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Lead Reduction in Ambient Air: Technical Feasibility and Cost Analysis at Domestic Primary Lead Smelters and Refineries

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ACFM	Actual cubic feet per minute	μm	micrometer
h/yr	hour per year	st	short ton
kW•h	kilowatt hour	st/d	short ton per day
lb	pound	st/month	short ton per month
lb/d	pound per day	st/yr	short ton per year
$\mu g/m^3$	microgram per cubic meter		

LEAD REDUCTION IN AMBIENT AIR: TECHNICAL FEASIBILITY AND COST ANALYSIS AT DOMESTIC PRIMARY LEAD SMELTERS AND REFINERIES

By Richard D. Smith,[1] Orville A. Kiehn,[2] David R. Wilburn,[3] and Robert C. Bowyer[4]

ABSTRACT

The Bureau of Mines evaluated the emission control methods, including the capital investments and operating cost, necessary for further reducing lead levels in ambient air at the Glover, Herculaneum, and Buick smelter-refineries in Missouri and the East Helena, MT, smelter. The U.S. Environmental Protection Agency (EPA) has proposed more stringent lead in ambient air standards than those currently in effect. This report presents theoretically achievable lead emission reductions and estimated capital and operating costs.

Lead emission inventories theoretically can be reduced from 1985 levels by 2,421 lb/d at the three Missouri operations by containing and filtering fugitive emissions within structural enclosures and baghouses. The aggregated capital and operating costs in 1986 dollars using conventional environmental and workplace technologies are estimated to be $250,014,100 and $18,507,800, respectively. Estimated total incremental cost is $0.063/lb as refined lead. Additional regulatory costs attributable to Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, workplace standards are included since proposed environmental controls may otherwise degrade workplace conditions.

Continuous drossing is evaluated as an alternative to conventional OSHA controls. Substituting continuous drossing for conventional workplace technology results in an estimated aggregated capital and operating costs of $258,344,800 and $15,719,600, respectively. Estimated total incremental cost is $0.062/lb as refined lead. For comparison, the average open market price of refined lead during the first quarter of 1986 was $0.184/lb.

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INTRODUCTION

Lead is currently listed as a criteria pollutant by the Environmental Protection Agency (EPA); the maximum allowable level of lead in air is 1.5 $\mu g/m^3$. The domestic primary lead industry is required to meet this standard using currently available control technology. Periodic review of this standard is required by the Clean Air Act of 1970 (1),[5] as amended in 1977 (2).

In response to heightened public awareness of the continued degradation of the Nation's air quality, the Clean Air Act gave the EPA the responsibility of providing guidance and support for establishing State and local air pollution control programs. This legislation mandated that the EPA develop uniform ambient air quality standards on a national basis for those pollutants present in specified concentrations and over a specified time period which, if exceeded, would pose a significant danger to the health and welfare of the public. Under these guidelines, the EPA developed ambient standards for sulfur dioxide, total suspended particulates, nitrogen dioxide, carbon monoxide, ozone, and non-methane hydrocarbons. Although the EPA proposed the ambient air quality standards, States were given the primary responsibility to develop and implement a plan for attaining the ambient standards. Concentrations of regulated air pollutants in ambient air are measured at the industry fenceline and/or property line; i.e., where the pollutants are first encountered by the public.

Lead was added to the criteria pollutants in 1977 as a result of a court decision (3). The ambient lead standard was set at 1.5 $\mu g/m^3$ averaged over a calendar quarter (3 months). Currently, proposals are under review that would reduce the lead in ambient air standard from 1.5 g/m^3 to between 0.5 to 1.0 $\mu g/m^3$.

Ambient lead standards are defined in terms of mass loading per volume of ambient air. However, these standards neither specify the method with which to achieve compliance nor how to determine the effectiveness of individual compliance methods. This study evaluates the theoretical lower limit of lead emissions in pounds per day that are achievable using existing technology. The determination of actual lead values applicable to ambient lead levels at the fenceline for the ambient air standard using computer modeling or other methods are not considered in this report.

In September 1985, a meeting was held in San Francisco, CA, between members of the American Mining Congress (AMC) and the Bureau to discuss the ongoing Bureau study, "Impacts of Environmental, Health, and Safety Regulations Upon Cost of Production in the Primary Domestic Lead Industry." At that meeting, a plan was developed to examine the technical feasibility and the related anticipated costs of reducing the ambient lead compliance level from the current 1.5-$\mu g/m^3$ level.

The purpose of this study is to analyze the technology available to the domestic primary lead industry for purposes of meeting the current EPA ambient air standard for lead. In addition, the study assesses technical feasibility and costs associated with further reductions from the present lead in ambient air standard (4). Preliminary findings of this report were presented to the Clean Air Scientific Advisory Committee (CASAC) meeting on March 11-12, 1986. The meeting was the EPA's periodic review of the National Ambient Air Quality Standards (NAAQS), as required by the Clean Air Act.

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[5]Underlined numbers in parentheses refer to items in the list of references preceding the appendixes.

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METHODOLOGY OF ANALYSIS

Three primary tasks were set for the project:

Task 1.--Collect plant-specific data to determine current plant performance.

Task 2.--Analyze efficiencies of pollution control equipment and determine their potential for further reducing lead in air. Develop engineering methods to achieve the best available control technology (BACT), as opposed to current reasonable available control technology (RACT). Consider the impact of environmental controls on OSHA workplace lead standards in the cost estimates.

Task 3.--Develop cost data associated with further reducing airborne lead emissions from the smelters and refineries.

As the project progressed, task 2 was amended to include lead source emission data, utilizing a lead emissions inventory approach rather than attempting to predict the lead level that would be measured at the property-line monitoring stations. This was decided because (1) computer modeling capabilities required to evaluate airborne lead dispersion were not available to the Bureau, (2) agreement has not been reached between industry and the EPA on current computer modeling techniques, and (3) the Bureau was most technically suited to an engineering evaluation by emission source. Current lead source emission data would be reported in terms of pounds per day of lead emitted, and estimates would be developed regarding expected lead source emissions at the potential optimum efficiencies of the equipment.

Computer modeling is greatly influenced by the sophistication of the particular model used and the quality and quantity of the available data. These data are influenced by design and location of structures, pollutant characteristics, wind patterns, topographic irregularities, distance from the source, and temperature inversions and other weather conditions. This report identifies existing lead emission inventories and suggests potential emission reduction methods based on BACT. Computer modeling techniques may be applied to these data.

FIGURE 1.—Primary lead smelters and refineries in United States.

Six primary lead production facilities remain within the United States (fig. 1). These operations are located at Buick, MO (AMAX Lead Co. of Missouri); East Helena, MT (ASARCO Inc.); Glover, MO (ASARCO Inc.); Herculaneum, MO (St. Joe Lead Co.); Omaha, NE (ASARCO Inc.); and El Paso, TX (ASARCO Inc.). With the exception of East Helena and El Paso, which are smelters processing metallurgically complex lead sulfide concentrates, and Omaha, which is a refinery, all plants are smelter-refineries processing the metallurgical simple lead concentrates from the Missouri lead belts. Omaha is not included in the study because it is classified as a refinery. El Paso is not included because its lead line is temporarily shut down. The remaining operations are evaluated in this study.

DATA COLLECTION AND REVIEW

The Bureau initiated this study by collecting historical lead emissions data at each of the four selected sites as well as obtaining data from State and Federal agencies. Plant data included flow sheets; plan and elevation drawings and sketches; plant modifications and related emission levels on a datable basis; emission control performance data; and regulatory documents and studies. Site maps were also obtained that identified plant facilities, ownership boundaries, proximity to highways, railways, and site and regional topography. For each site, a tabulation was made of the current lead emissions, control technologies in place, and the efficiency of the equipment in reducing lead emissions. No single operation supplied a complete spectrum of required information. Fortunately, an overlap of data among plant sites allowed interpolative placement of certain data at Buick, Glover, and Herculaneum.

Emission data collected for ASARCO's East Helena smelter presented difficulties in interpretation due to the emission formats used. Data originally collected by ASARCO during 1977 were in the lead emission inventory format. At the time of the State Implementation Plan (SIP), the data format was changed to reflect the chemical mass balance for monitored ambient emissions. Correlation of the lead emission inventory format with the chemical mass balance format was not done; therefore, only general comments can be made concerning emissions at East Helena. The cost study was performed using engineering methods developed for the Missouri operations and adjusted to East Helena's unique conditions. Although a direct comparison of emission inventory to cost at that smelter is not possible, it is reasonable to assume that some reduction of emissions is achievable at that cost.

Data presented in this report are those that each operation reported to the State regulatory agencies. Controlled and uncontrolled lead emissions data are based upon either actual test results or best estimates for representative unit processes under typical operating conditions, which are defined as follows:

Uncontrolled emissions.--Emissions from sources where no control methods have been applied. Uncontrolled emissions are used as the reference to assess the efficiency of emission control methods.

Controlled emissions.--Emissions resulting from sources where active control methods have been applied.

Emission sources for each operation were reviewed according to the three major emission source types: point source, process fugitive, and open fugitive emissions.

Point source.--These emissions typically result from process exhausts and only occur during plant operation. Emissions of this type are ducted through an emission control device prior to discharge to the environment. An example of point-source emissions is blast furnace off-gases, which are ducted through a baghouse for emission control before discharge to the atmosphere.

Process fugitive.--These emissions are a direct result of process operations but, for various reasons, have not been collected as part of a process exhaust and cannot be treated as a point source. Process fugitive emissions occur only during plant operation. These emissions typically result from leaks in mechanical seals. Repair of the worn seals and/or redesign of the processing equipment may reduce these emissions. Under certain conditions, they may be confined for emission control purposes, and then become point source emissions.

Open fugitive.--These emissions (also called "fugitive dust") result from factors not necessarily related to active plant operation. Examples are wind-blown dust from stock piles, or local soils containing a high in situ lead content. Control of stock piles may be achieved by structural enclosures or chemical stabilization. Soils may be controlled by paving, planting, and chemical stabilization.

DETERMINATION OF OPTIMUM EFFICIENCY

After review and analysis of the individual site emission control methods and emission data (5-12), the Bureau instituted a study to evaluate the feasibility of additional control procedures to improve the efficiencies of existing equipment. Theoretically optimum emission control methods were developed using historical data, advice from emission control device suppliers, and the principal authors' working knowledge of emission control methods. Calculated data for these proposed methods are presented for Glover, Buick, and Herculaneum. East Helena could not be analyzed in this manner because controlled and uncontrolled emission data for this plant cannot be correlated with the present chemical mass balance method being used by the State of Montana (9-12).

POINT-SOURCE EMISSIONS

Emission control devices are used to reduce point-source emissions. Through engineered design changes, the devices may be modified to reduce point-source emissions. A comparison of controlled versus uncontrolled emissions is essential since emission control devices are evaluated on a percent-efficiency basis.

Overall historical emission control efficiencies were calculated as follows:

$$(UE - CE)(100)/(UE) = \text{Percent efficiency},$$

where,

UE = uncontrolled emissions in mass units per unit time,

CE = controlled emissions in mass units per unit time,

and

Percent efficiency = percent emission control efficiency.

Control efficiencies were then compared with the efficiencies for similar control devices, operating on the basis of similar particle size distribution and material density. Data were frequently unavailable for emission control devices and for control methods at the plants and had to be acquired from alternate sources. Operating data on Ducon UW-4 dynamic scrubbers were supplied by Buick (13) and Herculaneum (14), which are two of many plants where the scrubbers are used. Information of efficiency versus density and/or size distribution results for dynamic scrubbers, venturi scrubbers, electrostatic precipitators, and baghouses were obtained from vendor data (15-16) and EPA reports (17-20).

Chemical mass balance studies (11-12, 21) provided insight into the chemitries and size distributrion of emission sources. These studies were applied with care since the data do not include large-diameter, large-mass particulates that settled prior to capture in a monitoring device. Typical emission control device efficiencies derived from EPA tests using silica particulates as the control medium are shown in table 1.

Lead particulates are denser than silica and thus require adjustment of the expected efficiencies. In the case of the filter collectors (baghouses), the effect of density is insignificant. Efficiency may be improved by design changes such as bag material and/or air-to-cloth ratio. These modifications are site specific and are applied for the purpose of meeting design standard rather than for enhancing collector efficiency. Therefore, no proposed efficiency change due to lead density for baghouse operations is assumed for this study.

Electrostatic precipitator (ESP) efficiency is dependent on particle mass and electrical properties of the substance. However, no reported information on equipment efficiency for lead particles

TABLE 1. - Efficiency of emission control devices on silica particulate, percent (17)

(Particulate density: 2.65 g/cm^3)

Particle size range..............µm..	All	<5	5-10	10-20	20-44	>44
Baghouse............................	99.7	99.5	100	100	100	100
Electrostatic precipitator..........	97.0	72	94.5	97	99.5	100
Dynamic scrubber....................	98.5	93	98	99	100	100
Venturi scrubber....................	99.5	99	99.5	100	100	100
Weight distribution.................	NAp	20	10	15	20	35

NAp Not applicable.

TABLE 2. - Efficiency of emission control devices on lead-compound particulate, percent

(Particulate density: 9.53 g/cm^3)

Particle size range..............µm..	All	<5	5-10	10-20	20-44	>44
Baghouse..............................	99.7	99.5	100	100	100	100
Electrostatic precipitator...........	97.0	72	94.5	97	99.5	100
Dynamic scrubber.....................	99.0	96	98.8	99.7	100	100
Venturi scrubber.....................	99.9	99.3	99.9	100	100	100
Weight distribution..................	NAp	20	10	15	20	35

could be found in the literature; thus, no further change in ESP efficiency could be projected. ESP's are installed to remove the coarser particulates; the exhaust gases are then treated in baghouses. This flow stream reduces operating difficulties and assists the baghouse in reaching operational efficiency. (No ESP's are expected to be used in single-unit applications.)

On the other hand, the efficiency of wet-collection devices (scrubbers) improves as particulate mass, or density, increases. As the kinetic energy of a particle increases, the ability of the particle to penetrate scrubber water droplets increases. This, in principle, is the manner in which the particle is removed from the gas stream. Kinetic energy and density may be shown to be related as follows:

$$E_k = mv^2/2,$$

where,

E_k = kinetic energy,

m = mass of the particle,

v = velocity of the particle,

and,

$$m = 0.5236D^3d,$$

where,

D = particle diameter,

and d = particle density.

Combining equations yields--

$$E_k = (0.2618D^3d)(v^2).$$

For a given system, if the design velocity remains constant, the kinetic energy can be related to density and particle size. Thus, an expected adjustment in efficiency for lead particulates can be projected for decreases in size and density.

TABLE 3. - Efficiency of emission control devices in steel applications, percent

Emission control devices	Efficiency
Baghouse......................	95
Electrostatic precipitators:	
Single-stage plate.........	95
Single-stage pipe..........	99
Dynamic scrubber.............	80
Venturi scrubber.............	99

Calculated dynamic scrubber efficiencies of 99.0 pct (table 2) compare favorably with actual data of 99.3 pct from the Missouri Department of Natural Resources and from industry (8, 13-14). The authors' field notes on venturi scrubber efficiencies also support these conclusions. Baghouse filter efficiency appears to approach the theoretical engineering design limits, while electrostatic precipitator efficiencies can reach 99.95 pct under ideal conditions (16).

Another published source provides a slightly different perspective on control device efficiencies. As can be seen by comparing table 3 with tables 1 and 2, there are definite differences in accepted efficiencies due to actual experience and based on equipment application.

Baghouse efficiencies can be improved under specific conditions to greater than 99 pct by using special, high-performance bag fabrics. Similar performance improvements can be achieved with wet scrubbers by increasing the pressure drop across the system.

For each site, the Bureau reviewed the current emission control efficiencies and proposed those best theoretically obtainable based on the data shown in tables 1 and 2. At each site, these proposed maximum efficiencies were applied to the uncontrolled emissions data, and new controlled emissions data for each point source were calculated.

No equipment changes were proposed for any point source since all sites are currently using the best available control technology (BACT). Therefore, any improvements in emission control would be based on more efficient operation of the equipment; the improvement would generally be less than 1 pct. It should be noted that improvements may be possible by placing control devices in series, but this approach does not appear to further control point-source emissions.

PROCESS FUGITIVE EMISSIONS

Process fugitive emissions were examined from the position that these emissions might be confined and treated as a point source. This costly approach was selected after other options failed to show any significant effect. In the point-source approach, entire buildings containing unit processes (e.g., the sinter machine) would be sealed and ventilated by an emission control device. The approach is beyond reasonable available control technology (RACT) (18). Therefore, the methods used for point-source emissions were modified and applied to process fugitive emissions to permit reasonable building access and to allow for probable architectural leakage.

OPEN FUGITIVE EMISSIONS

Open fugitive emissions were examined on an individual basis. Previous actions taken by industry to control open fugitive emissions and the resultant control responses were evaluated for effectiveness. Since open fugitive emissions cannot be controlled by emission control devices, predicting the effectiveness of control measures are more difficult than is the case of predicting control effectiveness for the other emission types. Typical solutions involve stabilization and/or removal of the source. The predicted improvements are "best judgment" estimates based on historical record.

COSTING METHODOLOGY

Estimates for capital and operating costs were prepared in terms of July 1, 1985, U.S. dollars.

Site design includes calculations for the following:

- Closing existing openings on process-related buildings presently emanating lead-bearing fugitive dust.
- Enclosing open concentrate, sinter, and storage areas that are sources of dusts containing lead.
- Installing new baghouses and adding fans for positive ventilation.
- Adding selective local controls.

The Montana and Missouri SIP's, along with the consent orders (5, 11), were examined to assure that only post-SIP items were estimated.

BUILDING ENCLOSURES

Process fugitive emissions can be controlled by complete enclosure and ventilation. For existing buildings, enclosure can be accomplished by installing siding, with railroad and personnel access doors where required. The erection of new metal-sided buildings is required for concentrate and material handling and storage. Costs also include labor for the construction of facilities designed to enclose a lead-bearing fugitive-dust emitter and to provide air ingress through new wall-mounted ventilators.

Following design and cost determination for each enclosure, the volume enclosed by the structure was calculated from the dimensions given in the section and plan views of on site drawings. The existence, shape, and location of each structure on the drawings was verified by recent aerial photographs of each site. This procedure served to check the existence of new construction not identified from company-supplied older drawings.

The enclosure was designed to allow a controlled amount of air to enter and leave each structure. The air, at approximately 15 building air volume changes per hour at an air-to-cloth ratio of 1.5:1, enters each building through opposing wall-mounted ventilators, sweeps across process equipment, and exits the roof of the structure through a plenum to a baghouse. A motor-connected fan supplies exhausted building air to the baghouse in a forced-draft configuration.

Proposed new structures to house existing materials-handling equipment, concentrate, fluxes, and re-treated material were costed with outdoor-air heaters. Existing structures housing process equipment were costed less makeup air heaters. Heat-load calculations for 15 building air volume changes per hour at an air-to-cloth ratio of 1.5:1 were not performed on existing structures due to the lack of detail engineering information required to develop building heat balances. If building-air heating is necessary, it cannot be assumed that a portion of the warm baghouse filtered air can be recycled to the structure without additional treatment due to the problem of recirculating undesirable ultrafine lead-bearing particulates and deleterious gases.

Building enclosure costing was based on applicable procedures outlined in casting manuals (23-25). Depending upon the individual plant situation, existing buildings were either modified or new structures were added to adequately enclose existing process equipment or to concentrate storage areas. When necessary, costs were included for excavation, reinforced concrete, strip footings, steel columns, cross ribs, strip-backing steel, and siding to building walls. Costs for similar building types per square foot or floor area (25), including associated lighting and heating, were used to estimate the cost construction or modification. Large overhead rollup doors were assumed to permit passage of trains and vehicles. Personnel access doors were placed and costed as appropriate.

Costs of materials, labor, construction equipment usage, and subcontracts were tabulated and summarized for a direct cost subtotal. A subcontractor's overhead and profit (O&P) of 25 pct of direct cost, and a general contractor's O&P of 12.5 pct of direct cost were added to the direct cost. Indirect costs were factored against labor costs and added. Construction camp costs were added. Allocation of 4 pct for sales tax and 4 pct for freight were added. To this total is added escalation from January 1984 to July 1985, and a 12-pct lump sum for engineering, procurement, and construction management. A contingency of 25 pct was added to address any additional elements that may have been omitted. Contingency accounts for unforeseen but real elements of cost due to the following:

1. Incomplete drawings and design criteria.
2. Preliminary telephone quotations.
3. Labor productivity unknowns.
4. Unforeseeable events.
5. Startup unknowns.

BAGHOUSES

A two-component approach was used in the design and costing. The design involves the enclosing of process buildings to permit the use of fans connected to baghouses to collect the lead-bearing dust. This approach addresses the requirement for environmental control but results in the subsequent problem of an increase in lead levels in the workplace. The second procedure addresses this problem through installation of local controls that enclose and/or ventilate individual process equipment.

The combination of building ventilation and local control has been demonstrated to be partially successful in Belgium (26-27). The amount of lead-laden dust during operation of the Belgian smelter is less than the 1.5-μg/m^3 EPA requirement and the 150-μg/m^3 OSHA requirement. Attempts by the domestic primary lead industry have not matched the Belgian results because of dissimilarities in plant design and operating practice.

Baghouse capital costs were determined using the following costing format and assume an average of 15 air changes per hour at an air-to-cloth ratio of 1.5:1.

I. Building closure capital
   A. Direct costs
      1. Materials
      2. Labor
      3. Construction equipment usage
      4. Subcontracts
   B. Subcontractor's overhead and profit (0.25 × A)
   C. General contractor's overhead and profit (0.125 × A)
   D. Indirect costs, materials, and labor (0.825 × A2)
      1. Temporary facilities (0.06 × A2)
      2. Miscellaneous services expense (0.09 × A2)
      3. Services handling (0.066 × A2)
      4. Travel expense (0.012 × A2)
      5. Field staff payroll (0.16 × A2)
      6. Project insurance and bonds (0.017 × A2)
      7. Payroll burden and fees (0.22 × A2)
      8. Small tools (0.035 × A2)
      9. Equipment rentals and maintenance (0.15 × A2)
      10. Vacation, holiday, and sick leave (0.015 × A2)
   E. Costs for construction camp (0.35 × A2)
   F. Freight (0.04 × A1)
   G. Sales tax (0.04 × A1)
   H. Escalation to July 1, 1985 (0.029 × A)
   I. Subtotal (A + B + C + D + E + F + G + H)
   J. Engineering, construction management, procurement, and fees (0.12 × I)
   K. Subtotal (I + J)
   L. Contingencies (0.25 × K)
   M. Total, building enclosures (K + L)

II. Baghouse capital
   A. Primary equipment cost (baghouse only)
   B. Ancillary equipment cost (fans, diffusers, etc.)
   C. Instrumentation and controls (0.15 × [A + B])
   D. Subtotal (A + B + C)
   E. Sales tax (0.04 × D)
   F. Subtotal (D + E)
   G. Installation (1.39 × D)
      1. Foundation and support (0.04 × D)
      2. Handling and erection (1.00 × D)
      3. Electrical (0.08 × D)
      4. Piping (0.01 × D)
      5. Insulation (0.07 × D)
      6. Painting (0.02 × D)
      7. Site preparation (0.02 × D)
      8. Facilities and buildings (0.15 × D)
   H. Installation sales tax (0.02 × G)
   I. Indirect costs (1.09 × D)
      1. Engineering, construction management, procurement fees (0.20 × D)
      2. Construction and field indirects (0.30 × D)
      3. Construction fees, contractors, overhead, and profit (0.20 × D)
      4. Startup (0.01 × D)
      5. Contingency (0.24 × D)
      6. Prefeasibility study (0.03 × D)
      7. Feasibility study (0.10 × D)
      8. Performance testing (0.01 × D)
   J. Freight (0.04 × D)
   K. Insurance (0.01 × D)
   L. Total, baghouse capital (F + G + H + I + J + K)

III. Grand total, I + II

No volume corrections were made for in-place equipment or structural steel. Baghouse costs based on building volume air changes were determined using adjustment multipliers reported (28) for factoring the capital cost of a baghouse, and a factored base equipment cost estimate (29) for primary and ancillary baghouse equipment, instrumentation, and controls.

Base equipment capital costs were derived using the volumetric air flow rate determined from building volume and 15 air changes per hour at an air-to-cloth ratio of 1.5:1. The total actual cubic feet per minute (ACFM) of air flow is multiplied by $5.00/ACFM to obtain the baghouse primary equipment cost. The ancillary cost for the baghouse fans is obtained by multiplying the total actual cubic feet per minute by $0.50. The sum of the baghouse and ancillaries cost ($5.50/ACFM) is multiplied by 0.15 (a factor of 15 pct) to obtain the cost of instrumentation and automatic control in either a factory-fabricated or a field-erected system. The total cost of the above equipment represents the base equipment cost (BEC).

A sales tax of 4 pct is added to the BEC, which is then multiplied by a factor to account for equipment installation and indirect costs. Percentages of installation cost components including site preparation, foundations and supports, handling and erection, electrical piping, insulation, painting, facilities, and buildings are shown in the foregoing format; the particular cost category is adjusted with the multiplier to reflect unusual site conditions. As an example, the average handling and erection factor of 0.5 times the BEC was adjusted to 0.75 times BEC for a smelter with a large, scattered system that requires long ducts and piping and on-site fabrication with extensive welding and erection. For another smelter, the handling and erection factor was increased from 0.5 to 1.0 times BEC to account for equipment removal and site renovation for a large system. Most percentage factors were used as given (28) without adjustment for installation cost. A 2-pct sales tax on equipment and material only has also been added to the installation cost.

The factoring components for determining the indirect BEC include engineering, construction management and procurement cost, construction and field indirects, construction fees, startup costs, performance tests, prefeasibility and feasibility engineering, and contingency. Unlike the case for the installation factor adjustment, the factors of indirect cost (28) were significantly adjusted to allow for custom equipment, automatic control, large-capacity equipment, several subcontractors directed by a general contractor, feasibility studies, a guarantee of efficiencies and operating specifications, final performance certification, and penalties for failure to meet design criteria.

A freight cost of 4 pct of BEC and an insurance cost of 1 pct of BEC are also included in the baghouse capital cost total.

In summary, the method for capital costing of process dust collection presented involves the cost of enclosing process buildings to permit building ventilation with fans. The fans pull fugitive lead-bearing particulate airstreams through collecting baghouses. The approach is highly sensitive to building volume and air-change rate. The study is based on an average of 15 air changes per hour, disrergarding the volume occupied by process and mobile equipment, internal structural steel, process materials, and personnel. In practice, the air-change rate required for each process would be evaluated separately. Low-temperature process areas with relatively low concentrations of lead dust (e.g., concentrate storage areas) may require fewer than 15 air changes per hour; high-temperature process areas generating high concentrations of lead dust may require more than 15.

The estimate presented includes approximately a 13- to 14-pct contingency and is approximately +30 pct accurate. This is an order-of-magnitude estimate that can be substantiated for this level of study and engineering detail.

The estimates do not include (1) OSHA considerations that may result from enclosures, specifically the blast furnace drossing areas; (2) the costs required to construct ducting and centrally located elevated stacks to meet best engineering practice for new point emissions, or (3) working capital costs. According to an unconfirmed report, a Belgian plant, using similar technology, (i.e., building enclosure and local control for numerous baghouses), attained OSHA-level in-plant lead ambient within 50 $\mu g/m^3$ in all areas, including the blast furnace drossing areas. For personnel comfort, the proposed building siding in the blast furnace dross area must be evaluated as to need.

The need for constructing elevated, centrally located stacks and associated ducting as opposed to locating stub stacks near each baghouse was not resolved by representatives of the primary lead industry for this analysis. At some smelters, the required space for duct runs is available only at a premium. The need to significantly elevate the baghouse discharge is a debatable issue.

A separate cost area identified as working capital could include a provision for increased property tax, royalties, fees, spare parts, supplies, and the cost of labor for a finite period (60 days). Most of what would be considered working capital has already been included in operating costs.

Baghouse operating cost estimates are factored (30) on an assumed direct labor staffing table considered necessary to operate the additional baghouses and ancillary equipment. Labor wages were determined from current labor union contracts at each property. Energy costs are based upon fan brake horsepower requirements at an assumed 68-pct efficiency for the applicable utility kilowatt hour charge. From these energy and labor costs, other indirect operating costs are determined, based on a factored system. These factors account for maintenance, indirect costs, general administrative costs, supervision, and payroll burden and fringes. Bag replacement cost is calculated at an expected average life of 2-1/2 yr per bag and at an overall of 20 pct of the baghouse primary equipment cost. The following format was used to determine baghouse operating cost:

1. Direct labor DL (labor wages + shift differential + overtime).
2. Direct labor supervision (0.15 × DL).
3. Maintenance labor (1.00 × DL).
4. Maintenance labor supervision (0.20 × DL).
5. Payroll burden and fringes (0.35 of [1 + 2 + 3 + 4]).
6. Maintenance materials and supplies [0.5 of (3 + 4)].
7. Indirect costs (0.4 × [1 + 2 + 3 + 4]).
8. General and administrative costs (0.15 × DL).
9. Bag replacement costs (0.2/2.5 yr) × (II A [from baghouse capital format]).
10. Power costs (total annual kW•h × utility charge/kW•h).

LOCAL CONTROLS

In addition to enclosing existing buildings, erecting new concentrate buildings, and ventilating these buildings with fans and associated baghouse systems, additional local environmental controls in the workplace are required in some areas in order to comply with OSHA standards. It is generally accepted that enclosure for environmental reasons will aggrevate airborne lead levels in the workplace. As a result, local controls are included as part of this study. Local control costs for the three smelter-refineries and the one smelter were estimated based on two local conrol plans supplied by the primary lead industry. Since these supplied capital and operating costs are company proprietary, a detailed breakdown of these costs with associated methodology cannot be disclosed. Totals for calculated capital and operating cost for each facility are reported in table 4. Costs are reported for conventional processing technology and for an alternative system utilizing continuous drossing that is currently being evaluated in Australia and Canada. Continuous drossing consists of close connection of the blast furnace, the forehearth (settler), and the continuous

TABLE 4. - Capital and operating cost summary for two alternative ambient lead environmental controls for Buick, Glover, Herculaneum, and East Helena

Conventional process technology:	
Capital:	
Existing building enclosures	$5,217,500
Baghouse	161,933,600
New building	31,243,200
Local control	51,619,800
Total	250,014,100
Operating:	
Baghouse	13,960,700
New building	638,400
Local control	3,908,700
Total	18,507,800
Continuous-drossing technology:	
Capital:	
Existing building closure	5,217,500
Baghouse	161,933,600
New building	31,243,100
Local control	59,950,500
Total	258,344,800
Operating:	
Baghouse	13,960,700
New building	638,400
Local control	1,505,600
Total	16,104,700

drossing induction-heated furnace to eliminate intermittent open handling of molten lead and dross in ladles, kettles, and skimmers and minimize the particulate lead emissions.

Local controls in this study include, by definition, any engineering design that may be used to reduce lead emissions within the workplace and that, of themselves, do not significantly decrease lead emission levels in the environment. These would include conveyor enclosures, ladle covers, appropriate hooding for drossing and refinery kettles, and all related ventilation. Continuous drossing capital and operating costs were developed from proprietary data based on engineering details of an Australian process.

Costs for local controls at each facility were developed separately; where necessary, costs were scaled from base costs based upon individual facility parameters; e.g., building volume and number of kettles. Costs for controls already incorporated in existing plants that have been defined in the SIP's have not been included here.

Two alternative sets of costs, conventional and continuous drossing, are reported. In conventional drossing, local controls are implemented through modifications of existing process technology. Standard sintering, blast furnace operations, conventional batch drossing, and refining systems as are in operation at the plant sites today, are each modified to reduce the airborne lead levels in the air around each respective unit process. Despite the application of local controls, appreciable quantities of airborne lead are released into the atmosphere near the conventional batch-drossing operations from transporting, pouring, and stirring of the dross. Capital and operating costs reflect implementation of these modifications.

In continuous drossing, the drossing furnace is positioned close to the blast furnace and connected to the forehearth discharge. The melt flows continuously from the forehearth to the drossing induction-heated furnace. The operations of transporting, pouring, and stirring are eliminated. The relatively low level of airborne lead is efficiently captured in fan-driven suction hoods connected to particle-capture baghouses. A continuous-drossing system could significantly reduce ambient lead concentrations in the drossing area.

COSTING SUMMARY AND ECONOMIC ANALYSIS

A summary of estimated incremental capital and operating costs for additional ambient air environmental controls for the four pyrometallurgical operations is presented in table 4. The incremental cost of refined lead would be $0.063/lb from the conventional smelting circuits and $0.062/lb from a continuous-drossing circuit. Costs are estimated for mid-1985 using the following parameters:

- o Construction to begin in 1986 and end in 1987 (1 year construction).
- o Operation ends in 1996 (10 yr operational life).
- o DCFROR is 15 pct on invested equity capital.
- o Annual lead capacity is 559,000 st.
- o Debt to equity ratio of required capital investment is 3:1 (75 pct debt, 25 pct equity).
- o A 10 pct interest rate on debt financing was assumed.

If the current lead emission level of the Buick, Glover, and Herculaneum pyrometallurgical facilities of approximately 3,840 lb/d were reduced to the theoretically achievable lead emission level of 1,420 lb/d, a reduction of 2,424 lb/d of lead discharged to the atmosphere could be realized. Recovery and credit of the lead at a $0.184/lb value would not change the stated $0.063/lb operating cost.

As shown in table 4, use of continuous drossing would increase plant capital costs by $8,330,700, but the operating costs would decrease $2,403,100/yr.

CONCLUSIONS

Lead emission inventories theoretically can be reduced to below 1985 reported levels at the Buick, Glover, Herculaneum, and East Helena primary lead plants. Capital and operating cost estimates include individual dust collection and venting of all concentrate-handling and lead-processing facilities. Conventional OSHA local controls are included in the costs; continuous-drossing techniques, which would assist in compliance with OSHA standards, are costed separately.

Using conventional process technology, the aggregated capital costs to the four plants are estimated to be $250,014,100. Aggregated annual operating costs are estimated to be $18,507,800. Total cost for theoretically achievable emission reduction is estimated as $0.063/lb of refined lead. The average open market price of refined lead for the first quarter of 1986 was $0.184/lb.

Aggregated capital costs are estimated to be $258,344,800 for augmenting conventional process technology with continuous drossing. Aggregated annual operating costs are estimated to be $15,719,600. Total cost for continuous drossing is estimated at $0.062/lb of refined lead.

The estimates do not include (1) OSHA considerations that may result from building enclosures; specifically, blast furnace drossing areas or the need and related costs for constructing ducts and centrally located elevated stacks to comply with best engineering practice for new point-source emissions, or (2) certain components of working capital costs not included in operating costs, such as possible increases in property tax on the new improvements.

The costing methodology is highly sensitive to certain engineering design factors; specifically, building volume, air-change rate, and ability to recirculate building air during cold weather.

Building volumes are the basis of the primary engineering calculations. Accurate measurement of building volumes as well as exclusions of occupied volumes is essential to proper sizing and costing of the ventilation system.

The study is based on an average 15 air changes per hour and an air-to-cloth ratio of 1.5:1, disregarding the volume occupied by process and mobile equipment. In practice, the air-change rate would be evaluated independently for each process location.

Recirculating building air during cold weather may not be possible due to the potential for buildup of an excessive amount of very fine lead particulates in the recirculating air, which would exceed OSHA limits. Should that be the case, costs could be increased by the cost of installation and operation of space heaters.

MISSOURI

Theoretical maximum emission levels for the Missouri smelter-refinery sites were calculated and compared with current emission levels (table 5). The values must be used with discretion since equipment efficiencies decrease with use. Also, the design parameters for emission control devices are seldom met in actual practice because operational data, such as particulate loadings and size distributions, are unavailable for on-site conditions.

It has been demonstrated that the Missouri smelter-refinery sites, where simple sulfide ores are processed, can achieve 98.5 pct efficiency. It is probable that they can achieve +99 pct efficiency, but that can only be defined by actual operating data acquired after all proposed modifications have been installed.

MONTANA

East Helena presents a unique problem of definition. Early studies used the lead emissions inventory method. No baseline data for unconrtrolled emission levels appear to have been reported. Furthermore, not all emission sources were evaluated. Later, the method of reporting was changed to the chemical mass balance method. A chemical mass balance allows the determination of emission quantities generated by each source and a comparison of those quantities to the local lead in the monitored ambient air. Unfortunately, this method does not provide an analysis that can be used to determine the total emissions produced by each source since a portion of the emissions is deposited prior to collection by the monitoring station some distance away. Since a common scientific correlation has not been found between the study methods, no quantitative lead emission inventory could be determined. It can only be stated that East Helena's present ambient lead emission levels exceed EPA limits. This is true even if the emission contributions from non-ASARCO sources are subtracted from the total values.

Control methods similar to those used in evaluating the Missouri sites can be applied to East Helena. Specifically, it can be assumed that what can be

TABLE 5. - Comparison of current and theoretical lead emissions and control efficiencies at Buick, Glover, and Herculaneum

Plant	Current		Theoretical		Emission reduction, lb/d
	Emission summary, lb/d	Efficiency, pct	Emission summary, lb/d	Efficiency, pct	
Buick[1]	1,181	97.7	654	98.8	527
Glover	882	98.8	329	99.6	553
Herculaneum	1,780	97.9	436	99.5	1,344

[1]Adjusted to 135,000 st/yr.

achieved at Herculaneum can be applied to East Helena, since they are similar in technology and in method of construction. However, the nature of the concentrates and the meteorological conditions at the two sites are radically different. East Helena processes a very complex sulfide ore with resulting differences in operation and stockpiling. East Helena has a higher frequency of temperature inversions than does Herculaneum, resulting in occasionally higher concentrations of airborne lead than at Herculaneum. All of these factors and lack of data make it difficult, if not impossible, to obtain a firm estimate of the theoretical optimum emissions attainable from the East Helena site.

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APPENDIX A.--BUICK SMELTER-REFINERY DATA

Operational data, a description of environmental regulation implementation technology, and erected capital and operating costs for the Buick smelter-refinery are summarized in this appendix. A plan view of the facility is shown in figure A-1. Tables A-1 and A-2 report actual historical lead emission data, and table A-3 reports theoretical emission values based on best available control technology (BACT) for this facility. A summary of estimates for building enclosures, baghouses, and local controls capital costs is given in table A-4. Table A-5 shows a factored estimate of operating costs of additional baghouses. Table A-6 summarizes all capital and operating cost estimates for reducing lead in ambient air to its lowest theoretical level. The table gives the costs utilizing conventional process technology as well as an alternative approach using continuous-drossing technology.

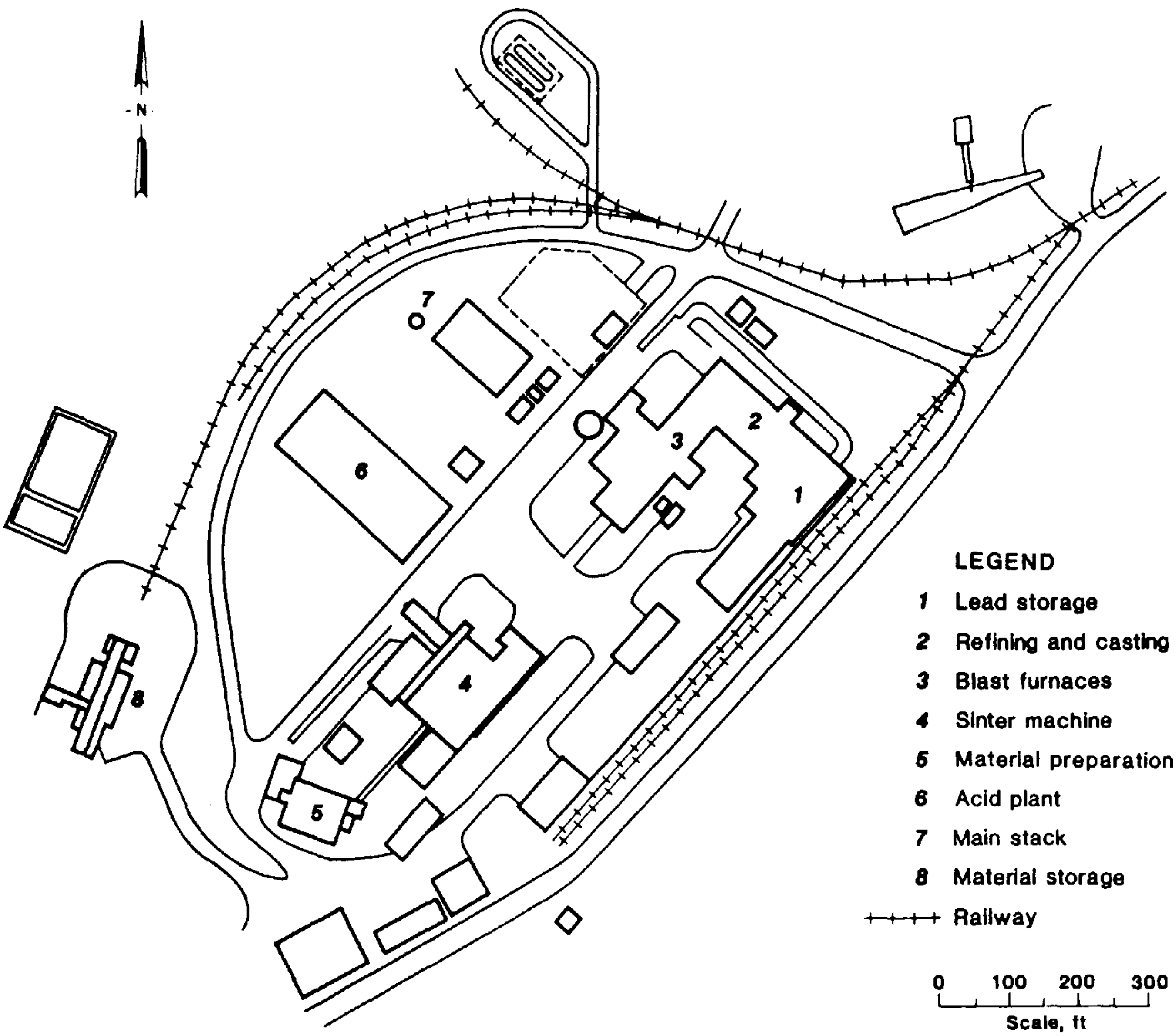

FIGURE A-1.—Buick smelter-refinery.

Ownership...... AMAX Lead Co. of Missouri (managing partner) and Homestake Mining Co.

History........ Constructed in 1965-67; operational in 1968.

Design capacity Refined lead - 140,000 st/yr.

Recent capacity utilization. 1981 - 72 pct; 1982 - 91 pct; 1983 - 102 pct; 1984 - 73 pct; 1985 - 102 pct.

Products and byproducts. Refined lead, silver dore, copper matte, cadmium, black sulfuric acid.

Technology..... Updraft sintering (optional partial offgas recirculation), conventional smelting, sulfuric acid plant, and pyrometallurgical refining.

Feed sources... Custom and captive smelting; since the end of 1983, some concentrates are from the company's Buick Mine; also, concentrates from Cominco were processed until the end of 1984.

Product grades. Lead bullion is 98 pct; refined lead grade is +99.99 pct.

Buick's single-contact sulfuric acid plant is designed to produce 221 st/d of sulfuric acid from sinter machine high-strength offgas, which contains 4 to 7 pct SO_2. The facility had utilized a six-compartment baghouse to remove dust from the high-strength SO_2 offgases. In 1983, this baghouse was replaced with an ESP and a venturi scrubber operated in series. Low-strength SO_2 offgases from the sinter machine and the blast furnaces are treated by a baghouse. A 200-ft stack is included in the facility design to discharge major process offgases.

Table A-1 is based upon 1979 data as reported in the Missouri SIP. The tabulation presents the control methods and the uncontrolled and the controlled emission levels. The reported production rate was 135,000 st/yr of refined lead, which produced an uncontrolled lead emission inventory of 52,451 lb/d and resulted in a controlled lead emission inventory of 4,105 lb/d. Overall emission control efficiency was 92.2 pct.

Point-source emissions contributed 23.7 pct to the total controlled lead emission inventory. These were controlled at an efficiency of 97.9 pct and limited to 971 lb/d. This was accomplished using a baghouse and acid plant for on the sinter machine to control high-strength SO_2 offgas, and a baghouse for the low-strength offgases from the sinter machine and blast furnace. Other point sources were controlled by the use of nine dynamic scrubbers. The two principle emission sources were the main stack (341 lb/d) and the scrubber 1 stack (349 lb/d).

Process fugitive emissions accounted for 69.0 pct of the total controlled lead emission inventory. These were controlled at an efficiency of 51.7 pct and were limited to 2,831 lb/d. These resulted from several sources although 2,122 lb/d was attributed to the sinter machine and its ancillary equipment.

Open fugitive emissions accounted for 7.3 pct of the total controlled lead emission inventory. These emissions were controlled at an efficiency of 35.9 pct and were limited to 303 lb/d. These resulted from several sources although 244 lb/d was attributed to resuspension of dusts and to open storage.

Table A-2 is based upon the 1985 Missouri Air Quality Data and Lead Emissions report. The control methods essentially indicate compliance with the consent order, which is part of the SIP and the resultant uncontrolled and controlled emission levels at the Buick smelter-refinery.

TABLE A-1. - Buick smelter-refinery: Emission control methods and lead emission inventory, 1979, at 135,000 st/yr refined lead (5)[1]

Emission source	Control method and/or environment	Emission inventory, lb/d		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack (sinter plant, blast furnaces, others).	Baghouses and acid plant	34,100	341	99.0
Scrubber stack:				
1 (sinter preparation).	Dynamic scrubber........	833	25	97.0
2 (sinter crushing and return handling).	...do..................	2,494	349	86.0
3 (sinter return)......	...do..................	500	9	98.2
4 (sinter return)......	...do..................	2,126	64	97.0
5 (sinter return)......	...do..................	2,126	64	97.0
6 (sinter preparation and return).	...do..................	2,126	64	97.0
7 (blast furnace charge preparation).	...do..................	790	24	97.0
8 (blast furnace charge preparation).	...do..................	790	24	97.0
9 (blast furnace charge preparation).	...do..................	227	7	96.9
Total or average....	NAp....................	46,112	971	97.9
PROCESS FUGITIVE EMISSIONS				
Ore concentrate storage, unloading, and handling.	Enclosed building.......	352	70	80.1
Mixing and pelletizing...	Enclosed building with conveyor scrubbers.	465	279	40.0
Sinter machine, sinter crushing, return and handling.	Semienclosed building, electrostatic precipitator, and settling chamber.	4,244	2,122	50.0
Blast furnace charging, slag granulation, roof ventilator.	Enclosed building with semienclosed conveyor.	234	94	59.8
Molten lead transfer.....	Enclosed building with roof ventilator.	192	77	59.9
Dross kettles............	Enclosed building.......	49	39	20.4
Lead casting.............	...do..................	180	90	50.0
Baghouse dust transfer...	Enclosed building, wet pugging and conveyors.	150	60	60.0
Total or average....	NAp....................	5,866	2,831	51.7
OPEN FUGITIVE EMISSIONS				
Sinter transfer..........	Open storage pile.......	18	18	0
Storage (to dump pile)...	...do..................	16	16	0
Secondary and slag pile..	...do..................	25	25	0
Resuspension.............	Water spray plant roads and paved areas.	414	244	41.1
Total or average....	NAp....................	473	303	35.9
Grand total or av...	NAp....................	52,451	4,105	92.2

NAp Not applicable.

[1]Underlined numbers in parentheses refer to items in the list of references preceding the appendixes.

TABLE A-2. - Buick smelter-refinery: Emission control methods and lead emission inventory, 1985, at 161,000 st/yr refined lead (8)

Emission source	Control method and/or environment	Emission inventory, lb/d		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack (sinter plant, blast furnaces, others).	Add electrostatic precipitator and venturi scrubber.	40,669	251	99.4
Scrubber stack:				
1 (sinter preparation).	No change..........	993	22	97.8
2 (sinter crushing and return handling).	...do..............	2,974	22	97.8
6 (sinter preparation and return).	...do..............	2,535	93	96.3
7 (blast furnace charge preparation).	...do..............	942	57	93.9
8 (blast furnace charge preparation).	...do..............	942	15	98.4
9 (blast furnace charge preparation).	...do..............	271	11	95.9
Stack, baghouse (sinter return).	Replaces scrubbers 3-5.	5,668	17	99.7
Total or average....	NAp................	54,994	488	99.1
PROCESS FUGITIVE EMISSIONS				
Ore concentrate storage, unloading, and handling.	Add conveyor skirts and hoods.	420	17	96.0
Mixing and pelletizing...	...do..............	555	166	70.1
Sinter machine, sinter crushing, return and handling.	Add baghouse, conveyor skirts and hoods.	5,061	277	94.5
Blast furnace charging, slag granulation, roof ventilator.	Add conveyor skirts and hoods; modify blast furnaces.	234	22	90.6
Molten lead transfer.....	Add improved standard procedures.	229	64	72.1
Dross kettles............	No change..........	58	47	19.0
Lead casting.............	...do..............	215	107	50.2
Baghouse dust transfer...	...do..............	179	71	60.3
Total or average....	NAp................	6,951	771	88.9
OPEN FUGITIVE EMISSIONS				
Sinter transfer..........	Add storage building.	18	5	72.2
Storage (to dump pile)...	No change..........	16	16	0
Secondary and slag pile..	Add storage building.	25	3	88.0
Resuspension.............	Add paving and vacuum cleaning.	414	122	70.5
Total or average....	NAp................	473	146	69.1
Grand total or av...	NAp................	62,418	1,405	97.7

NAp Not applicable.

The reported production rate of 161,000 st/yr of refined lead in 1985 was an extrapolated value based on limited months of production owing to a protracted strike. Actual 1985 annual production was 131,500 st/yr. Based on the extrapolated 1985 data, an uncontrolled lead emission inventory of 62,418 lb/d was controlled to a lead emission inventory of 1,405 lb/d. Overall emission control efficiency was 97.7 pct. Adjusting the 1985 data to the 1979 annual production rate of 135,000 st/yr, the uncontrolled emission inventory would be 52,451 st/yr; the controlled emission inventory would be 1,181 lb/d. Overall efficiency remained at the 1985 level of 97.7 pct. An emission reduction of 2,700 lb/d is indicated from table A-2 with a true reduction based on 1979 production rates of 2,264 lb/d as calculated.

Point-source emissions in 1985 contributed 34.7 pct to the total controlled lead emission inventory. These emissions were controlled at an efficiency of 99.1 pct to 488 lb/d on an extrapolated basis and 409 lb/d on a 1979 adjusted basis.

The principal source was the main stack at 251 lb/d on an extrapolated basis and 211 lb/d on an adjusted 1979 production rate basis. Consent order plant improvements were essentially complete.

Process fugitive emissions accounted for 54.9 pct of the total controlled lead emission inventory. These emissions were controlled at an efficiency of 88.9 pct and were limited to 771 lb/d on an extrapolated basis and 646 lb/d on a 1979 adjusted basis.

Open fugitive emissions would account for 10.3 pct of the total controlled lead emission inventory. These emissions would be controlled to an efficiency of 69.1 pct and would be limited to 146 lb/d. Resuspension of soils would result in 102 lb/d based on 1979 production. Since these are uneffected by production rate, no adjustment was necessary.

Table A-3 is the theoretically optimum lead emission inventory based on investigations. The production rate was assumed to be 135,000 st/yr of refined lead, which was reported in 1979. The uncontrolled lead emission inventory would be 52,451 lb/d and would result in a controlled lead emission inventory of 654 lb/d. Overall efficiency of plant emission controls would be 98.8 pct. An indicated emission reduction in 1985 would be 751 lb/d; a true indicated reduction based on 1979 production levels would be 524 lb/d.

Point-source emissions would contribute 30.9 pct to the total controlled lead emission inventory. These emissions would be controlled to an efficiency of 99.6 pct and are limited to 202 lb/d. The principal source would remain the main stack at 136 lb/d.

Process fugitive emissions would account for 46.8 pct of the total controlled lead emission inventory. These would be controlled to an efficiency of 94.8 pct and would be limited to 306 lb/d. The sinter area would account for 170 lb/d.

Open fugitive emissions would account for 22.3 pct of the total controlled lead emission inventory. These would be controlled to an efficiency of 69.1 pct and would be limited to 146 lb/d. Resuspension of dust would result in 122 lb/d based on 1979 production.

Table A-4 reports detailed capital cost estimates for Buick outlining the costs associated with the following:

- o Enclosing existing openings on process-related buildings presently emanating lead-bearing fugitive dust.
- o Installing new baghouses and adding positive fan-induced ventilation.
- o Adding new buildings to enclose concentrate, sinter, and lead-bearing dust storage areas.
- o Adding selective local controls.

TABLE A-3. - Buick smelter-refinery: Theoretical emission control methods and lead emission inventory at 135,000 st/yr refined lead

Emission source	Control method and/or environment	Emission inventory, lb/d		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack (sinter plant, blast furnaces, others).	Optimize baghouse efficiency.	34,100	136	99.6
Scrubber, stack:				
1 (sinter preparation).	Operational improvement to match scrubber 2.	883	6	99.3
2 (sinter crushing and return handling).	No change...........	2,494	17	99.3
6 (sinter preparation and return).	Operational improvement to match scrubber 2.	2,126	15	99.3
7 (blast furnace charge preparation).	...do...............	790	6	99.3
8 (blast furnace charge preparation).	...do...............	790	6	99.3
9 (blast furnace charge preparation).	...do...............	227	2	99.3
Stack, baghouse (sinter return).	No change...........	4,752	14	99.7
Total or average....	NAp.................	46,112	202	99.6
PROCESS FUGITIVE EMISSIONS				
Ore concentrate storage, unloading, and handling.	Add building and positive ventilation.	465	19	95.9
Mixing and pelletizing...	Enclosure and positive ventilation of building.	465	19	95.9
Sinter machine, sinter crushing, return and handling.	...do...............	4,244	170	96.0
Blast furnace charging, slag granulation, roof ventilator.	Seal roof ventilator and add positive ventilation.	234	9	96.2
Molten lead transfer.....	Cover ladle during transfer.	192	25	87.0
Dross kettles...........	Enclosure and positive ventilation of building.	49	2	95.9
Lead casting............	...do...............	180	7	96.1
Baghouse dust transfer...	No change...........	150	60	60.1
Total or average....	NAp.................	5,866	306	94.8
OPEN FUGITIVE EMISSIONS				
Sinter transfer..........	No change...........	18	5	72.2
Storage (to dump pile)...	...do...............	16	16	0
Secondary and slag pile..	...do...............	25	3	88.0
Resuspension............	...do...............	414	122	70.5
Total or average....	NAp.................	473	146	69.1
Grand total or av...	NAp.................	52,451	654	98.8

NAp Not applicable.

TABLE A-4. - Buick smelter-refinery: Estimate of capital cost (1985) for building enclosures, baghouses, and local controls

Control	Equipment: Primary	Equipment: Ancillary	Instrumentation and controls	Construction materials	Subcontractor installation	Field labor
Enclosure of existing buildings for--						
Storage and reclamation (bunker)................	NAp	NAp	NAp	1,200	619,900	200
Sinter preparation.......	NAp	NAp	NAp	5,500	195,500	1,700
Sinter crushing..........	NAp	NAp	NAp	42,900	8,400	13,200
Smelting, drossing, refining................	NAp	NAp	NAp	18,000	NAp	5,700
Blast furnace preparation	NAp	NAp	NAp	4,700	NAp	1,500
Total.................	NAp	NAp	NAp	72,300	823,800	22,300
Baghouses for--						
Storage and reclamation (bunker)................	789,000	52,600	126,240	NAp	1,345,298	NAp
Sinter preparation.......	615,000	41,000	98,400	NAp	1,048,616	NAp
Sinter crushing..........	1,455,000	97,000	232,800	NAp	2,480,872	NAp
Smelting, drossing, refining.	3,375,000	225,000	540,000	NAp	5,754,600	NAp
Blast furnace preparation	372,000	24,800	59,520	NAp	634,285	NAp
Total.................	6,606,000	440,400	1,056,960	NAp	11,263,671	NAp
Grand total.........	6,606,000	440,400	1,056,960	72,300	12,087,471	22,300

Control	Construction equipment usage	Sales tax: Construction materials	Sales tax: Capital equipment	Freight	Insurance	Contractor's overhead and profit
Enclosure of existing buildings for--						
Storage and reclamation (bunker)................	100	NAp	48	48	NAp	233,025
Sinter preparation.......	NAp	NAp	220	220	NAp	76,013
Sinter crushing..........	200	NAp	1,716	1,716	NAp	24,263
Smelting, drossing, refining................	NAp	NAp	720	720	NAp	8,888
Blast furnace preparation	NAp	NAp	188	188	NAp	2,325
Total.................	300	NAp	2,892	2,892	NAp	344,514
Baghouses for--						
Storage and reclamation (bunker)................	NAp	26,906	38,714	38,714	9,678	NAp
Sinter preparation.......	NAp	20,972	30,176	30,176	7,544	NAp
Sinter crushing..........	NAp	49,617	71,392	71,392	17,848	NAp
Smelting, drossing, refining................	NAp	115,092	165,600	165,600	41,400	NAp
Blast furnace preparation	NAp	12,686	18,253	18,253	4,563	NAp
Total.................	NAp	225,273	324,235	324,135	81,033	NAp
Grand total.........	300	225,273	327,027	327,027	81,033	344,514

Control	Construction and field indirect	Engineering procurement and constr. management	Escalation to July 1985	Contingency	Totals	Worker-hours
Enclosure of existing buildings for--						
Storage and reclamation (bunker)................	235	104,733	18,021	244,377	1,221,887	11
Sinter preparation.......	1,998	34,443	5,878	80,368	401,840	91
Sinter crushing..........	15,510	13,174	1,876	30,739	153,694	673
Smelting, drossing, refining................	6,698	4,969	687	11,595	57,977	298
Blast furnace preparation	1,763	1,301	180	3,036	15,181	78
Total.................	26,204	158,620	26,642	370,115	1,850,579	1,151
Baghouses for--						
Storage and reclamation (bunker)................	1,054,946	NAp	NAp	NAp	3,482,096	NAp
Sinter preparation.......	822,296	NAp	NAp	NAp	2,714,180	NAp
Sinter crushing..........	1,945,432	NAp	NAp	NAp	6,421,353	NAp
Smelting, drossing, refining................	4,512,600	NAp	NAp	NAp	14,894,892	NAp
Blast furnace preparation	497,389	NAp	NAp	NAp	1,641,749	NAp
Total.................	8,832,663	NAp	NAp	NAp	29,154,270	NAp
Local controls.............	NAp	NAp	NAp	NAp	24,169,469	NAp
Grand total.........	8,858,867	158,620	26,642	370,115	55,174,318	1,151

NAp Not applicable.

All costs are as of July 1985, and assume the use of conventional process technology in use at the plant. Base equipment capital costs were derived using the volumetric air flow rate determined from building volume and 15 air changes per hour.

Table A-5 outlines the procedure for estimating for factored operating costs at Buick. Cost estimates are factored based on estimated staffing requirements considered necessary to operate the additional baghouses and ancillary equipment. Wage rates were determined from current labor union contracts at Buick. Power costs were based upon estimated consumption requirements and known utility charges.

Table A-6 summarizes all estimated capital and operating costs required to achieve the theoretical lead emission inventory levels. The table includes costs for enclosing existing buildings, adding baghouses and associated ventilation systems, erecting new buildings for the containment of storage areas, and adding selected local controls. Two sets of costs are provided: costs for meeting the proposed ambient lead standards by means of (1) conventional drossing technology, and (2) a continuous-drossing system similar to that in use in Australia.

TABLE A-5. - Buick smelter-refinery: Factored operating cost estimate for additional baghouses

Cost category	Calculation	Annual cost
(1) Labor:		
(a) Direct labor,[1] 4 operators:		
Regular	4 × 2080 h/yr × \$11.94/h	\$99,341
Overtime	4 × 110 h/yr × \$11.94/h × 1.5	7,880
Subtotal direct labor	(Regular + overtime)	107,221
(b) Direct labor supervision	15 pct of (a) = 0.15 × \$107,221	16,083
(c) Maintenance labor	100 pct of (a) = 1.0 × \$107,221	107,221
(d) Maintenance labor supervision	20 pct of (a) = 0.20 × \$107,221	21,444
(e) Subtotal labor and supervision	(a) + (b) + (c) + (d)	251,969
(f) Payroll burden and fringe benefits	35 pct of (e) = 0.35 × \$251,969	88,189
(1) Total labor	(e) + (f)	340,158
(2) Maintenance materials and supplies	50 pct of (c) = 0.5 × \$107,221	53,613
(3) Indirect	40 pct of (e) = 0.40 × \$251,969	100,788
(4) General and administrative	15 pct of (a) = 0.15 × \$107,221	16,083
(5) Bag replacement	20 pct of baghouse capital costs every 2-1/2 yr = 0.2 × \$6,606,000 ÷ 2.5	528,480
(6) Power	3,466 kW at 3.71¢/kW·h	1,080,144
(7) Subtotal	(1)+(2)+(3)+(4)+(5)+(6)	2,119,266
(8) Contingency	20 pct of (7)	423,853
(9) Grand total	(7)+(8)	2,543,119

[1]Average costs based on current Missouri smelter-refinery labor contract including adjustments for shift differentials and wage rates.

TABLE A-6. - Buick smelter-refinery: Capital and operating cost summary for two alternative ambient lead environmental controls

Conventional process technology:	
Capital:	
Existing building enclosure	$1,850,579
Baghouse	29,154,270
Local control	24,169,469
Total	55,174,318
Operating:	
Baghouse	2,543,100
Local control	974,200
Total	3,517,300
Continuous-drossing technology:	
Capital:	
Existing building enclosure	1,850,579
Baghouse	29,154,270
Local control	25,625,269
Total	56,630,118
Operating:	
Baghouse	2,543,100
Local control	666,900
Total	3,210,000

APPENDIX B.--GLOVER SMELTER-REFINERY DATA

Operational data and environmental regulation implementation technology and erected capital and operating costs for ASARCO's Glover smelter-refinery are summarized on the following pages. Figure B-1 is a plan view of the facility showing the plant layout. Table B-1 reports actual historical lead emission data, and table B-2 reports theoretical emission values based on best available control technology (BACT) for this facility. A summary of estimates for building enclosures, baghouses, and local control capital costs is given in table B-3. Table B-4 shows a factored estimate of operating costs for additional baghouses. Table B-5 summarizes all estimates of capital and operating costs for reducing lead in ambient air to its lowest theoretical level. The table gives the costs utilizing conventional process technology as well as an alternative approach using continuous-drossing technology.

Ownership...... ASARCO Inc.

History........ Constructed in 1966-67; operational in 1968.

Design capacity Refined lead - 100,000 st/yr.

Recent capacity utilization. 1981 - 76 pct; 1982 - 132 pct (includes stockpile reduction); 1983 - 93 pct; 1984 - 78 pct.

Products and byproducts. Refined lead, copper matte, silver dore, cadmium.

Technology..... Updraft sintering with no offgas recirculation, conventional smelting, or pyrometallurgical refining.

Feed sources... Since 1984, plant smelts and refines concentrates from Cominco American Inc. mines on a toll basis. In previous years, concentrates were from Ozark Lead.

Refining does not include softening for removal of antimony, tin, arsenic and bismuth. The plant does not have an acid plant. The sinter plant operates with a baghouse and stack.

Table B-1 is based upon 1979 data as reported in the Missouri SIP. The tabulation lists the control methods and the uncontrolled and the controlled emission levels. The designed production rate was 110,000 st/yr of refined lead, which produced an uncontrolled lead emission inventory of 73,594 lb/d and resulted in a controlled lead emission inventory of 882 lb/d. Overall emission control efficiency was 98.8 pct. The plant achieved an ambient lead value for the study period of 1.18 $\mu g/m^3$, which was well within the standard. ASARCO opted to use a computer model to regulate the emission dispersion; consequently, no further testing has been reported.

Point-source emissions contributed 62.5 pct to the total controlled lead emissions inventory. These emissions were controlled at an efficiency of 99.2 pct and limited to 551 lb/d. This was accomplished using baghouses on the sinter machine and blast furnace to control offgases. Other point sources were controlled by using baghouses and a scrubber. The two principal sources were the main stack and the sinter crushing returns stack at 203 lb/d and 214 lb/d, respectively.

Process fugitive emissions accounted for 19.7 pct of the total controlled lead emissions inventory. These emissions were controlled at an efficiency of 95.6 pct and were limited to 174 lb/d. The three principle sources were the sinter building, the blast furnace area, and the drossing area, which produced 51 lb/d, 64 lb/d, 64 lb/d, and 43 lb/d, respectively.

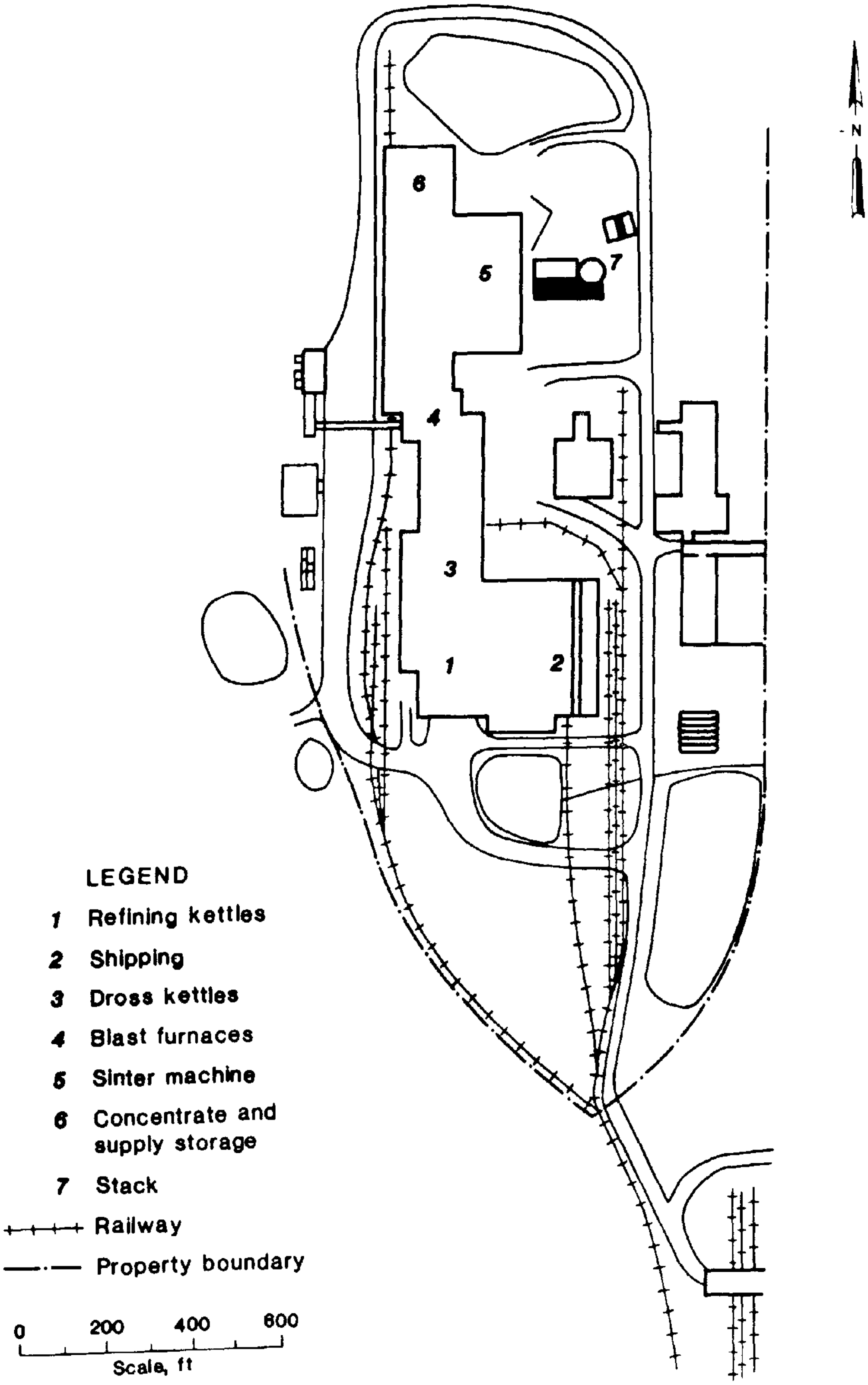

FIGURE B-1.—Glover smelter-refinery.

TABLE B-1. - Glover smelter-refinery: Emission control methods and lead emission inventory, 1979, at 110,000 st/yr refined lead (5)

Emission source	Control method and/or environment	Emission inventory, lb/d		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack (sinter machine).	Baghouse...........	14,500	203	98.6
Stack (blast furnace and drossing kettles).	...do..............	9,970	100	99.0
Stack (sinter preparation mixing system).	Venturi scrubber...	1,685	34	98.0
Stack (sinter crushing returns).	Baghouse...........	42,800	214	99.5
Total or average....	NAp................	68,955	551	99.2
PROCESS FUGITIVE EMISSIONS				
Sinter building..........	Semienclosed building with frequent washdown.	3,284	51	98.4
Blast furnace area.......	Semienclosed building with ventilated tapping operation.	183	64	65.0
Drossing area............	Semienclosed building with kettle fumes to baghouse and ladles water cooled after transfer.	176	43	75.6
Refinery area............	Semienclosed building with gravity tapping.	120	122	90.0
Concentrate storage and handling.	Semienclosed building with submerged bins.	175	97.7	
Total or average....	NAp................	3,938	174	95.6
OPEN FUGITIVE EMISSIONS				
Concentrate truck unloading.	Open area; no control.	55	55	0
Granulated storage pile..	...do..............	1	1	0
Baghouse dust unloading..	Clinkered by moisturization in baghouse.	254	1	99.6
Resuspension.............	Water spray plant roads and paved areas.	391	100	74.4
Total or average....	NAp................	701	157	77.6
Grand total or av...	NAp................	73,594	882	98.8

NAp Not applicable.

TABLE B-2. - Glover smelter-refinery: Theoretical emission control methods and lead emission inventory, at 110,000 st/yr refined lead

Emission source	Control method and/or environment	Emission inventory, lb/d		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack (sinter machine).	Improve baghouse efficiency.	14,500	44	99.7
Stack (blast furnace and drossing kettles).	...do...............	9,970	30	99.7
Stack (sinter preparation mixing system).	Improve scrubber efficiency (higher pressure drop).	1,685	3	99.8
Stack (sinter crushing returns).	Improve baghouse efficiency.	42,800	128	99.7
Total or average....	NAp................	68,955	205	99.7
PROCESS FUGITIVE EMISSIONS				
Sinter building..........	Enclose building and ventilate with baghouse.	3,284	10	99.7
Blast furnace area.......	...do..............	183	1	99.5
Drossing area............	...do..............	176	1	99.4
Refinery area............	...do..............	120	1	99.2
Concentrate storage and handling.	...do..............	175	1	99.2
Total or average....	NAp................	3,938	14	99.4
OPEN FUGITIVE EMISSIONS				
Concentrate truck unloading.	Building with baghouse ventilation.	55	8	85.5
Granulated storage pile..	No change..........	1	1	0
Baghouse dust unloading..	...do..............	254	1	99.6
Resuspension.............	...do..............	391	100	74.4
Total or average....	NAp................	701	110	84.3
Grand total or av...	NAp................	73,594	329	99.6

NAp Not applicable.

Open fugitive emissions accounted for 17.8 pct of the total controlled lead emission inventory. These emissions controlled at an efficiency of 77.6 pct and were limited to 157 lb/d. These resulted from several sources although 100 lb/d was attributed to resuspension of soils and open storage.

Table B-2 is the theoretically optimum lead emission inventory based on investigations. The production rate was assumed to be 110,000 st/yr of refined lead. The uncontrolled lead emissions inventory would be 73,594 lb/d and would result in a controlled lead emissions inventory of 329 lb/d. Overall emissions control efficiency would be 99.6 pct. The emission level would be 553 lb/d less than in 1979.

Point-source emissions would contribute 62.3 pct to the total controlled lead emissions inventory. These emissions would be controlled to an efficiency of 99.7 pct and limited to 205 lb/d. The principal source would be sinter crushing returns at 128 lb/d.

Process fugitive emissions would account for 4.3 pct of the total controlled lead emissions inventory. These would be controlled to an efficiency of 99.6 pct and would be limited to 14 lb/d. The sinter building would account for 10 lb/d.

TABLE B-3. - Glover smelter-refinery: Estimate of capital cost (1985) for building enclosures, baghouses, and local controls

Control	Equipment: Primary	Equipment: Ancillary	Instrumentation and controls	Construction materials	Subcontractor installation	Field labor
Enclosure of existing buildings for--						
Blast furnace, drossing, and refining...	NAp	NAp	NAp	368,200	29,200	115,300
Receiving bin........	NAp	NAp	NAp	203,300	14,600	65,300
Sintering............	NAp	NAp	NAp	50,500	15,300	15,900
Truck unloading......	NAp	NAp	NAp	NAp	223,200	NAp
Total............				622,000	282,300	196,500
Baghouses for--						
Blast furnace, drossing, and refining...	8,475,000	565,000	1,356,000	NAp	11,851,440	NAp
Receiving bin........	7,414,500	494,300	1,186,320	NAp	10,368,437	NAp
Sintering............	4,237,500	282,500	678,000	NAp	5,925,720	NAp
Truck unloading......	97,500	6,500	15,600	NAp	44,252	NAp
Total............	20,224,500	1,348,300	3,235,920	NAp	28,189,849	NAp
Grand total.....	20,224,500	1,348,300	3,235,920	622,000	28,472,149	196,500

Control	Construction equipment usage	Sales tax: Construction materials	Sales tax: Capital equipment	Freight	Insurance	Contractor's overhead and profit
Enclosure of existing buildings for--						
Blast furnace, drossing, and refining...	1,700	NAp	14,728	14,728	NAp	192,900
Receiving bin........	1,900	NAp	8,132	8,132	NAp	106,913
Sintering............	NAp	NAp	2,020	2,020	NAp	30,638
Truck unloading......	NAp	NAp	NAp	NAp	NAp	83,700
Total............	3,600	NAp	24,880	24,880	NAp	414,151
Baghouses for--						
Blast furnace, drossing, and refining...	NAp	237,029	415,840	415,840	103,960	NAp
Receiving bin........	NAp	207,369	363,805	363,805	90,951	NAp
Sintering............	NAp	118,514	207,920	207,920	51,980	NAp
Truck unloading......	NAp	885	4,784	4,784	1,196	NAp
Total............	NAp	563,797	992,349	992,349	248,087	NAp
Grand total.....	3,600	563,797	1,017,229	1,017,229	248,087	414,151

Control	Construction and field indirect	Engineering procurement and constr. management	Escalation to July 1985	Contingency	Totals	Worker-hours
Enclosure of existing buildings for--						
Blast furnace, drossing, and refining...	135,478	106,458	14,918	248,402	1,242,012	6,014
Receiving bin........	76,728	59,193	8,268	138,116	690,582	3,253
Sintering............	18,683	16,492	2,369	38,480	192,402	842
Truck unloading......	NAp	37,605	6,473	87,744	438,722	NAp
Total............	230,889	219,748	32,028	512,742	2,563,718	10,109
Baghouses for--						
Blast furnace, drossing, and refining...	11,331,640	NAp	NAp	NAp	34,751,749	NAp
Receiving bin........	9,913,681	NAp	NAp	NAp	30,403,168	NAp
Sintering............	5,665,820	NAp	NAp	NAp	17,375,874	NAp
Truck unloading......	60,996	NAp	NAp	NAp	236,497	NAp
Total............	26,972,137	NAp	NAp	NAp	82,767,288	NAp
Local controls.........	NAp	NAp	NAp	NAp	11,697,600	NAp
Grand total.....	27,203,026	219,748	32,028	512,742	97,028,606	10,109

NAp Not applicable.

TABLE B-4. - Glover smelter-refinery: Factored operating cost estimate for additional baghouses

Cost category	Calculation	Annual cost
(1) Labor:		
(a) Direct labor,[1] 4 operators:		
Regular........................	4 × 2080 h/yr × $11.94/h........	$99,341
Overtime.......................	4 × 110 h/yr × $11.94/h × 1.5...	7,880
Subtotal direct labor.......	(Regular + overtime)............	107,221
(b) Direct labor supervision......	15 pct of (a) = 0.15 × $107,221.	16,083
(c) Maintenance labor.............	100 pct of (a) = 1.0 × $107,221.	107,221
(d) Maintenance labor supervision.	20 pct of (a) = 0.20 × $107,221.	21,444
(e) Subtotal labor and supervision..............	(a) + (b) + (c) + (d)...........	251,969
(f) Payroll burden and fringe benefits.....................	35 pct of (e) = 0.35 × $251,969.	88,189
(1) Total labor..............	(e) + (f).......................	340,158
(2) Maintenance materials and supplies	50 pct of (c) = 0.5 × $107,221..	53,613
(3) Indirect..........................	40 pct of (e) = 0.40 × $251,969.	100,788
(4) General and administrative........	15 pct of (a) = 0.15 × $107,221.	16,083
(5) Bag replacement...................	20 pct of baghouse capital costs every 2-1/2 yr = 0.2 × $20,224,500 ÷ 2.5............	1,617,960
(6) Power.............................	10,372 kW at 3.71¢/kW·h.........	3,232,330
(7) Subtotal.................	(1)+(2)+(3)+(4)+(5)+(6).........	5,360,932
(8) Contingency.......................	20 pct of (7)...................	1,072,186
(9) Grand total.............	(7)+(8).........................	6,433,118

[1]Average costs based on current Missouri smelter-refinery labor contract including adjustments for shift differentials and wage rates.

Open fugitive emissions would account for 33.4 pct of the total controlled lead emissions inventory. These emissions would be controlled to an efficiency of 84.3 pct and would be limited to 110 lb/d. Resuspension of soils would account for 100 lb/d of that total.

Table B-3 reports detailed capital cost estimates for Glover, outlining the costs associated with the following:

- o Enclosing existing openings on process-related buildings presently emanating lead-bearing fugitive dust.
- o Installing new baghouses and adding positive fan-induced ventilation.
- o Adding new buildings to enclose concentrate, sinter, and lead-bearing dust storage areas.
- o Adding selective local controls.

All costs are as of July 1985 and assume the use of conventional process technology currently in use at the plant site. Base equipment capital costs were derived using the volumetric air flow rate determined from building volume and 15 air changes per hour.

Table B-4 outlines the procedure for estimating factored operating costs at Glover. Cost estimates are factored based on estimated staffing requirements considered necessary to operate the additional baghouses, and ancillary equipment. Wage rates were determined from current labor union contracts at Glover. Power costs were based upon estimated consumption requirements and known utility charges.

Table B-5 summarizes all estimated capital and operating costs required to achieve the theoretical lead emission inventory levels. Included are costs for enclosing existing buildings, adding baghouses and associated ventilation systems, erecting new buildings for the containment of storage areas, and selected local controls. Two sets of costs are provided: costs for meeting the proposed ambient lead standards by means of (1) conventional drossing technology, and (2) a continuous-drossing system similar to that in use in Australia.

TABLE B-5. - Glover smelter-refinery: Capital and operating cost summary for two alternative ambient lead environmental controls

Conventional process technology:	
Capital:	
Existing building enclosure	$2,563,718
Baghouse	82,767,288
Local control	11,697,600
Total	97,028,606
Operating:	
Baghouse	6,433,100
Local control	1,363,200
Total	7,796,300
Continuous-drossing technology:	
Capital:	
Existing building enclosure	2,563,718
Baghouse	82,767,288
Local control	13,746,600
Total	99,077,606
Operating:	
Baghouse	6,433,100
Local control	802,400
Total	7,235,500

APPENDIX C.--HERCULANEUM SMELTER-REFINERY DATA

Operational data and environmental regulation implementation technology and costs for St. Joe Lead Co.'s Herculaneum smelter-refinery are summarized on the following pages. Figure C-1 is a view of the facility. Tables C-1 and C-2 report actual historical lead emission data, and table C-3 reports theoretical emission values based on best available control technology (BACT) for this facility. A summary of estimates for building enclosures, baghouses, and local control capital costs is given in table C-4. Table C-5 shows a factored estimate of operating costs for additional baghouses. Table C-6 summarizes all estimates of capital and operating costs for reducing lead in ambient air to its lowest theoretical level. The table gives the costs utilizing conventional process technology as well as an alternative approach using continuous-drossing technology.

Ownership...... Fluor Corp.

History........ Constructed in 1891 and originally designed to use downdraft sintering. Expanded periodically.

Design capacity Lead bullion -225,000 st/yr.

Recent capacity utilization. 1981 - 79 pct; 1982 - 95 pct; 1983 - 101 pct; 1984 - 60 pct.

Products and byproducts. Refined lead (including alloys), silver, lead-copper matte, sulfuric acid.

Technology..... Updraft sintering, conventional smelting, sulfuric acid plant, and pyrometallurgical refining.

Feed sources... Lead sulfide concentrates produced from company mines in Missouri.

Product grades. Refined lead grade ranges from 99.99 pct to 99.999 pct.

Herculaneum has a single-contact sulfuric acid plant with a capacity of 6,600 to 7,700 st/month. The plant has three baghouses, the third of which was added in 1973.

Table C-1 is based upon 1979 data as reported in the Missouri SIP. The tabulation lists the control methods and the uncontrolled and the controlled emission levels. The reported production rate was 225,000 st/yr of refined lead, which produced an uncontrolled lead emission inventory of 83,871 lb/d and resulted in a controlled lead emission inventory of 1,974 lb/d. Overall emission control efficiency was 97.6 pct.

Point-source emissions contributed 45.7 pct to the total controlled lead emission inventory. These emissions were controlled at an efficiency of 98.8 pct and limited to 903 lb/d. This was accomplished using a baghouse and acid plant for the high-strength SO_2 offgas from the sinter mmachine and a baghouse for the low-strength offgases from the sinter machine and blast furnace. Other point sources were controlled by the use of five dynamic scrubbers. The principal source was the main stack at 610 lb/d.

Process fugitive emissions accounted for 47.3 pct of the total controlled lead emission inventory. These emissions were controlled at an efficiency of 88.4 pct and were limited to 933 lb/d. The four principal sources are mixing and pelletizing (191 lb/d), sinter machine and sinter return (191 lb/d), reverberatory furnace leaks (120 lb/d), and blast furnace conveyor (124 lb/d).

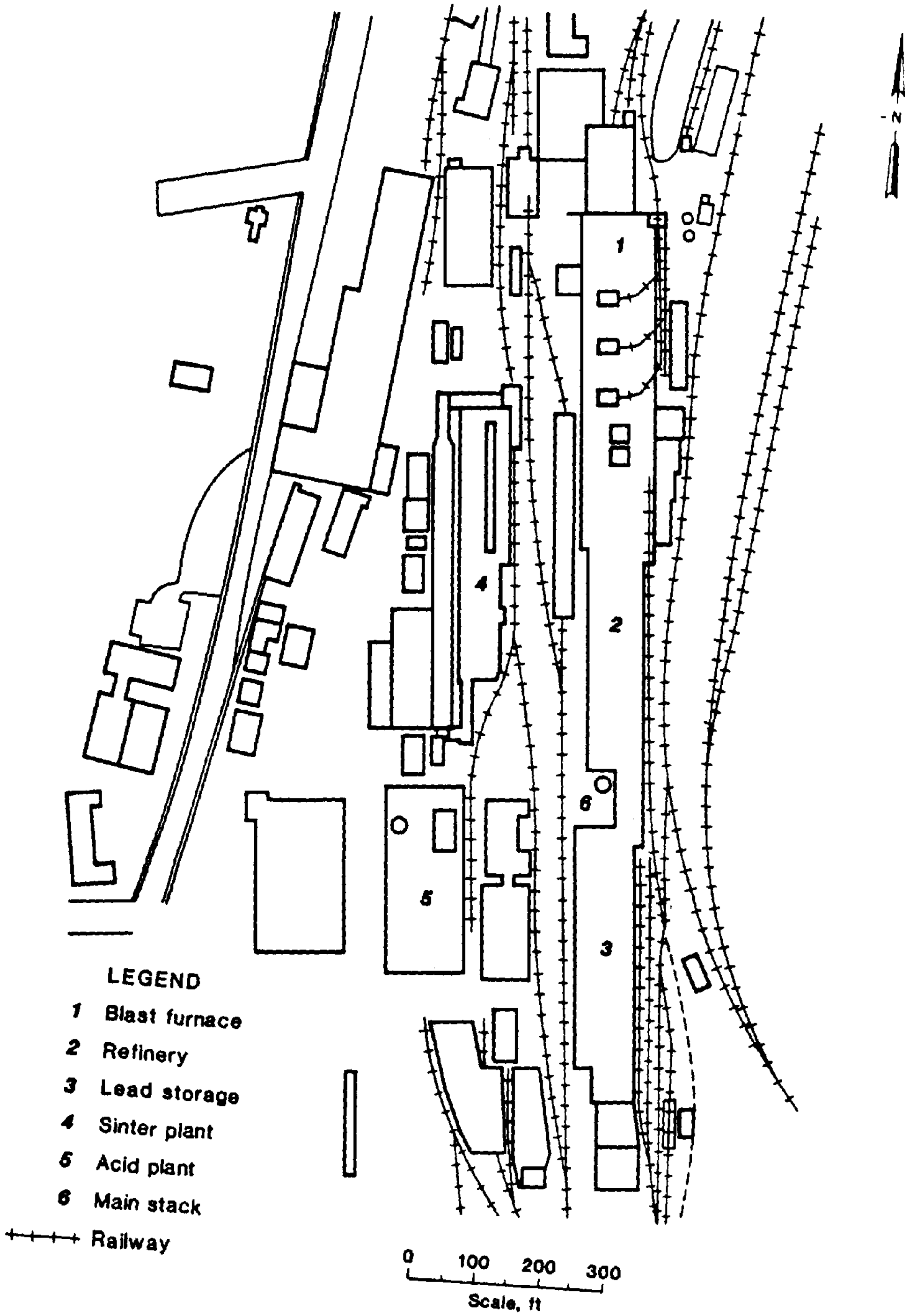

FIGURE C-1.—Herculaneum smelter-refinery.

TABLE C-1. - Herculaneum smelter-refinery: Emission control methods and lead emission inventory, 1979, at 225,000 st/yr refined lead (5)

Emission source	Control method and/or environment	Emission inventory, lb/d		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack (sinter plant, blast furnaces, and drossing).	Baghouses and acid plant	61,000	610	99.0
Scrubber stack:				
1 (sinter breaker)..	Dynamic scrubber........	4,285	86	98.0
2 (sinter crushing and screening).	...do...................	380	8	97.9
3 (sinter crushing).	...do...................	4,000	80	98.0
4 (sinter crushing).	...do...................	5,525	110	98.0
8 (sinter return)...	...do...................	475	9	98.1
Total or average...	NAp.....................	75,665	903	98.8
PROCESS FUGITIVE EMISSIONS				
Lead concentrate unloading.	Semienclosed building with submerged bins.	38	19	50.0
Baghouse dust unloading.	...do...................	295	88	70.2
Mixing and pelletizing.	Enclosed mix bins with washdown equipment.	882	191	78.3
Sinter machine and sinter return circuit.	Roof ventilation........	5,174	191	96.3
Blast furnace monitor.	Enclosed ventilator with baghouse and washdown.	316	17	94.6
Lead pouring to ladle.	Enclosed with exhaust through roof monitor.	290	95	67.2
Dross kettle..........	Enclosed building with exhaust through roof monitor.	74	61	17.6
Reverberatory furnace.	Enclosed process with baghouse exhaust through roof monitor.	462	120	74.0
Lead casting..........	Enclosed building and belt conveyors.	226	27	89.8
Conveyor to blast furnaces.	Semienclosed transfer points.	253	124	51.0
Total or average..	NAp.....................	8,050	933	88.4
OPEN FUGITIVE EMISSIONS				
Lead concentrate storage.	Open storage pile.......	6	6	0
Fenced property resuspension.	Paving and wet road sweeping.	144	126	12.5
Slag pile.............	Open storage............	4	4	0
Lead concentrate transfer.	Open handling...........	2	2	0
Total or average..	NAp.....................	156	138	11.5
Grand total or av.	NAp.....................	83,871	1,974	97.6

NAp Not applicable.

Open fugitive emissions accounted for 7.0 pct of the total controlled lead emission inventory. These emissions were controlled at an efficiency of 11.5 pct and were limited to 138 lb/d. These resulted from several sources although 126 lb/d was attributed to resuspension of dust.

Table C-2 is based upon the 1985 Missouri Air Quality Data and Lead Emissions report. The control methods listed essentially indicate compliance with the consent order, which is part of the SIP and the resultant uncontrolled and controlled emission levels at the smelter-refinery. The reported production rate was 225,000 st/yr of refined lead. The uncontrolled lead emission inventory was 83,871 lb/d, and the controlled lead emission inventory was 1,780 lb/d. Overall emission control efficiency was 97.9 pct. The emission reduction over that of the previous reported year was 194 lb/d.

Point-source emissions in 1982 contributed 85.9 pct to the total controlled lead emission inventory. These emissions were controlled at an efficiency of 98.0 pct and limited to 1,529 lb/d. Individual data were not available to isolate the principal source, although it was believed to be the main stack. Consent-order plant improvements were essentially complete.

Process fugitive emissions accounted for 12.1 pct of the total controlled lead emission inventory. These emissions were controlled at an efficiency of 97.3 pct and were limited to 216 lb/d.

Open fugitive emissions accounted for 2.0 pct of the total controlled lead emission inventory. These were controlled to an efficiency of 77.6 pct and would be limited to 35 lb/d. Resuspension of dusts accounted for 23 lb/d.

Table C-3 is the theoretically optimum lead emission inventory based on investigations conducted. The production rate was assumed to be 225,000 st/yr of refined lead. The uncontrolled lead emission inventory would be 83,871 lb/d and would result in a controlled lead emission inventory of 436 lb/d. Overall emission control efficiency would be 99.5 pct. The emission reduction over that of the previous reported year would be 1,344 lb/d.

Point-source emissions would contribute 65.6 pct to the total controlled lead emission inventory. These emissions would be controlled to an efficiency of 99.6 pct and limited to 286 lb/d. The principal source would remain in the main stack at 183 lb/d.

Process fugitive emissions would account for 26.4 pct of the total controlled lead emission inventory. These emissions would be controlled to an efficiency of 98.6 pct and would be limited to 115 lb/d.

Open fugitive emissions would account for 8.0 pct of the total controlled lead emission inventory. These emissions would be controlled to an efficiency of 77.6 pct and would be limited to 35 lb/d. Resuspension of dusts would account for 23 lb/d.

Table C-4 reports detailed capital cost estimates outlining the costs associated with the following:

- Enclosing existing openings on process-related buildings emitting lead-bearing fugitive dust.
- Installing new baghouses and adding positive fan-induced ventilation.
- Adding new buildings to enclose concentrate, sinter, and lead-bearing dust storage areas.
- Adding selective local controls.

All costs are as of July 1985 and assume the use of conventional process technology in use at the plant site. Base equipment capital costs were derived using the volumetric air flow rate determined from building volume and 15 air changes per hour at an air-to-cloth ratio of 1.5:1.

TABLE C-2. - Herculaneum smelter-refinery: Emission control methods and lead emission inventory, 1982, at 225,000 st/yr refined lead (6)

Emission source	Control method and/or environment	Emission inventory, lb/d		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack (sinter plant, blast furnaces, drossing).	No change............	61,000	NA	NAp
Scrubber stack:				
1 (sinter breaker)..	...do.................	4,285	NA	NAp
2 (sinter crushing and screening).	...do.................	380	NA	NAp
3 (sinter crushing).	...do.................	4,000	NA	NAp
4 (sinter crushing).	...do.................	5,525	NA	NAp
8 (sinter return)...	...do.................	475	NA	NAp
Total or average...	NAp..................	75,665	1,529	98.0
PROCESS FUGITIVE EMISSIONS				
Lead concentrate unloading.	No change............	38	NA	NAp
Baghouse dust unloading.	...do.................	295	NA	NAp
Mixing and pelletizing.	Add dynamic scrubber..	882	NA	NAp
Sinter machine and sinter return circuit.	Add 5 new dynamic scrubbers and conveyor cover.	5,174	NA	NAp
Blast furnace monitor.	Enclose and ventilate charge makeup and weighing.	316	NA	NAp
Lead pouring to ladle.	No change............	290	NA	NAp
Dross kettle..........	Improve ventilation...	74	NA	NAp
Reverberatory furnace.	No change............	462	NA	NAp
Lead casting..........	...do.................	226	NA	NAp
Conveyor to blast furnaces.	Enclose and ventilate charge makeup and weighing.	253	NA	NAp
Total or average..	NAp..................	8,050	216	97.3
OPEN FUGITIVE EMISSIONS				
Lead concentrate storage.	No change............	6	6	0
Fenced property resuspension.	Additional paving and new sweeper.	144	23	84.0
Slag pile.............	No change............	4	4	0
Lead concentrate transfer.	...do.................	2	2	0
Total or average..	NAp..................	156	35	77.6
Grand total or av.	NAp..................	83,871	1,780	97.9

NA Not available. NAp Not applicable.

TABLE C-3. - Herculaneum smelter-refinery: Theoretical emission control methods and lead emission inventory, at 225,000 st/yr refined lead

Emission source	Control method and/or environment	Emission inventory, lb/d		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack (sinter plant, blast furnaces, drossing).	Optimize efficiency...	61,000	183	99.7
Scrubber stack:				
1 (sinter breaker)..	...do.................	4,285	30	99.3
2 (sinter crushing and screening).	...do.................	380	3	99.3
3 (sinter crushing).	...do.................	4,000	28	99.3
4 (sinter crushing).	...do.................	5,525	39	99.3
8 (sinter return)...	...do.................	475	3	99.3
Total or average...	NAp..................	75,665	286	99.6
PROCESS FUGITIVE EMISSIONS				
Lead concentrate unloading.	Add unloading and bedding building with ventilation.	38	2	96.0
Baghouse dust unloading.	Enclose and ventilate building and conveyors.	295	12	96.0
Mixing and pelletizing.	Optimize efficiency...	882	6	99.3
Sinter machine and sinter return circuit.	Enclose building and add baghouse ventilation.	5,174	36	96.0
Blast furnace monitor.	...do.................	316	13	96.0
Lead pouring to ladle.	...do.................	290	12	96.0
Dross kettle..........	...do.................	74	3	96.0
Reverberatory furnace.	Replace baghouse with larger unit.	462	18	96.0
Lead casting..........	...do.................	226	11	96.0
Conveyor to blast furnaces.	Add baghouse ventilation.	253	2	99.3
Total or average..	NAp..................	8,050	115	98.6
OPEN FUGITIVE EMISSIONS				
Lead concentrate storage.	No change.............	6	6	0
Fenced property resuspension.	...do.................	144	23	84.0
Slag pile.............	...do.................	4	4	0
Lead concentrate transfer.	...do.................	2	2	0
Total or average..	NAp..................	156	35	77.6
Grand total or av.	NAp..................	83,871	436	99.5

NAp Not applicable.

TABLE C-4. - Herculaneum smelter-refinery: Estimate of capital cost (1985) for building enclosures, baghouses, and local controls

Control	Equipment: Primary	Equipment: Ancillary	Instrumentation and controls	Construction materials	Subcontractor installation	Field labor
Enclosure of existing buildings for--						
Blast furnace, drossing, refining..............	NAp	NAp	NAp	50,300	19,200	15,300
Blast furnace bins and conveyors..............	NAp	NAp	NAp	13,800	11,500	3,600
Sinter mix bins.........	NAp	NAp	NAp	34,100	11,100	10,100
Sintering..............	NAp	NAp	NAp	37,300	NAp	11,800
Rail unloading..........	NAp	NAp	NAp	12,200	11,500	3,000
Total................	NAp	NAp	NAp	147,700	53,300	43,800
Baghouses for--						
Blast furnace, drossing, refining..............	4,375,500	291,700	700,080	NAp	7,460,519	NAp
Blast furnace bins and conveyors..............	237,300	16,200	38,025	NAp	107,864	NAp
Sinter mix bins.........	525,000	35,000	84,000	NAp	895,160	
Sintering..............	3,000,000	200,000	480,000	NAp	5,115,200	NAp
Rail unloading..........	143,400	8,600	22,800	NAp	64,676	NAp
Total................	8,281,200	551,500	1,324,905	NAp	13,643,419	NAp
Grand total........	8,281,200	551,500	1,324,905	147,700	13,696,719	43,800

Control	Construction equipment usage	Sales tax: Construction materials	Sales tax: Capital equipment	Freight	Insurance	Contractor's overhead and profit
Enclosure of existing buildings for--						
Blast furnace, drossing, refining..............	400	NAp	2,012	2,012	NAp	31,950
Blast furnace bins and conveyors..............	200	NAp	552	552	NAp	10,913
Sinter mix bins.........	200	NAp	1,364	1,364	NAp	20,813
Sintering..............	NAp	NAp	1,492	1,492	NAp	18,413
Rail unloading..........	400	NAp	488	488	NAp	10,163
Total................	1,200	NAp	5,908	5,908	NAp	92,252
Baghouses for--						
Blast furnace, drossing, refining..............	NAp	149,210	214,691	214,691	53,673	NAp
Blast furnace bins and conveyors..............	NAp	2,157	11,661	11,661	2,915	NAp
Sinter mix bins.........	NAp	17,903	25,760	25,760	6,440	NAp
Sintering..............	NAp	102,304	147,200	147,200	36,800	NAp
Rail unloading..........	NAp	1,294	6,992	6,992	1,748	NAp
Total................	NAp	272,868	406,304	406,304	101,576	NAp
Grand total........	1,200	272,868	412,212	412,212	101,576	92,252

Control	Construction and field indirect	Engineering procurement and constr. management	Escalation to July 1985	Contingency	Totals	Worker-hours
Enclosure of existing buildings for--						
Blast furnace, drossing, refining..............	17,978	16,995	2,471	39,654	198,272	795
Blast furnace bins and conveyors..............	4,230	5,543	844	12,933	64,667	192
Sinter mix bins.........	11,868	11,102	1,610	25,905	129,526	526
Sintering..............	13,865	10,294	1,424	24,020	120,100	616
Rail unloading..........	3,525	5,106	786	11,914	59,570	156
Total................	51,466	49,040	7,135	114,426	572,135	2,285
Baghouses for--						
Blast furnace, drossing, refining..............	5,850,335	NAp	NAp	NAp	19,310,399	NAp
Blast furnace bins and conveyors..............	148,678	NAp	NAp	NAp	576,461	NAp
Sinter mix bins.........	701,960	NAp	NAp	NAp	2,316,983	NAp
Sintering..............	4,011,200	NAp	NAp	NAp	13,239,904	NAp
Rail unloading..........	89,148	NAp	NAp	NAp	345,650	NAp
Total................	10,801,321	NAp	NAp	NAp	35,789,397	NAp
New buildings............	NAp	NAp	NAp	NAp	12,506,000	NAp
Local controls...........	NAp	NAp	NAp	NAp	11,322,000	NAp
Grand total........	10,852,787	49,040	7,135	114,426	60,189,532	2,285

NAp Not applicable.

Table C-5 outlines the procedure for estimating factored operating costs at Herculaneum. Cost estimates are factored based on estimated staffing requirements considered necessary to operate the additional baghouses, etc. Wage rates were determined from current labor union contracts in the area. Power costs were based upon estimated consumption requirements and known utility charges.

Table C-6 summarizes all estimated capital and operating costs required to achieve the theoretical lead emission inventory levels. Included are costs for enclosing existing buildings, adding baghouses and associated ventilation systems, erection of new buildings for the containment of storage areas, and selected local controls. Two sets of costs are provided: costs for meeting the proposed ambient lead standards by means of (1) conventional drossing technology and (2) a continuous-drossing system similar to that in use in Australia.

TABLE C-5. - Herculaneum smelter-refinery: Factored operating cost estimate for additional baghouses

Cost category	Calculation	Annual cost
(1) Labor:		
(a) Direct labor,[1] 4 operators:		
Regular	4 × 2080 h/yr × $11.94/h	$99,341
Overtime	4 × 110 h/yr × $11.94/h × 1.5	7,880
Subtotal direct labor	(Regular + overtime)	107,221
(b) Direct labor supervision	15 pct of (a) = 0.15 × $107,221.	16,083
(c) Maintenance labor	100 pct of (a) = 1.0 × $107,221.	107,221
(d) Maintenance labor supervision.	20 pct of (a) = 0.20 × $107,221.	21,444
(e) Subtotal labor and supervision	(a) + (b) + (c) + (d)	251,969
(f) Payroll burden and fringe benefits	35 pct of (e) = 0.35 × $251,969.	88,189
(1) Total labor	(e) + (f)	340,158
(2) Maintenance materials and supplies	50 pct of (c) = 0.5 × $107,221.	53,613
(3) Indirect	40 pct of (e) = 0.40 × $251,969.	100,788
(4) General and administrative	15 pct of (a) = 0.15 × $107,221.	16,083
(5) Bag replacement	20 pct of baghouse capital costs every 2-1/2 yr = 0.2 × $8,281,200 ÷ 2.5	662,496
(6) Power	4,464 kW at 3.88¢/kW•h	1,454,907
(7) Subtotal	(1)+(2)+(3)+(4)+(5)+(6)	2,628,045
(8) Contingency	20 pct of (7)	525,609
(9) Grand total	(7)+(8)	3,153,654

[1]Average costs based on current Missouri smelter-refinery labor contract including adjustments for shift differentials and wage rates.

TABLE C-6. - Herculaneum smelter-refinery: Capital and operating cost summary for two alternative ambient lead environmental controls

Conventional process technology:	
Capital:	
Existing building enclosure	$572,135
Baghouse	35,789,397
New building(s)	12,506,000
Local control	11,322,000
Total	60,189,532
Operating:	
Baghouse	3,153,700
New building(s)	212,800
Local control	1,150,600
Total	4,517,100
Continuous-drossing technology:	
Capital:	
Existing building enclosure	572,135
Baghouse	35,789,397
New building(s)	12,506,000
Local control	13,901,200
Total	62,768,732
Operating:	
Baghouse	3,153,700
New building(s)	212,800
Local control	57,300
Total	3,423,800

APPENDIX D.--EAST HELENA SMELTER DATA

Operational data and environmental regulation implementation technology and costs for ASARCO's East Helena smelter are summarized on the following pages. Figure D-1 is a plan view of the facility. Tables D-1 through D-3 report actual historical lead emission data. It was not possible to present theoretical data since two types of incompatible methods of reporting data were used for this facility. A summary of estimates for building enclosures, baghouses, and local control capital costs is given in table D-4. Table D-5 shows a factored estimate of operating costs for additional baghouses. Table D-6 summarizes

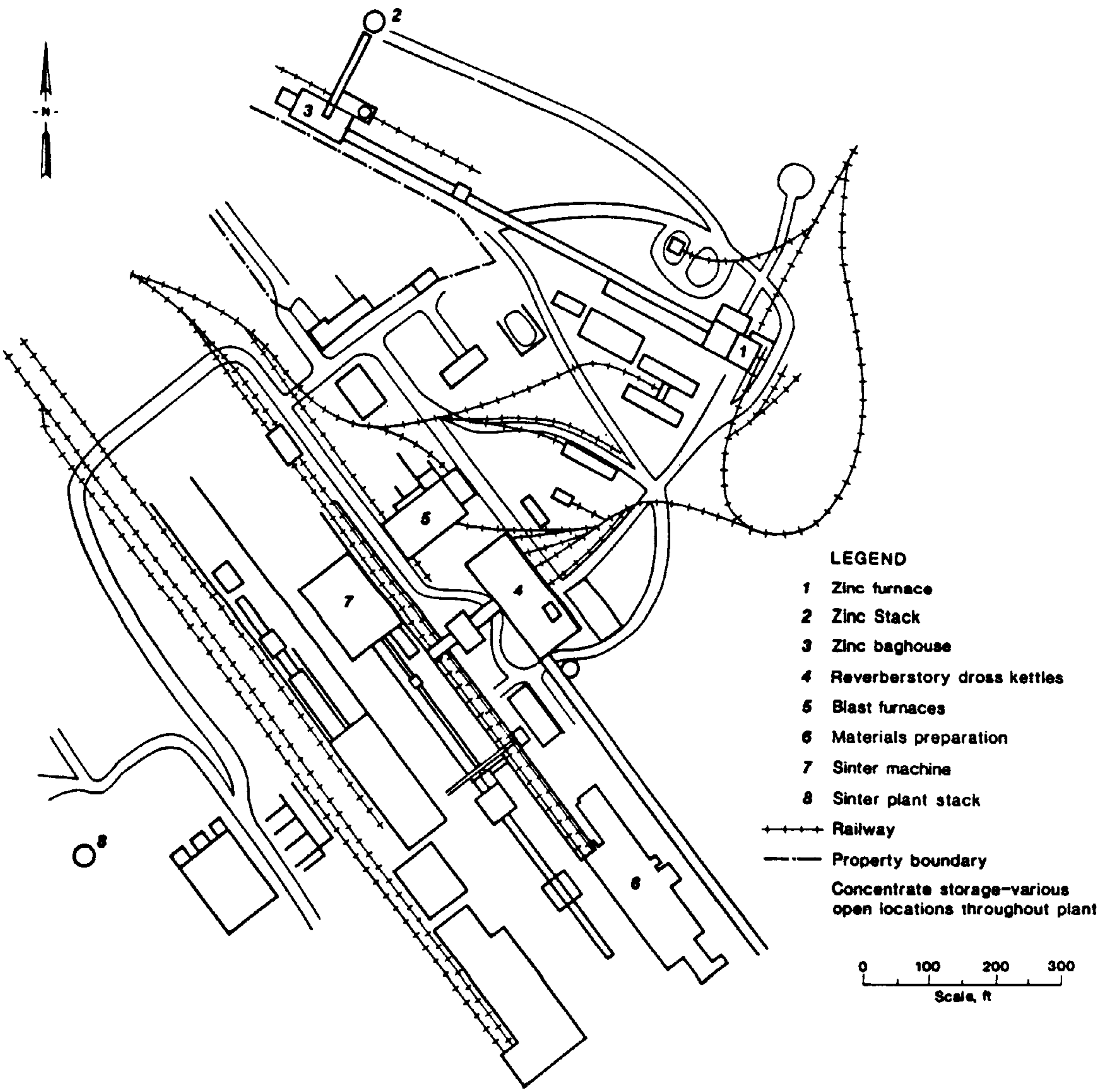

FIGURE D-1.—East Helena smelter.

all estimates of capital and operating costs for reducing lead in ambient air to its lowest theoretical level. The table gives the costs utilizing conventional process technology as well as an alternative approach using continuous-drossing technology.

Ownership......	ASARCO Inc.
History........	Constructed in 1888 with periodic modifications.
Design capacity	Lead bullion - 90,000 st/yr.
Recent capacity utilization.	1981 - 61 pct; 1982 - 71 pct; 1983 - 65 pct; 1984 - 77 pct.
Products and byproducts.	Lead bullion, "black" or "white" sulfuric acid (normally black), zinc oxide (discontinued 1982), speiss (metallic arsenides and antimonides), and copper matte.
Technology.....	Updraft sintering with offgas recirculation, conventional smelting, sulfuric acid plant with hydrogen peroxide clarification.
Feed sources...	Custom smelting - sources from Montana, Idaho, Utah, Colorado, Australia, Canada, Mexico, Central America, and South America.
Product grades.	Lead bullion - 98 pct.

East Helena has a double contact sulfuric acid plant and a 425-ft stack.

Early emission studies at East Helena used the lead emission inventory method. No baseline uncontrolled emission level appears to have been reported. In addition, at the time of the SIP, the method for analyzing emissions was changed to a chemical mass balance (CMB) program. This method allows determination of the sources and amounts that contribute to the total value of the ambient lead monitored, but it does not provide a quantitative analysis that can be used to determine total emission per unit time by source. Tables D-1, D-2, and D-3 identify the known lead emission data for this site. All data are for a design level of 92,000 st/yr lead bullion.

Because data are unreported for equipment efficiencies as related to uncontrolled lead emissions and since no acceptable method exists to translate microgram-per-cubic-meter readings to lead emissions on a pound-per-day basis, it can only be stated that the ambient lead emission levels are above the current EPA levels. This is true even if the background emission contributions not related to the smelter-refinery operation are subtracted from the total values.

Control methods similar to those used in evaluating the Missouri sites can be applied to East Helena. Owing to similarities in age, it can be assumed that what can be achieved at Herculaneum can also be accomplished at East Helena. There the similarity stops. The nature of the concentrates and the meteorological conditions are radically different. Simple sulfide ores are processed at the Missouri sites. East Helena processes a very complex sulfide ore with resulting differences in operation and stockpiling as compared to Herculaneum. The climate and topography of the area is conducive to temperature inversions, which deposit more particulate than are deposited by Herculaneum. Simply put, all of these factors and lack of data make it virtually impossible to make a decision on the theoretical optimum emissions attainable from the East Helen a site.

Table D-1 is based upon 1977-79 data as reported in EPA reports. The tabulation presents limited information on control methods and controlled emission levels at the East Helena smelter. The reported design rate was 92,000 st/yr of lead bullion. No total lead emission inventory could be determined; only the point-source emissions could be identified with certainty at 173 lb/d. No plant efficiency can be calculated.

TABLE D-1. - East Helena smelter: Emission control methods and lead emission inventory,[1] 1979, at 92,000 st/yr lead bullion (9-10)

Emission source	Control method and/or environment	Emission inventory, lb/d		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack.............	Electrostatic precipitator, acid plant.	NA	109	NAp
Zinc stack.............	Baghouse...........	NA	36	NAp
Blast furnace stack.....	...do...............	NA	28	NAp
Total or average....	NAp................	NA	173	NAp
PROCESS FUGITIVE EMISSIONS				
Sinter building.........	Not specified.......	NA	6	NAp
Drossing and reverberatory building.	...do...............	NA	67	NAp
Blast furnace..........	...do...............	NA	4	NAp
Zinc-fuming facility....	...do...............	NA	1	NAp
Zinc furnace...........	...do...............	NA	3	NAp
Total or average....	NAp................	NA	81	NAp

NA Not available. NAp Not applicable.
[1]No open fugitive emissions were recorded.

Point-source emissions were primarily from the main stack at 109 lb/d.

Process fugitive emissions were incompletely identified, although emissions in the drossing and reverberatory areas appeared to be significant at 67 lb/d.

Open fugitive emissions were not attributed to any available source.

Table D-2 is based upon Montana's Air Quality Implementation Plan (10). The data, which were developed using the CMB method, display the relative contribution of each source to the total measurement at the ambient-air-monitoring station located beyond the fence line. Although highly appropriate to allocating source responsibility for emissions, it does not allow for an engineered evaluation of corrective measures to be applied to each source. An overall monitored emission level of 5.61 $\mu g/m^3$ was obtained for the community of East Helena as a whole; of which 4.34 $\mu g/m^3$ was attributed to the smelter.

Point-source emissions were not specifically identified.

Process fugitive emissions accounted for 2.36 $\mu g/m^3$ or 42.1 pct as identified by CMB.

Open fugitive emissions accounted for 1.98 $\mu g/m^3$ or 35.3 pct as identified by CMB.

Non-ASARCO emissions accounted for 1.27 $\mu g/m^3$ or 34.0 pct as identified by CMB.

Table D-3 is based upon CMB data as provided by ASARCO (21). An overall monitored emission level of 5.29 $\mu g/m^3$ was obtained for the community of East Helena as a whole; of which 3.49 $\mu g/m^3$ was attributed to the smelter.

Point-source emissions were not specifically identified.

Process fugitive emissions accounted for 3.33 $\mu g/m^3$ or 63.0 pct as identified by CMB.

TABLE D-2. - East Helena smelter: Emission control methods and lead emission inventory, 1981, at 92,000 st/yr lead bullion (11-12)

Emission source	Control method and/or environment	Emission inventory, µg/m³		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack.............	No change...........	NA	NA	NAp
Zinc stack.............	...do................	NA	NA	NAp
Blast furnace stack....	...do................	NA	NA	NAp
Total or average...	NAp.................	NA	NA	NAp
PROCESS FUGITIVE EMISSIONS				
Drossing and reverberatory building........	Not specified.......	NA	NA	NAp
Blast furnace..........	...do................	NA	NA	NAp
Zinc-fuming facility...	...do................	NA	NA	NAp
Speiss pit stack.......	...do................	NA	0.12	NAp
Total or average...	NAp.................	NA	2.36	NAp
OPEN FUGITIVE EMISSIONS				
Concentrate storage....	Not specified.......	NA	1.98	NAp
Total or average...	NAp.................	NA	1.98	NAp
Grand total or av	NAp.................	NA	5.61	NAp

NA Not available. NAp Not applicable.

Open fugitive emissions accounted for 0.16 µg/m³ or 3.0 pct as identified by CMB.

Non-ASARCO emissions accounted for 1.80 µg/m³ or 34.0 pct as identified by CMB.

Table D-4 reports detailed capital cost estimates for East Helena, outlining the costs associated with the following:

o Enclosing existing openings on process-related buildings presently emanating lead-bearing fugitive dust.

o Installing new baghouses and adding positive fan-induced ventilation.

o Adding new buildings to enclose concentrate, sinter, and lead-bearing dust storage areas.

o Adding selective local controls.

All costs are as of July 1985 and assume the use of conventional process technology currently in use at the plant site. Base equipment capital costs were derived using the volumetric air flow rate determined from building volume and 15 air changes per hour at an air-to-cloth ratio of 1.5:1.

TABLE D-3. - East Helena smelter: Emission control methods and lead emission inventory, 1984, at 92,000 st/yr lead bullion (22)

Emission source	Control method and/or environment	Emission inventory, μg/m³		Overall control efficiency, pct
		Uncontrolled	Controlled	
POINT-SOURCE EMISSIONS				
Main stack..............	No change..........	NA	NA	NAp
Zinc stack..............	...do..............	NA	NA	NAp
Blast furnace stacks....	...do..............	NA	NA	NAp
Total or average...	NAp................	NA	NA	NAp
PROCESS FUGITIVE EMISSIONS				
Sinter building.........	Not specified......	NA	NA	NAp
Drossing and reverberatory building.........	...do..............	NA	NA	NAp
Blast furnace...........	...do..............	NA	NA	NAp
Zinc-fuming facility....	...do..............	([1])	([1])	([1])
Material handling building (new deal)....	...do..............	NA	NA	NAp
Slag pouring............	...do..............	NA	NA	NAp
Speiss pit stack........	...do..............	NA	0.32	NAp
Total or average...	NAp................	NA	3.33	Nap
OPEN FUGITIVE EMISSIONS				
Concentrate storage.....	Not specified......	NA	0.16	NAp
Total or average...	NAp................	NA	.16	NAp
NON-ASARCO EMISSIONS				
Road and soil dust......	Not specified......	NA	0.90	NAp
Transportation..........	...do..............	NA	.16	NAp
American Chemet.........	...do..............	NA	.42	NAp
Other...................	...do..............	NA	.32	NAp
Total or average...	NAp................	NA	1.80	NAp
Grand total or av	NAp................	NA	5.29	NAp

NA Not available. NAp Not applicable. [1]Operation suspended.

TABLE D-4. - East Helena smelter: Estimate of capital cost (1985) for building enclosures, baghouses, and local controls

Control	Equipment: Primary	Equipment: Ancillary	Instrumentation and controls	Construction materials	Subcontractor installation	Field labor
Enclosure of existing buildings for--						
Blast furnace receiving bins	NAp	NAp	NAp	2,322	NAp	734
Sintering	NAp	NAp	NAp	4,537	7,630	1,296
Blast furnaces	NAp	NAp	NAp	14,326	31,439	3,994
Drossing and reverberatory	NAp	NAp	NAp	6,212	34,827	1,300
Total	NAp	NAp	NAp	27,397	73,896	7,324
Baghouses for--						
Blast furnace receiving bins	150,000	10,000	24,000	NAp	68,080	NAp
Sintering	1,316,250	87,750	210,600	NAp	2,244,294	NAp
Blast furnaces	882,750	58,850	141,240	NAp	1,505,148	NAp
Drossing and reverberatory	941,250	62,750	150,600	NAp	1,604,894	NAp
Total	3,290,250	219,350	526,440	NAp	5,422,416	NAp
Grand total	3,290,250	219,350	526,440	27,397	5,496,312	7,324

Control	Construction equipment usage	Sales tax: Construction materials	Sales tax: Capital equipment	Freight	Insurance	Contractor's overhead and profit
Enclosure of existing buildings for--						
Blast furnace receiving bins	NAp	NAp	93	93	NAp	1,146
Sintering	137	NAp	181	181	NAp	5,100
Blast furnaces	533	NAp	573	573	NAp	18,860
Drossing and reverberatory	584	NAp	248	248	NAp	16,096
Total	1,254	NAp	1,095	1,095	NAp	41,202
Baghouses for--						
Blast furnace receiving bins	NAp	1,362	7,360	7,360	1,840	NAp
Sintering	NAp	44,886	64,584	64,584	16,146	NAp
Blast furnaces	NAp	30,103	43,314	43,314	10,828	NAp
Drossing and reverberatory	NAp	32,098	46,184	46,184	11,546	NAp
Total	NAp	108,449	161,442	161,442	40,360	NAp
Grand total	1,254	108,449	162,537	162,537	40,360	41,202

Control	Construction and field indirect	Engineering procurement and constr. management	Escalation to July 1985	Contingency	Totals	Worker-hours
Enclosure of existing buildings for--						
Blast furnace receiving bins	863	641	89	1,495	7,476	67
Sintering	1,523	2,518	394	5,874	29,371	206
Blast furnaces	4,693	9,174	1,458	21,406	107,029	205
Drossing and reverberatory	1,528	7,475	1,245	17,441	87,204	NAp
Total	8,607	19,808	3,186	46,216	231,080	478
Baghouses for--						
Blast furnace receiving bins	93,840	NAp	NAp	NAp	363,842	NAp
Sintering	1,759,914	NAp	NAp	NAp	5,809,008	NAp
Blast furnaces	1,180,296	NAp	NAp	NAp	3,895,843	NAp
Drossing and reverberatory	1,258,514	NAp	NAp	NAp	4,154,020	NAp
Total	4,292,564	NAp	NAp	NAp	14,222,713	NAp
New buildings	NAp	NAp	NAp	NAp	18,737,146	NAp
Local controls	NAp	NAp	NAp	NAp	4,430,700	NAp
Grand total	4,301,171	19,808	3,186	46,216	37,621,639	478

NAp Not applicable.

Table D-5 outlines the procedure for estimating operating costs for East Helena. Cost estimates are factored based on estimated staffing requirements considered necessary to operate the additional baghouses, and ancillary eqiupment. Wage rates were determined from current labor union contracts at East Helena. Power costs were based upon estimated consumption requirements and known utility charges.

Table D-6 summarizes all estimated capital and operating costs at East Helena required to achieve the theoretical lead emission inventory levels. Included are costs for enclosing existing buildings, adding baghouses and associated ventilation systems, erecting new buildings for the containment of storage areas, and selected local controls. Two sets of costs are provided: costs for meeting the proposed ambient lead standards by means of (1) conventional drossing technology, and (2) continuous-drossing system similar to that in use in Australia.

TABLE D-5. - East Helena smelter: Factored operating cost estimate for additional baghouses

Cost category	Calculation	Annual cost
(1) Labor:		
(a) Direct labor,[1] 4 operators:		
Regular........................	4 × 2080 h/yr × \$13.618/h.......	\$113,302
Overtime......................	4 × 110 h/yr × \$11.94/h × 1.5...	7,880
Subtotal direct labor.......	(Regular + overtime)............	122,290
(b) Direct labor supervision......	15 pct of (a) = 0.15 × \$122,290.	18,343
(c) Maintenance labor.............	100 pct of (a) = 1.0 × \$122,290.	122,290
(d) Maintenance labor supervision.	20 pct of (a) = 0.20 × \$122,290.	24,458
(e) Subtotal labor and supervision.............	(a) + (b) + (c) + (d)..........	287,381
(f) Payroll burden and fringe benefits....................	35 pct of (e) = 0.35 × \$287,381.	100,583
(1) Total labor.............	(e) + (f)......................	387,964
(2) Maintenance materials and supplies	50 pct of (c) = 0.5 × \$122,290..	61,145
(3) Indirect.........................	40 pct of (e) = 0.40 × \$287,381.	114,952
(4) General and administrative........	15 pct of (a) = 0.15 × \$122,290.	18,343
(5) Bag replacement..................	20 pct of baghouse capital costs every 2-1/2 yr = 0.2 × \$5,008,500 ÷ 2.5............	400,680
(6) Power............................	2,475 kW at 2.61¢/kW·h..........	542,619
(7) Subtotal.................	(1)+(2)+(3)+(4)+(5)+(6).........	1,525,703
(8) Contingency......................	20 pct of (7)..................	305,141
(9) Grand total.............	(7)+(8)........................	1,830,844

[1]Based on baghouse operator rate from 1985 East Helena labor contract including adjustments for shift differentials.

TABLE D-6. - East Helena smelter: Capital and operating cost summary for two alternative ambient lead environmental controls

Conventional process technology:	
Capital:	
Existing building enclosure	$271,070
Baghouse	21,805,869
New building(s)	11,114,000
Local control	4,430,700
Total	37,621,639
Operating:	
Baghouse	1,830,800
New building(s)	425,600
Local control	420,700
Total	2,677,100
Continuous-drossing technology:	
Capital:	
Existing building enclosure	271,070
Baghouse	21,805,869
New building(s)	11,114,000
Local control	6,677,440
Total	39,868,379
Operating:	
Baghouse	1,830,800
New building(s)	425,600
Local control	[1]-21,000
Total	2,235,400

[1]Continuous drossing produces a net operating savings for local controls.

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