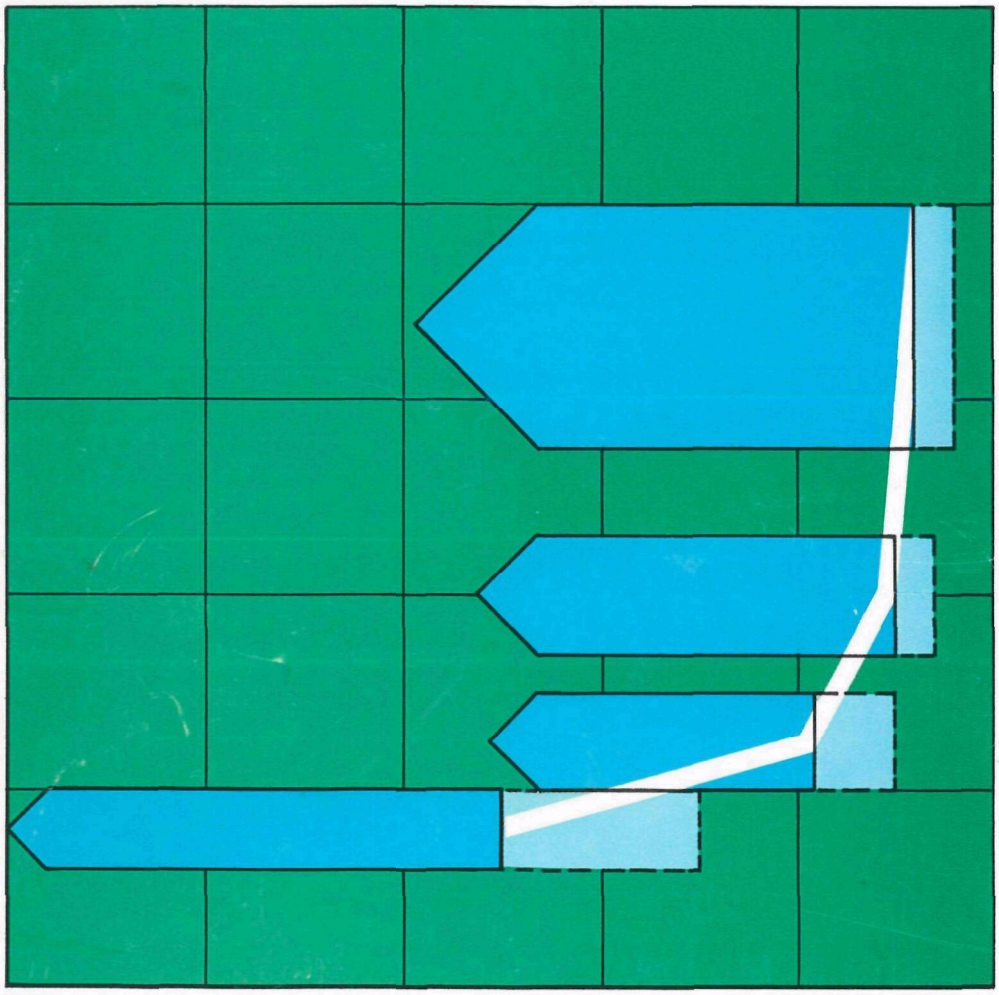
Economic Impact of Anticipated Pollution Abatement Costs

Primary Copper Industry

Report to
Environmental Protection Agency



Part 1 Executive Summary

Arthur D. Little, Inc.

ECONOMIC IMPACT OF ANTICIPATED POLLUTION ABATEMENT COSTS ON THE PRIMARY COPPER INDUSTRY

Report to

ENVIRONMENTAL PROTECTION AGENCY

PART I - EXECUTIVE SUMMARY

Arthur D Little, Inc.

PART I - EXECUTIVE SUMMARY

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PART I - EXECUTIVE SUMMARY

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PREFACE

This report was prepared in rough draft form during March-May 1972. At that point in time, as required by law, the states had submitted their respective plans for implementation of pollution control (SIP or State Implementation Plans) but EPA had not decided whether or not these plans would be acceptable. Because of this, we evaluated the economic impact of pollution control legislation based on control standards that were judged by us to have a high probability of being enforced.

The acceptable SIPs were released by EPA on July 27, 1972 (Federal Register 37, 145, July 27, 1972, pp. 15094-15113). These standards vary significantly from the standards assumed by us for the "base case" in our economic impact analysis. Because of this, our analysis of economic impact, though consistent with the assumptions used by us, is somewhat dated. An analysis of the economic impact of the July 27 regulations would require rewriting of major portions of this report and the analysis would still be incomplete since the requirements for meeting the Secondary Ambient Standards will not be available for another 18 months. Also, these standards have been challenged in court by the industry.

In Appendix A we have included a summary of the major differences between our assumptions and the July 27 regulations and the general consequences.

I. INTRODUCTION

This analysis provides an assessment of the economic impact on the primary copper industry that will result from air and water pollution control requirements anticipated through 1976. The information presented here was developed in a period of seven weeks under a contract with the Environmental Protection Agency to provide information that could be used in formulating Federal policy for pollution abatement programs affecting the non-ferrous metal industry over the next five years.

There are several topics that Federal policy-makers must consider when setting regulatory standards. The scope of the present study was basically limited to an analysis of the impact or consequences of a certain set of air and water pollution standards. Topics outside the scope of the present study but relevant to policy-making would include a cost vs. benefits analysis of pollution control, impact on the industries from Federal regulations in other areas, e.g. Occupational Health and Safety and means for resolving the differences in philosophy on how best to achieve a set of environmental goals.

The information contained in this analysis is based upon our knowledge and experience with the non-ferrous metal industry plus data derived from a number of sources. These were:

- The staff at Environmental Protection Agency who provided considerable background material and the basis for their calculations which have been reported in the Cost of Clean Air, March 1972, and other earlier publications.

- Knowledgeable executives within the non-ferrous metal industry who provided details of their plans for air and water pollution abatement and provided cost breakdowns during personal interviews and/or telephone conversations.

- Partial transcripts of hearings in several western states; when available.

- The United States Bureau of Mines

- Boards of Health in several western states

- Published data in the technical literature

The approach used in this study has been to assess the impact of air and water pollution control legislation on the industry using a plant-by-plant analysis. Capital investment costs were obtained from the individual companies or estimated by ADL. Data obtained from the individual companies were analyzed for consistency and were reduced to a common basis. The incremental operating costs resulting from air and water pollution control were also estimated in a similar fashion. All costs reported in the body

of the report are in current 1972 dollars and do not include corrections for inflationary changes. In general, the capital cost estimates reported are of the "pre-engineering" type, i.e., costs estimated by using scaling factors without detailed material or energy balances (at best ± 30%).

The impact of these costs was evaluated under two extreme conditions, one representing excess of supply over demand (which would not permit a price increase) and an excess of demand over supply, in which case, a price increase would permit the costs of pollution control to be passed completely on to the consumer. The underlying economic assumption was a real growth in GNP of 4% per year through 1976.

The following assumptions have been made in this study regarding pollution abatement standards.

- Federal ambient air quality standards were assumed to apply in all cases. These standards refer to sulfur dioxide concentrations at ground level outside plant boundaries. These standards are:

  Primary Ambient (to protect human welfare)

annual arithmetic mean	80 $\mu g/m^3$

  Secondary (to protect property)

annual arithmetic mean	60 $\mu g/m^3$

- Emission standards limit the emission of sulfur dioxide from a plant to a certain rate and require the recovery of a certain percentage of sulfur in the feed materials. In general, emission standards as a means for achieving ambient concentration targets are "restrictive" in the sense that certain lower cost strategies (tall stacks, preheated dilution air, etc.), which would otherwise be adequate for achieving these targets, can no longer be used. However, these lower cost strategies may not be optimal for meeting ambient standards in all cases; for example when frequent occurrence of adverse weather conditions results in substantial curtailed production.

  Because the emission standards are in a state of flux, they were examined under two sets of assumptions. The first was the uniform application of a 90% sulfur recovery or 10% sulfur emission standard. The second was based on State Implementation Plans which had been submitted to the EPA. The costs developed under this latter case have been termed "local" and this is the base case for the financial analysis. These assumed "local" emission standards (which would apply in addition to ambient standards and dictate the pollution control strategy) are as follows:

State	Assumed % Sulfur Recovery for "Local" Case
Arizona	90
Idaho	0*
Missouri	0*
Montana	90
Nevada	60
New Mexico	60
Oklahoma	0*
Pennsylvania	0*
Texas	43
Utah	0*
Washington (Puget Sound)	90

*Zero denotes Federal Ambient Standard is more stringent than local emission standard, or no local emission standard.

The cost figures for the uniform 90% standard have been presented in the report for comparison purposes only and the economic impact analysis considers only those costs listed as "local." Emission standards requiring sulfur above 90% were not considered.[1]

- Particulate control standards considered were those that would require recovery of particulates of over 99.8% of the throughput (Federal Register, 36-158, August 14, 1971, p. 15495-6.). (This standard affects only those smelters with old Cottrells on their reverb offgases when these gases are vented directly via the stack.)

- The water pollution standards were assumed to be those based on the removal of suspended solids by settling and permitting a level of residual heavy metal concentrations in discharge streams that might be obtained after heavy metal ion removal as the hydroxides. Filtration systems for removal of suspended solids were not considered.[2]

1 The July 27, 1972 standards require over 90% sulfur recovery at three copper smelters.

2 It appears that this technique might not be adequate to meet the latest guidelines from Federal and state agencies in all instances.

II. FINDINGS AND CONCLUSIONS

A. INDUSTRY STRUCTURE

The United States has been the largest copper producing country in the world since before the turn of the century. Most of the copper mined in the United States is produced in five western states--Arizona, Utah, New Mexico, Montana and Nevada. There are 27 major mines that account for over 95% of the copper output. A major portion of the mine production is accounted for by producers such as Kennecott, Phelps Dodge, Anaconda, Newmont and Inspiration, who are integrated from mining through fabrication. Numerous small companies participate only in mining and beneficiation sectors of the copper industry and sell or arrange for toll treatment of their concentrates at the custom smelters of Asarco. Some of the larger mining companies are Duval and Pima.

Traditionally the smelters have been situated near the mines in order to minimize transportation costs for concentrates. The approximate flow of concentrates between mines and smelters in early 1972 is shown in Table 1.

At the present time, there are 15 primary smelters in the U.S., thirteen of them west of the Mississippi. Table 2 is a list of the primary smelters and their approximate capacities in 1970. By 1976 the capacity at Magma is expected to increase to about 200,000 tons of copper per year. Depending on a variety of pollution-related factors, the capacity at Anaconda might increase, that at Douglas will decrease, while the capacities at the remaining smelters will not change significantly. It appears that the only new copper smelter to be constructed will be built by Phelps Dodge in Southern Hidalgo County, New Mexico. The smelter capacity will be about 100,000 tons of copper per year.

The major portion of the smelter output of blister copper is electrorefined, while a smaller portion is fire refined. Fabricating companies are the principal consumers of refined copper. They work the metal into semi-finished form such as sheet, strip, rod, tube, wire and extruded or rolled shapes which are the raw materials for the manufacturing industries.

Many large domestic producers through subsidiaries or stockholdings operate foreign properties in both the developed and developing countries and are also involved domestically in the production of other nonferrous metals such as aluminum, lead and zinc. The financial posture of some of the companies has been changed by expropriation of certain foreign holdings and nationalization in other countries continues to be a threat.

TABLE 1

APPROXIMATE FLOW OF CONCENTRATES BETWEEN COPPER MINES AND SMELTERS

MINES		SMELTERS: Kennecott, Utah	Kennecott, Hayden, Ariz.	Kennecott, Hurley, N.M.	Kennecott, McGill, Nev.	Asarco* El Paso, Texas	Asarco* Hayden, Arizona	Asarco* Tacoma, Wash.	P-D, Morenci	P-D, Ajo	P-D, Douglas	P-D, New, N.M.	Anaconda	Inspiration	Newmont	Cities Service
Kennecott------	Utah Copper	1														
	Ray, Ariz.		1													
	Chino, N.M.			1												
	Veteran, Tripp, Nev.				1											
Phelps Dodge---	Morenci, Ariz.								1							
	New Cornelia, Ariz.									1						
	Lavender Pit, Ariz.										1					
	Tyrone, N.M.								1		1					
Magma----------	San Manuel, Ariz.														1	
	Magma, Ariz.														1	
Anaconda-------	Twin Buttes, Ariz.						1							1		
	Berkeley, Mont.												1			
	Yerington, Nev.												1	2		
	Butte Hill, Mont.												1			
Pima----------	Pima, Ariz.					1	1				1					
Inspiration----	Inspiration, Ariz.													1		
	Christmas, Ariz.													1		
Asarco---------	Mission, Ariz.					2	1									
	Silver Bell, Ariz.					2	1									
Duval----------	Sierrita						2	1								
	Mineral Park						2	1								
	Esperanza					1	2									
	Battle Mtn., Nev.					1		1								
Cities Service -	Copper Cities, Ariz.													1		
	Copper Hill, Tenn.															1
Bagdad Cu------	Bagdad, Ariz.						1				2					
Others						1	1	1						1	1	

1 - major flow

2 - minor flow

* Flows to Asarco Smelters can vary month to month

SOURCE: ADL Estimates based on data in ABMS Yearbook 1970 and Annual Reports.

TABLE 2

COPPER SMELTING WORKS OF UNITED STATES

Company	Location	Approximate Capacity Tons of Copper Per Year (4)	Annual Capacity Tons of Material (1)	Number of Employees
American Smelting & Refining Co.	El Paso, Texas	100,000	576,000	975
American Smelting & Refining Co.	Hayden, Ariz.	180,000	960,000	450
American Smelting & Refining Co.	Tacoma, Wash.	110,000	600,000	1,000
Anaconda Company	Anaconda, Mont.	210,000	1,000,000	2,000
Cities Service Company				
Copperhill Operations	Copperhill, Tenn.	15,000	90,000	*
Inspiration Consolidated Copper Co.	Miami, Ariz.	140,000	450,000	*
Magma Copper Company				
San Manuel Division	San Manuel, Ariz.	100,000	403,000	*
Kennecott Copper Corporation:				
Nevada Mines Division	McGill, Nev.	70,000	400,000	*
Chino Mines Division	Hurley, N.M. (2)	90,000	400,000	*
Ray Mines Division	Hayden, Ariz.	80,000	420,000	*
Utah Copper Division	Garfield, Utah	300,000	1,000,000	*
Phelps Dodge Corporation:				
Douglas Smelter	Douglas, Ariz.	110,000	875,000	650
Morenci Branch	Morenci, Ariz.	190,000	900,000	*
New Cornelia Branch	Ajo, Ariz.	70,000	300,000	*
White Pine Copper Company	White Pine, Mich.	90,000	90,000 (3)	*

(1) At end of 1970. In tons of 2,000 lb.

(2) Produces fire-refined copper as well as blister.

(3) Tons of product.

(4) ADL estimates.

*Not available separately; included in Table IV-3

SOURCE: American Bureau of Metal Statistics Yearbook, 1970
ADL estimates

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The domestic copper, lead and zinc industries are interdependent to the extent that by-products or residues from one industry form a part of the input to the other as indicated in Table 3. A consequence of this interrelationship is that if one industry were eliminated, a significant impact would be felt by the others.

The western copper, lead and zinc industry is a significant producer of by-products. In certain instances, especially at the western lead smelters, the value of by-products can equal or exceed that of the primary product--lead. In Table 4, we present the estimated quantity of by-products produced by these industries in 1968, the latest year for which consistent data were available. This quantity has been put in the perspective of domestic mine production, domestic refinery production and domestic demand in order to indicate the relative importance of the by-products. Also included in the table is a gross value of these by-products. The value of the by-products as contained in the primary metal is considerably below this--perhaps as low as 50% of the gross value in some cases. In general, the by-product supply and production is inelastic, i.e., not dependent on demand or price of the by-product but dependent only on the primary metal production. Any factor (pollution related or otherwise) that changes the output of the primary product would automatically affect by-product output. An apparent exception might be the western lead smelter where, because of the high volume of co-products, higher co-product prices (e.g. silver, bismuth, etc.) can decrease the sensitivity of primary metal production to primary metal price.

An important aspect of the entire primary non-ferrous industry is that traditionally the smelters and refineries have been operated as <u>service</u> operations at a fixed and relatively low profit margin which is not very sensitive to the price of the finished product. Hence, the impact of any change in price of the primary metal has to be reflected back and affects directly the value of the concentrate. In the 1960's, the traditional rule-of-thumb in determining concentrate value in the copper industry was to assume 4¢/lb. for smelting charges and 5¢ for refining charges so that the value of copper contained in the concentrate is very approximately 9¢/lb. below the cathode or wirebar market price. (The current operating margin in the copper industry is about 10¢/lb., in the lead industry about 4-6¢/lb.--and complicated by co-product values--and that in the zinc industry is about 8-10¢/lb.).

Because of this mechanism, any increase in smelting or refining costs cannot be "absorbed" by the smelter or refinery but can only be passed backward to the mine and the net-back (the net concentrate value realized at the mine; e.g. smelter payment minus transportation costs) would be decreased. Should the market supply/demand constraints permit an upward adjustment in primary metal price, this increase would then be reflected back to the mine. The mechanism described above is of primary importance to custom and toll smelters since it is possible that a decreased concentrate value can result in mine closings and loss of smelter feed material.

TABLE 3

CROSS-FLOW OF MATERIALS BETWEEN PRIMARY COPPER, LEAD AND ZINC INDUSTRIES

	Source	Material Produced By Source	Industries Where Treated
A) Mining and Milling	Cu mills	Pb-Zn concentrate	Western Pb smelter; Zn smelter
	Pb-Zn mills	Cu concentrate	Cu smelters
	Pb mills	Cu concentrate	Cu smelters
	Pb-Zn mills	Pb conc.; Zn conc.	Pb smelter; Zn smelter
B) Smelting	Cu smelter	Pb-Zn converter dust	Western Pb smelter
	Pb smelter	ZnO fume from slag	Electrolytic Zn plant
	Pb smelter	Pb-Cu dross	Pb smelter
	Pb smelter	Au, Ag Cu matte	Cu smelter
	Zn-Pb smelter	Cd fume	Cd refinery
	Zn Horizontal retorts	Pb-Zn residue	Western Pb smelter
	Zn electrolytic	Pb-Zn residue	Western Pb smelter
	Cu smelter	Cu-As-Sb converter dust	Cu smelter (Tacoma)
	Pb smelter	Cu-As-Sb speiss	Cu smelter (Tacoma)
	Ag-Pb-Sb-Cu conc.	Cu-As-Sb speiss	Cu smelter (Tacoma)
C) Refining	Pb refinery	Bi dross	Bismuth refinery
	Pb refinery	Au-Ag skimmings	Au,Ag refinery
	Pb refinery	Pb-Cu dross	Pb smelter
	Cu refinery	Slag fume & residues	Cu &/or Pb smelter
	Cu refinery	anode slimes	By-product refinery (Au, Ag, Pt, Se, Te, Ni)

SOURCE: ADL

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TABLE 4

1968 STATISTICS REGARDING BY-PRODUCTS AND CO-PRODUCTS FROM U.S. Cu-Pb-Zn INDUSTRY

By-Product or Co-Product	Source	Estimated Quantity of By-Product in Short Tons	Gross Value Million $	Quantity of By-Product as % of Domestic Mine Production[1]	Quantity of By-Product as % of Smelter/ Refinery Production[2]	Quantity of By-Product as % of Domestic Demand[3]
Antimony	lead-silver	1,019	1.1	58	8	2
Arsenic	copper-lead	2,900	0.4	100	47	12
Bismuth	lead-zinc	350	2.8	100	88	30
Cadmium	zinc-lead	1,890	11.3	100	35	28
Gallium	zinc	NA	NA	NA	NA	NA
Germanium	zinc	10	1.8	100	84	25
Gold	copper	510*	30.6	34	30	6
Indium	zinc	230*	0.7	100	49	42
Manganese	zinc	8,000	5.3	NA	NA	NA
Molybdenum	copper	11,700	46.8	25	25	42
Nickel	copper	2,000	5.0	13	13	1
Platinum	copper	5*	0.6	100	8	1
Rhenium	copper	1.2	2.9	100	100	310
Selenium	copper	316	5.7	100	100	29
Silver	lead-zinc-copper	19,260*	34.7	59	31	11
Tellurium	copper	60	0.7	100	100	55
Thallium	zinc	1.3	--	100	49	40

*Thousand Troy Ounces

1. 100% indicates all of domestic production is a by-product; less than 100% indicates other production from a primary source or a source other than Cu-Pb-Zn mining.
2. 100% indicates absence of ore imports; less than 100% (and less than column 5) indicates ore or concentrate imports.
3. Greater than 100% (or greater than column 6) indicates exports.
4. NA: not available.

SOURCE: Adapted from Mineral Facts and Problems, U.S. Department of Interior, Bureau of Mines, Bulletin 650 (1970).

However, essentially the mechanism operates in the case of producers integrated from mining through smelting and refining since the concentrate transfer price is related to the primary metal price and again the mines would have to absorb the increased smelting and refining costs under adverse market conditions. Figure 1 illustrates this mechanism based on actual custom smelting contracts that were in effect several years ago.

B. FINANCIAL PERFORMANCE

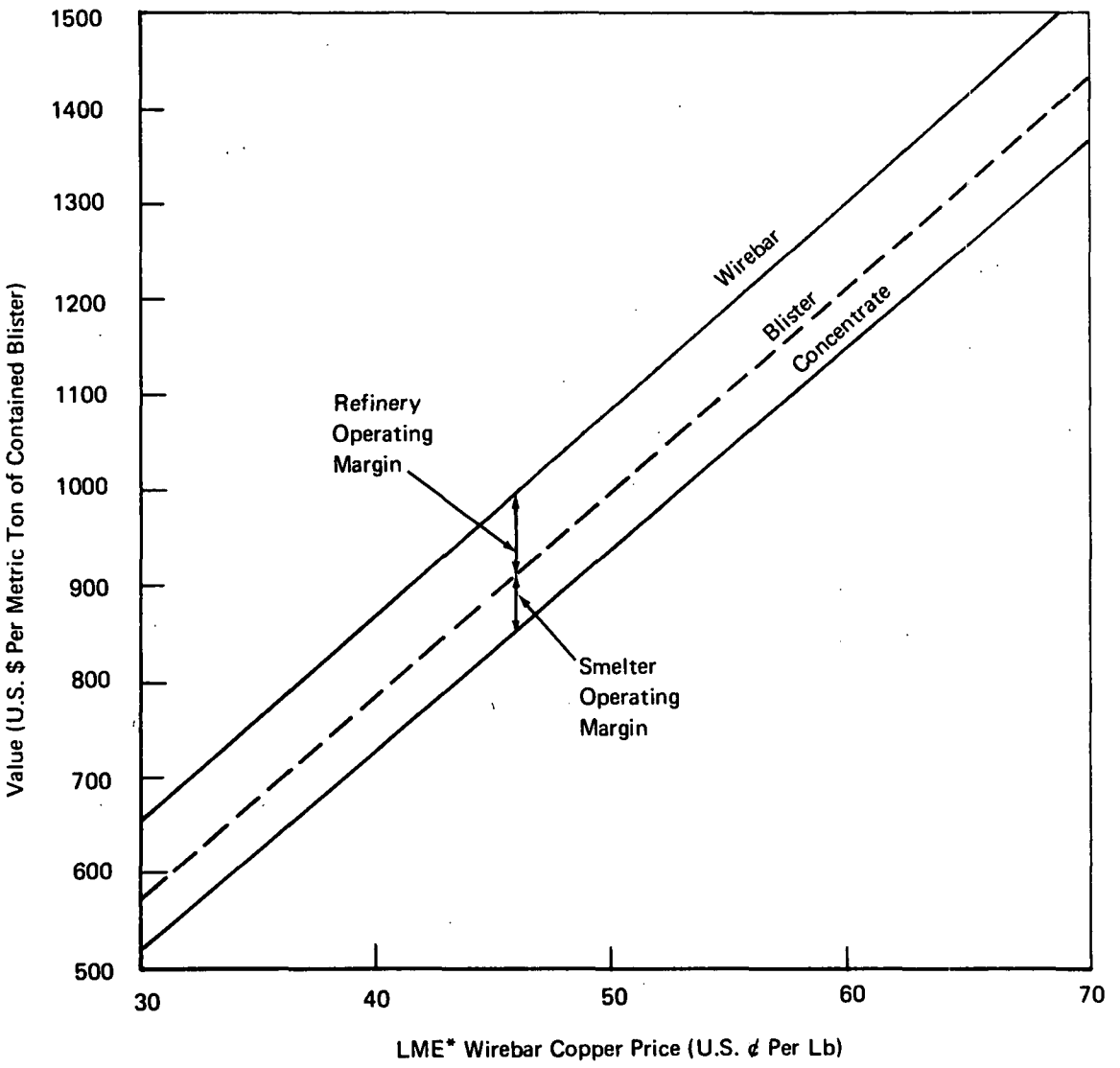
Given generally similar operating, tax, and pricing structures; and because of the overlap in company participation in copper, lead and zinc mining, smelting, and/or refining; we found it meaningful and convenient to group the major companies together to study from the financial viewpoint. Tables 5 and 6 summarize the financial performance of these companies. An index of growth rate is not presented, since sales and earnings of the primary nonferrous metals companies are cyclical. A major influence on earnings are the operating rate and metal prices. The latter fluctuate more than annual consumption or demand since prices tend to be sensitive to small imbalances between supply and demand and varying international situations. In most cases, 1971 was a year of depressed operating margins due to strikes, price declines and other adverse factors.

C. MARKET CHARACTERISTICS

1. Supply and Demand

Over the past 20 years, world consumption of copper has been increasing at an average annual rate of 4 to 4-1/2% to its present level of 7.9 million tons per year of refined metal. Despite competition from plastics and aluminum, consumption is expected to increase at about the same rate worldwide over the next decade with a slightly lower rate in the industrialized countries. The U. S. is a leading producer and consumer of primary copper, accounting for about one-third of Free World production and consumption. Despite this, the U. S. has been in a position of undersupply since the early 1960's. Domestic mine production has been increasing recently at an adjusted rate of about 3-1/2% per year whereas the consumption has yet to regain the 1966 level. In line with the assumption of a 4% real growth in GNP made for this study, we would expect a growth in copper consumption at an average annual rate of about 3%.

Primary copper mine capacity worldwide is expected to increase at the rate of about 6.2% per year based on announced and planned projects up to 1975. Barring serious upheavals which can limit mine capacity, future demand may not be strong enough to absorb all of the additional output that is planned.



* (London Metal Exchange)

Source: Arthur D. Little, Inc.

FIGURE 1 DIAGRAMMATIC REPRESENTATION OF VARIATION IN CONCENTRATE VALUE WITH CHANGES IN WIREBAR PRICE

TABLE 5

REFERENCE DATA

NON-FERROUS METALS COMPANIES*

	Asarco	Anaconda Co.	Copper Range	Inspiration Consolidated	Kennecott Copper	Newmont Mining	Phelps Dodge	St. Joe Minerals	Amax	Gulf Resources (Bunker Hill)
Percent Change in Earnings										
Due to 1¢ copper price change:	(low)	(high)	(high)	(med-high)	(low)	(low-med)	(low)			
Due to Pb-Zn metals price change:	(low)	(high)	(high)	(med.)	(low)		(low)	(high)	(low)	(med. - high)
Due to aluminum price change:		(low)					(low)		(med.)	
Reported Income Tax Rate, Percent										
1971	11.0%	$440 MM U.S. tax loss carry forward 1971-81 (and $190 MM foreign tax credits)	(credit)	27.7%	15%	19.3%	35.07%	29.8%	17% } excludes dividend income	nil
1970	22.3%		29.4%	33.1%	30%	32.2%	37.6%	29.6%	22% }	27%
Mine Production-U.S.A.										
Copper (thous. short tons)									Note: Also 20% Equity in Copper Range Co.	
1971	75.8	182.0	58.6	54.4	456.1	101 }	281.2		182.0 } custom smelter refined	
1970	83.4	242.1	67.8	67.1	518.9	112 }	313.5		215.0 }	
Lead (thous. short tons)										
1971	18.7	16.4 } Toole Smelter Closed '71			68.6	Joint venture with Asarco. Also holds 8.1% of St. Joe Minerals	Note: P-D owns 772,500 shares Amax stock	303.2	N.A.	44-own 85-others
1970	28.4	18.1 }			83.7			318.4	75.0	40-own 83-others
Zinc (thous. short tons)										
1971	43.1	0.7 } Great Falls Closing '72			17.4			144.0 (conc. produced)	N.A.	67-own 53-others
1970	63.3	0.1 }			21.7			66.4 mine	32.0	50-own 64-others
Silver (million troy ounces)										
1971	6.66	3.87			3.7				20.0	9.6 } refined
1970	6.84	5.02			4.3				40.0	7.8 }
Aluminum Production (thous. short tons)										
1971	33.6% interest in Revere Copper and Brass	171.7			owns 925,000 shares Kaiser Aluminum		40% interest in Consolidated Aluminum Corp. (Conalco)		260.0	
1970		177.3							247.0	

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed.

*For a discussion of New Jersey Zinc Company, a subsidiary of Gulf and Western Industries, see text.

TABLE 5 (Continued)

	Asarco	Anaconda Co.	Copper Range	Inspiration Consolidated	Kennecott Copper	Newmont Mining	Phelps Dodge	St. Joe Minerals	Amax	Gulf Resources	Cyprus Mines
Estimated Revenue Breakdown											
Copper											
Mining	13-17%	5-10%	75-85%	94-98%	50-55%	85%	40-45%				25-30%
Fabrication		60-65%	15-20%	2-06%	10-15%		40-45%				
Custom Smelting	13-17%	nom.			nom.	nom.	5-10%				
subtotal	26-34%	65-75%	95+%	100%	60-70%	85-90%	90-93%		30%		25-30%
Zinc								44%		76%, includes silver	10-15%
Lead								35%			
Coal					25%					13%	
Aluminum		15-17%					7-10%		35%		
Primary											
Fabrication											
Other Sales											
All Other, n.e.c.	66-74%	8-20%	nom.		8-11%	10-15%		21%	35%	11%	55-60%
	100%	100%	100%		100%	100%	100%	100%	100%	100%	100%
Approximate Earnings Distribution											
Copper											
Mining-U.S.	20-25%	60-70%	95-105%	92+%	68-72%	40-45%	79-83%				
Mining-Foreign	40-45%	15-20%			10%	30-35%	5%				
subtotal	60-70%	80-85%	95-105%	92+%	78-82%	70-80%	85±%				45-55%
Fabrication	2%	2- 4%	(nil)	nom.	nom.		5-10%				
Custom Smelting	5%	1- 2%			nom.		nom.		7-10%	[Lead, zinc and silver account for 41% of profit in 1970, and a loss in 1971]	
Total, Copper	70-75%	84-88%	95-100%	95%	85±%	70-80%	95±%				50-60%
Zinc								30±%			10-15%
Lead								65±%			
Coal					10-12%						
Aluminum		nil					nom.		10-15%		
Primary											
Fabrication											
Other Sales											
All Other, n.e.c. including interest and dividends	25-30%	10-15%	≤5%	≤5%	3- 5%	20-30%	5±%	5±%	80±%		25-35%
	100%	100%	100%	100%	100%	100%	100%	100%	100%		100%
Approximate Source of Pre-tax Profits											
U.S.A.	40-50%	70-80%	100%	100%	95±%	} 70%	95%	80-90%			40-50%
Canada	5±%	2±%					1%	} 5±%			10-15%
Mexico	5-10%	15-20%									---
South America	15-20%					5%	5%	10-15%			10-20%
Australia	25-30%	(nom.)			nil	(nom.)	(1%)				10-20%
Africa						20-30					---
Other	(nom.)				nil						15-20%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

TABLE 5 (Cont'd)

SELECTED FINANCIAL DATA: MAJOR U. S. NON-FERROUS METALS COMPANIES

1971	Asarco	Anaconda	Copper Range	Inspiration	Kennecott	Newmont	Phelps Dodge	St. Joe	Amax	Gulf Resources	Cyprus Mines
Sales (in millions of dollars)	656.8	946.5	88.6	66.2	1,066.9[o]	240.5[o]	703.6	194.4	756.9	116.2[o]	203.2
Pre-tax Profit (in millions of dollars)	51.7	(5.2)	(6.1)	12.1	102.9	67.5	113.7	27.9	65.8	(3.5)	58.6
Net Income (in millions of dollars)	46.0	(8.7)[a]	(3.5)	8.7	87.2	54.5	73.8	19.6	55.4	(3.9)	27.8
Cash Flow from Operations and Holdings (in millions of dollars)	60.0	84.5	4.9	14.6	180.0	86.0	110.3	29.1	86.5	1.2[d]	52.5
Increase (Decrease) in Debt	14.4	25.0	12.0	(0.1)	52.0	93.2	78.7	(1.0)	130.6	4.6	(5.5)
Dividends Paid	46.2	10.9	0.6	4.8	58.0	28.2	42.9	13.7	36.5	1.1	9.1
Current Ratio: Assets/Liabilities	2.1	3.1	3.2	3.7	2.4	3.5	3.4	3.0	3.3	1.9	1.8
Net Working Capital	174.0	265.0	30.3	19.0	269.0	79.3	209.0	46.5	302.0	18.3	35.8
Capital Expenditures	37.4	89.9	11.9	9.8	150.0 (net)	129.1	75.5	21.2	139.5	7.4	38.1
Long-term Debt, year end	38.1	391.5	36.3	nil	314.6	201.6	166.0	10.7	392.0	48.6	34.9
Equity, year end	673.3	821.0	101.7	69.7	1,192.9	444.1	710.2	171.3	625.2	28.4	207.5
Debt ÷ (debt and equity) Percent based on book values	5.4	32.3	27.3[e]	nil	20.9	31.2	19.0	5.9	38.5	63.1	14.3
Scheduled Debt Repayment (1972 payment excluded from long-term debt at year end 1971)											
1972	3.6	24.6	1.3		43.4[e]	8.7	0.1	1.0	25.7	2.9	
1973	3.6	19.2	7.0[e]		43.2[e]	26.7	0.1		23.4	6.5	
1974	3.6	35.5	7.0		62.3[e]	31.8	12.9		27.5	6.0	
1975	5.2	58.1	N.A.		5.1[e]	44.3	0.1		20.6	5.9	
1976	1.6	64.0	N.A.		21.7[e]	33.5	0.1[c]		29.7	5.9	
Long-term Financing (in millions of dollars, 1971)			20.0	[b]	200.0	101.9	150.0		156.9	22.0	
Employment, year end	13,600	27,481	3,644	2,009	30,400	N.A.	15,500	4,503 (USA)	16,000	2,700 1,940 @ Bunker Hill	

Notes: p = preliminary; e = estimate
a/ Before extra-ordinary charge due to write-off of Chilean properties and other expense.
b/ Agreement for $13MM advances from toll customer.
c/ Above before $22 MM to be received from Conalco debentures.
d/ $19.7MM write-downs and reserves, net, excluded.
o/ Includes other revenues and/or income, as reported.

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed.

TABLE 6

FINANCIAL PERFORMANCE DATA

COPPER, LEAD AND ZINC COMPANIES*

Company	Net Sales For the Year	Operating Income Before Depreciation	Net After Tax Earnings (Before Extraordinary Items)	Capital Expenditures	Operating Ratio: Operating Income As A Percent of Sales		Net After Tax Return On Stockholders' Equity	Ratio of Capital Expenditures To Gross Plant At Year End
	MILLIONS OF DOLLARS				PERCENT			
Amax								
1971	756.9	97.9	55.4	139.5				
1970	840.7	115.2	83.6	110.2 (ex. RST)				
1969	753.5	99.8	69.1	63.0				
1968	570.6	81.9	59.8	101.2				
			Avg. 67.0	Avg. 103.5	Avg. 13.6%		Avg. 13.5%	Avg. 14.6%
Anaconda								
1971	946.5	66.9	(8.7)	89.9				
1970	977.4	108.9	68.1	90.5				
1969	1410.6	393.1	99.3	127.0				
			Avg. 52.9	Avg. 102.4	Avg. 15.4%	Net Income/Sales	Avg. 4.7%	Avg. 8.1%
Asarco								
1971	656.8	26.3	46.0	37.4				
1970	717.8	57.5	88.8	68.7				
1969	771.0	60.1	99.4	25.0				
1968	634.1	38.1	73.2	37.2				
			Avg. 76.9	Avg. 42.1	Avg. 6.5%	Avg. 11.0%	Avg. 13.1%	Avg. 9.9%
Copper Range								
1971	88.6	4.7	(3.24)	11.9				
1970	97.5	21.9	9.6	14.0				
1969	10.23	27.8	15.9	12.1				
1968	82.1	19.9	9.7	14.4				
			Avg. 8.0	Avg. 13.1	Avg. 19.9%		Avg. 9.6%	Avg. 7.9%
Inspiration Consolidated								
1971	65.8	16.9	8.7	9.8				
1970	88.8	30.5	17.8	9.7				
1969	69.5	22.5	13.4	9.4				
1968	43.9	8.7	5.7	9.0				
			Avg. 11.4	Avg. 9.5	Avg. 28.1%		Avg. 21.0%	Avg. 9.6%
Kennecott Copper								
1971	1053.4	191.4	87.2	162.5				
1970	1133.1	322.3	185.0	163.2				
1969	1050.0	286.9	165.4	152.0				
1968	724.5	171.9	111.2	150.0				
			Avg. 137.2	Avg. 156.9	Avg. 24.4%		Avg. 13.1%	Avg. 10.5%
Cyprus Mines (incl. Pima Consol.)								
1971	203.2	66.9	27.8	42.5				
1970	202.5 [141.8 ex Pima]	74.2 [32.6 ex Pima]	27.4	28.1				
1969	113.5	24.4	24.0	31.5				
1968	113.0	21.2	21.3	8.5				
			Avg. 25.1	Avg. 27.6	Avg. 27.5%	(Including Pima 1970-1971)	Avg. 15.2%	Avg. 14.4%
Phelps Dodge								
1971	703.6	140.5	73.8	75.5				
1970	716.2 Restated	184.7 Restated	108.0	89.2				
1969	672.1 628.9	138.4 N.A.	89.5	87.3				
1968	550.4 531.7	98.1 N.A.	64.6	77.7				
			Avg. 84.0	Avg. 82.4	Avg. 20.7%		Avg. 14.7%	Avg. 10.1%
St. Joe Minerals								
1971	194.4	29.6	19.6	21.2				
1970	161.3	35.2	26.2	15.2				
1969	179.0	53.1	37.5	13.4				
1968	150.8	36.8	25.0	10.3				
			Avg. 27.0	Avg. 15.0	Avg. 22.8%		Avg. 18.7%	Avg. 6.8%
Gulf Resources Chemical								
1971	115.2	7.8	(3.85)	7.4				
1970	114.4	13.1	4.56	4.0				
1969	113.7	12.1	3.77	5.4				
1968	104.9	11.7	3.45	9.5				
			Avg. 1.98	Avg. 6.6	Avg. 10.0%		Avg. 3.9%	Avg. 6.2%
Newmont Mining		**						
1971	197.5	55.2	54.5	129.1				
1970	214.8	97.6	75.2	135.3				
1969	197.0	83.8	64.1	57.0				
1968	154.1	61.3	50.3	58.1				
			Avg. 61.0	Avg. 95.0	Avg. 39.0%		Avg. 17.4%	Avg. N.A.

NOTE: While reasonable care was taken in compiling this data and presenting it in as consistent a fashion as is possible, we cannot guarantee absolute comparability from one company to the next, due to differences in the nature of earnings, and differences in their accounting for certain balance sheet and income statement items. To the best of our knowledge the above data present an accurate and meaningful basis for selective comparisons.

The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable, but its accuracy and completeness are not guaranteed.

*For a discussion of New Jersey Zinc Company, a subsidiary of Gulf and Western Industries, see text.
*This table should be read in conjunction with Table VIII-1.

**Excludes dividends, interest, net gain on sales of securities and other income in the following amounts:

1968 - $39.3
1969 - 40.4
1970 - 43.6
1971 - 43.0

2. Prices

During the 1960's, the annual average copper (f.o.b. domestic refinery) price varied from a low of 29.9¢ per pound in 1961 to a high of 57.7¢ per pound in 1970. During 1970, the price was 59.7¢ per pound for about four months. The price variation in 1972 until October was 2.25¢ per pound, the late October price being 49.985¢ per pound. The prices on the London Metal Exchange have traditionally been much more volatile.

Although the non-ferrous metal market is not a classic commodity market in a sense of a very large number of small producers, the non-differentiated nature of the primary metal products and supply-demand characteristics in the industry, including the foreign sources, indeed result in a commodity market.

Although an examination of projected world mine capacity would indicate an excess of supply over demand (which normally indicates stable or falling prices) until 1976 and perhaps up to 1980, we believe that both types of supply-demand imbalance could occur at different periods through and beyond 1976 since a relatively small difference between supply and demand can have a major impact on price. Because of this, the impact of pollution abatement costs has been analyzed under both alternatives of supply-demand imbalance.

D. TECHNOLOGICAL CHARACTERISTICS

Smelting practice in the U.S. is fairly uniform from smelter to smelter. About half of the copper smelters roast their charge prior to feeding to the reverberatory (reverb) furnace (calcine smelting), while the other half feed the concentrates directly (green feed smelting). The subsequent steps consist of melting the charge in the reverberatory furnace to form matte, a mixture of copper and iron sulfides and a slag (which is discarded); converting the matte to blister copper and finally fire-refining to remove the oxidizable impurities and/or electrolytic refining to remove and recover the precious metal impurities in the copper.

E. ISSUES

At the present time, there is considerable disagreement between the industry and governmental control agencies on the subject of pollution control. The major issues are identified below without comment:

- The state of development of technology for SOx emission control. It is generally agreed that SOx emissions can be reduced by manufacture of sulfuric acid from roaster gases and from converter off-gases with improved gas handling facilities. The industry believes that various types of scrubber technology is not proven or tested on an adequate commercial scale in order to guarantee system performance on an operational basis.

- The 90% sulfur recovery standard. This standard is disputed on the basis that it is more stringent than the degree of sulfur recovery necessary to meet Federal ambient standards and hence imposes unnecessary financial burden on the industry. A related issue is that the 90% sulfur recovery standard was recommended on the basis of unproven lime-limestone scrubber technology.

- The estimated cost of pollution control. The early estimates have varied a great deal since they were based on differing accounting and cost-estimating basis (e.g. inclusion or non-inclusion of gas collection facilities) and on the basis of either industry-wide models or plant-by-plant summations. Over the past two years, differences between industry and EPA cost estimates have narrowed.

- The superimposed time table. The industry feels that this does not permit orderly development of new technology. The repeated revision of pollution control targets within the guidelines hinders or prevents the selection of an optimum strategy.

- Strategies for meeting ambient standards. The industry favors using a variety of techniques including tall stacks, preheated dilution air and closed-loop control for meeting ambient air quality standards. EPA appears to favor the use of permanent SOx emission control techniques to achieve ambient air quality.

- The ability to raise the necessary capital. This is an issue because the industry believes that capital required on pollution control equipment could not be justified on a conventional return-on-investment basis.

F. POLLUTION CONTROL TECHNOLOGY

Given the time scale required for implementation of pollution abatement plans, industries would have to rely on proven technologies.

1. Air Pollution

a. Add-on equipment - proven from an operational viewpoint.

- improved converter gas collection; acid manufacture
- above method, plus roasting; acid manufacture
- tall stacks; preheated dilution air
- production curtailment with/without "closed-loop" control, i.e. production rate controlled by ambient concentrations measured by sensors in the field.

b. Major process changes or innovations (acid plant necessary)

- Hoboken converters or tight water cooled hoods
- flash smelting
- electric furnace smelting
- direct smelting of concentrates in a converter

c. Add-on equipment - not proven on this scale from an operational viewpoint

- DMA (dimethylaniline) scrubbing; followed by liquid SO_2, or elemental sulfur production
- lime, limestone or caustic scrubbing

d. New processes - not proven

- continuous smelting
- hydrometallurgical treatment of sulfide concentrates

2. Water Pollution

a. Proven

- removal of suspended solids by settling and filtration
- partial metal removal as hydroxides with lime
- high degree of plant water recycle

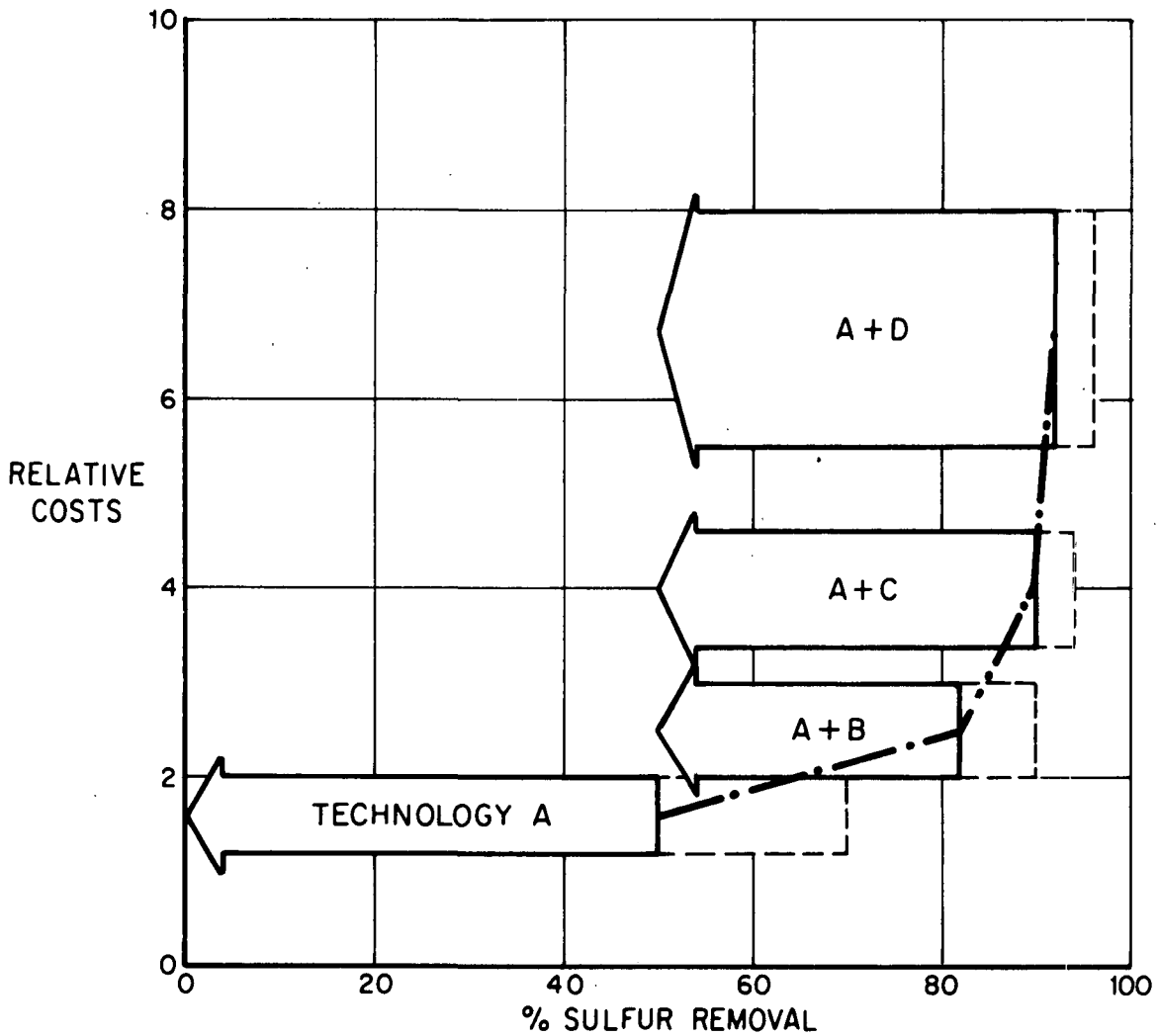
b. Unproven on a large scale

- ion exchange
- reverse osmosis

G. GENERALIZED COSTS OF EMISSION CONTROL

The several options for pollution control listed above are associated with differing degrees of emission control and result in different ambient SOx concentration since the latter are affected by stack height and local weather patterns.

We have prepared Figure 2 in order to show the costs associated with different degrees of emission control. The figure is based on the sequential selection of emission control strategy since a particular technology can be an optimum within a particular range of emission control objectives. We have selected collection of converter gases and acid manufacture as the basic strategy (Technology A) since these gases are a major source of SOx emissions that can be obtained in adequate concentrations for acid manufacture. This strategy can recover from about 45% to perhaps 70% of the sulfur in the feed materials, the exact recovery depending on the nature of the concentrate and type of reverb operations. The vertical axis in Figure 2 has been labelled "relative costs"; however, these are approximate costs in ¢/lb. of copper incurred in direct operating



Note: Technology A – Acid manufacture from converter gases
Technology B – Roasting and acid manufacture in addition
Technology C – Scrubber technology such as lime-limestone or DMA scrubbing plus acid plant
Technology D – Scrubber technology such as caustic or DMA scrubbing plus elemental sulfur production

FIGURE 2: **GENERALIZED COST FOR DIFFERENT DEGREES OF EMISSION CONTROL**

costs plus 20% per year of capital costs for fixed charges. For example, the horizontal bar for Technology A extends from 0% to 50% and indicates the range of emission control assured by this technology. Its dotted extension to 70% denotes the area where it might be applicable but where its performance could not be guaranteed. The cost range denoted by this bar is the range of total costs (i.e. direct operating plus fixed costs) expected when this technology is used to obtain the maximum recovery it is capable of or about 50% sulfur removal.

We have selected roasting of concentrates (Technology B) as the second strategy. We believe that the use of this approach in conjunction with the converter gas collection--acid manufacture approach will recover over 80% of the sulfur and might approach 90% sulfur recovery, though the latter could probably not be guaranteed. (The numbers in the McKee report* can be manipulated to show a "sulfur recovery" of over 90% by assuming a double absorption acid plant and assuming "sulfur recovery" to include sulfur leaving the plant with reverb slag.)

Removal of over 83% of the sulfur requires the application of a variety of technologies in both the smelting operations and the sulfur oxide removal processes. A variety of decision paths are possible and we have chosen such removal technologies as lime-limestone scrubbing or DMA absorption with recovery of liquid sulfur dioxide for sale or for additional acid production as representative of Technology C. Since these technologies do not as yet have a firm basis for detailed engineering and operating costs, their application to any specific smelter would result in a wide variation of costs as shown by the bar for Technology A plus C.

In the case of certain smelters--where local acid markets are nonexistent, where disposal of calcium sulfate from acid neutralization or scrubbing might create potential water pollution problems, or where greater than 90% removal might be required to insure meeting ambient air quality standards--the use of caustic scrubbing, DMA absorption with elemental sulfur production and so on might be required. This Technology D would be expected to have even higher costs and variability from smelter to smelter and the total cost is shown as Technology A plus D.

To show approximately the rapid increase in costs of sulfur removal as higher and higher percentage recoveries are required, a dotted line has been drawn on Figure 2 connecting the mid-points of the estimated ranges. This line is characteristic of operating processes as higher and higher recovery efficiencies are required while reflecting the variability that exists between smelter locations.

*Arthur G. McKee and Co., "Systems Study for Control of Emissions - Primary Nonferrous Smelting Industry", Volumes I-III, National Technical Information Service, PB 184 884, PB 184 885 and PB 184 886.

H. DIRECT IMPACT ON THE PRIMARY COPPER INDUSTRY

1. Introduction

The cost of production of nonferrous metals, as is the case with most natural resource based commodities, can vary over a wide range within the industry. The smelters, presently based on similar operating practice, have similar costs and are essentially "service operations" for transforming the concentrates to the primary metal. The major variations in production cost occur at the mines and mills.

As an illustration of the magnitude of this variation, we include Figure 3, which shows out-of-pocket operating costs of 19 uranium mines plotted versus cumulative production of U_3O_8. The mines have been ranked so that the lowest cost mines are on the left. Figures such as this can be read in two ways:

- to find the probable production when the price is fixed by external factors; and
- to determine the costs associated with a certain level of production; for example, when production is to be increased, the price has to rise to at least cover the costs of the highest cost producer.

Cost data for individual mines and mills in the primary copper industry are proprietary and were not available to us directly from the industry and could not be estimated by us in detail within the scope of this study. Had these cost data been available for the non-ferrous industry, a figure similar to Figure 3 would have been obtained. Recently, security analysts have indicated[1] that copper production costs (from mining to primary metal) vary from about 33¢/pound to 50¢/pound for the major copper companies.

The industry-wide capital and operating costs for pollution control have been presented later in Chapter III. It should be noted that only those costs reported for meeting the "local" standard (defined in detail on page 3) have been used in this section. These costs were estimated on a plant-by-plant and company-by-company basis. As might be expected, our estimates of facilities show that these costs do not fall equally or "fairly" on all the firms or facilities. The age and condition of existing facilities, vagaries of nature insofar as the richness of an orebody and the kinds and amounts of contained impurities, weather and location factors, determine how hard a particular mine and mill, smelter, refinery or corporate entity will be hit.

When these costs are reflected back to the mines, again a figure similar to Figure 3 would be obtained and the impact of these costs on the industry would have to be analyzed from two viewpoints: one representing an excess of supply over demand (which would not permit a price increase) and

[1] R. Shorr, "Copper Industry", Dean Witter & Co., Inc., New York (1971)

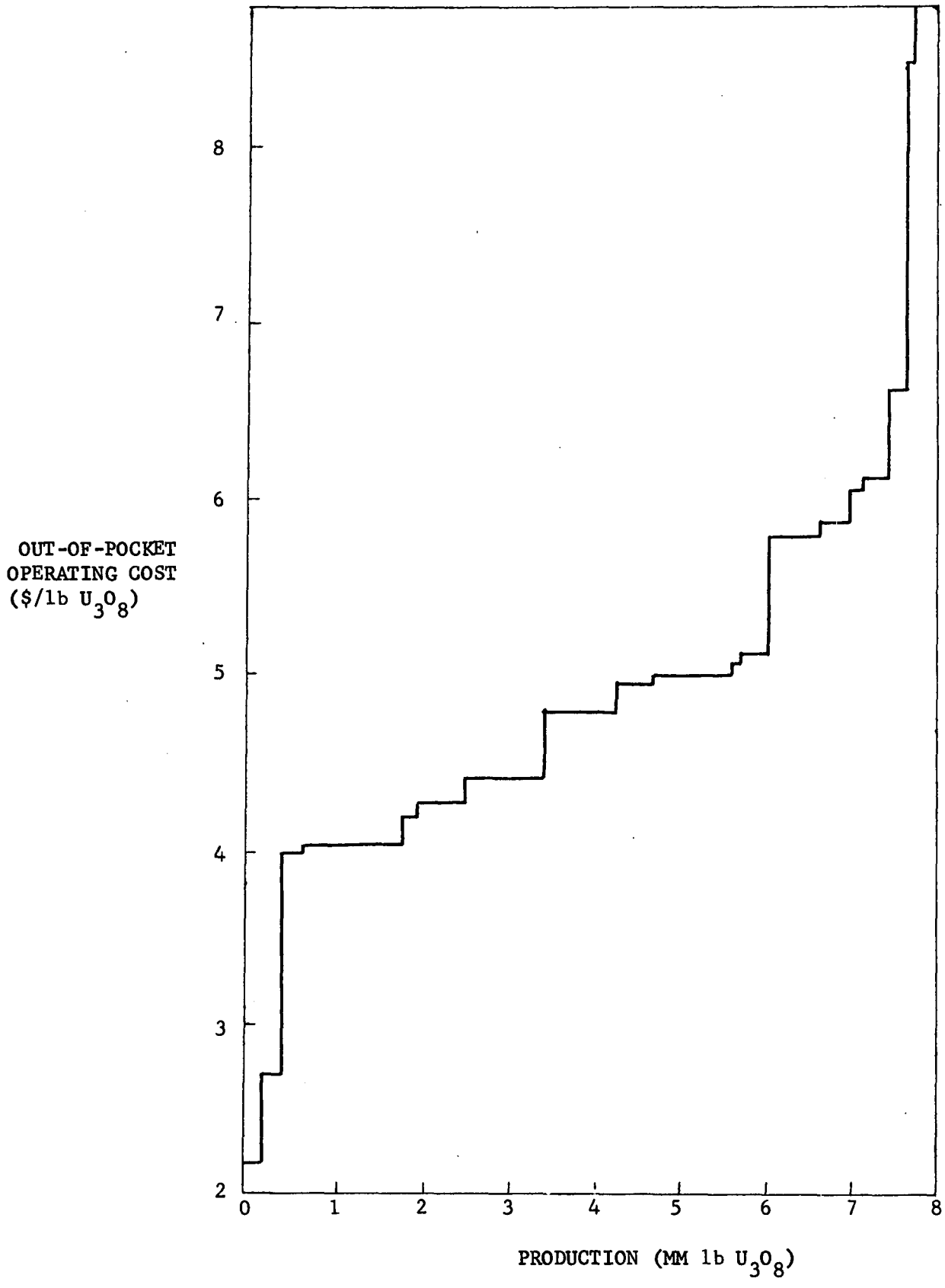


FIGURE 3: OUT-OF-POCKET OPERATING COSTS AND PRODUCTION OF 19 UNDERGROUND URANIUM MINES

an excess of demand over supply, in which case, a price increase would permit a complete pass on of pollution costs. Based on past market behavior, we would expect both types of supply-demand imbalance to occur at different times through and beyond 1976 and hence have considered both types of imbalances to be equally likely and have addressed ourselves to the implications of these alternatives in each case. Thus, the two cases which we have considered for the impact analysis can be described as:

- Full pass on, i.e., the market price is increased enough to cover the cost experienced by the marginal producer who has the highest overall cost; i.e., lies on the right-hand extreme of a figure such as Figure 3; and

- zero pass on, i.e., all pollution abatement costs are absorbed by the primary producers.

Conceptually, the consequences of the full pass on assumption would be a decrease in consumption (as predicted by long-term elasticity of demand), substitution by other materials (the cross elasticity phenomenon), increased profits for the lower cost producers and a disruption in the traditional trade pattern (imports of primary copper, recently at about 5% of primary consumption, would increase if overseas prices are lower than domestic prices). Also, the increased price would affect the fabricators, the major consumers of primary copper and this impact would have to be analysed in the context of <u>their</u> ability to absorb or pass on these increased costs.

On a more practical level, the following factors appear to be more significant. Based on information developed in the main body of the report, it appears that the full pass on assumption would require the major marginal or high cost copper producer to increase the price by about 4-5¢/lb above present levels. Costs for transporting copper internationally rarely exceed 2¢/lb and adding the current tariff of 0.8¢/lb, a ceiling of about 3¢/lb above the international (LME) price would be established. This ceiling would influence the ability of the domestic producers to fully pass on their costs. This price increase is such that its effects would be of the same order of magnitude as the normal background of supply-consumption irregularities, cyclical variations and long-term growth patterns, though it may be argued that pollution control costs affect the baseline rather than the cyclical variations.

The zero pass on assumption has numerous consequences and these are discussed in detail in the remainder of this section. Basically, because smelting and refining are low profit "cost plus" operations, the pollution abatement costs could be borne mainly by the mines. However, they also affect the smelters, stockholders (via reduced income) and government entities (via reduced tax collections). Under the present tariff situation, minimal impact is felt by the fabricators or other subsequent consumers, since their demand would be fulfilled either from domestic or foreign sources under this assumption.

2. Capsule Findings

- Industry-wide impact ("local" case; see page 3 for assumptions)

  Air pollution control:

estimated capital investment	$ million	522
estimated direct operating costs	$ million/year	40.6

  Water pollution control:

estimated capital investment	$ million	30.5
estimated direct operating costs	$ million/year	4.8

- Smelter closings

  High probability: Tacoma (Asarco)
  Douglas (Phelps Dodge)

  Medium probability*: McGill (Kennecott)

  Low probability: rest

- Impact of smelter closing:

  - Net potential industry-wide capacity shortage - tons copper/year - 100,000-200,000

  - Impact on non-integrated mines from lack of smelter capacity... export of a large amount of concentrates and reimport of primary metal unlikely.

  - Loss of ability to handle arsenical materials if Tacoma closed... severe impact on northwestern copper, lead and silver mining industry.

- Company impact: increased operating cost at domestic operations... possible effect on internal long-range planning.

- Employment:

  - Direct employment loss (from Douglas and Tacoma closings)- 1250

  - Direct employment gains - 400-800

- Industry will be impacted by government regulations in other areas...these effects tend to be additive.

*Probability reported to be higher if emission standards in Nevada exceed 60% sulfur recovery.

- Enforcement of air pollution regulations industry wide could lead to a net power consumption as high as 80-100 megawatts.

- Capacity shortage would lead to a balance of payment deficit of up to $400 million if we assume primary metal is imported to fulfill this demand. Deficit would be greater if copper is imported in the form of higher value-added semi-finished or finished goods.

- Availability of smelter byproduct acid would be in excess of current and projected demand and would severely impact the western merchant acid industry.

3. Plant Shutdown Probabilities

- Introduction

The closing of any plant is a decision based on a wide variety of factors and includes consideration of factors other than just the incremental cost of pollution control. These decisions include comparisons of the cost of production from a refitted plant versus alternatives such as producing at other domestic or international plants or new locations, purchasing unfinished or semifinished products for down-stream operations or stopping production altogether. Also, increased production costs at mines usually imply a loss of reserves. These decisions have to be made on the basis of anticipated future capital and operating expenses and they are particularly difficult for an outsider to predict because they require access to the company's highly sensitive, direct out-of-pocket cost information and full knowledge of the alternatives open to the company's management.

In the absence of this information for the entire industry, our judgments have to be necessarily qualitative. However, we believe that we have isolated the areas where the maximum impact would occur under the zero pass-on assumption.

- General Considerations

The increase in the cost of air pollution control with increasing degrees of sulfur recovery at the smelter was discussed earlier. As expected, the maximum impact of this cost occurs on smelters when 90% sulfur recovery or more is required. (Because of poor location, one or two smelters might have to approach 90% sulfur recovery to meet Federal Ambient standards or utilize production curtailment under adverse weather conditions which could result in a significant reduction in output.) Only one Arizona smelter has low incremental costs. The reason for this is that this particular smelter has been moving in the direction of increasing sulfur recovery for many years and a major portion of the funds have already been spent.

These increased costs at the smelter have to be considered in the context of the mine-mill-smelter interrelationship and generally, this increased cost has to be passed back to the mines since we have assumed zero pass-on to the consumer*. Under these conditions, the general alternatives open to the mine management (of both independent or integrated companies) are:

a. divert concentrates to a smelter offering better netbacks;
b. absorb the increased costs;
c. shut down because the increased costs cannot be absorbed;
d. selectively mine high grade portions of the ore (this decreases reserves and mine life);
e. significantly increase the capacity to take advantage of the economies of scale.

The mines can also be affected by decisions at the smelter; for example:

f. The shutdown of marginal mines or diversion of concentrates to other smelters can leave a smelter with insufficient feed materials and lead to a smelter shutdown. This, in turn, can result in closing of mines that cannot ship their concentrates to more distant smelters.
g. If mine production is in excess of smelting capacity, mines have to curtail production or shutdown because of the absence of a concentrate outlet.

In the period through 1976, we believe that there will be little or no excess smelting capacity; instead there is a strong possibility of a smelter bottleneck (discussed separately). Under these conditions, alternatives (a), (e) and (f) have a low probability of occurrence.

- Smelter Closings

Assuming the requirements of 90% sulfur recovery, we believe that the Douglas, Arizona smelter of Phelps Dodge and the Tacoma, Washington smelter of Asarco will be severely affected and might shutdown. Although the impact on the remaining smelters will be less severe and is not expected to lead to a smelter shutdown under the present assumption, more stringent standards could have a severe impact on these remaining smelters and the mines supplying them. For example, recent Kennecott testimony in Nevada indicates that any standard requiring over 60% sulfur recovery at the McGill smelter (and therefore requiring other technology in addition to acid manufacture from converter off-gases) would push the mine-smelter complex into a sub-marginal situation and lead to the termination of the Nevada operations.

*It should be noted that even if we make the questionable assumption that the smelters forego all profit in order to decrease the pass-back to the mines, this does not provide significant relief to the mines--the pass-back decreases by less than 10%.

Douglas is in part a custom smelter but it also smelts material from Phelps Dodge's Bisbee and other mines. (The open pit Bisbee mine is scheduled to close in 1973, due to exhaustion of reserves.) Phelps Dodge believes that this smelter could be modified to meet ambient standards (by permanent reduction of sulfur input plus intermittent curtailment of operations), but feels that conversion of the smelter for SO_2 recovery, as would be required for emission standards, is not justified. Therefore, this smelter would remain open only if an emission standard is not imposed in Arizona.* The imposition of an emission standard in this case would hasten the demise of an old smelter which otherwise has years of available operating life. Phelps Dodge has announced plans for a new smelter in Hidalgo County, New Mexico, which is being sized to meet Phelps Dodge's mine output in Tyrone. Thus, the closing of the Douglas smelter would not affect PD's capability for smelting its own concentrates in the long term but only affect its toll and custom smelting customers (Pima and others) and Phelps Dodge mine expansion plans.

The other smelter in danger of shutdown (again, as a result of emission control regulations) is the Tacoma smelter of Asarco. This decision-making process is complicated by the fact that Asarco as the major custom smelter, is dependent on outside sources for smelter feed, cannot participate directly in decisions affecting its supply of concentrates, and has to compete in an international market for them. Already, Asarco cannot compete for certain concentrates out of British Columbia because Japanese smelters offer better netbacks to the Canadian mines. With increased pollution abatement costs**, we expect Asarco to be even less competitive internationally for concentrates, except perhaps the high arsenic concentrates unacceptable to other smelters. Also, because of Tacoma's urban location, some of the lower cost pollution abatement technologies might not be usable.

Based on discussions with Asarco's management, we believe that the decision regarding the Tacoma smelter will not be reached before the end of 1973 and a major factor will be whether or not a 90% emission standard will be imposed in the Puget Sound area.

Tacoma is the only processor of arsenical materials in the U.S. The concentrates or residues from lead, silver and copper producers in the northwest contain arsenic. The economics at these

*The latest Arizona regulations do not impose such a standard, but the regulation has not been approved by the EPA.

**Asarco is sharing the costs of pollution abatement measures already undertaken with the mines by requiring a "pollution surcharge" of 1-1.5¢/lb of copper accounted for.

plants are strongly dependent on obtaining a credit for values contained in the arsenical stream and this is presently possible since Tacoma accepts these materials (see Table 3). Thus, Tacoma's arsenic handling capacity is irreplacable and should Tacoma close, an arsenic treatment facility, similar to Tacoma's would have to be provided. In general, these arsenical residues contain soluble arsenic compounds and would have to be stored in silos.

If an arsenic treatment facility is not available, a severe impact would be felt by the Montana smelter of Anaconda and a large portion of the northern Idaho mines. (In the remainder of this discussion, we assume that in the event that Tacoma closes, an alternative arsenic treatment facility will be constructed and will be available to the northwestern producers.)

- Capacity Impact

A shortage of smelting capacity in the U.S. would occur if the two smelters--Douglas and Tacoma--are closed. This loss in smelting capacity is for "custom smelting" and the non-integrated mines would suffer a major impact since the new smelter (Phelps Dodge in New Mexico) will primarily treat the output of PD's Tyrone mine. Because of this potential shortage, the non-integrated mines have recently proposed to form a consortium to consider the building of a new smelter. Except for the PD smelter, we do not expect serious consideration of other smelter construction plans until after all uncertainties relating to Douglas and Tacoma have been resolved.

It should be noted that acid leaching of oxide ores, waste dumps or tailings might substantially increase the domestic production of primary copper. This would tend to maintain the equilibrium or narrow the gap between the demand and domestic production. However, this would not directly solve the problem confronting the independent mines--finding a smelter for treating their sulfide concentrates.

In recent years, the export of concentrates (and the accompanying pollution) to foreign smelters and reimport of primary copper has been proposed as a solution to domestic environmental problems. The implications of this suggestion are discussed in the next section.

- Mine Impact

As mentioned under "General Considerations", when the lack of excess smelter capacity freezes mine-to-smelter concentrate flow patterns, an impact can occur on a mine from two general causes: pass-back of increased smelter costs, or absence of concentrate outlets.

We believe that the mines of Duval Corporation (who ship their concentrates to Asarco) and of the Anaconda Company will suffer a large impact. This impact arises primarily from the fact that the concentrates produced by these mines would be treated at smelters with higher-than-average incremental pollution control costs and because the mines are medium to high cost mines. We believe that these increased costs alone will not be severe enough to cause mine closings. The other mine is the Ruth, Nevada mine of Kennecott that can suffer a potentially severe impact if more stringent standards are imposed in Nevada.

There are many small mines that might also be affected but nothing is known about their operating costs or operating margins. Data from the Census Bureau indicate that these mines produce less than five percent of the domestic mine output of copper and employ less than five percent of the total employment in copper mining. Thus even if this segment were eliminated completely, the impact on mine production or total industry employment will not be severe.

We believe that the proposal for large-scale export of concentrates (and pollution) abroad is not realistic over the short-term for several reasons. The only country with a reservoir of excess smelting capacity at the present time is Japan, the excess capacity being a result of decreased copper consumption from a slowdown in Japan's industrial activity. In the past, the Japanese smelters have been able to offer better terms for concentrates because of lower labor costs and because they obtained positive netbacks from acid sales. The latter is no longer true. Also, the Japanese smelters are faced with pollution regulations as stringent as the United States and would be reluctant to import pollution above and beyond what is unavoidable in obtaining copper for its internal use. The expansion of Japanese smelting capacity has been undertaken as a means of assuring the supply of copper for their domestic fabricating industry. A significant amount of new mine capacity in the world results from tie-ins or long-term contracts with Japan and these projects would have priority over U.S. concentrates for toll smelting. Thus, we believe that it will be easy to sell concentrates to Japan when their domestic demand is high and reimport semifinished or finished, high value-added products but that Japanese smelters will undertake only a minimal amount of toll smelting (i.e., returning significant quantities of lower value-added primary metal.)

The transportation costs involved in shipping Arizona concentrates to Japan and reimporting the copper are of the order of 3-4¢/lb. This is about the same as the incremental cost of pollution control at most locations in the U.S.; hence, the netback to a U.S. mine is lower after a Japanese pollution abatement surcharge is taken into account.

In the long term, increased operating costs at domestic plants would increase the attractiveness of locating smelters abroad, preferably in remote locations, and could accelerate a trend for the major nonferrous metal companies to invest abroad.

- Water Pollution

  The water pollution control costs affect mainly the Coastal refineries since the scarcity of water in the west has required proper water management at western mines, mills, smelters and refineries. Assuming that the effluent water standards correspond to the type of residual concentrations obtainable after heavy metal ion removal as hydroxide, and suspended solids removal by settling, we find these costs to be small when compared to the air pollution costs and are not expected to have any significant impact. Furthermore, the impact is more or less uniform within the industry.

4. Impact on Individual Companies

In general, the capital and operating costs to achieve pollution abatement would not be incurred by the companies in the absence of pollution abatement regulations, i.e., they cannot be justified on the basis of conventional return-on-investment criteria.

We assessed the factors affecting the individual plants during our consideration of plant shutdown probabilities. In this section, we assess the impact on the corporate entities of the decision to invest in the pollution abatement facilities. In general, we would assume that a large industrial corporation which is clearly viable has access to substantial capital--in the form of debt and/or equity.

In a plant-by-plant and company-by-company analysis of pollution abatement impact, two viewpoints have to be considered. The availability of capital for pollution abatement equipment at each plant has to be viewed from the standpoint of the resources available to the entire corporation. However, the justification for spending this capital at a particular plant would result from a study of that particular plant's economics which would take into account alternatives such as the cost of production from a refitted plant, shifting production to other plants, and most important, the probability that this particular plant will remain a profitable entity.

The impact on individual companies was analyzed by aggregating the company-by-company capital expenditures and operating and maintenance cost requirements for the "local" case for meeting air and water pollution abatement standards. These were then compared with each company's sources of revenues, earnings, cash flow, debt-equity structure, and record of performance in terms of operating margin, return on equity, capital expenduture, etc. Table 7 places future pollution abatement costs in the perspective of total company operations. These costs estimated by us for

TABLE 7

SELECTED PRIMARY NONFERROUS METALS* COMPANIES POLLUTION ABATEMENT COSTS

[From perspective of total company operations]

	1971 Sales Level X 1968-71 Avg. Operating Margin	Base Level or "Normal" Operating Income Pre-Tax $MM/Year	Avg. Capital Spending Rate 1968-71 $MM/Year	Cum. Capital Outlay for PA 1972-1975 (Estimated) $MM	÷ 4 = $MM/Year	Annualized Rate as Percent of Avg. Capital Spending % (Rounded)	Probable Oper. & Maint. Costs of Pollution Abatement Equip. $MM/Year (Rounded)	O&M Cost As Percent of Normal Base OP Income % (Rounded)	Annual PA O&M + 10% Outlay ÷ Normal OP Income %
AMAX	757 x 13.6%	103	103	9.3	2.2	2	0.8	1	1.8
ASARCO	657 x 11.0%[a]	72	42	119.6	30.0	71	14.5	20	37
Anaconda	947 x 15.4%	146	102	93.0	23.3	23	7.0	5.0	11.2
Gulf Resources & Chem.	115 x 10.0%	11.5	7	5.0	1.25	18	0.2	2	6.1
Inspiration	66 x 28.1%	19	10	45.5	11.4	114	2.8	15	39.0
Kennecott	1,053 x 24.4%	257	157	111.0	27.8	18	7.4	3	7.2
National Zinc	N.A.	0.2-2.0**	<1.0	<10.8	<2.7	large	1.4	large	large
Newmont	198 x 39%	77.4	95.0	40.5	10.1	10.6	4.9	6.4	11.7
Phelps Dodge	704 x 20.7%	146	82	90.5	22.6	27	7.5	5.1	11.6
St. Joe Minerals	194 x 22.8%	44	15	10.9	2.7	18	1.0	2	4.8

[a] The ratio of net income to sales was used as a more meaningful figure for ASARCO in this context.

*For a discussion of New Jersey Zinc Company, a subsidiary of Gulf and Western Industries, see text.

**Estimated.

SOURCE: The information presented above has been obtained from company annual reports and SEC filings, statistical services, financial manuals, and other sources believed to be reliable but its accuracy and completeness are not guaranteed.

ADL estimates.

Arthur D Little Inc

copper, lead and zinc were adjusted to reflect post-1972 costs by deducting the amount already spent and reported in individual company annual reports.

Table 7 highlights those companies which appear to be most impacted by pollution control costs in relation to their normal pattern of earnings, capital spending and financial position. Of the copper producers, Asarco and Inspiration will be affected the most. The impact on Inspiration is the result of the smelter reconstruction project. In Asarco's case, presumably its extremely low debt-to-equity ratio and its earnings record will enable the company to raise long-term debt if it so chooses. However, the impact of pollution abatement operating costs could be large, especially in the absence of the ability to pass along the costs. The impact on the other companies is less severe.

5. Employment Impact

- Employment Loss

  The closing of the Tacoma smelter would directly affect its employees, estimated at 600, and indirectly affect 1200 other jobs (on the assumption of a 2:1 multiplier). Because of Seattle-Tacoma's urban environment, the local impact would be diffuse.

  The closing of the Douglas smelter (employment of 650) will have a major impact on the surrounding area since, after the mines close in 1973, it would be the remaining major industry in the towns of Douglas (population 12,000) and Bisbee (population 10,000). Similarly, the closing of small mines could have a large local impact on isolated mining communities in the west.

- Employment Gains

  The pollution abatement equipment at smelters would increase employment by about 25 to 60 employees at each plant or 330 to 780 employees in the western U.S. (This would indirectly lead to 660 to 1560 more jobs.) The employment gains at copper refineries will be relatively small.

  The installation of pollution abatement equipment will increase the demand for construction labor and severe shortages could occur in Arizona. These could lead to construction delays and/or increase in costs significantly above those estimated in this report.

I. INDIRECT IMPACTS

1. Domestic Mine Production and Strategic Considerations

We believe that government policy in other areas affecting exploration and access to mineral deposits would have a much more serious impact on future

domestic mining activity than the reduced netbacks to the mine resulting from pollution abatement costs. Since copper is a material which is stockpiled, any policy that affects domestic mine production has strategic implications. Current trends in government policy impact these industries at many levels and, in general, these impacts tend to be additive.

2. Fuel, Energy and Raw Material Availability

At present, smelters generate most of their internal electricity requirement by utilizing waste heat. The increased energy consumption resulting from pollution abatement will result in a net power consumption as high as 80-100 megawatts for the entire copper industry. Also, should the demand for limestone for SO_2 control in the fossil fuel power plants affect its availability and cost, an impact will be felt by the nonferrous metal industry.

3. Balance of Payments

An adverse change in the balance of payments, amounting up to about $400 million, could occur if the Douglas and Tacoma smelters were closed before new smelting capacity were available since this would lead to a smelter bottleneck and the incremental refined metal needed by the fabricators would have to be imported. This is based on a 3% growth in demand. If these smelters are not closed prematurely, the impact on the balance of payments will be much smaller. The balance of payment deficit can be larger than shown if copper is imported in the form of higher value-added semi-finished or finished goods.

4. Alternate Materials

Plastics and aluminium are considered substitutes for copper. These industries are also being severely impacted by changing raw material costs, increases in other operating costs and new pollution abatement costs. In the absence of detailed comparative impact studies on the latter commodities, we are unable to reach firm conclusions regarding the possibilities of substitution of copper by these materials.

5. Merchant Acid Industry

Our survey of sulfuric acid markets indicates that the acid has a negative value at the smelter and in some instances neutralization of smelter acid would be cheaper than sale in direct competition with merchant acid production. The leaching of oxide copper ores, waste piles and tailings is an attractive alternative to neutralization with limestone and would be pursued wherever possible since this approach (besides disposing the acid) has the potential for increasing copper production. Should the demand for limestone (for SO_2 removal and other purposes) substantially increase its price and the smelter acid is not all used up for leaching, the sale of smelter acid would force the closing of the western merchant acid industry.

6. Financial and Tax Aspects

If the "passing-back" of the pollution abatement cost were to either decrease the value of the concentrate or raise the cost of mining, this could have the effect of lowering the amount of depletion allowed for tax purposes. Other things being equal, this would have the effect of further reducing net after tax income from mining and decreasing the cash flow.

To the extent that effective tax rates are relatively low for the major primary nonferrous metal companies, they may have more incentive to use investment tax credit provisions than rapid amortization for pollution abatement facilities.

Industrial development bonds could be advantageous for the financing of pollution abatement equipment since they allow a corporation to conserve cash over the short term (by taking advantage of the leasing provisions typically incorporated) and serve as a source of "off-balance-sheet" financing. The tax-exempt feature generally means a lower effective interest cost; one to two percentage points less than regular commercial financing. At this point in time, it is not clear what percentage of total pollution abatement cost could be financed in this fashion.

III. SUMMARY OF POLLUTION ABATEMENT COST ESTIMATES

The basic premise in our approach to estimating the capital investment requirements for pollution control was to accept the fact that the age and physical condition of many of the plants would require a judicious play-off of capital and operating expenses at each location to meet air and water quality or emission standards at "minimum" expense and disruption of an operating facility. The short timetable for achievement of environmental goals and the unproven nature of some of the SOx recovery and new smelting technology (and an apparent absence of strong economic incentives for a rapid change in favor of the latter) would mean that in most instance proven add-on pollution control equipment would be utilized.

A plant-by-plant approach was used in our analysis since capital investment and operating costs are highly dependent on the nature of specific plants and there are only a small number of plants. The capital cost estimates for air pollution abatement at the thirteen western smelters are shown in Table 8, and the basis for cost estimation used is presented in Part III of the report. The Michigan smelter was not considered since it already meets the Federal ambient primary and secondary standards and the Cities Service smelter was not considered because the plant is undergoing extensive modernization and will presumably meet all the anticipated requirements after the modernization is completed.

The cost estimates in Table 8 refer to three standards: the Federal ambient, "local" and 90% sulfur recovery. The technology selected for achieving these standards is indicated in the footnotes. Technologies for dilution of SOx discharges were included where appropriate as a means of meeting the ambient standards. "Local" emission standard was assumed to be 90% in Arizona*, Montana and the Puget Sound area in Washington and lower in all other locations. Details of the various assumptions for this case were presented earlier on page 3. For the financial impact analysis of the previous chapter, this "local" cost was considered as the base case. The final column is the estimate of capital costs if a uniform 90% sulfur recovery standard were applied to all smelters. In states with 90% emission control, the "local" cost is based on the use of lower cost alternative technology, in some cases.

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* Subsequent to the writing of this report, Arizona regulations were amended so that 90% sulfur recovery was not required by the State regulations. These have not been approved by EPA.

TABLE 8

ESTIMATED CAPITAL INVESTMENT NECESSARY TO ADAPT EXISTING COPPER SMELTERS FOR AIR POLLUTION ABATEMENT

(millions of $)

	For Federal Ambient Standards		Total Cost with Emission Standards in Addition	
	Cost	Approximate % S Recovery	"Local"[2,3]	90% S Recovery
1.	27	90	27	27
2.	13[4]	0	-	74 (Plant will close)
3.	82	55	85	122
4.	45	55	90	90
5.	36	65	46	46
6.	30	60	45	45
7.	15	90	15	15
8.	23	60	23	35
9.	24	60	24	36
10.	45	70	45	78
11.	20	55	20	33
12.	17	55	50	70
13.	16	55	52	52
Total Capital Investment	393		522	723

[1]Actual recovery might vary ± 15% from the number shown.

[2]In states with 90% control, local includes alternate technology.

[3]Local costs have been considered as the base case in evaluating the economic impact. "Local" assumes 90% sulfur recovery in Arizona, Montana and Washington.

[4]Plant output will decrease significantly.

SOURCE: ADL Estimates

TABLE 8 (Cont'd)

ASSUMED TECHNOLOGY FOR EACH PLANT

PLANT NO.

1. Dust collection, precipitators, DMA and acid plant
2. Ambient: Roaster, reverb, converter gas handling and gas cleaning, field monitoring equipment.
   90%: Company estimate.
3. Ambient: Reverb modernization (1), converter aisle changes, gas handling and gas cleaning, acid plants.
   Local: Roasters, converter aisle changes, gas handling and gas cleaning, acid plants, slag flotation.
   90% Sulfur Recovery: Closed-in reverbs, waste-heat boilers, gas handling and cleaning, acid plants.
4. Ambient: Converter gas handling, gas cleaning, dust collection, acid plant.
   Local: Roasting, electric furnace, converter gas handling, gas cleaning, dust collection, acid plants.
5. Ambient: Converter gas handling, gas cleaning, dust collection, acid plant, neutralization.
   Local: Converter gas handling, gas cleaning, dust collection, acid plant, neutralization, limestone scrubbing.
6. Ambient: Converters, converter gas handling, gas cleaning, dust collection, acid plant.
   Local: Electric furnace, converters, converter gas handling, gas cleaning, dust collection, acid plant.
7. Ambient: Converter gas handling, gas cleaning, dust collection, slag flotation, acid plant expansion, monitoring equipment.
8. Ambient: Converter gas handling, gas cleaning, dust collection, acid plant, neutralization, monitoring equipment.
   90%: Ambient plus lime/limestone scrubbers.
9. Ambient: Converter gas handling, gas cleaning, dust collection, acid plant, tall stack, monitoring equipment.
   90%: Ambient plus lime/limestone scrubbers.
10. Ambient: Roasters, converter gas handling, gas cleaning, monitoring equipment.
    90%: Roasters, dryer, new furnace (1), converter gas handling, gas cleaning, dust collection, slag flotation, monitoring equipment.
11. Ambient: Converter gas handling, gas cleaning, dust collection, acid plant, monitoring equipment.
    90%: Ambient plus acid plant expansion, lime/limestone scrubbing.
12. Ambient: Converter gas handling, gas cleaning, dust collection, acid plant, monitoring equipment.
    Local: Ambient plus roasters, acid plant expansion, slag flotation, furnace modernization.
    90%: Ambient plus closed-in furnaces, DMA scrubbers, SO_2 plant, elemental sulfur plant.
13. Ambient: Converter gas handling, gas cleaning, DMA scrubbing, liquid SO_2 plant, monitoring equipment.
    Local: Ambient plus closed-in reverb, gas cleaning, DMA scrubbing, SO_2 plant, elemental sulfur plant.

Estimated yearly direct operating and maintenance expenses (exclusive of amortization and debt service charges) are shown in Table 9. In preparing these estimates we made allowance for maintenance as a function of capital investment varying this according to the severity of the operation. A survey of sulfuric acid markets indicated that surplus acid would be available which would have to be disposed of by sales to distant customers, neutralization or oxide ore leaching -- its equivalent from an acid disposal viewpoint. We have assumed a uniform negative netback of $4 per ton of surplus acid.

Although air pollution abatement costs predominate in the copper industry, investments in water pollution control will be required at mines, smelters and refineries. In general, the mines and smelters have excellent water management programs because there are largely located in arid regions where such practices are mandatory. On the other hand, refineries are often located in water plentiful regions and have not incorporated such good water management programs. Our estimates for water pollution control are based on very little data from the industry since, except in a few isolated instances, the paramount problem in capital and operating costs lies in air pollution control and most of their internal work has been concentrated in that area. Also, the costs are based on the assumption that neutralization with lime and settling will be adequate. It is seen that the figures shown are an order of magnitude less than for air pollution control. The results of our estimates are shown in Tables 10 and 11.

TABLE 9

ESTIMATED DIRECT OPERATING & MAINTENANCE COSTS

AT EXISTING COPPER SMELTERS FOR AIR POLLUTION ABATEMENT*

Plant Number	Millions of Dollars/Year: For Federal Ambient Standards	Total Costs with Emission Standards in Addition: Local	90%S Rec.
1	1.6	1.6	1.6
2	0.4	-	- (Plant will close)
3	2.7	5.1	7.3
4	3.2	7.6	7.6
5	3.9	5.0	5.0
6	2.2	2.7	2.7
7	1.2	1.2	1.2
8	1.9	1.9	2.8
9	1.6	1.6	2.4
10	2.2	2.2	2.9
11	2.4	2.4	3.6
12	2.3	3.6	6.1
13	0.9	5.7	5.7
Total	26.9	40.6	48.9

SOURCE: ADL Estimates

*No indirects, amortization or debt service charges

TABLE 10

ESTIMATED INVESTMENT COSTS FOR WATER POLLUTION CONTROL*

IN THE COPPER INDUSTRY

Company Number	Millions of Dollars
1.	3.0
2.	10.0
3.	0.5
4.	3.0
5.	4.0
6.	5.5
7.	4.0
8.	0.5
Total	30.5

*The technology selected might not be adequate to meet latest Federal and state guidelines in all cases.

TABLE 11

ESTIMATED DIRECT OPERATING COSTS FOR WATER POLLUTION CONTROL*

IN THE COPPER INDUSTRY

Company Number	Millions of Dollars/Year
1.	1.50
2.	1.00
3.	0.05
4.	0.50
5.	0.50
6.	0.75
7.	0.50
8.	0.05
Total	4.85

*No indirects, amortization or debt service charges.

APPENDIX A

IMPACT OF EPA REGULATIONS OF JULY 1972

The purpose of this appendix is to assess qualitatively the effects of the new regulations promulgated by EPA in July 1972. (See Federal Register - July 27, 1972, Volume 37, No. 145, Part III).

These new regulations have the following features:

- The regulations are of the "emission type", i.e. they limit SO_2 emissions from each smelter (in lb. SO_2/hour) to a specified amount. Thus, they require the recovery of a substantial fraction of sulfur in the feed materials when the smelters are operating at capacity and/or require a production curtailment.

- We understand that the permissible SO_2 emission rates for each smelter were calculated on the basis of available air quality data and atmospheric dispersion models. We also understand that "emission type" regulations were adopted because EPA believes that other SO_2 control philosophies such as "closed-loop" control (based on measuring ambient SO_2 concentrations and utilizing this information to control the smelter operating rate), might be more difficult to enforce and would lead to degradation of air in areas where air quality is superior to the Federal standards. However, recent conversations with EPA indicate that it would accept a "closed-loop control" scheme if it can be shown that these systems are workable.

- The proposed regulations are for achieving Primary or health-related ambient air quality standards only, and EPA believes that these would be achievable by the utilization of acid plant technology and production curtailment. If the standards cannot be met by this technology but require scrubbers, a two-year extension, until July 31, 1977, is available.

- An 18-month extension has been granted to the states for submitting implementation plans acceptable to the EPA for meeting the Secondary ambient air quality standards. Presumably, these standards would be more stringent and might be based on the further utilization of then available technology (e.g., scrubbers) and production curtailment.

- All SO_2 emissions have to be captured and vented via a stack. This presumably includes low level emissions such as "converter aisle emissions."

A. GENERAL CONSEQUENCES

In general, the adoption of fixed emission standards is more expensive because it eliminates certain lower cost strategies which could be used for meeting ambient standards. For example, tall stacks and preheated dilution air can no longer be used even in cases where they might be the lowest cost strategy for meeting the Federal ambient standards.

The other aspect of these fixed emission standards is that in most cases they require sulfur recoveries considerably in excess of those achievable by using acid plants and would require scrubbers and/or a permanent production curtailment. This is because under a fixed emission standard, the smelter cannot increase its operating rate under favorable weather conditions. The closed-loop control approach, on the other hand, provides such a mechanism so that a smelter can make up to some extent the production lost during unfavorable weather.

The regulation on low level emissions can have a major impact if they are interpreted to apply to all low level emissions. For example, if converter aisle emissions are included, the air in the aisles will have to be collected and vented via a stack.

A detailed and complete analysis of the impact of these regulations is not possible with the scope of the present effort. Furthermore, such an analysis would be incomplete since new and presumably more stringent standards would be passed in 18 months for meeting Federal Secondary Ambient standards. Also, because of litigation and the fact that the specific approach for meeting the secondary standards has not been delineated, the smelters could not properly plan their compliance schedules.

We have evaluated the extent of the permanent production curtailment required at each smelter by the new regulations under the assumption that scrubbers are not used and this has been presented in Table A-1. The table shows the percent SO_2 recovery required when the plant is operating normally, the approximate sulfur recovery that might be achieved by using acid plants (using converter gases and roaster gases if roasters are already present) and an estimate of the extent of the permanent production curtailment.

In our opinion, permanent production curtailments of greater than about 10-15% are serious and, if enforced, indicate a high probability of plant shutdown.

TABLE A-1

	% SOx Recovery at Normal Plant Throughput Required by New Regulations	% SOx Recovery Achievable with Acid Plants	Estimated Degree of Production Curtailment - %
Copper Smelters			
1. Phelps Dodge, Douglas, Ariz.	90	-	100[4]
2. Phelps Dodge, Morenci, Ariz.	90	55-60	15-25
3. Phelps Dodge, Ajo, Ariz.	70	NA	0
4. Kennecott, Garfield, Utah	76	65-70	5-10
5. Kennecott, Hayden, Ariz.	96.7	90	5-8
6. Kennecott, McGill, Nev.	60	60	0
7. Kennecott, Hurley, N.M.	60	60	0
8. Asarco, Hayden, Ariz.	96.7	55	35-45
9. Asarco, El Paso, Texas	43	55	0
10. Asarco, Tacoma, Wash.	90	55-60	20-30
11. Anaconda, Montana	89	55-60	30-35
12. Newmont, San Manuel, Ariz.	94.5	65	25-30
13. Inspiration, Ariz.	73	NA	0
Lead Smelters			
1. St. Joseph Minerals, Mo.	75[1]	75[6]	0
2. Missouri Lead, Mo.	75[1]	75[6]	0
3. Asarco, Mo.	75[1]	75[6]	0
4. Asarco, El Paso, Texas	A.P.[2]	NA	0
5. Asarco, E. Helena, Mo.	87	70-80	10-20
6. Bunker Hill, Idaho	96	70-80	15-25
Zinc Plants			
1. Asarco, Corpus Christi, Texas	A.P.[2]	85-95	-
2. Bunker Hill, Idaho	96	85-95	0-10
3. Amax, E. St. Louis, Ill.	A.P.[2]	85-95	-
4. National Zinc, Bartlesville, Okla.	?	80-90	-
5. Asarco, Amarillo, Texas[4]	-	-	-
6. Amax, Blackwell, Okla.[4]	-	-	-
7. New Jersey Zinc, Pa.	85[3]	85-95	-
8. St. Joseph Minerals, Pa.	85[3]	85-95	-

[1]Estimated; regulations for 2000 ppm of SOx

[2]A.P. - acid plant will be adequate

[3]Estimated; regulations for 500 ppm of SOx

[4]Plants will close

[5]N.A. - not applicable - plant modified for a higher recovery

[6]Acid plants modified

SOURCE: ADL Estimates.