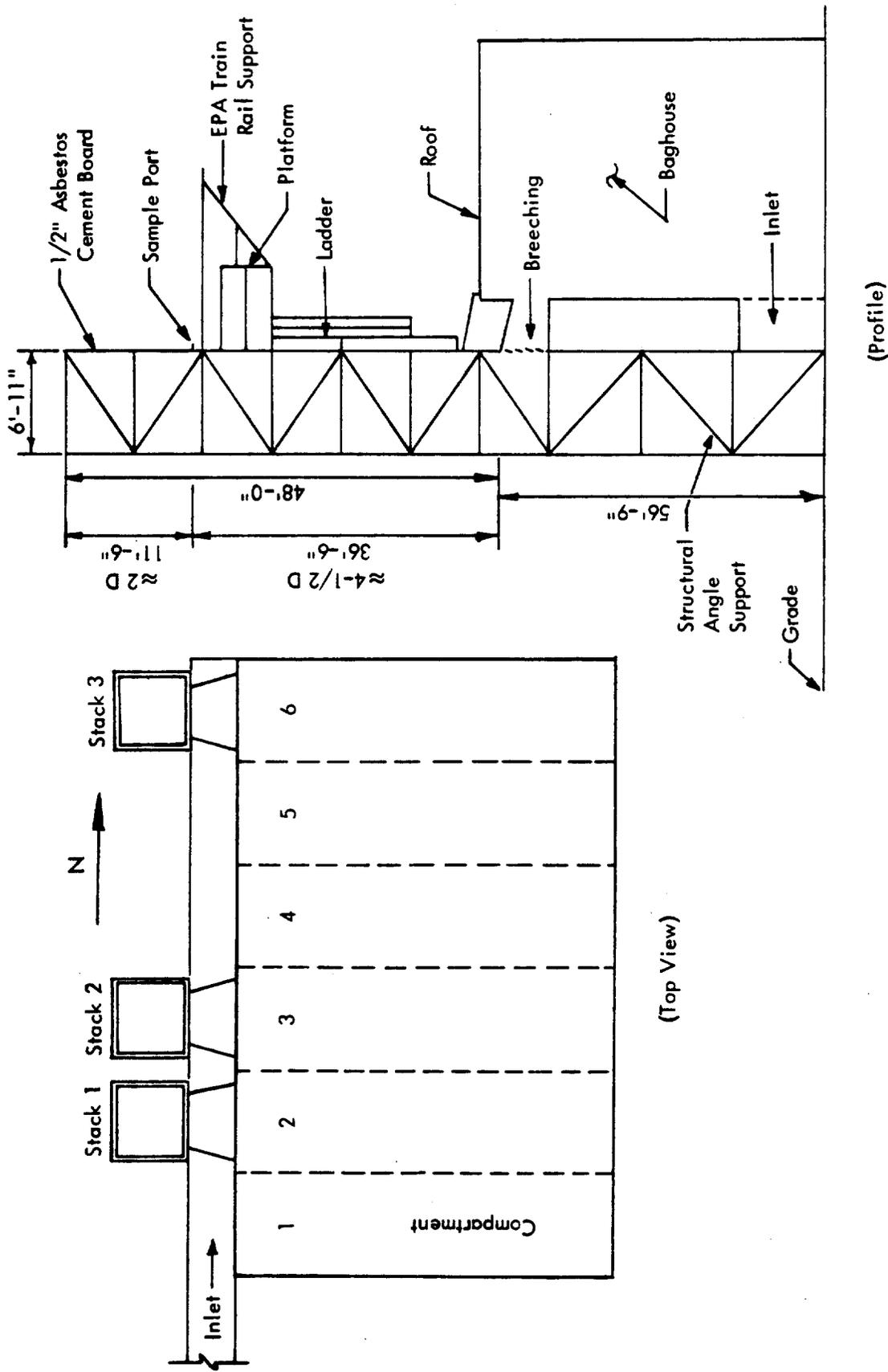
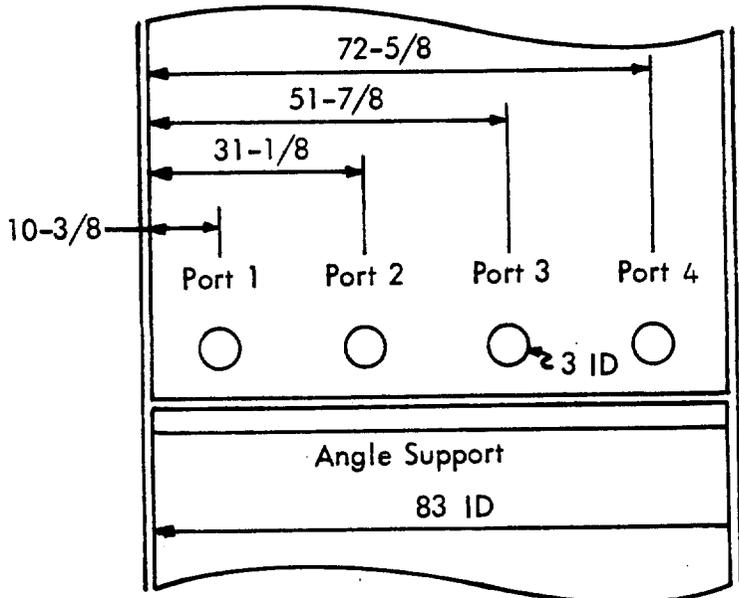
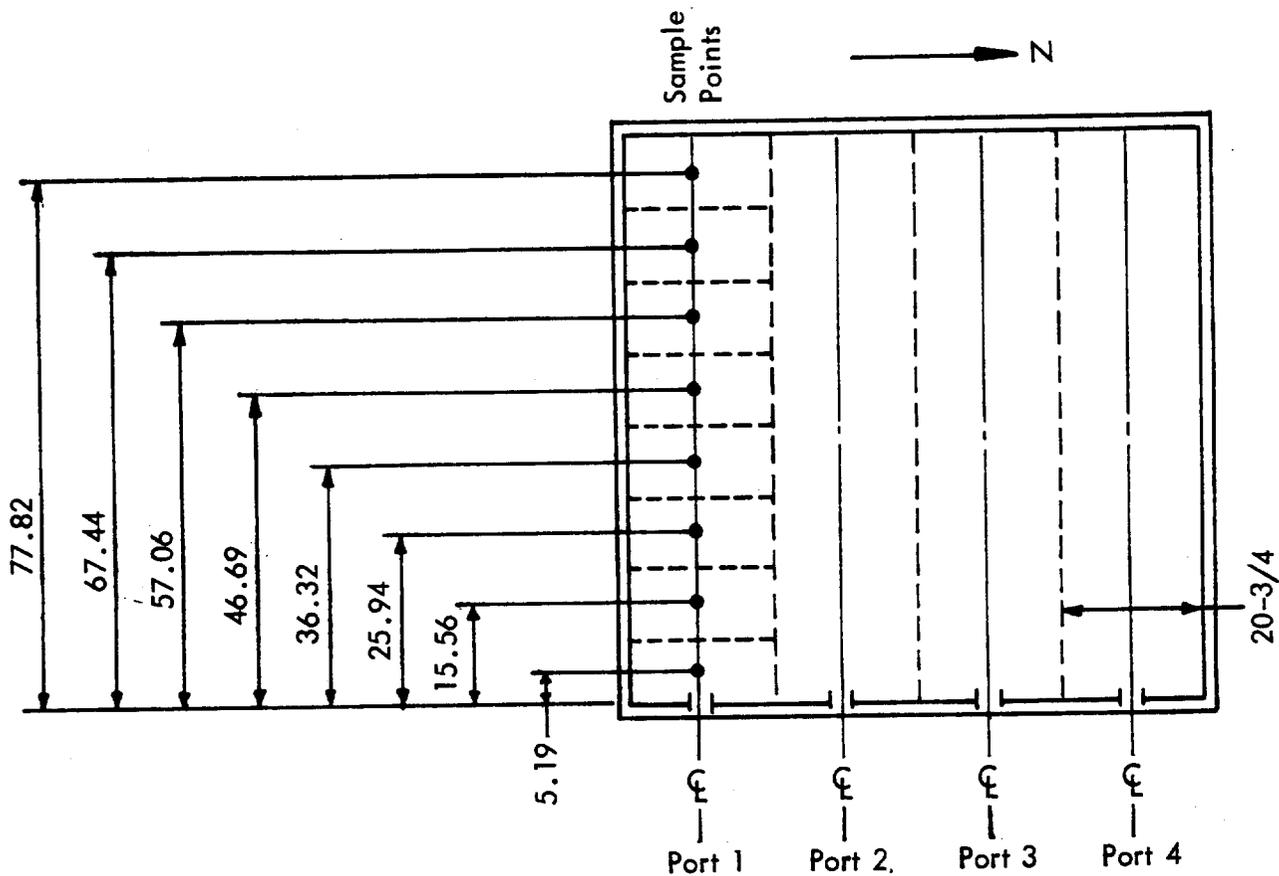


Figure 13 - Blast Furnace Baghouse and Stack(s) Configuration



(All Dimensions--Inches)

Figure 14 - Sample Port-Point Configuration

Ducts B and C were sampled simultaneously for 2 hr. The points in Duct C were sampled for 10 min with readings every 5 min, a total of 2 hr. The 16 points in Duct B were sampled for 4 min with a total time of 64 min per traverse or 2 hr 8 min total sampling. When sampling was discontinued on Duct C to change ports, the sampling on Duct B was continued for 4 min and then discontinued until sampling was started again on Duct C.

At the blast furnace all particulate sampling was conducted simultaneously for a minimum of 2 hr. The 7-ft duct (12 points) was sampled for 10 min on a point (total of 2 hr) with readings taken every 5 min. Sampling on the exhaust stacks was 4 min per point, 32 points for a total of 2 hr 8 min. When the crews on the exhaust stacks stopped to change ports the crew on the duct also stopped until all four crews were ready to go.

The Andersen* particle size sampling was conducted at Stack F Port 3 Point 3 using the RAC* Staksampler equipment with a 3-ft glass lined probe and an Andersen* sampler.

The Orsat samples were taken by using a stainless steel probe which contained a glass wool filter. The probe was inserted to Point 3 of each stack and samples were pumped directly into the Orsat analyzer for 5 min to purge the probe, line and Orsat. Three analyses were made for each test, and each analysis lasted 5 min. Ducts B, C and D were sampled

* Mention of a company name or product does not constitute endorsement by EPA.

and analyzed for each test. Stacks E, F and G were analyzed for Test 3. On Tests 4 and 7 only G was analyzed. The results of the Orsat analyses for Test 3 showed that the three stacks had the same composition within the accuracy of the method.

A Dräger tube was used to obtain approximate analysis of the SO₂ in the gases from the sinter exhaust ducts and the blast furnace exhaust duct. A stainless steel probe with a glass wool filter was inserted into the stack to Point 3 and a sample withdrawn into the tube using an MSA* hand pump. This was done for each test.

Lime is added to the particulate from the blast furnace in the duct between the water spray chamber and the baghouse. Each day that particulate sampling was conducted around the pollution control system for the baghouse, a lime sample was taken for the purpose of determining the lime addition rate. The sample was taken from the vibratory feeder for a period of 1 min. The lime was weighed and the lime addition rate of 44.7 lb/hr was determined from the weight of lime collected in 1 min.

C. Analytical Procedures

The particulate analysis was accomplished using the procedures in the Federal Register, 36 (159), 15,715-15,716, 17 August 1971.

After the samples were analyzed for particulates, the solid residue was digested in 10 ml of boiling aqua regia for 1 hr with reflux.

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The liquid was cooled, diluted to 50 ml and analyzed for lead on the atomic absorption spectrophotometer.

The Andersen particle analysis on the plates was done in the field. Then each plate was carefully washed with acetone into a sample container. The probe wash and filter were treated as particulate samples and returned to the MRI laboratories for particulate and lead analysis. The acetone was evaporated from each of the particulate samples and then they were analyzed for lead content using the procedure described above.

Orsat and SO₂ (approximate) analyses were conducted in the field as described in Section V-B.

The large filter used to collect particulate samples from the inlet ducts to the sinter and blast furnace control system had enough particulate that it was not necessary to digest the filters for lead analysis. A weighed sample of the particulate from the large filters was digested for lead analysis. The small filters used in the baghouse exhaust stacks were digested along with the particulate for lead analysis.

All particulate and lead blanks have been subtracted from the values before they were reported.