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Impact of Existing and Proposed Regulations upon the Domestic Lead Industry

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THE IMPACT OF EXISTING AND PROPOSED REGULATIONS UPON THE DOMESTIC LEAD INDUSTRY

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The U.S. Bureau of Mines has investigated the domestic primary and secondary lead smelting and refining industries to determine the economic impacts of existing and proposed environmental, health, and safety regulations. The impacts are assessed in terms of capital and operating costs for existing and alternative smelting/refining technologies. Industry response to regulatory implementation is estimated and quantified in terms of import value from lost lead production.

For the primary lead industry, regulatory compliance may add up to 1.15 ¢/lb refined lead to operating cost for rehabilitated plants. Alternative smelting/refining methods could reduce net operating costs by as much as 4.36 ¢/lb refined lead. Capital expenditures would vary from $750 to $1,000 per annual mt of smelter capacity. Secondary lead smelter operating costs would increase about 3.8 ¢/lb refined lead to comply with existing regulations. Capital expenditures would average about $124 per annual mt of smelter capacity.

Implementation and enforcement of proposed regulations would result in closure of the primary lead industry and additional expenditures for compliance by the secondary lead industry. Enforcement of the most extreme proposed regulations would force the secondary lead industry to close.

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FOREWORD

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

¢/lb	cent per pound	M	million
g	gram	Mmt	million metric tons
mt	metric ton	pct	percent
mt/yr	metric ton per year	tr oz	troy ounce
µg	microgram	yr	year
$\mu g/m^3$	microgram per cubic meter		

ACRONYMS

BAT	Best Available Technology
BCT	Best Conventional Technology
BDT	Best Demonstrated Technology
CAA	Clean Air Act
CWA	Clean Water Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
DCFROR	Discounted Cash Flow Rate of Return
EPA	Environmental Protection Agency
MRP	Medical Removal Program
NAAQS	National Ambient Air Quality Standard
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
RCRA	Resource Conservation and Recovery Act
SWDA	Solid Waste Disposal Act
TWA	Time weighted average

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By R. J. Isherwood,[1] R. C. Smith,[2] O. A. Kiehn,[3] and M. R. Daley[4]

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*** INTRODUCTION

The Bureau of Mines' Minerals Availability Program (MAP) has been conducting studies in support of U.S. mineral policy. Lead studies have been an important part of this program since the publication of IC 8646 "Availability of U.S. Primary Lead Resources" in 1974. Other lead studies have included IC 8962 "Lead and Zinc Availability-Domestic" 1983, IC 9156 "Domestic Secondary Lead Industry: Production and Regulatory Compliance Costs" 1987, and a primary lead study "Impacts of Environmental, Health, and Safety Regulations upon Costs of Production in the Primary Domestic Lead Industry" 1987, (unpublished). This study summarizes the primary and secondary lead industries present level of environmental regulatory compliance, analyzes the degree of compliance capability, estimates the capital and operating costs to comply with existing and proposed proposed environmental, health, and safety regulations, and quantifies the economic impacts to the lead industry and the United States.

The Bureau undertook this study because of the disparity between the Environmental Protection Agency (EPA) and industry estimates as to the industry's ability to comply with regulations and the cost of compliance. The industry maintains that enforcement of existing regulations would put many companies out of business and promulgation of more stringent regulations would shut down the entire industry. Many companies maintain that even if they could comply with regulations, the cost of compliance would be prohibitive.

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*** DOMESTIC LEAD INDUSTRY

The United States is the largest consumer and producer of primary and secondary lead. Ninety percent of the primary lead production comes from eight mines in Missouri. Primary smelting and refining capacity, during 1987, consisted of two smelters and refineries in Missouri, a smelter in

Montana, and a refinery in Nebraska. The secondary lead industry, at yearend 1986, consisted of 24 operating smelters; most located east of the Mississippi River except for a few in Texas and California (fig. 1). Some of these smelters have shut down recently for a variety of reasons; not all are permanent closures.

In 1987, the U.S. produced over one million mt of refined lead, which consisted of 374,000 mt from primary sources and 658,000 mt from old scrap. The primary lead industry produces pure lead, whereas almost one-half of secondary production is antimonial lead. About 70 pct of all lead used in the U.S. is consumed by the transportation industry, primarily as lead-acid storage batteries. The remaining 30 pct is distributed between gasoline additives, construction materials, oxides and chemicals, ammunition, electrical, and miscellaneous applications. Most secondary production is for storage batteries for the transportation and electrical industries, while primary production is used more heavily in the other demand sectors (fig 2).

Wastes and process emissions are generated during smelting and refining of lead which may be harmful to human health and the environment. The primary lead industry's chief areas of concern are air pollution from gaseous sulfur dioxide (SO_2), lead particulates in ambient air, and high blood-lead levels for workers exposed to lead particulates. The secondary lead industry is principally concerned with controlling lead particulates, acid neutralization, slag and organic waste disposal. The nature of smelter feed stock is the reason for the different industry concerns. Primary smelter feed stock is ore concentrates which contain large quantities of sulfides. Thus, the problem of controlling SO_2 emissions

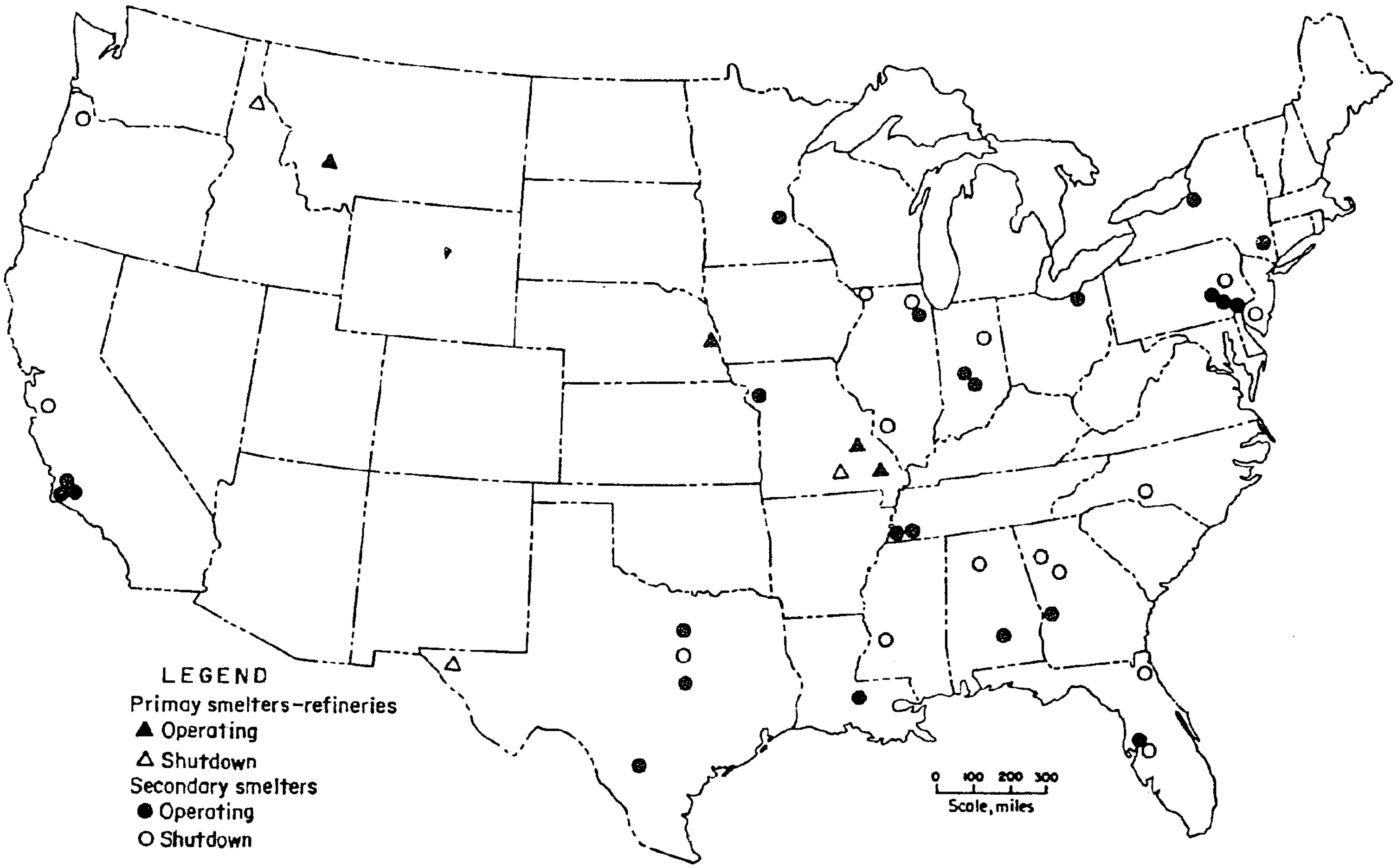
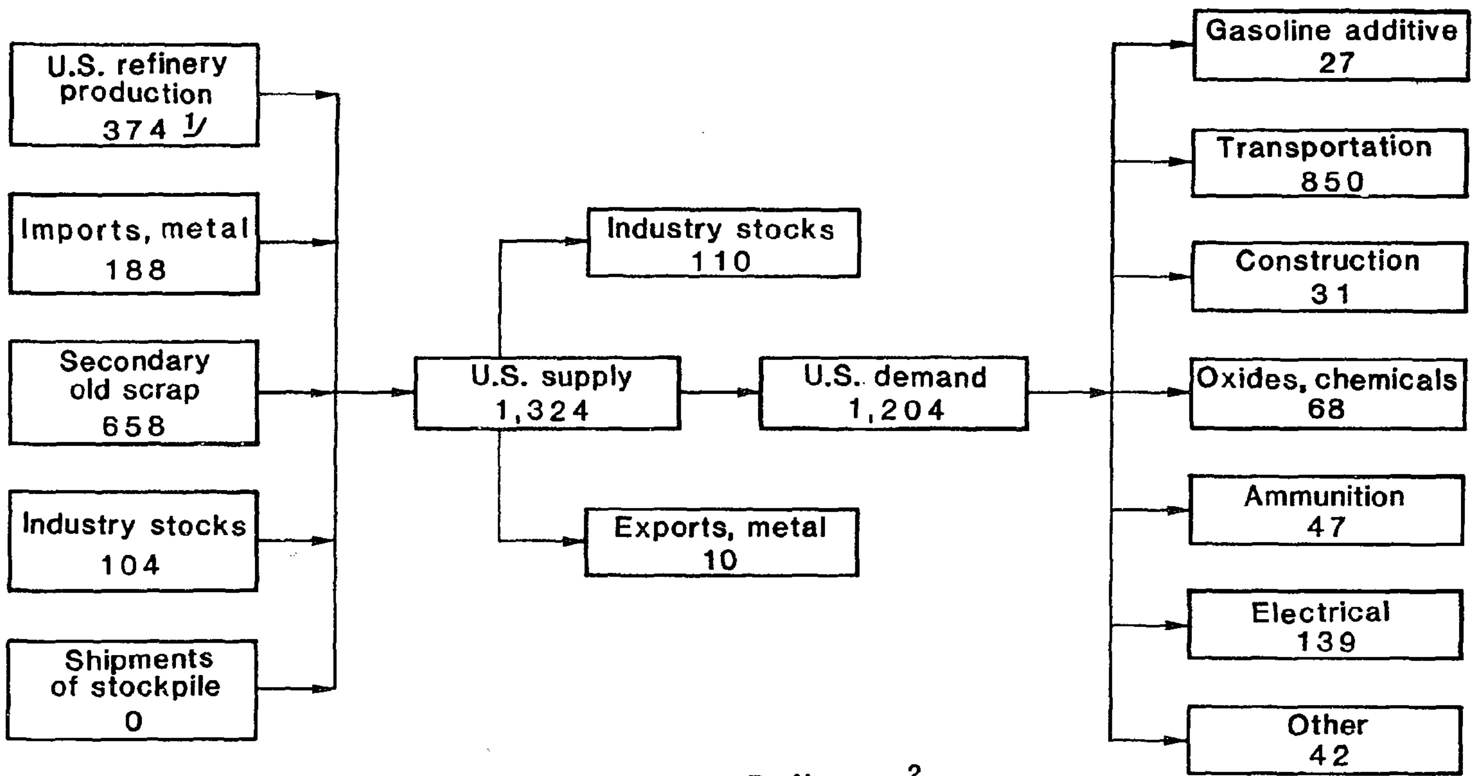


Figure 1. - Primary and secondary lead smelter/refinery locations.



	Refinery production[2]	Value[3]
U.S. total	1,032	$614M
World total	5,630	$3,351M

[1] Includes 37,000 mt from foreign ore and bullion

[2] Thousands of metric tons

[3] Lead price = $0.27/pound (1987 cash avg LME)

Figure 2. - U.S. supply-demand relationships for domestic lead.

is the major concern. Secondary smelter feed stock is predominantly scrap automotive batteries which contain sulfuric acid. Acid neutralization and waste discharge are therefore of prime concern.

*** METHODOLOGY

In order to determine the economic impact of environmental, health, and safety regulations on the domestic lead smelting and refining industry, the Bureau of Mines conducted studies of the primary and secondary lead industries. Primary and secondary lead producers were contacted to provide operational and cost data. Site visits were made to most of the plants. Operating costs were estimated and the portion of the operating cost attributable to the present level of regulatory compliance was identified. Also, the amount of capital needed to purchase and install any additional regulatory equipment and the corresponding change in operating cost were estimated. Primary lead industry capital and operating costs were estimated for alternative flash and bath (QSL) smelting technology. For primary lead operations, regulatory costs were grouped into four categories: particulates, SO_2, health and safety, and water. Secondary operations, because they are in compliance with SO_2 standards, were grouped similarly with the exception of the SO_2 category. Results were individually estimated and then consolidated as industry averages for both primary and secondary industries. Confidentiality is maintained and averaging for secondary smelters moderates the wide variations due to the number of plants, variations in size, degree of integration, and technological variations.

In addition to capital and operating costs, economic analyses were performed using the Bureau's MINSIM 9 computer program to determine the price of lead necessary to cover production costs plus profit after performing the regulatory improvements. These analyses were based on the following assumptions: a 60:40 debt/equity ratio, a 12.5 pct interest rate, a 5 year loan payback, a 15 year operating life and a 15 pct Discounted Cash Flow Rate of Return (DCFROR). All costs are based on 1987 dollars.

Finally, three scenarios were developed to illustrate the lead industry economic impact to the United States. The first scenario shows the current U.S. condition and projection of production (domestic supply) and demand. The next two scenarios show the possible changes in supply as a result of enforcement of existing and proposed environmental, health, and safety regulations. Along with the scenarios, lead prices are predicted, and economic impacts are quantified in terms of lost production, lost jobs and wages, and the import value with respect to lead.

*** ENVIRONMENTAL, HEALTH, AND SAFETY REGULATIONS

Regulations that impact the domestic lead industry are contained in the Clean Air Act (CAA), the Clean Water Act (CWA), the Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limit (PEL), OSHA's Medical Removal Program (MRP), The Resource Conservation and Recovery Act (RCRA), and the Solid Waste Disposal Act (SWDA). Although the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as "Superfund", and RCRA would impact the domestic lead industry, primary lead operations are currently exempted under the Bevill amendment. The possible impact of Superfund and RCRA were not included in the analysis of primary lead smelters as cost estimates associated with these regulations were considered to be too speculative and lacked proper definition at the time of this study. However, RCRA regulations are considered for the secondary lead industry for the transportation and disposal of hazardous wastes. Individual state regulations, which may be more stringent than Federal regulations, were not considered, except for Missouri's water standards for the primary lead smelters. The applicable parts of the Federal regulations which affect the domestic lead industry are presented in table 1.

This study also considers proposed modifications to regulations which, if promulgated, would affect the domestic lead industry. Specifically, there are two proposed modifications to the National Ambient Air Quality Standard (NAAQS) for lead in ambient air and one proposed modification for SO_2 emissions. The two modifications for lead are: 1.0 $\mu g/m^3$ lead in ambient air at fenceline, and 0.5 $\mu g/m^3$ lead in ambient air at fenceline. The proposed change for SO_2 is 0.2 ppm for a one-hour limit.

Table 1. - Pertinent environmental and health and safety regulations affecting the domestic lead industry

Regulation	Date promulgated	Effective dates: Primary	Effective dates: Secondary
Health & Safety			
OSHA- Permissible exposure limit (PEL)			
Occupational exposure to inorganic lead limited to 50 µg/m^3 TWA by engineering controls.	3/1/79	3/1/89	3/1/84
OSHA - Medical removal program (MRP)			
Final Lead Standard. Action level 50 µg/100 g. Return level 40 µg/100 g following two consecutive blood-lead tests.	3/1/83	3/1/83	3/1/83
Particulates		5 year grace period	
Lead:			
EPA - National Ambient Air Quality Standard (NAAQS)			
Primary and secondary standards amended to 1.5 µg/m^3 arithmetic mean over calendar quarter or plant boundary.	10/5/78	10/5/78	10/5/78
SO_2:			
EPA - National Primary and Secondary Ambient Air Quality Standards:	7/1/85	7/1/85	7/1/85
Water	Modified period		
EPA - Clean Water Act (CWA)			
State regulations more stringent than Federal. Best Available Technology (BAT), Lime and settle.	1970 - 1977		

Ambient conc limits SO_2 (arithmetic avg): µg/m^3	ppm	Averaging period
1,300[1]	0.50	3 hours
365[1]	0.14	24 hours
80[1]	0.03	1 year

Table 1. - Pertinent environmental and health and safety regulations affecting the domestic lead industry--Continued

Regulation	Date promulgated	Effective dates Primary	Secondary
Missouri standards (Example)			
Lead 0.1 µg/liter			
Zinc 1.0 µg/liter			
Cadmium 0.1 µg/liter			
pH 6.0 - 9.0			
Federal Clean Water Act. Best Conventional Technology (BCT). Best Demonstrated Technology (BDT). Discharge during 25-year, 24-hour rainfall on settling ponds.	1983-1984		

[1]Not to be exceeded more than once per year.

*** REGULATORY COMPLIANCE CAPABILITY

Primary and secondary smelters are not in compliance with all environmental, health, and safety regulations. The four primary lead facilities; Glover, Herculaneum, and Buick in Missouri, and East Helena in Montana, do not fully comply with OSHA's PEL standard in all plant areas. Some areas may be within the 100 $\mu g/m^3$ standard but other areas of the plants may be as high as 300 to 500 $\mu g/m^3$. For OSHA's MRP, primary smelters indicate 99 pct of employees have blood-lead levels below 60 µg lead per 100 g of blood, but fewer people are below the 50 µg standard.

Primary smelters do not comply with the NAAQS standard of 1.5 $\mu g/m^3$ of lead in ambient air at fenceline. The plants range from 1.5 to 2.5 $\mu g/m^3$. For the SO_2 portion of NAAQS, primary smelters could not comply with the 0.5 ppm three-hour limit without a change in processing technological; from pyrometallurgy to hydrometallurgy.

Primary smelters are within compliance levels for the CWA. By treating run-on and process waters with lime and settle technology, the plants are able to meet the standards.

Smelter attainment levels can be improved by either upgrading the existing plants or changing smelting technology. However, these alternatives still will not meet all of the regulations. Upgrading existing plants would involve enclosing buildings, adding baghouses, and upgrading ventilation based on 10 air changes per hour. But upgrading the existing plants would attain a PEL of only 100 to 150 $\mu g/m^3$ lead, and SO_2 would be greater than the 0.5 ppm standard. Smelters would be able to comply with all regulations except PEL by changing to flash or bath smelting technology. This technology would include double contact-absorption acid plants, required ventilation, and baghouses. The attainment level would be between 50 and 100 $\mu g/m^3$ lead. Attaining the proposed NAAQS standards for lead is not economically feasible for the primary industry even with a change to flash or bath smelting.

It is easier for secondary lead plants to attain existing lead and SO_2 limits because of the type of metal feed stock, the smaller plant sizes, and the lower impurity levels requiring less refining stages. Presently, plants average between 50 to 70 $\mu g/m^3$ lead for OSHA-PEL and could readily attain the 50 $\mu g/m^3$ with added ventilation. Also, greater than 99 pct of employees have blood-lead levels below 50 µg/100 g of blood for MRP.

The present NAAQS lead level for secondary smelters averages approximately 1.7 $\mu g/m^3$ although some plants are as low as 1.0 $\mu g/m^3$. With ventilation improvement, most smelters could achieve the proposed 1.0 $\mu g/m^3$ level. With only a minor concentration of sulfate present in the feed stock, secondary plants are in compliance with the three-hour 0.5 ppm SO_2 standard. Attaining the proposed SO_2 standard is not anticipated to be difficult even though emission levels are uncertain after ventilation improvement.

Water standard attainment is one of the most difficult tasks for secondary smelters. Difficulties with battery acid neutralization, contained soluble elements, and total suspended solids are the main problem areas. Many states have water standards more stringent than Federal standards which compounds the problem. For this study, lime and settle technology is the base model, because EPA determined this technology to be BAT. Summarized in table 2 are the various regulations and the present plant attainment levels.

*** COMPLIANCE COSTS

This section presents the estimated capital and operating costs for regulatory compliance in January 1987 dollars. For the primary lead industry, capital costs were estimated for the rehabilitation of three Missouri smelter-refineries and for the construction of new flash or bath smelter facilities which could replace the combined capacity of the three Missouri smelter-refineries. For operating costs in the primary lead industry, costs were estimated for the 3 Missouri plants, for existing plants rehabilitated, and for replacing the existing plants with flash or bath smelters. For the secondary lead industry, the average total capital and operating costs to comply with all existing regulations were estimated. Capital costs are presented in dollars per annual metric ton of smelter capacity. Operating costs for both primary and secondary smelters are in cents per pound of refined lead.

Table 2. - Regulatory compliance requirements and attainment levels

Regulation	Present primary & secondary attainment levels
Health & Safety	
OSHA - Permissible exposure limit (PEL) Occupational exposure to inorganic lead limited to 50 $\mu g/m^3$ TWA.	Primary: Plants > 100 $\mu g/m^3$. Attainable by changing to flash smelting, enclosing buildings, and ventilating at 10 airchanges per hour.
	Secondary: Plants > 50 $\mu g/m^3$. Attainable by hooding and increased ventilation.
OSHA - Medical removal program (MRP) Final Lead Standard. Action level 50 μg/100 g. Return level 40 μg/100 g following two consecutive blood lead tests.	Primary: > 99 pct employees are less than 60 μg per 100 g blood. Attainment by lowering PEL below 100 $\mu g/m^3$.
	Secondary: > 99 pct employees are below the 50 μg standard. Plants essentially in compliance.
Particulates	
Lead: EPA - National Ambient Air Quality Standard (NAAQS). Primary and secondary standards amended to 1.5 $\mu g/m^3$ arithmetic mean over calendar quarter or plant boundary.	Primary: Attainment for lead by building enclosure, additional ventilation and baghouses. Will not meet SO_2 standard by this control method. For SO_2 attainment, technology change to flash or bath smelting is required.
	Secondary: Plants average about 1.7 $\mu g/m^3$ at fenceline. Attainment for lead by building enclosure, additional ventilation and baghouses. In compliance with the SO_2 standard.
SO_2: EPA, National Primary and Secondary Ambient Air Quality Standards:	

Ambient conc limits SO_2 (arithmetic avg) $\mu g/m^3$	ppm	Averaging period
1,300[1]	0.50	3 hours
365[1]	0.14	24 hours
80[1]	0.03	1 year

Table 2. - Regulatory compliance requirements and attainment levels—Continued

Regulation	Present plant attainment levels
Water	
EPA - Clean Water Act (CWA)	Primary: Plants are in compliance with the standards.
State regulations more stringent than Federal. Best Available Technology (BAT), lime and settle.	Secondary: In general, secondary plants are in compliance but occassionally exceed limits. Because State standards can supercede Federal standards, if more stringent, the level of compliance is difficult to determine.
Missouri standards (Example) Lead 0.1 µg/liter Zinc 1.0 µg/liter Cadmium 0.1 µg/liter pH 6.0 - 9.0	
Federal Clean Water Act. Best Conventional Technology (BCT). Best Demonstrated Technology (BDT). Discharge during 25-year, 24-hour rainfall on settling ponds.	

[1]Not to be exceeded more than once per year.

PRIMARY LEAD INDUSTRY

In order to evaluate the possible cost impacts of existing and proposed regulations on the domestic primary lead industry, two alternative methods of compliance were evaluated: 1) Rehabilitation of the three Missouri smelter-refineries to flash smelting with upgraded ventilation and particulate control systems to meet the NAAQS boundary ambient lead limit of 1.5 $\mu g/m^3$ and OSHA's PEL of between 100 and 50 $\mu g/m^3$. 2) Construction of one new facility to replace the production of the combined capacity of the three Missouri smelter-refineries. The plant would be located adjacent to the Mississippi River for acid sale and transportation and would incorporate all modern technology including either Outokumpu flash smelting or QSL bath smelting.

Capital Costs

The estimated capital costs to rehabilitate the three Missouri smelter-refineries by replacement of sinter-blast furnace technology with concentrate drying, flash smelting, continuous drossing, and double-absorption acid plants are presented in table 3. The particulates category includes building enclosure, additional ventilation, and dust collection equipment to provide a total plant achievement of 1.5 $\mu g/m^3$ lead at property boundary. Equipment requirements are based on 10 air changes per hour. The SO_2 category includes a new acid plant which would achieve an SO_2 air quality of 0.2 ppm one-hour basis without a shutdown requirement for adverse weather conditions. The existing plants have effluent water treatment and health and safety under control and require only minor capital additions for facilities improvements. Also, by improving particulate emissions, the health and safety MRP level is estimated to improve from 60 to 50 μg/100 g of blood.

The capital expenditure for rehabilitated plants is presented as dollars per annual mt of capacity for each of the four environmental categories. The combined capacity of the three plants would be approximately 400,000 mt/yr, therefore, the combined capital requirement would be approximately $400 million.

Table 3. - Missouri rehabilitated plants capital requirements by environmental area (1987 dollars)

Environmental category	$ per annual mt of capacity
Particulates	$ 410
SO_2	578
Water	7.50
Health & safety	5.00
Total	$1,000.50

The estimated capital expenditure for construction of a new 400,000 mt/yr capacity "green field" flash smelting facility is approximately $300 million, significantly less than the cost of rehabilitating the individual plants. The design capacity matches the present Missouri output. The hypothetical plant would incorporate all current design technology including concentrate drying, flash smelting, continuous drossing, double absorption acid plant, and total ambient ventilation and collection of airborne particulates from all areas of the plant. The entire capital cost is considered to be environmentally related as the new plant would be constructed primarily for meeting environmental regulations, while maintaining the same amount of production capacity (table 4).

Table 4. - Missouri replacement plant capital requirements by environmental area - flash smelter basis (1987 dollars)

Environmental category	$ per annual mt of capacity
Particulates	$ 282
SO_2	418
Water	25
Health & safety	25
Total	$ 750

Particulates and SO_2 categories represent the majority of the costs because they include the more costly smelting/refining equipment as well as pollution control equipment. Water and health and safety costs are higher for the "green field" plant because the rehabilitated scenario plants have existing and acceptable facilities.

The capital cost for bath smelting was roughly estimated because of the limited amount of available information. It was determined that three bath furnaces in one smelter complex would be required to achieve the 400,000 mt/yr replacement capacity. The total capital cost would be about $400 million.

Operating Costs

Operating costs for smelting and refining primary lead are presented for four cases: the existing three Missouri plants, the existing plants rehabilitated, the existing plants replaced by one flash smelter with a capacity of 400,000 mt/yr, and the existing plants replaced by one bath smelter complex capable of producing 400,000 mt/yr. The costs are in cents per pound of refined lead.

Production costs decrease, for all cases, over the existing plants as fewer personnel are needed and metallurgical coke requirements are eliminated. Costs decrease further with the economy of scale of the flash and bath smelter facilities. Also, smelter lead recovery would improve from 95 pct to 96 pct by using flash or bath smelting technology, further decreasing the costs. The acid credit improves because sulfur recovery increases from approximately 31 pct for existing Missouri plants to 95 pct for the rehabilitated and new plants, and the quality improves from black to white-grade acid. Also, since the overland freight cost is eliminated due to the river location of the smelter, the acid value increases. As a result, the acid credit would exceed the cost of producing the acid.

Particulates and SO_2 control costs increase significantly with plant rehabilitation. Overall, regulatory costs, as a percentage of net operating costs, increase from 20 pct for existing plants to 37 pct for rehabilitated plants, 36 pct for the new flash smelter, and 40 pct for the bath smelter (table 5).

Table 5. - Operating cost estimates for Missouri smelters and refineries (¢/lb refined lead, 1987 dollars)

Cost area	Existing plants	Rehabilitated plants	New Flash plant	New Bath plant
REGULATORY				
Water	0.15	0.19	0.16	0.16
SO_2	.55	1.09	.85	.85
Particulates	.91	1.56	1.12	1.12
Health & safety	.46	.38	.33	.33
Subtotal	2.07	3.22	2.46	2.46
PRODUCTION	8.74	6.66	5.66	5.04
Subtotal	10.81	9.88	8.12	7.50
LESS: ACID CREDIT	(.30)	(1.21)	(1.35)	(1.35)
NET COST	10.51	8.67	6.77	6.15

SECONDARY LEAD INDUSTRY

In order to evaluate the impact of regulatory compliance, the present production costs and the additional capital and operating costs for regulatory compliance were determined. Because the secondary lead industry is extremely variable with respect to degree of integration, market conditions, production capacity, and products; operating costs were standardized to reflect only those costs associated with acquiring and converting scrap lead into refined metal. Any additional operations such as battery manufacture were excluded. The capital and operating costs are presented as industry averages. Additional capital and operating costs to meet existing and proposed environmental regulatory compliance are presented in three categories: particulates, health and safety, and water.

Capital Costs

Capital costs for regulatory compliance are extremely variable among secondary lead smelters. Variables such as smelter capacity, state regulations, plant technology, type of products, age, and degree of integration all affect the regulatory compliance costs. An industry average for the present level of regulatory compliance is $55 per annual mt of smelter capacity but can be as high as $95 per annual mt of capacity (1986 data).

The costs necessary to comply with existing environmental regulations have been separated into three categories: particulates, water, and health and safety. The particulates category includes the costs necessary to comply with the NAAQS standard of 1.5 $\mu g/m^3$ of lead in ambient air at fenceline. The water category includes the CWA lime and settle technology as best available technology (BAT) and the various pretreatment standards for publicly owned water treatment facilities. The SWDA is also included. The health and safety category includes OSHA's PEL at 50 $\mu g/m^3$ of lead in air and the MRP standard of 50 µg lead per 100 g of blood.

The average total cost to comply with all existing regulations is estimated to be $124 per annual mt (Jan. 1987 dollars) of smelter capacity (table 6). This cost represents an industry average and is not necessarily applicable to any particular smelter.

Table 6. -- Capital costs to meet existing regulations for secondary smelters (1987 dollars)

Category	$/annual mt of capacity
Particulates	63
Health and safety	24
Water	37
Total	124

Capital costs necessary to comply with proposed NAAQS regulations were estimated for the 1.0 and 0.5 $\mu g/m^3$ of lead in ambient air at fenceline. The 0.5 $\mu g/m^3$ proposal was estimated based on industry response to probable equipment requirements. This estimate does not imply that performing the necessary capital expenditures would guarantee compliance.

In order to meet the 1.0 $\mu g/m^3$ proposal, capital investment would be an additional $131 per annual mt of smelter capacity. Attempting to meet the 0.5 $\mu g/m^3$ proposal would require an additional expenditure of $266 per annual mt of smelter capacity (going from 1.0 to 0.5 $\mu g/m^3$). If the standard was changed from 1.5 to 0.5 $\mu g/m^3$, then the total cost would be $397 per annual mt capacity. These costs would be in addition to compliance costs for meeting existing regulations.

Operating Costs

Secondary lead smelter operating costs are presented as industry averages and are based on ¢/lb refined lead. Costs include purchase of scrap lead, processing, and environmental regulatory compliance. Total operating costs varied from 20 to 24 ¢/lb with an average of 22 ¢/lb (table 7). The present environmental regulatory compliance costs were as high as 4.5 ¢/lb for some smelters that are actively pursuing compliance requirements but averaged 3 ¢/lb for the industry.

Table 7. - Average operating costs for the Secondary lead industry (1987 dollars)

Cost item	¢/lb refined lead
Scrap lead purchase........................	9
Processing cost............................	10
Regulatory cost............................	3
Total......................................	22

Average additional operating cost estimates in order to fully comply with existing environmental, health, and safety regulations would add approximately 3.8 ¢/lb to those costs show in table 7. The cost breakdown is presented in table 8.

Table 8. - Secondary lead smelter operating cost estimates to meet existing regulations (1987 dollars)

Category	¢/lb refined lead
Particulates (NAAQS, PEL partial)...........	2.0
Health & safety (RCRA, MRP, PEL partial)....	1.4
Water (CWA, SWDA)...........................	0.4
Total.......................................	3.8

The particulates category includes expenditures necessary to achieve the NAAQS 1.5 $\mu g/m^3$ standard and the control equipment part of the PEL standard. Although PEL is directly related to health and safety, the removal of lead in air is more directly associated with NAAQS compliance. Therefore the cost includes operating and maintaining baghouses, ventilation, and hooding for PEL with process off-gas treatment for NAAQS.

The health and safety category includes safety equipment, laundry service, floor sweeping, medical exams, personal hygiene, and RCRA. Medical removal is also included in this category. Employees whose blood-lead levels exceed the 50 µg limit are removed from the work site until their lead levels are reduced to 40µg/100 g blood.

The water category covers the operation of a lime and settle water treatment plant and compliance with the various state effluent standards for publicly owned water treatment facilities. The operating costs for water treatment vary by location and range from 0.4 to 2.0 ¢/lb refined lead. More stringent water standards will require the use of carbon towers, precipitation tanks, ion exchangers, rotary vacuums, and filter presses. Presently, very few smelters incorporate this technology.

For the proposed NAAQS standards of 1.0 $\mu g/m^3$ and 0.5 $\mu g/m^3$ of lead in ambient air, the operating cost estimates are presented in table 9.

Table 9. – Secondary lead smelter operating cost estimates for proposed regulations (1987 dollars)

Standard	¢/lb refined lead
From:	
1.5 $\mu g/m^3$ to 1.0 $\mu g/m^3$	0.55
1.0 $\mu g/m^3$ to 0.5 $\mu g/m^3$	1.45
1.5 $\mu g/m^3$ to 0.5 $\mu g/m^3$	2.00

*** ECONOMIC ANALYSIS

Economic analyses were performed for primary and secondary plants to determine what the price of lead would need to be to cover production costs and a DCFROR of 15 pct. Results from the MINSIM 9 computer program for Missouri operations (including mining, milling, smelting, and refining) are presented in table 10. Byproduct credits for zinc, copper, precious metals, and acid sales are shown in parentheses. The bath technology is also shown as an alternate to flash smelting as units have been sold to China and Canada, but are not yet operative.

Table 10. -- Economic evaluations for primary lead cases

(¢/lb refined lead, 1987 dollars)

Cost area	Existing Plants	Rehabilitated Plants	New Flash Plant	New Bath Plant
Mine & mill production	14.17	14.17	14.17	14.17
Smelter & refinery production[1]	12.79	10.01	9.32	8.52
Regulatory	2.75	4.35	3.51	3.51
Capital recovery[2]	1.55	4.38	3.62	5.33
Return on investment	0.41	3.93	5.15	5.14
Corporate overhead[3]	3.00	3.00	3.00	3.00
Other (royalty, taxes, misc.)	1.07	2.09	2.20	2.50
Subtotal	35.74	41.93	40.97	42.17
Less: byproduct credits[4]	(11.94)	(12.63)	(12.77)	(12.77)
Net cost	23.80	29.30	28.20	29.40

1. Includes concentrate transportation costs and improved recovery.
2. Includes capital costs, loan interest costs and working capital.
3. Includes metal transportation costs to the consumer.
4. By-product credits include zinc at 42.5 ¢/lb; copper at 85.6 ¢/lb; silver at $7.59/tr oz; and sulfuric acid white-grade river location at $45/st, white-grade inland location and black-grade river location at $35/st,; and black-grade inland location at $25/st.

Mine-mill costs remain equal for all scenarios at about 14 ¢/lb. Using the existing plant scenario as a base for comparison, flash and bath plant scenarios production costs decrease despite additional concentrate transportation costs to the river location. Reasons for the decrease include the new technology, economies of scale, fewer operators, and the elimination of the use of metallurgical coke.

Bath smelting has the lowest estimated smelter-refinery production cost. However, it has a higher capital cost than flash smelting, because present bath smelting units are limited to approximately 130,000 mt/yr. As a result, three bath furnaces would be required resulting in higher capital expenditure ($400 million vs $300 million) and higher net cost. As shown, using the existing plants as a base for comparison, regulatory costs, capital recovery, return on investment, and miscellaneous expenses increase for the rehabilitated plants and the flash and bath plants.

For the economic analysis of the secondary lead industry, three cases were evaluated: existing plants, plants with capital expenditures to meet existing regulations, and plants with capital expenditures to meet proposed regulations. Analysis parameters include a 15-pct DCFROR; a scrap lead purchase cost of 9 ¢/lb refined lead, a processing cost of 10 ¢/lb refined lead, and a regulatory cost of 3 ¢/lb refined lead (22 ¢/lb total); a 60:40 pct debt/equity ratio; a 12.5 pct interest rate and a 5-yr loan payback. The "other" category includes state and federal income taxes, profit, and miscellaneous costs (table 11).

For existing secondary plants, a selling price of 23.1 ¢/lb refined lead would be required to obtain a 15-pct DCFROR. Plants investing capital to comply with existing regulations would require a selling price of 27.2 ¢/lb refined lead, and plants investing capital to comply with the proposed regulation of 0.5 $\mu g/m^3$ would require a selling price of 29.2 ¢/lb refined lead to obtain a 15-pct DCFROR.

Table 11. - Economic evaluation for secondary lead cases (¢/lb refined lead, 1987 dollars)

Cost area	Existing condition	Existing regulation	Proposed regulation[1]
Scrap lead.................	9	9	9
Conversion cost...........	10	10	10
Regulatory cost...........	3	6.8	7.8
Other[2].....................	1.1	1.4	2.4
Total...................	23.1	27.2	29.2

1. Based on the 0.5 $\mu g/m^3$ NAAQS standard.
2. Includes taxes and return on investment.

*** REGULATORY IMPACTS ON THE LEAD INDUSTRY

Three scenarios were considered in order to quantify the impacts from enforcement of existing environmental, health, and safety regulations and from proposed regulations. Impacts are measured in terms of jobs and wages lost by the industry and support industries, and the import value of lead to supplement the lost production. The scenarios are based on the present total domestic demand for lead and projection of future demand to the year 2000. Lead demand, currently projected by the Bureau of Mines, for the year 2000 is 1.32 Mmt. Domestic lead production for 1987 was valued at $614 million. This is based on the London Metal Exchange (LME) average 1987 cash value of 27 ¢/lb and domestic production of 1,032,000 mt of lead.

For this study, a lead price of 30 ¢/lb was used for the existing situation (scenario 1). The other two scenarios use different lead prices because supply-demand principles were allowed to influence the price. Scenario 2 uses a lead price of 40 ¢/lb which is based on the fact that loss of primary production represents a 6 pct loss of world supply. Scenario 3 uses a lead price of 60 ¢/lb which is based on the fact that a combined loss of primary and secondary production represents an 18 pct loss of world supply.

Labor and wages were developed from information also supplied by the Bureau's lead commodity specialist, and sources such as the Census of Manufacturers and County Business Patterns of Missouri. The Bureau's Branch of Economic Analysis developed multiplier factors for indirect labor and wages using the IMPLAN input-output model.

The first scenario assumes that existing and proposed regulations, which could force primary and secondary smelters to close, would not be enforced. As a result, primary smelters could continue to produce at levels roughly equal to current production (Buick and El Paso would remain closed). Primary production is forecast to increase to 400,000 mt/yr in 1989 and remain at that level through the year 2000 (fig. 3).

Production from old scrap at secondary smelters is projected to increase to 700,000 mt/yr by 1989 and continue to increase at the same rate that lead demand increases. The increase in secondary production is based on the assumption that 75 pct of domestic consumption goes into batteries and that 90 pct of the batteries would eventually be recovered. Additional lead is also recovered from new scrap and from other sources of old scrap.

Under this scenario, imports of refined lead would average 100,000 to possibly as high as 150,000 mt/yr. (Net imports of pig lead from 1969 to 1987 averaged 135,000 mt/yr.) At a lead price of 30 ¢/lb, this results in a lead import value of $66 to $99 million annually. There would be no impact on jobs and wages.

The second scenario assumes that existing regulations will be enforced. Primary smelters will be unable to fully comply with the current NAAQS standard of 1.5 $\mu g/m^3$, OSHA's PEL limit, and the 0.5 ppm 3-hour SO_2 limit, and therefore, would be forced to close. However, it is possible that domestic mine production could continue if the mines are able to economically compete on the world market. A minimum of 15 years of concentrate supply (at 400,000 mt/yr of contained lead metal) may be available for export or toll smelting-refining from lead deposits in the new lead belt of Missouri (fig. 4).

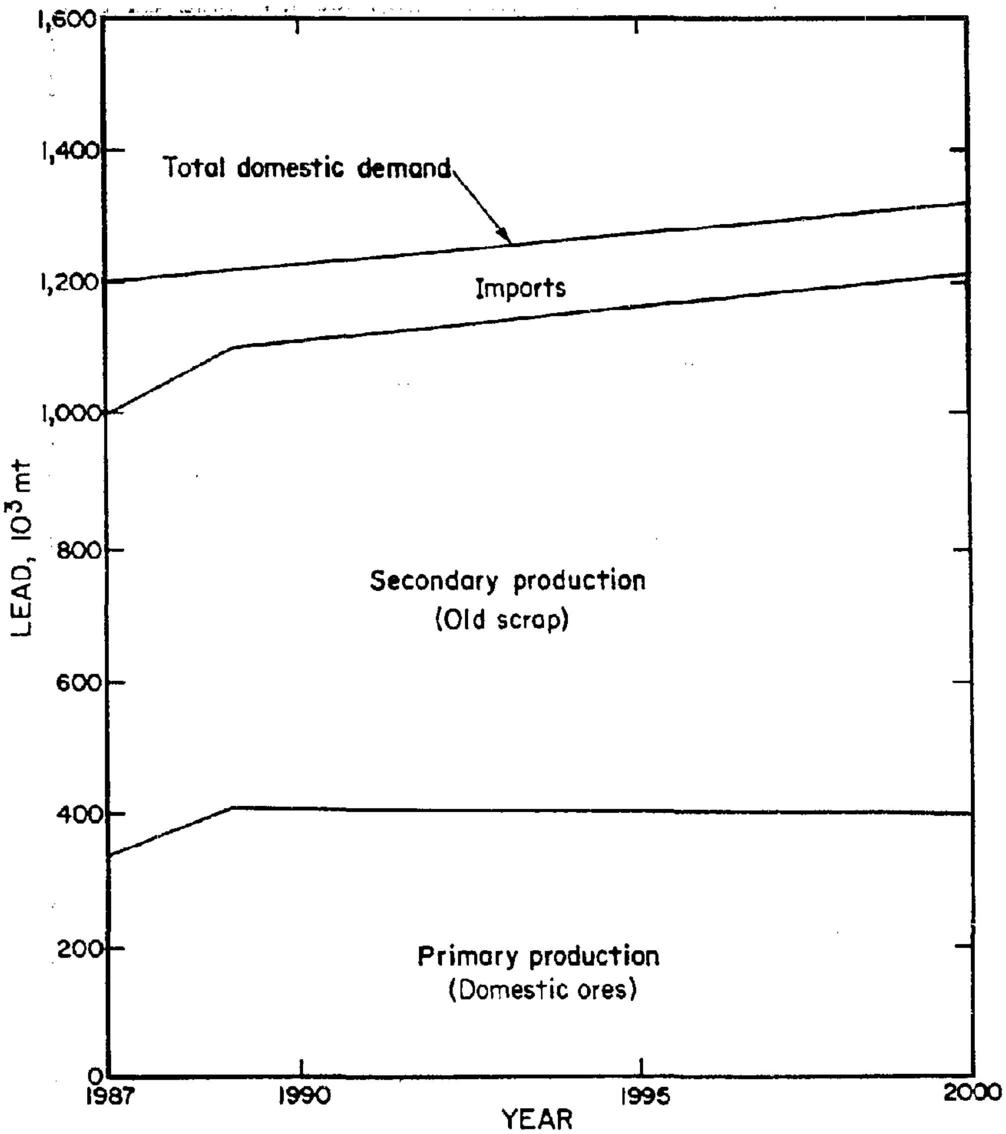


Figure 3. - Scenario 1 - Existing condition.

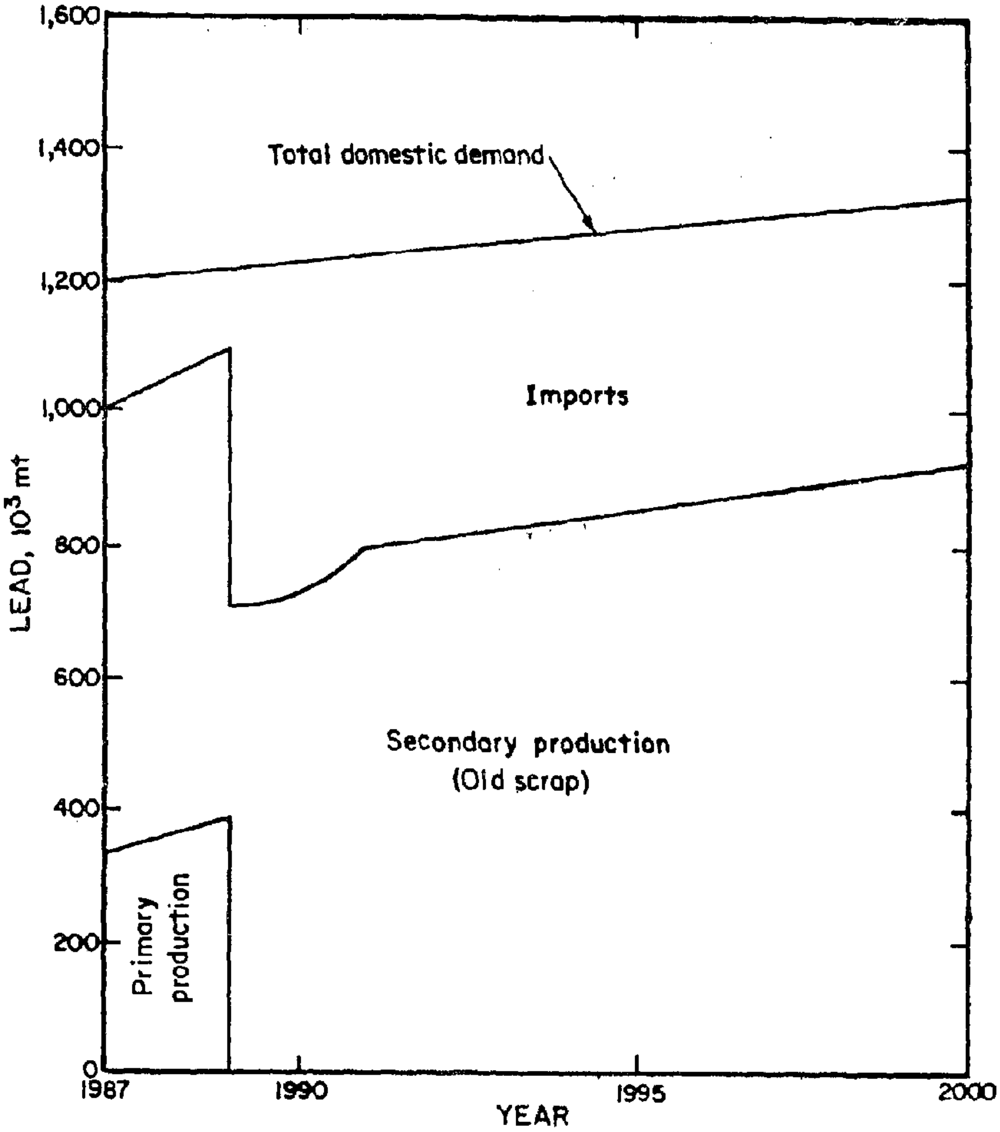


Figure 4. - Scenario 2 - Enforcement of existing regulations.

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The secondary lead industry is capable of complying with existing environmental regulations, although it will add significantly to capital and operating costs. Proposed NAAQS standards are economically achievable for the 1.0 $\mu g/m^3$ but probably not for the 0.5 $\mu g/m^3$ standard. Strict enforcement of existing regulations may have the impact of closing several small secondary smelters and one or two larger secondary smelters. The Bureau estimates that loss of capacity from secondary smelters would be about 100,000 mt for the first year. By contrast, it is expected that the larger secondary smelters will increase capacity to account for the loss of production from closure of other secondary smelters. As a result, it is projected that secondary old scrap production would increase from 700,000 to 800,000 mt/yr between 1989 and the early 1990's, and continue to increase (up to 900,000 mt/yr) gradually through the year 2000 if recycling approaches 70 pct of demand. Imports of lead would increase significantly, from the recent average of 135,000 mt/yr to as much as 500,000 mt/yr under this scenario. At a lead price of 40 ¢/lb, the import value would reach nearly $441 million per year. (This deficit would be reduced if production and export of domestic lead concentrates continued).

The last scenario assumes that existing regulations and the proposed NAAQS standard of 0.5 $\mu g/m^3$ will be enforced. A 5-year period was allowed for promulgation and implementation of this proposed regulation, resulting in the closure of secondary smelters by 1994. Under this scenario, primary as well as secondary smelters would be forced to shut down. As in the second scenario, it is possible that domestic mine production could continue if the mines are able to compete in the world market (fig. 5).

Under this scenario, the United States would be forced to rely totally on imports to meet domestic demand. As a result, at a lead price of $0.60/lb (a realistically probable price for lead), the import value for lead could reach nearly $1.75 billion annually by the year 2000. Table 12 summarizes the results of all three scenarios.

Table 12. - Economic impacts from regulatory enforcement

Item	Scenario 1	Scenario 2	Scenario 3
Jobs lost:			
Direct..............	NAp	2,000	3,700
Indirect[1]...........	NAp	900	6,000
Income lost:			
Direct..............	NAp	$ 62 M	$ 115 M
Indirect[1]...........	NAp	16 M	100 M
Import value[2].........	$ 66 M	$ 441 M	$ 1,746 M
Total value..........	$ 66 M	$ 519 M	$ 1,961 M

[1]Indirect jobs and income represent the support industries to the domestic lead industry.
[2]Value basis: Scenario 1 @ 100,000 mt imports and 30 ¢/lb lead (year 2000), Scenario 2 @ 500,000 mt imports and 40 ¢/lb lead (year 1989), Scenario 3 @ 1,320,000 mt imports and 60 ¢/lb lead (year 2000).

New technology could reduce the dependency of foreign sources of lead for scenario three. For example, the Bureau has investigated the electrolytic recovery of lead from scrap batteries. With high lead prices, this processing technique would be economically feasible. Based on a positive secondary industry commitment, possibly eight strategically located electrolytic plants operated by at least three companies would produce about 400,000 mt/yr. Net dependency would be reduced to about 920,000 mt/yr or an annual import value of about $810 million (at 40 ¢/lb) by the year 2000.

*** CONCLUSIONS

Regulatory compliance costs have added significantly to capital and operating costs for the domestic lead industry. From 1970 to 1985, capital expenditures by the primary lead industry for compliance are estimated to be $221 million (current dollars) and the regulatory operating cost attributable to this present level of compliance is 2.5 ¢/lb refined lead. Regulatory compliance operating cost for the secondary industry presently (1987) averages 3.0 ¢/lb refined lead.

At present, both primary and secondary lead smelters are not in full compliance with existing regulations. If these regulations were strictly enforced, the primary industry would probably be forced to shut down. The secondary industry would be able to comply, but a capital expenditure of about $87 million would be required; operating cost would increase by about 3.8 ¢/lb.

The primary industry cannot afford high capital expenditures to upgrade to BAT which will not totally meet OSHA's PEL and NAAQS proposed regulations. The average lead selling price (generally less than 30 ¢/lb in recent years) may not justify capital expenditures as high as $400 million, even though operating costs would be reduced by alternate smelting technology.

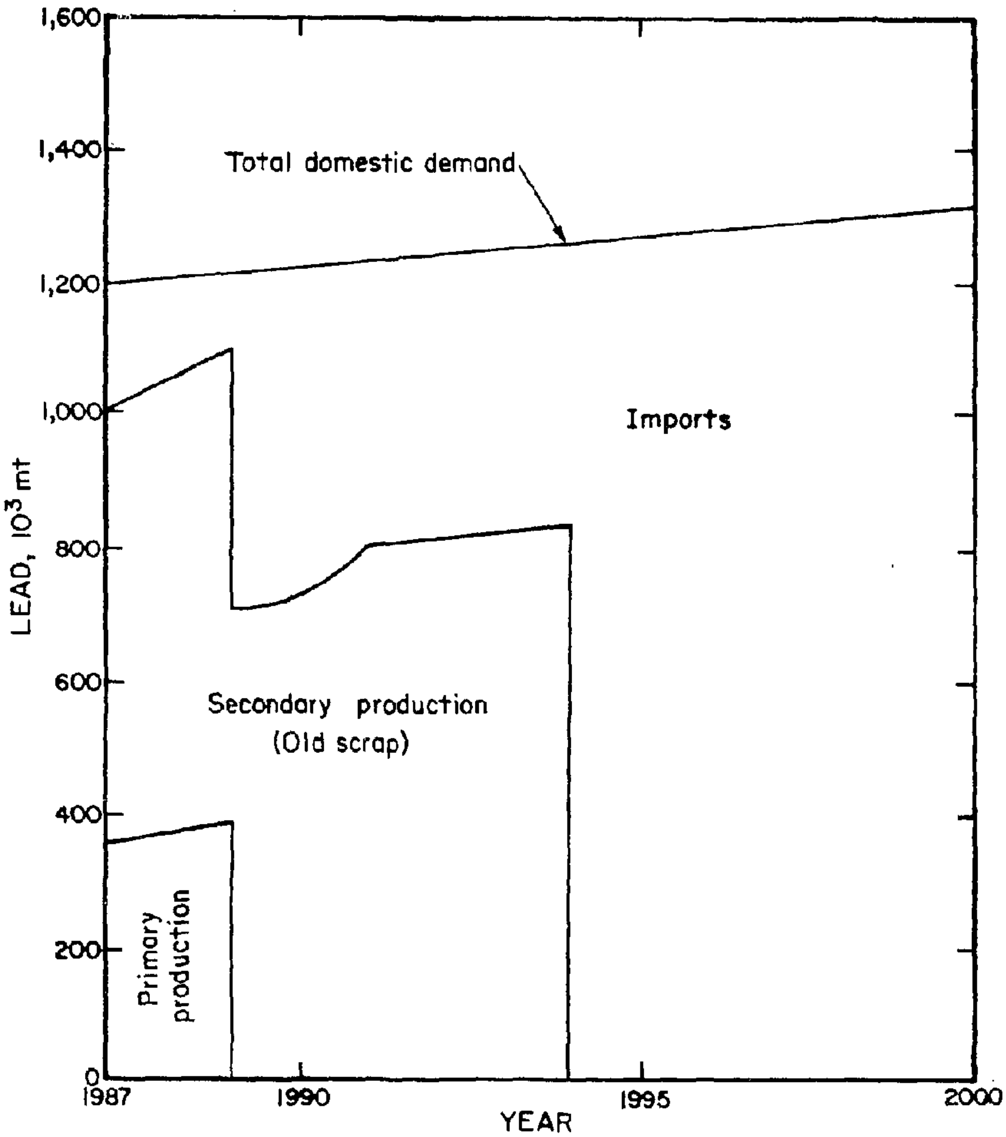

Figure 5. - Scenario 3 - Enforcement of proposed regulations.

If proposed regulations were promulgated, then the primary industry would completely shut down. It is unlikely that the secondary industry can comply with the 0.5 $\mu g/m^3$ standard for NAAQS even with an expenditure of $280 million. Therefore, it is expected that the secondary industry would also shut down rather than try to meet proposed 0.5 m/m^3 standard.

Significant environmental and health and safety improvements can be accomplished while maintaining a viable domestic lead industry. However, this requires regulations that are within attainable limits, that are uniformly enforced, assurance that standards will not change in the short term, and a willingness by industry to install the BAT in order to meet the established standards. Industry and government must take an active cooperative approach to these problems. By doing so, they may establish the vehicle for an environmentally sound minerals policy from which all domestic minerals industries can benefit.

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