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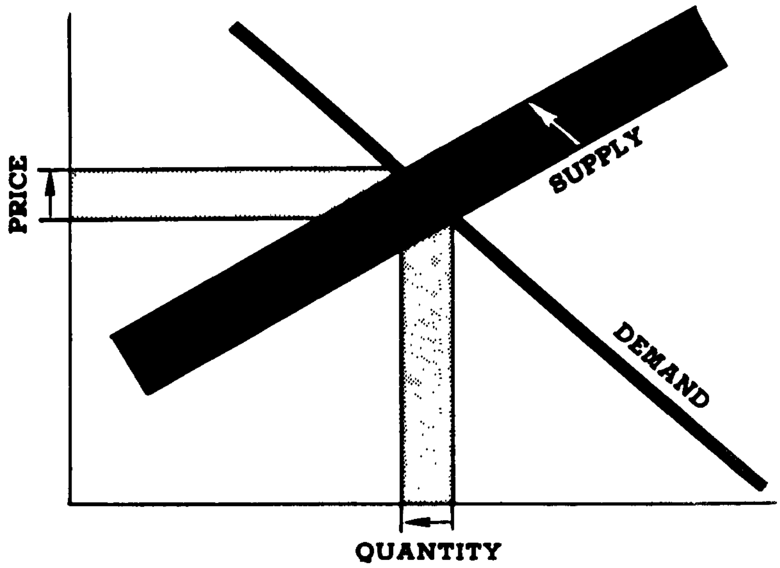
ECONOMIC ANALYSIS OF PRETREATMENT STANDARDS:

THE SECONDARY COPPER AND ALUMINUM SUBCATEGORIES OF THE NONFERROUS METALS MANUFACTURING POINT SOURCE CATEGORY



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ECONOMIC ANALYSIS OF PRETREATMENT STANDARDS FOR THE SECONDARY COPPER AND ALUMINUM SUBCATEGORIES OF THE NONFERROUS METALS MANUFACTURING POINT SOURCE CATEGORY

Prepared for

Office of Water Planning and Standards
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U.S. Environmental Protection Agency
Washington, D.C. 20460

PREFACE

The attached document is a contractor's study prepared for the Office of Water Planning and Standards of the Environmental Protection Agency (EPA). The purpose of the study is to analyze the economic impact which could result from the application of alternative Pretreatment Standards to be established under section 307(b) of the Federal Water Pollution Control Act, as amended.

The study supplements the technical study, "EPA Development Document," supporting the issuance of interim final regulations under section 307(b). The Development Document surveys existing and potential waste treatment control methods and technology within particular industrial source categories and supports interim final promulgation of Pretreatment Standards based upon an analysis of the feasibility of these standards in accordance with the requirements of section 307(b) of the Act. Presented in the Development Document are the investment and operating costs associated with various alternative control and treatment technologies. The attached document supplements this analysis by estimating the broader economic effects which might result from the required application of various control methods and technologies. This study investigates the effect of alternative approaches in terms of product price increases, effects upon employment and the continued viability of affected plants, effects upon foreign trade and other competitive effects.

The study has been prepared with the supervision and review of the Office of Water Planning and Standards of EPA. This report was submitted in fulfillment of Contract 68-01-1541 by Arthur D. Little, Inc. Work was completed as of November 1976.

This report is being released and circulated at approximately the same time as publication in the Federal Register of a notice of interim final rule making under Section 307(b) of the Act for the subject point source category. The study is not an official EPA publication. It will be considered along with the information contained in the Development Document and any comments received by EPA on either document before or during interim final rule making proceedings necessary to establish final regulations. Prior to final promulgation of regulations, the accompanying study shall have standing in any EPA proceeding or court proceeding only to the extent that it represents the views of the contractor who studied the subject industry. It cannot be cited, referenced, or represented in any respect in any such proceeding as a statement of EPA's views regarding the subject industry.

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I. EXECUTIVE SUMMARY

A. PURPOSE AND SCOPE

The purpose of this study was to provide the Environmental Protection Agency with an assessment of the economic impact on the U.S. secondary aluminum and secondary copper smelting and refining industries of the costs of compliance with pretreatment requirements stipulated under the Federal Water Pollution Control Amendments of 1972.

For this study, the secondary aluminum industry is defined as that portion of SIC 3341 (Secondary Nonferrous Metals) which recovers, processes, and remelts various grades of aluminum-bearing scrap to produce aluminum or an aluminum alloy as a product. This does not include the casting or alloying of remelted ingots, or pigs, nor those operations of the primary aluminum industry, in which certain categories of scrap are recycled.

Also, for this study, the secondary copper industry is defined as that portion of SIC 3341 that consists primarily of establishments engaged in recovering copper metal and copper alloys from new and used scrap and residues from various melting operations. It includes establishments involved in the melting and refining of copper alloys from brass and/or bronze scrap to produce alloyed copper, as well as those melting copper-bearing scrap to recover principally pure copper (unalloyed copper). By this definition, the industry does not include the collection, preliminary grading and preparation of scrap, the production of brass and bronze ingots from essentially virgin metals, nor the recycling of copper-base materials by the fabrication industry.

B. INDUSTRY OVERVIEW

1. Secondary Aluminum Industry

In the secondary aluminum industry, there are approximately 100 producers. We have obtained information on 69 of the largest producers, representing more than 94 percent of the total production and 90 percent of the total employment. Plants in this industry vary all the way from very small operations located on sites as small as one acre and employing as few as six people to fairly complex ones with on the order of 400 employees at a given site, occupying up to 50 acres. Plant production ranges from 250 to 4500 tons per month.

The general product of the industry is specification aluminum alloy in ingot or sow form; it is mainly used for die casting and, to a lesser extent, for permanent mold and sand casting. Some plants deliver hot metal, and some smelters produce semi-specification material which is used in steel mills as deoxidizers. This material comes in the shape of small ingots, notched bar, and shot, and is also produced in certain other shapes. A small segment of the industry consumes billet-grade aluminum scrap used in the manufacture of extrusion billets. There are 18 POTW dischargers in the industry, and they represent 18 percent of its total plants.

2. Secondary Copper Smelting and Refining Industry

In the secondary copper smelting and refining industry in the United States, there are approximately 70 producers of either brass and bronze ingots or secondary refined copper. The plants in this industry fall into two fairly distinct categories: (a) producers of brass and bronze ingots and (b) producers of unalloyed copper. There are 63 plants in the brass and bronze ingot category. Of these, we were able to obtain information on 37 plants. The general plant size is small, with production ranging from 500-1500 tons per month and employment ranging from 10-500 people. These plants generally produce ingots or shots to specification. Several of these plants are diversified, being involved as well in other secondary metal processing operations, such as secondary aluminum, lead, and zinc. There are 15 POTW dischargers in this industry, representing 24 percent of the total number of plants and 30 percent of the total production.

There are seven producers of unalloyed copper. The plant sizes range from 1500-18,000 tons per month with employees ranging from 100-1800 people. These plants generally utilize sophisticated technology and equipment and are integrated towards producing finished products, such as tubes and rods. Some plants also produce precious metals as recovered by-products.

C. PRETREATMENT STANDARDS

1. Secondary Aluminum

The interim final pretreatment control levels for the secondary aluminum industry would affect the following pollutants: oil and grease for metal cooling wastewater; aluminum for scrubwater from demagging operation, and aluminum and ammonia for residue milling wastewater. These control levels are summarized in Table I-1.

2. Secondary Copper

The interim final pretreatment control levels for any wastewater discharged to Publicly Owned Treatment Works (POTW's) for the secondary copper industry are summarized in Table I-2. The pollutant parameters controlled would include: copper, zinc (dissolved), lead, cadmium, mercury, and oil and grease.

TABLE I-1

PRELIMINARY PRETREATMENT CONTROL LEVELS
FOR SECONDARY ALUMINUM INDUSTRY

(mg/1)

Waste Stream	Effluent Characteristic	Pretreatment Levels: Maximum for any 1 day	Pretreatment Levels: Average of daily values for 30 consecutive days shall not exceed
Metal Cooling	Oil and Grease	100.0	100.0
Fume Scrubbing	Aluminum	100.0	50.0
Residue Milling	Aluminum	100.0	50.0
	Ammonia	100.0	50.0

Source: Pretreatment Supplement - Development Document for Secondary Aluminum, EPA, August 1976.

TABLE I-2

PRELIMINARY PRETREATMENT CONTROL LEVELS FOR SECONDARY COPPER INDUSTRY

(mg/l)

Effluent Characteristic	Pretreatment Levels: Maximum for any 1 day	Pretreatment Levels: Average of daily values for 30 consecutive days shall not exceed
Copper	0.50	0.25
Zinc (dissolved)	2.0	1.0
Lead	1.0	0.5
Cadmium	1.0	0.5
Mercury	0.18	0.09
Oil and Grease	100	100

Source: Pretreatment Supplement - Development Document for Secondary Copper, EPA, August 1976.

D. IMPACT ANALYSIS

1. Secondary Aluminun

Table I-3 summarizes the impact of pretreatment or zero-discharge standards on the secondary aluminum industry. The POTW dischargers represent 18 percent of the plants in the industry.

For compliance with pretreatment standards, the capital requirements of the POTW dischargers would be $877,600. This represents 16.4 percent of the average annual investment, or 2.0 percent of the capital in place. The capital requirements for zero discharge would be $1,606,900, representing 30.0 percent of the average annual investment, or 3.7 percent of the capital in place.

The total incremental increase in annualized operating costs for pretreatment would amount to $352,590; operating and maintenance would account for 57 percent of these costs. The incremental costs represent less than one percent of sales. The incremental cost for zero discharge would be $437,574, 37 percent of which would be for operating and maintenance costs. This increase in costs would represent less than one percent of sales.

No price increases as a result of compliance with pretreatment or zero-discharge standards are likely. No plant closures are anticipated and impacts on employment, the community, and industry growth and trade are likely to be minimal.

2. Secondary Copper

Table I-4 summarizes the impact of pretreatment or zero-discharge standards on the brass and bronze segment and unalloyed copper segment of the secondary copper industry.

In the brass and bronze segment, representing 24 percent of the plants in the segment, the capital requirements to meet pretreatment standards would be $508,700, or 33 percent of the average annual investment, and 3.6 percent of the capital in place. For zero discharge, the capital requirement would be $704,800, or 46 percent of the average annual investment. This would represent 4.9 percent of the capital in place. The annualized operating cost for pretreatment would be $227,770, 61 percent of which represents operating and maintenance costs. The annualized costs for zero discharge would be $293,290, 58 percent of which represents the operating and maintenance costs. In the case of both pretreatment and zero discharge, the these costs represent less than one percent of sales. No price increases are expected as a result of compliance with pretreatment or zero-discharge standards.

TABLE I-3

SUMMARY OF IMPACTS ON SECONDARY ALUMINUM INDUSTRY FROM PRETREATMENT AND ZERO-DISCHARGE STANDARDS

INDUSTRY	Secondary Aluminum	
SIC CODE	Part of SIC 3341	
No. of Plants in Segment	100	
Percent of Total Plants in Industry	100	
No. of Plants Discharging to Municipal System	18	
Percent of Total Plants in Segment	18	
	Pretreatment	Zero Discharge
COST OF POLLUTION ABATEMENT		
Capital Costs For Segment		
Total Capital Cost	$877,600	$1,606,900
Total Capital Expenditures as Percent of Average Annual Investment	16.4	30.0
Total Capital Expenditures as Percent of Total Capital in Place	2.0	3.7
Annualized Costs For Segment		
Total Incremental Increase Including Capital Charges	$352,590	$ 437,574
Total Incremental Increase Excluding Capital Charges	200,984	159,982
Total Incremental Increase Including Capital Charges as Percent of Sales	0.14	0.18
EXPECTED PRICE INCREASE		
Expected Increase Due to Pollution Control	Price Increase Unlikely	
PLANT CLOSURES		
Total Closures Anticipated of % Reduction of Segment Capacity Due to Closures	None	
EMPLOYMENT		
Total Number of Employees Affected	None	
Percent of Total Employees in Segment		
COMMUNITY EFFECTS	None	
IMPACT OF INDUSTRY GROWTH	Minimal	
BALANCE-OF-TRADE EFFECTS	Minimal	

TABLE I-4

SUMMARY OF IMPACTS ON THE BRASS AND BRONZE SEGMENT OF THE SECONDARY COPPER INDUSTRY

INDUSTRY	Brass & Bronze		Unalloyed	
SIC CODE	Part of 3341		Part of 3341	
No. of Plants in Segment	63		7	
Percent of Total Plants in Industry	100		100	
No. of Plants Discharging to Municipal System	15		1	
Percent of Total Plants in Segment	24		14	
	Pre-treatment	Zero Discharge	Pre-treatment	Zero Discharge
COST OF POLLUTION ABATEMENT				
Capital Costs for Segment				
Total Capital Cost	$508,700	$704,800	$547,500	$641,900
Total Capital Expenditures as Percent of Average Annual Investment	32.8	45.5	29.1	34.1
Total Capital Expenditures as Percent of Total Capital in Place	3.6	4.9	3.8	4.5
Annualized Costs for Segment				
Total Incremental Increase Including Capital Charges	$227,770	$293,290	$278,320	$318,790
Total Incremental Increase Excluding Capital Charges	$139,892	$171,535	$126,714	$41,198
Total Incremental Increase Including Capital Charges as Percent of Sales	0.26	0.34	0.27	0.31
EXPECTED PRICE INCREASE				
Expected Increase Due to Pollution Control	Price Increase Unlikely			
PLANT CLOSURES				
Total Closures Anticipated of % Reduction of Segment Capacity Due to Closures	Possibility of Closure for 2 Plants (Plant 12 and 13) <1.0%		No Closures	
EMPLOYMENT				
Total Number of Employees Affected	20-30		None	
Percent of Total Employees in Segment	<1.0%		--	
COMMUNITY EFFECTS	Minimal		Miminal	
IMPACT OF INDUSTRY GROWTH	Minimal		Minimal	
BALANCE-OF-TRADE EFFECTS	Minimal		Minimal	

There is the potential for closure of two plants, representing less than 1.0 percent of production, and 20-30 persons, representing less than one percent of the industry employment, could also be affected. As these plants are located in urban areas, no significant community impacts are expected. The impact on industry growth and trade is likely to be minimal as well.

There is one POTW discharger in the unalloyed copper segment, representing 14 percent of plants. The capital requirements for meeting pretreatment standards in this industry would be $547,500, or 29 percent of the average annual investment. This would amount to 3.8 percent of the total capital in place. For zero discharge, the capital requirements would be $641,900, or 34 percent of the average annual investment, or 4.5 percent of the total capital in place. The annualized operating costs would be $278,320, 46 percent of which would be for operating and maintenance. For zero discharge, the annualized operating cost would be $318,790, 13 percent of which would be operating and maintenance costs.

As a result of compliance with pretreatment or zero-discharge standards, no price increase is expected, nor is it likely that pollution abatement costs will result in any plant closures. Nor are any effects on employment, the community, industry growth, or balance of payments expected.

E. LIMITS OF THE ANALYSIS

The main limitation of this analysis is due to the modelling approach used to quantify impacts. Such an approach was necessitated by the paucity of specific financial data on each plant. Modelling will not predict the financial characteristics exactly for a particular plant; however, it can allow for basic differences between plants and provide reasonable estimates of financial characteristics against which the impact of compliance can be assessed.

It should be emphasized that in our analysis we only evaluated impacts due to the proposed pretreatment standards.

The costs of compliance with pretreatment and zero-discharge standards were provided by the Environmental Protection Agency and are subject to all limitations of their cost analysis.

II. METHODOLOGY

In this study, the direct and secondary economic impact of pretreatment (and zero discharge) standards on the aluminum and copper industries are quantified. Direct impact is defined as the effect on the financial conditions of the POTW discharging plants, and secondary impact is defined as the effects on consumers, employment, communities, trade, and the like.

A. MICROECONOMIC FOUNDATIONS

The industries being analyzed are similar in their structure. They consist of oligopolistic price-setting sectors (i.e., primary producers) which are characterized by vertical integration, well-defined price leadership roles and high barriers to entry. In addition, each industry contains a competitive fringe of scrap producers and secondary refiners. The structure of these competitive fringes differs somewhat for each industry; however, on the whole, the competitive fringes can be assumed to be "workably competitive"[1] subsectors of the particular industries to which they belong. The industry products (for the primary and competitive fringe) are assumed to be homogeneous.[2]

The analysis of such competitive fringes is theoretically straightforward. Deterministic price and output solutions for a competitive industry or competitive sub-sector of an industry occur at the intersection of supply and demand curves, where supply curves represent the horizontal summation of the marginal cost curves of the member firms. Economic rents may accrue in light of differential cost conditions across members. However, no member of a competitive sector can affect price; they are all price-takers. Short-run production decisions on the part of a given firm are made by comparing the market price with production costs.

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[1]For some discussion of this concept, see J.M. Clark, "Toward a Concept of Workable Competition," The American Economic Review, June 30, 1940, pp. 241-256; J.M. Clark, Competition as a Dynamic Process (Washington DC: The Brookings Institute, 1961); C.E. Ferguson, A Microeconomic Theory of Workable Competition (Durham: Duke University Press, 1964); or F.M. Scherer, Industrial Market Structure and Economic Performance (Chicago: Rand McNally, 1971), pp. 33-38.

[2]This assumption is not as extreme as it sounds. It holds for most uses of the relevant metals. For example, scrap copper is substitutable for primary refined copper in most uses except wire. Attempts to disaggregate copper use by some homogeneous demand categories has not been particularly successful. For a discussion see Arthur D. Little, Inc., Econometric Simulation and Impact Analysis Model of the U.S. Copper Industry, Technical Appendix to Economic Impact of Environmental Regulations on the U.S. Copper Industry, and Charles River Associates, Economic Analysis of the Copper Industry (March, 1970).

Such a supply curve[1] is pictured in Figure II-1. The curve relates the level of production of the competitive sub-sector to market price (=MC). However, the supply curve in Figure II-1 must be integrated into a model synthesizing the behavior and structure of the price-taking competitive fringe with the price-setting behavior of the oligopolistic primary producers. This is accomplished through modelling techniques schematized in Figure II-2. Using the copper industry as an example, let d_T be the total demand curve for refined copper in the United States. At any given price P_o, the competitive secondary industry will be in equilibrium and will supply a certain amount Q_{so} (Figure II-1) since the members are price takers. That will leave d_P as the net demand curve facing the oligopolistic primary producers. The supply behavior of the competitive fringe will therefore affect the behavior of the price-setting oligopolistic producers because whatever price is chosen by them will initiate some supply response by the secondary market. Since $\partial Qs/\partial P>0$, the primary producers cannot raise prices indefinitely. However, competition from the secondary industry does not constrain the price-setting behavior of the primary producers to a particular price, since the price elasticity of secondary supply is limited. Stigler[2] derives an estimate of the relationship of elasticities of the two demand curves (Figure II-2) and the supply elasticity in the secondary industry (Figure II-1):

$$\eta_P = \eta_T\left(1 + \frac{Q_s}{Q_p}\right) - \eta_s\left(\frac{Q_s}{Q_p}\right)$$

where

η_P = elasticity of demand in the primary sector,

η_T = market elasticity for total demand

Q_s = output of the secondary sector

Q_P = output of the primary sector

η_s = price elasticity of supply in the secondary sector

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[1]This discussion is abbreviated. If the reader is unfamiliar with the concepts, he (she) is suggested to peruse J. Henderson and R. Quandt, Microeconomic Theory (McGraw Hill; New York, 1958); or E. Mansfield, Microeconomics, Theory and Application (W.W. Norton; New York, 1970).

[2]George Stigler, The Theory of Price (New York: The Macmillan Company, 1966), p. 342. This derivation assumes perfect homogeneity between the primary and competitive secondary sectors. If such perfect homogeneity does not exist, (and it does not), then the analysis is made only slightly more complicated. See ADL, op. cit.

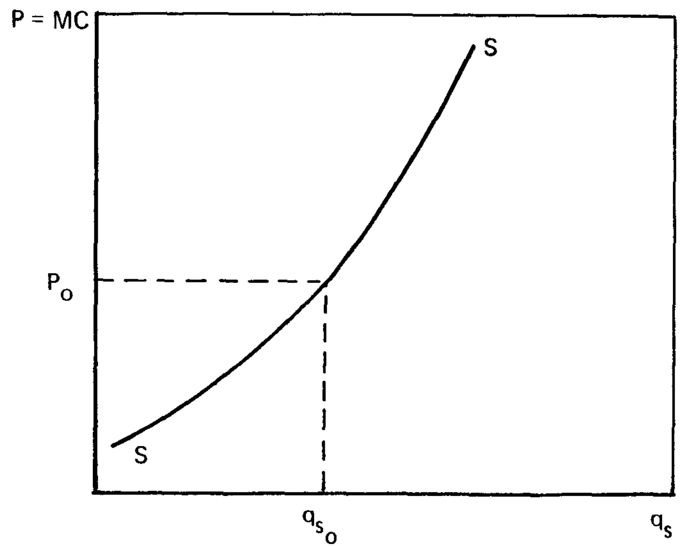

FIGURE II–1 COMPETITIVE FRINGE SUPPLY

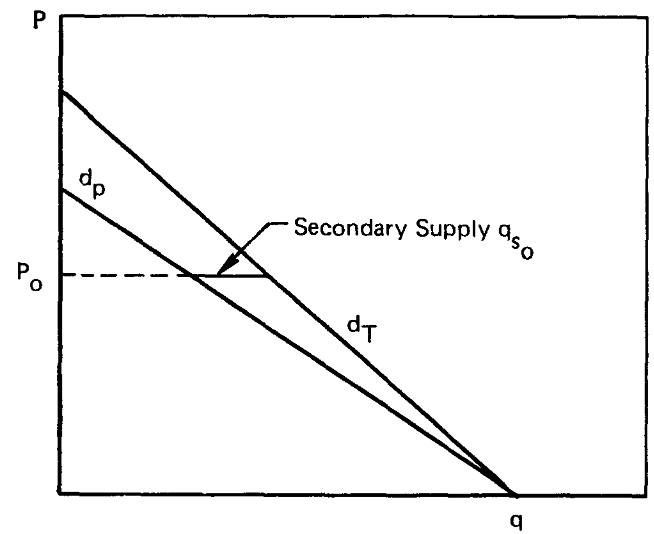

FIGURE II–2 TOTAL DEMAND AND NET DEMAND

Figure II-2 indicates that the price setting behavior of the oligopolistic producers is influenced by competitive supply. If such competitive supply were infinitely elastic, the oligopolistic producers would have no pricing discretion ($\eta_s = \infty$ and $\eta_p = -\infty$). However, competitive fringe supply is not perfectly elastic and the primary producers do possess some pricing discretion. This is indicated in Figure II-3, where the net demand is reproduced (with some change of scale) from Figure II-2, and the cost curves and marginal revenue curves for the primary producers are added.[1] Two pricing solutions are indicated in Figure II-3:

(1) (P_1, Q_1) the collusive monopolistic solution (MR = MC); and,

(2) (P_2, Q_2) the "full cost pricing" solution (P = ATC).

Clearly, many other pricing solutions are possible;[2] however, the point here is not the development of static or dynamic oligopolistic pricing models. The purpose is to indicate the market structure for the industries being analyzed and the requirements forced upon the analysis by that market structure and the phenomena being analyzed.

The secondary industries that are covered in this study are subsets of industries and have primary counterparts that produce close substitutes and compete with them in scrap markets. The secondary sector cannot affect price, they are all price takers. Furthermore, not all the plants in the secondary industry are affected by these standards and in all cases the increased costs represent less than 1.6 percent of product price. It is therefore expected that the pretreatment standards will have a small effect on the supply curve in Figure II-1. As a result, the net demand curve (d_p) in Figure II-2, will, in essence, remain unaltered. Consequently, the pricing and production solutions in Figure II-3 will be unaltered (that is, any changes will be in the margin of production error). If the competitive fringe cost curves and supply curves are essentially undisturbed by pretreatment standards, the lack of effects is intuitively expected.

The impact analysis is therefore predicated on the assumption that the firms in the secondary aluminum and copper industries will absorb the incremental cost of compliance with environmental standards, as production levels or price do not change as a result of compliance.

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[1]For simplicity, horizontal marginal cost curves are assumed in Figure 1c. Such an assumption seems realistic for copper but less realistic for aluminum. The use of the marginal cost curve (MC), the average total cost curve (ATC), and the marginal revenue curve is assumed familiar to the reader. If not, the reader should consult, J. Henderson and R. Quandt, op. cit., or Edwin Mansfield, op. cit.

[2]For a more detailed discussion of these pricing solutions in general, see Henderson and Quandt, op. cit., and Mansfield, op. cit. For a discussion with respect to the copper industry, see ADL, op. cit.

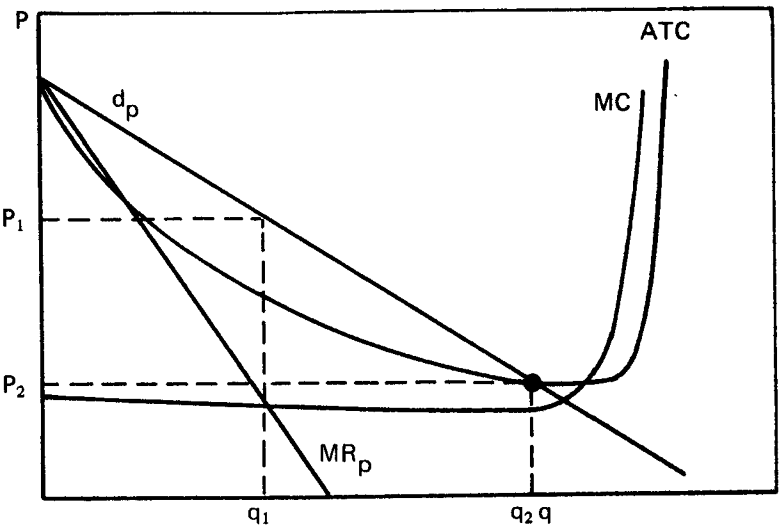

FIGURE II–3 NET DEMAND AND THE PRICING BEHAVIOR OF THE PRICE SETTING OLIGOPOLY

B. DIRECT IMPACT

Direct impact is predicated on the assumption that the firms in the industry will absorb the increase in costs and will not change their production levels as a consequence of complying with environmental standards. Consequently, their cost increases will directly affect the financial conditions of these impacted plants. These financial changes are quantified in this block. The following parameters are examined on a plant-by-plant basis: change in pretax profit and cash flow; availability of investment funds; and probability of closure. These impacts are evaluated at a specific point in time--namely, the year 1975. To the extent that 1975 is an atypical year, any findings will be biased. Therefore, industry projections have been made to evaluate how future conditions will differ from those prevailing in 1975.

1. Point Impacts

a. Models

To quantify direct impacts, ADL has developed process models for secondary aluminum, brass and bronze and secondary copper. These models are systems of deterministic process equations. The coefficients of the model equations express the relationships between physical inputs (e.g., labor and materials) and output (ingot tonnage).

The independent variable of the equations (the production inputs) is in a physical denomination, and, as a consequence, the initial model solutions will also be expressed in physical terms. To obtain costs, the vector of the physical input solutions for the plant is monetized by multiplying it by a vector of corresponding unit input prices.

The equations of the model utilize either an exponential or linear functional form. The exponential equation can be written:

$$Y = aX^b \qquad (1)$$

where

Y = input,

X = output,

a = scale parameter, and

b = growth parameter.

The value of "a" depends on the relative denomination (or scale) of the variables X and Y. The value of "b" depends on the nature of the relationship between X and Y. If b is less than 1, this means we have economies of scale in the use of the input. For example, if b is 0.8, this implies that a 1 percent increase in output (X) will need only 0.8 of 1 percent increase in the input (Y). Similarly, if b is greater than 1, we have diseconomies of scale, i.e, a given percentage increase in the output (X) will necessitate a more than proportional change in the input (Y).

The ADL model incorporates economies of scale in labor costs and diseconomies of scale in capital-related costs. Such a formulation is consistent with both industry characteristics and economic theory.

Many of the ADL equations use the linear form with a suppressed intercept. This equation can be written:

$$Y = bX \quad (2)$$

where

Y = input,

X = output, and

b = input-output coefficient.

The excessive rigidity implied by Equation (2) is acceptable in materials cost equations. In a material-output function, the relationships are physically constrained and the formulation of Equation (2) is optimal. The linear formulation is also appropriate in utility-output relationships.

b. Changes in Profit and Cash Flow

The process models are used to generate baseline costs, pretax profit, and cash flow for each POTW discharging plant. Utilizing the plant specific pretreatment (and zero discharge) costs supplied by the EPA, one can compute the actual and percentage deviations of each plant's profit and cash flows from the baseline scenario.

c. Capital Availability

To evaluate the availability of capital, the ratio of pretreatment-related investment to annual cash flow is computed for the plants. To the extent that the ratio is low the required capital can be financed from cash flow.

If the ratio is high, an qualitative analysis of external financing sources is necessary.

d. Plant Closure

Based on the process model, plants are screened into three categories:

(1) plants that are not covering their variable costs; plants in this category will shut down since by doing so they can avoid variable costs;

(2) plants that are covering their variable costs, but only a portion of their fixed costs; such plants will close down in the long run, but the timing is difficult to predict; and

(3) plants that are making a profit; whether this profit is sufficient to induce them to remain operating can be answered by the use of discounted cash flow analysis. A plant will remain operating if the summation of future discounted cash flows and discounted terminal salvage value exceeds the current salvage value.

Mathematically, the condition that dictates whether a plant will remain operating is given by the following equation.

$$CSV < CF + \frac{CF}{(1+i)} + \frac{CF}{(1+i)^2} + \frac{CF}{(1+i)^t} + \frac{TSV}{(1+i)^t} \quad (3)$$

where

CSV = current salvage value of business,

CF = cash flows,

TSV = terminal salvage value, and

i = cost of capital.

2. Industry Projections

The purpose of industry-trend analysis is to evaluate how representative 1975 is and how future conditions will differ. The three key variables that determine the operational profitability of the plants in the industry are: product price, production levels, and scrap price. The first two variables determine industry revenue and the third variable is a major determinant of cost. Trend equations have been fitted to each one of these variables. These trend equations serve two distinct, though interrelated, functions: (a) the equations can evalue how "normal" 1975 was in respect to the key variables; and (b) the equations can generate the future changes in these variables.

A variety of functional forms were experimented within the selection of the appropriate trend equation for each variable. The functions tried included linear, log-linear, linear-log, log-log, quadratic, and cubic. Mathematically these functional forms are:

$$Y - a + bT \quad \ldots \quad \text{(linear)} \quad (4)$$

$$\ln Y = a + bT \quad \ldots \quad \text{(log-linear)} \quad (5)$$

$$Y = \ln a + b \ln T \quad \ldots \quad \text{(linear-log)} \quad (6)$$

$$\ln Y = \ln a + b \ln T \quad \ldots \quad \text{(log-log)} \quad (7)$$

$$Y = a + b_1T + b_2T^2 \quad \ldots \quad \text{(quadratic)} \quad (8)$$

$$Y = a + b_1T + b_2T^2 + b_3T^3 \quad \ldots \quad \text{(cubic)} \quad (9)$$

a. Evaluating Normality of 1975

Utilizing the selected trend equations, we generated a predicted value for 1975 for each of the key variables. If the predicted trend value deviates from the actual value, this deviation can be attributed to the effect of cyclical or irregular forces. Therefore, a comparison of the actual and predicted values can give the direction and magnitude of cyclical and irregular forces in 1975.

b. Changes in Key Variables

The trend equations were used to generate predictions for the variables. If product prices are predicted to rise at a more rapid rate than scrap prices, this would mean increasing profit margins. Growing production levels would imply growing absolute returns. Therefore, these projections can capture how financial conditions are going to change in the industry margins. Growing production levels would imply growing absolute returns. Therefore, these projections can capture how financial conditons are going to change in the industry.

C. SECONDARY IMPACT

Utilizing the results from the direct impact block, one can determine the effect on secondary areas, such as employment, communities, trade, and the like. The techniques utilized are essentially ad hoc in nature and depend on the effect being studied. Employment changes, for example, are estimated by multiplying decreases in industry production by a labor-output ratio.

III. SECONDARY ALUMINUM SMELTING AND REFINING

A. INTRODUCTION

In Chapter III, we assess the impact of proposed pretreatment standards on the U.S. secondary aluminum smelting and refining subcategory of the non-ferrous metals processing category. These standards apply to existing sources that are introducing pollutants into Publicly Owned Treatment Works (POTW's).

B. TECHNOLOGY

Secondary aluminum smelters convert aluminum scrap into intermediate products, such as ingot, billets, and bars. The production cycle is comprised of the following steps: presmelting, smelting, and pouring and cooling the product line.

1. Presmelting

The preliminary treatment in preparing scrap for smelting depends on the type of scrap feed to the smelter. There are four types: borings and turnings, solids, residues, and old scrap.

a. Borings and Turnings

Scrap consisting of borings and turnings is often contaminated with cutting oils. Thus, it is first shredded in ring crushers and then dried in horizontal rotary drums. Free iron and other undesirable metallic elements are removed with magnetic separators during the drying stage.

b. New Clippings (Solids)

One form of solid scrap consists of new clippings. It is largely uncontaminated and requires little presmelter treatment. To prepare it for smelting, it only has to be sorted--either manually or mechanically--to remove obvious non-aluminum material.

c. Residues

Residue scrap is the most difficult to process, since it may contain as little as 10 percent aluminum. To recover the metallic aluminum, two processes may be used; one is wet, the other dry. In the dry method the residue is first crushed, then screened to remove the fines, and finally passed over a magnetic separator to remove iron. In the wet method, the residue is fed into a long drum, where it is washed in water. The water washes the fluxing salts and chemicals from the residue. The washed residue is then screened, dried, and passed through a magnetic separator, before being smelted.

Two points about residue processing should be noted: (1) because of special equipment needed, the processing of residues is limited to larger smelters; and (2) both the dry and wet dross processing cause pollution. High volumes of dust are created in the dry method, while the wet process can cause water pollution.

d. Old Castings and Sheet (Old Scrap)

Old castings and sheet scrap, a form of old scrap, is first sent to a huge crusher where it is reduced to small, fairly uniform dimensions. As it passes through the crusher, vibrating screens and magnetic separators remove pulverized non-metallics and free iron, respectively.

2. Smelting

In smelting scrap, the smelter is faced with a fundamental chemical constraint. In displacement reaction, only those elements that are higher than aluminum in the electromotive series can be removed from the molten mixture. In producing the secondary aluminum alloy then, the smelter has to practice dilution chemistry. This consists of adding primary ingots (or high-purity scrap) to the molten mixture to bring the composition up to the desired specification.

The smelting of aluminum takes place in a reverberatory furnace, or in the case of smaller companies, in a rotary furnace. The reverberatory furnace ranges in capacity from 30,000 to 180,000 lb, and can be charged using either side doors or a trough-like feeder, called a "forewell."

The smelting operation obviously consists of seven steps: (1) charging the scrap into the furnace, (2) adding the fluxing agents, (3) adding alloying agents, (4) mixing, (5) demagging, (6) skimming, and (7) degassing. All smelters may not necessarily incorporate all seven steps in their smelting operation, nor follow the order presented above. Each of these steps is described below.

a. Charging

Molten "heel" can be used to shorten the furnace cycle by about four hours. Heel is a molten metal of known composition which occupies the bottom of the furnace. It usually consists of metal left over from a previous cycle. If heel is not maintained in the furnace from heat to heat, it must be charged into the furnace (generally through the side doors). Once charged, the heel must be completely melted, sampled, and skimmed before other material can be charged. Subsequent scrap is charged through the forewell. After each charge, the slag is skimmed off and the metal sampled to determine its composition.

b. Fluxing

Because molten aluminum oxidizes rapidly, it must be covered with a molten flux to retard the oxidation. The flux most commonly used is a mixture of 47.5 percent NaCl, 47.5 percent KCl, and 5 percent fluoride-bearing salt. Once the oxides are trapped in the flux they are removed by skimming.

c. Alloying

Alloying agents are normally added to the aluminum melt after the scrap composition has been determined to bring the melt up to specification. Alloying agents include: copper, silicon, magnesium, and zinc. The addition of alloys provides minor amounts of fumes and dust that are removed from the working area by hoods positioned over the forewell.

d. Mixing

The mixing operation is performed almost continuously in the reverberatory furnace. Its purpose is to ensure uniform composition and to agitate the solvent fluxes into the melt. It is generally accomplished by injecting nitrogen gas or by use of mechanical puddlers. The mixing operation employs no water and produces no solid waste. Air pollution results only when a mixture of nitrogen and chlorine is used.

e. Demagging*

The major alloys supplied to the castings industry (Alloys 380 and 319), according to industry specifications, must have a magnesium content of less than 0.1%. This is due to the deleterious effects on ductility and volumetric growth which take place when magnesium silicide precipitates during room temperature aging. However, about 85% of the raw materials used in the secondary smelters come from mill products that are high in magnesium content. Although the secondary smelter tries to schedule a charge to the melting furnace that will keep the magnesium content low, he still ends up with a furnace bath containing 0.5-0.8 percent magnesium. Demagging is a halogenation process by which the magnesium content of a bath is reduced to specification. Magnesium removal is possible because of the tendency of halogens to react with magnesium in preference to aluminum. Demagging is generally achieved by the use of chlorine, aluminum chloride, or aluminum flouride. The demagging process causes air pollution--noxious halogen and halogen-compound emissions and particulate matter--which if controlled by wet scrubbing techniques can be a significant source of wastewater.

Chlorination is used very frequently in demagging operations because it can be used more efficiently and is relatively low cost. Chlorine gas is fed through tubes to the bottom of the melt. As it bubbles through the melt, it reacts with magnesium, and, in later stages, with aluminum to form chlorides which float to the surface where they combine with fluxing agents and are skimmed off. The aluminum chloride is a volatile compound and results in considerable fuming. This fuming makes ventilation and air pollution equipment necessary. If these fumes are controlled by wet scrubbing, then water pollution may result.

*Based on "Demagging in the Secondary Aluminum Industry," M.C. Mayalich, Journal of Metals, June 1975, pp. 6-10.

Chlorination demagging involves the reaction between chlorine or aluminum chloride gas at operating temperatures (1400-1500°F) and molten aluminum magnesium alloy; i.e., a gas-liquid reaction. The air pollution that results is related to the inefficiency of the demagging process. Consequently, the air polluting emissions can be reduced by increasing the demagging efficiency. The two basic approaches are by: (1) prolonging physical contact of reactants to ensure total reduction of aluminum or chloride before it reaches the surface of the bath; and (2) if some unreacted aluminum chloride reaches the surface of the bath, holding it there until the reduction is completed. Essential to either of these approaches is the requirement that molten aluminum alloy from the entire reverberatory furnace must be circulated through the reaction area since the entire furnace load has to be demagged.

Based on the first approach, Alcoa has developed a reaction container which has several chambers through which molten aluminum flows. Chlorine is introduced through a rotating "contacter" that disperses the gas in tiny bubbles. Demagging efficiencies of 100% have been reported. A salable byproduct of the process is anhydrous magnesium chloride salt which is collected on the surface of the melt in the reaction container.

An alternative, this approach is the metallics process developed by the Carborundum Company. In this process, chlorine gas is injected at a strategic point in the submerged stream of molten alloy generated by a pump. The specially designed discharge spout provides for intimate contact of the reactants. The flow rates of molten aluminum alloy and chlorine are so adjusted that only magnesium chloride is formed.

The method utilizing the second approach is the Derham process. In this process, a thick layer of flux is introduced into the chlorination chamber. The flux traps the aluminum chloride fumes and makes them available for further reaction at the aluminum-flux interface. Better than 97% efficiency has been reported at 0.1% magnesium levels. Magnesium chloride produced by demagging can be reused. The circulation of the molten metal from the main furnace hearth to the Derham unit is accomplished by pumping with an air-driven siphon. By maintaining a relatively thick cover of molten salt on the bath, the emissions of aluminum chloride to the atmosphere are greatly reduced. Consequently, the potential for effluent from emission scrubber water is greatly reduced.

Aluminum fluoride is an alternative demagging agent. When this compound is used in the process, air contaminants in the form of gaseous fluorides or fluoride dusts result. However, the fluorides can be controlled by either dry or wet methods. When controlled by a dry method, a problem involving solid wastes is created. When a wet method is used, problems involving both water pollution and solid-waste pollution are created. In the dry emission control process, coated baghouses (Teller modification) are used. The system differs from normal baghouse in that the bags are precoated with a solid to absorb effluent gases as well as particulates. Upon saturation, the coating is removed by vibration along with the coated dust.

It should be noted that, if the smelter is producing notched bar and shots (which are used as deoxidants by the steel industry), the magnesium content is not critical and the demagging step is not needed.

f. Skimming

After the contaminated semi-solid fluxing agent, known as slag (or dross), is skimmed from the surface of the melt, the slag is placed in a water-cooled "dross cooler" or pans to cool. Once cooled, the slag is either stored until shipped to a residue processor, reprocessed by the company, or dumped. If stored in the open, it is a source of ground and runoff water contamination because of the soluble salts it contains. Furthermore, during slag cooling, air pollution can occur if the slag is not conditioned properly.

g. Degassing

Molten aluminum will readily absorb hydrogen gas or other moisture or water vapor from the atmosphere. Gases dissolved in the metal will separate out during solidification, and the customer demands that the metal be gas-free. The metal is degassified by bubbling dry nitrogen, chlorine, or a mixture of the two gases through the molten metal bath. Chlorine gas is the most effective. Unless smelters are equipped with adequate air pollution control systems, they are hampered by the severe fuming caused by the chlorine gas. Because of this fuming and other hazards involved, smelters must have adequate ventilation and air pollution control equipment. Smelters without this equipment commonly use nitrogen or some other inert gas.

h. Tapping

Twenty-four to 42 hours after the furnace cycle is started, the metal is ready for pouring. Before being poured into the mold, the metal is cooled to approximately 1350°F. Even though furnaces are operated on a continuous basis, each heat is a batch operation and is only a part of a continuing series.

3. Pouring and Cooling of Product Line

The secondary smelter casts the molten aluminum into various shapes. In the case of "hot metal," however, the molten metal is transported in the liquid form to the foundries.

a. Ingots

Molten aluminum is poured into the ingot mold. Once solidified in the mold, the metal is generally cooled by a water spray that contacts both the molds and the hot metal as they move along a conveyor above a cooling pit. Non-contact cooling is also used in some plants. In non-contact cooling, water is pumped through passages in the mold, but does not actually touch the metal. Air cooling which generates no wastewater is also used in some cases. The water used for cooling may be sent to a cooling tower and then recirculated. Alternatively, in some cases the water is used only once and then discharged. Recirculated water builds up sludge in the cooling pit and the cooling tower, and this sludge must be removed at regular intervals. This process involves discharging the water.

b. Billets

The metal is first cast into 100-lb billet logs. Water lines inside the molds cool the billets, which are water quenched on leaving the molds. Once removed, each billet log is cut into shorter sections. Finally, billets are given a homogenizing treatment before being shipped.

c. Notched Bar

Notched bars are normally cast in 5-lb molds. Notched bar molds, like ingot molds, are cooled either by water spray, internal water lines, or air.

d. Shot

Shot is produced by pouring molten metal onto a vibrating feeder. Perforated openings in its bottom allow the molten metal to drop into a water bath below. The droplets solidify in the water, and are then dried, sized, and packed for shipment. The water is either sent to a cooling tower and recirculated or discharged immediately. The recirculated water, of course, causes sludge buildup.

e. Hot Metal

In some cases, hot metal is poured from the furnace into preheated crucibles. The crucibles are sealed and transferred by truck to the customers. Presently, crucibles with capacities of 15,000 and 38,000 lb are being used.

4. New Technology

No fundamental technological breakthroughs have occurred in this industry, but minor improvements have continually been introduced. The most important of these new developments are listed below:

(1) Improved mechanical methods for processing raw materials have been introduced;

(2) Furnace capacity has increased significantly; 20 years ago a 30,000-lb furnace would have been among the largest in the industry, but today 180,000-lb furnaces are common.

(3) Salvaging of residues is now common practice; 25 years ago most residues were discarded as wastes;

(4) The shipment of molten metal, pioneered by the primary industry in 1950, has been adopted by larger secondary smelters;

(5) Modern laboratory equipment, which has improved the level of quality control in the industry, is now commonly used;

(6) The oxygen fuel burner, which can shorten the furnace cycle by 25 percent, has been introduced to the industry; and

(7) Computers are being used by secondary smelters to process data.

C. INDUSTRY SEGMENTATION

The secondary aluminum industry can be broken into two segments:

(1) producers of alloy ingot and hot metal; and

(2) billet plate and sheet producers.

According to the EPA Development Document, POTW dischargers belong to segment 1.

1. Types of Firms

a. Concentration

Most firms in the secondary aluminum industry have one plant operation and are either family-owned or owned by small corporations. The minority of firms, which represents a large portion of the production, however, are either large corporations, or subsidiaries of large corporations, and are generally multiplant operations; for example, the U.S. Reduction Company; Apex Smelting Company, a division of American Metal Climax, Inc.; and the A & M Division, Vulcan Materials Company.

Table III-1 presents concentration ratios for the secondary aluminum industry based on the 1963, 1967, and 1972 Census surveys of manufacturing industries conducted by the U.S. Bureau of Census. Concentration ratios give the value of shipments made by the largest companies. The higher the ratios the greater the oligopolistic market power in an industry.

Table III-1 shows that, in 1972, the 4 largest companies producing aluminum ingot (SIC 33417) accounted for 50 percent of the value of shipments for the industry category; the 8 largest companies accounted for 69 percent; the 20 largest companies accounted for 89 percent; and the 50 largest companies accounted for over 98 percent of the value of shipments for the industry category.

Of the companies producing billets (SIC 33418), the table shows that in 1972 the 4 largest companies accounted for 80 percent and the 20 largest accounted for 100 percent of the value of shipments for the industry category.

TABLE III-1

PERCENT OF VALUE OF SHIPMENTS OF INGOTS AND BILLETS ACCOUNTED FOR BY THE LARGEST COMPANIES

Product	Year	Total Dollars (millions)	4 Largest Companies	8 Largest Companies	20 Largest Companies	50 Largest Companies
Ingot	1963	238.9	44	62	85	99
	1967	302.9	44	64	88	99+
	1972	341.0	50	69	89	98+
Billet	1963	13.9	85	99	100	--
	1967	39.3	72	97	100	--
	1972	28.7	80	--	100	--

Source: U.S. Bureau of the Census.

b. Integration

The integration level of these firms is low with the exception of billet manufacturers who produce siding, doors, windows, and other marketable products. Most smelters buy aluminum scrap, smelt and refine it to hot metal and billets. The consumers of these semi-finished products are the foundries and extruders. Another secondary product is de-oxidizing materials (notched bar and shot) which is used in steel mills.

A small segment of the industry consumes billet grade aluminum scrap for the manufacture of extrusion billets. Some, if not most, of the billet manufacturers also make semi-finished and finished products (such as extrusions) and building construction items (such as doors, windows, storm doors, and the like).

c. Diversification

With the exceptions of those firms which are owned by conglomerates, the level of diversification of most of the companies involved in secondary aluminum smelting is low. There are a few singular exceptions where the facility not only produces secondary aluminum, but handles brass, precious metals, and other completely unrelated materials (such as building products), and also carries out steel-warehousing and other miscellaneous activities.

2. Types of Plants

a. Production Levels

Plants in the industry vary all the way from very small operations located on sites as small as one acre and employing as few as six people to fairly complex ones employing up to 400 employees at a facility occupying up to 50 acres. At the same time, production of aluminum alloy can range from 3000 up to 55,000 short tons per year from a single plant. The production at each plant may vary significantly. Unlike primary aluminum plants, secondary plants do not operate around the clock seven days a week. However, they can step up production by operating extra shifts. There is not necessarily a relationship between either employment and site area or plant production and site area; for instance, several large producers in metropolitan areas have small plant sites due to the high cost of land.

b. Location

Most of the plants currently producing secondary aluminum metal are located near heavily industrialized areas which give them proximity to a supply of scrap as well as to their customers. These plants are chiefly located in the Midwest, in or near the Chicago and Cleveland metropolitan areas, and in the West, in the Los Angeles area. Approximately 45% of the U.S. secondary aluminum production is done within a 100-mile radius of downtown Chicago. Within a similar radius of Cleveland, another 20% of the production can be found. The remaining 35% are located on the East coast near the New York City-Philadelphia area, and on the West coast in California.

c. Technological Level

Plants in this industry vary in age with some of the facilities being 40 to 50 years old, and additions have been made over the years; in some cases, changes in technology are currently being implemented. Due to the unsophisticated nature of this industry, there is little need for extensive reliance on the buildings themselves to do anything more than shield from the weather. Thus, any safe structure can be used.

Most facilities generally operate at relatively low technological levels. Techniques for smelting have not changed basically in the last 40 years, although the furnaces today are much larger in size and are equipped with greater heat input capability. Thus they are able to generate more output per man-hour. Techniques for preparation of scrap are reasonably general. For instance, the preparation of turnings by crushing and drying is carried out at most plants. Dross processing is carried out by and large by companies who specialize in processing. Most of the competitors either sell their skimmings to the dross producers or dump them.

The general efficiency of these plants is low in terms of technology and energy utilization (fuel, electricity, manpower) as compared to other manufacturing industries. Heat recoveries from the furnaces are low, and many operations which could be automated are still accomplished by manual labor. By and large, the reason that new companies can enter the business as readily as they can because the general level of operations are reasonably labor-intensive and are not capital-intensive. This further tends to indicate the lack of high-level technology in the operation of this industry.

About the only exception that might be noted lies in the dry processing of drosses. This operation is now so sophisticated that enormous tonnages of material, if they are available, can be processed at relatively low costs, thus making drosses an attractive material.

Further, the level of mechanical auxiliaries and automated equipment is relatively low in this industry. As an example, very few plants have automated pouring and stacking equipment for handling their alloy ingots, and only a few have mechanical puddling devices available to assist in puddling scrap into the furnaces.

d. Integration

As with firms in general, the plants in the secondary aluminum industry are not integrated to any great extent with the same exceptions as those which applied to the firms.

3. Characteristics of POTW Dischargers*

a. Production

Production levels of the POTW dischargers range from 6,000 to 39,000 short tons per year. Compared to the rest of the industry, these plants are either medium or large. Of the 18 smelters discharging to POTW, 6 produce 500-999 short tons per month; the other 12 produce 1000-4,999 short tons per month. Thirteen of the 18 POTW discharging plants produce alloy ingot, 1 produces shot bar shapes and 4 produce both alloy ingot and molten alloy.

b. Location

No significant pattern differences in location exist between the two types of dischargers. The geographical distribution of POTW's is quite consistent with a focus around the Great Lakes, particularly near Cleveland and Chicago. The state by state distribution is as follows: Illinois (4), Ohio (3), California (2), New York (2), and Wisconsin, Pennsylvania, Indiana, Kansas, Washington, and Oklahoma (1).

c. Technology

With regard to technology, the POTW dischargers are representative of the industry.

4. Proportion of the Industry Represented by POTW Dischargers

The following characterization of secondary aluminum smelters discharging to POTW's is based on the EPA Development Document on Pretreatment Standards of July 1976.

Eighteen out of 71 plants discharge to a POTW. Of the remainder, 18 discharge directly to surface or subsurface waters; 34 claim no discharge status and the discharge status of 1 plant was not reported. The 18 POTW-discharging plants are operated by 13 companies. Three of the 13 companies are multiplant operations, one of which is primarily engaged in secondary smelting.

The total annual production of the 18 POTW dischargers is estimated at around 352,200 short tons based on the available data. In 1975, the total U.S. production of secondary aluminum by independent smelters, as reported by the U.S. Bureau of Mines, was 511,755 short tons. The POTW dischargers therefore account for approximately 69 percent of the industry. production in that year. Table III-2 presents a breakdown of number of plants, employees and production represented by (1) ingot producers using dross, (2) ingot producers not using dross, and (3) billet, plate, and sheet manufacturers.

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*Based on Supplemental for Pretreatment to the Development Document for the Secondary Aluminum Segment of the Nonferrous Metals Manufacturing Point Source Category, EPA, August 1976.

TABLE III-2

PLANTS, EMPLOYEES, AND PRODUCTION AND PERCENTS OF INDUSTRY TOTAL REPRESENTED BY EACH SEGMENT

	Plants		Employees		Production	
Segment[2]	Number	Percent[1] of Industry	Number	Percent[1] of Industry	Millions of lb/Month	Percent[1] of Industry
1	16	16	1340	25	42.8	26
2	43	43	3270	57	86.3	52
3	10	10	470	8	25.7	16
TOTALS	69	69	5080	90	154.8	94

[1]Percentages may not add due to independent rounding.

[2]Segment 1 - ingot producers using dross.
Segment 2 - ingot producers not using dross.
Segment 3 - billet plate and sheet manufacturers.

Source: ADL estimates.

D. FINANCIAL STRUCTURE OF THE SECONDARY ALUMINUM INDUSTRY

Published information on the financial structure of the secondary aluminum industry is scarce. At the industry level, financial information is available only from the Census of Manufactures published by the U.S. Department of Commerce, Bureau of the Census. The Census covering the industry in 1972 is the latest available. The next Census will be taken in 1978 and will cover manufacturing activity in 1977. Another publication by the U.S. Bureau of Census, Annual Survey of Manufactures, an update of census information, is available on a yearly basis. The surveys however, contain financial information only up to the four-digit SIC code level. Secondary aluminum is at the five-digit SIC code level of disaggregation and so the surveys are not useful for our purposes.

At the firm level, an even more severe lack of data exists. Most plants in the industry are owned by private firms whose financial information is privy. The annual reports of those plants that do belong to public companies are not helpful in that data are not plant-specific.

The Census of Manufactures is conducted on an establishment (or plant) basis; that is, a company operating establishments at more than one location is required to submit a report for each location. Each establishment is classified according to a Standard Industrial Classification (SIC) code. However, some establishments produce only the primary products of the industry in which they are classified, but this is rare. Most plants also produce other products. The data on value added, value of shipments, etc., will reflect all activities at the plant and not merely the primary activity. Specifically, the Census provides the following financial information:

- Value of shipments (VS), which represents the net selling values, f.o.b. plant, after discounts and allowances, but excluding freight charges and excise taxes.

- Cost of materials which includes:

  - the total delivered cost of all raw materials, semi-finished goods, parts, components, containers, scrap and supplies consumed or put into production;

  - the amount paid for electric energy purchased;

  - the amount paid for all fuels consumed for heat, power, or the generation of electricity;

  - the cost of work done by others on materials or parts furnished by the reporting establishment (contract work).

- Capital expenditures, which include the cost of plant and equipment for replacement purposes, as well as for additions to productive capacity. Costs associated with plants under construction, but not in operation during the year, are also included.

- Payrolls, which include the gross earnings paid to all employees on the payroll of reported establishments. It follows the definition of payrolls used for calculating the federal withholding tax, and includes all forms of compensation such as salaries, wages, commissions, dismissal pay, all bonuses, vacation and sick leave pay, and compensation in kind. It should be noted that this definition does not include employer's Social Security contributions or other non-payroll labor costs such as employees' pension plans.

- Value added by manufacture, which figure is derived by subtracting the total cost of materials from the value of shipments and adjusting the resulting amount by the net change in finished products and work-in-process inventories.

The Census report was utilized to derive the following information (presented in Table III-3):

- Value Added (VA)/Value of Shipments (VS). This is equivalent to value added per dollar of revenue.

- (VA - Payroll)/Value of Shipments (VS). If local taxes, insurance, and interest charges are subtracted from this column, we obtain an estimate of pretax cash flow per dollar of revenue.

- Capital Expenditures (CI)/Value of Shipments (VS). This is an estimate of the average rate of capital investment per dollar of revenue.

- Variable Costs (CV)/VS. CV is equal to payroll plus cost of materials. The ratio is an estimate of variable costs per dollar of revenue.

Comparison of the 1967 and 1972 Census data reveals that the value of shipments increased 6 percent from $409 to $434 million; cost of materials increased 7 percent from $327 to $351 million; payroll costs increased 10 percent from $37.5 to $41.3 million; pretax cash flow decreased 10 percent from $43.0 to $39.0 million; value added per dollar of revenue decreased from 20 to 19 cents and pretax cash flow per dollar of revenue went down from 11 to 9 cents; and finally capital investment per dollar of revenue remained at 2 cents and variable costs per dollar of revenue went from 89 to 90 cents.

1. Profits

Traditionally, net profit on sales for secondary aluminum smelters range from 1 to 2.5 percent. While some smelters list profits as low as

TABLE III-3

FINANCIAL RATIOS FOR THE SECONDARY ALUMINUM INDUSTRY[1]

Year	Payroll[2]	Materials[2]	VA[2]	VS[2]	VA - Payroll	CI[2]	$\frac{VA}{VS}$[3]	$\frac{VA - Payroll}{VS}$[3]	$\frac{CI}{VS}$[3]	$\frac{CV}{VS}$
1972	41.3	351.0	80.3	434.0	39.0	7.6	.19	.090	.02	.90
1967	37.5	327.0	81.1	409.0	43.6	9.4	.20	.11	.02	.89

Notes: VA = Value Added by Manufacturer
VS = Value of Shipments
CI = Capital Expenditure
CV = Variable Out-of-Pocket Costs

See text for interpretation of the ratios derived.

[1] Includes numbers for both ingot and billet producers since the data do not reveal any significant differences between these categories.

[2] Million dollars.

[3] Ratio of \$/\$.

Source: U.S. Bureau of the Census.

1 to 1.5 percent, most smelters consider a 2 percent profit on sales as standard. In the past three to four years, there are definite indications that profits have been significantly higher, in the range of 3 to 10 percent on sales.

2. Annual Cash Flow

The relationship of cash flow to net profit to cash flow varies according to the age of the establishment. Depreciation has been about 1 to 2 percent of sales so there can be a marked difference between pretax profit and cash flow in lean years.

3. Market Value of Assets

The market salvage value of the assets of any of these plants is considerably lower than net book value, unless the plant can be maintained as an operating unit. In general, the industry's businesses have been fairly negligent in the maintenance and upkeep of their facilities. Much of their equipment is single-purpose equipment, incapable of being utilized for any other purpose. On this basis, we estimate that these plants would have value somewhat less than local land costs, since the land values would have to be depressed by the cost of clearing up the sites. On the other hand, if these plants could be turned over to another operator who is able to operate it, the value could be substantially higher.

In one recent case, a large conglomerate shut down a smelting plant and was able to recover approximately 25% of its book value when it sold the plant to another smelter. In another case which took place three years ago, another conglomerate shut down a plant it was unable to sell as a "going" operation, but was able to salvage only between 2 and 3 cents on the book value dollar.

4. Cost Structure

Cost structures vary in the industry, depending on the type of scrap being utilized and the volume of operation. As an example, a plant utilizing a high percentage of dross metallics will have considerably higher operating costs, especially higher energy requirements. However, the cost of the drosses will be sufficiently low to offset these higher operation costs, allowing the plant to return a better-than-average profit much of the time.

a. Variable Costs

The chief component of variable costs consists of those materials consumed by the smelter; these include aluminum scrap, alloys, fluxes, and maintenance materials. In recent years, scrap costs have been about 60 percent of revenue. The other material costs have accounted for about 10 percent of revenue. On the average, labor costs account for 11 percent of revenue. For the larger plants, the figure is slightly below this average. The only other significant variable cost is that for utilities, including fuel, electricity, and water, which account for about 2 percent of revenue.

b. Fixed Costs and Profits

(1) Fixed Costs - The fixed-cost-and-profits category includes depreciation, interest, expenses, selling and administrative, and property taxes and insurance. Some of these costs, it should be noted, are not entirely fixed, but do depend on production levels. Fixed costs, on the average, account for about 5 percent of revenue.

(2) Profits - Gross profit margins in recent years, on the average, represent about 12 percent of revenue, while net profits represent about 7 percent of revenue and cash flow about 83 percent of revenue.

5. Constraints on Financing Additional Capital

The secondary smelters have relatively low fixed capital needs. Their working capital needs, however, are high. Net working capital averages about 25 percent of revenue. The working capital needs restrict the amount available for expansionary fixed investment.

a. Working Capital

Secondary smelters have high working capital needs. They usually pay up to 75 percent of the purchase price of scrap in cash at the time of confirmation of shipment and the balance in 30 days. Consequently, the cash prepayment for each railroad car of scrap is approximately $5,000, and it may be days or even weeks before the scrap arrives at the smelter. In the meantime, smelter products are always sold on credit with payment required in 30, 60, or 90 days. Thus, a secondary smelter generally buys for cash and sells on loan credit. This financial arrangement generates a tremendous need for liquid capital and has been a powerful motivation in convincing the small, family-owned smelter operators to either merge or go public.

The inventory of aluminum scrap that each smelter strives to maintain is determined by scrap availability, storage capacity, and operating cash on hand. Since aluminum is a light metal and the scrap material is bulky, large volumes of storage space are required. While some smelters operate with as much as a month of scrap in inventory, others operate with as little as a 2-day supply. A normal scrap inventory, however, represents about a 2-week supply of scrap. Smelters operating with a small inventory can influence local prices when in danger of running out of scrap. When scrap does not arrive at the smelter on schedule, the operator must buy quickly from a local supplier by offering a premium price. This practice can--and often does--raise general scrap prices within the area.

b. Fixed Capital

The general constraints on financing relate to the dollars needed for a particular project. The larger companies with a number of claims on their capital dollars from many divisions have been reluctant in the past several years to lay out large sums of money for plant improvements, pollution controls, and the like. On the other hand, many of the small companies with close ownership have been able to find the capital to make at least minimal improvements, though most capital expenditures are paid for via retained income without the use of long-term financing.

The small companies tend to do things on a less formalistic basis, performing a lot of "horseback" engineering, and they are adept at acquiring information and technology without great expense. Often these companies have been able to "home-make" quite capable machinery which would have cost several times its acquired cost if it had been purchased from normal commercial sources, or if it had been engineered to their specific requirements.

E. PRICING IN THE SECONDARY ALUMINUM INDUSTRY

The secondary aluminum industry buys scrap and converts it to ingots, hot metal, billets, and the like. Consequently, in considering prices, both the scrap market and the markets for secondary aluminum smelter products have to be examined.

1. The Scrap Market

Scrap is never deliberately created. It is the unavoidable byproduct of fabricating operations or a product of obsolescence. Scrap resulting from fabricating operations is called "new scrap," while scrap resulting from obsolescence is called "old scrap."

The major participants in the scrap market are the scrap collector, the scrap dealer, and the scrap consumers. The scrap collector gathers the various metals until he has a truckload to deliver to the dealer. The scrap dealer first identifies and segregates the scrap by alloy. The segregated scrap is next pressed or bundled into convenient packages and transported to the industrial consumers. The industrial consumers of aluminum scrap--in order of importance--are the secondary producers, the primary producers, and the non-integrated fabricators. The scrap consumption patterns, the international trade in scrap, the supply and demand for scrap, and the scrap price behavior are all described below.

a. Scrap Consumption Patterns

As stated earlier, scrap is classified into two categories: new scrap and old scrap. New scrap can be further disaggregated into borings and turnings, solids, and residues. Table III-4 shows the volumes of the various types of scrap consumed in 1975.

TABLE III-4

VOLUMES OF ALUMINUM SCRAP CONSUMPTION, 1975

	Secondaries		Others[1]	
	Short Tons	Percentage	Short Tons	Percentage
New Scrap				
Borings & Turnings	121,000	18.7	--[2]	--[2]
Solids	244,206	37.6	241,293	48.9
Residues	90,661	13.9	89,579	18.1
Other New Scrap	22,996	03.6	22,642	04.6
Old Scrap	169,640	26.2	140,464	28.4
TOTAL	648,503	100.0	493,978	100.0

[1]Includes primary producers and non-integrated fabricators.

[2]Withheld to avoid disclosing confidential information, was ignored in calculation of percentages.

Source: U.S. Bureau of Mines.

Borings and turnings result from machining castings, rods, bars, and forgings. Most of this scrap is generated by the aircraft and automobile industries. In 1975, borings and turnings accounted for 18.7 percent of the secondary smelters' scrap feed.

The solids, which include clippings and forgings, are purchased by the smelters in either a segregated (by alloy) or mixed form. The aircraft industry, the fabricators, and the manufacturing sector generate most of this scrap form. In 1975, solids accounted for 37.6 percent of the scrap feed of the secondary smelters.

Residues are waste material generated by the smelting of aluminum at the primary or secondary plants. The residues may be dross, skimmings, or slag. The use of residues has come of age in the last 25 years. Prior to that time, most of the residues were discarded as waste. In 1975, residues accounted for 13.9 percent of the secondary smelters' scrap feed.

Aluminum, in contrast with steel or other non-ferrous metals, is a relatively new product. Its recent advent has resulted in a comparatively low level of old aluminum stock. Old scrap supply, however, will become increasingly important with growth in stocks of aluminum goods and the continuing application of new technology for scrap recovery. In 1975, old scrap accounted for 26.2 percent of the secondary smelters' feed.

Can scrap is becoming an important source in the old aluminum scrap supply. Because of the current public interest in recycling, the high value of aluminum, and the visibility of aluminum cans in litter, some of the aluminum producers and users have initiated recycling of the all-aluminum cans by collecting them from the consumer. The collected cans are sometimes shredded at these centers or by a local scrap dealer. Most of the aluminum recovered from these cans is converted by the primary producers, mainly back into can sheet stock. Some of the can scrap also goes to secondary smelters, who demag it in making secondary alloy. The main problem in processing aluminum can scrap is the high melt losses associated with its recycling.

Table III-5 presents aluminum scrap consumption by both the secondaries and the other scrap consumers from 1960-1975. The amount of aluminum scrap consumed in the U.S. has risen sharply since 1960, but it has stabilized over the 1970's. However, its rate of growth has been greater than the growth rate of the overall economy.

b. International Scrap in Trade

International trade in scrap is a volatile component of the aluminum scrap market. Scrap trade operates as a clearinghouse for excess demand or supply conditions. When excess supply depresses domestic scrap prices, scrap dealers, particularly those on the West Coast, turn to exports as a viable alternative. On the other hand, when demand crunch conditions are manifested in the domestic market, imports ease the upward pressure on scrap prices.

TABLE III-5

ALUMINUM SCRAP CONSUMPTION LEVELS, 1960-1975

(Short Tons)

Year	Secondaries	Others*
1960	353,889	87,590
1961	331,705	166,411
1962	442,168	152,705
1963	493,168	154,321
1964	538,992	173,259
1965	579,844	236,776
1966	638,757	257,577
1967	617,145	265,650
1968	699,289	315,781
1969	742,118	366,979
1970	650,327	322,206
1971	639,909	364,869
1972	706,484	445,949
1973	736,819	525,620
1974	630,223	573,838
1975	648,503	493,978

*Includes primary producers and non-integrated fabricators.

Source: U.S. Bureau of Mines.

Traditionally, scrap exports have been greater than imports. During the 1960-1975 period, U.S. scrap exports exceeded imports in every year except 1971. The major export markets for U.S. aluminum scrap are Japan, West Germany, and Taiwan. The chief source of U.S. scrap imports is Canada.

Tables III-6, III-7, and III-8 present statistics on aluminum scrap trade. Tables III-6 and III-7 deal with regional flows, while Table III-8 presents aggregate historical trade statistics. In general, net exports have been decreasing from a level of 75,000 tons in 1965 to a 10,000-ton annual level in recent years.

c. Supply and Demand

The demand for scrap is a derived demand. Scrap is not demanded for itself, but for its use as a raw material that will become part of a durable manufacture. Consequently, one could say that scrap demand is a function of the durable manufacturing activity level in the economy. The supply of scrap is inelastic and the only increase in supply caused by an increase in price is due to depletion of inventories and small additions to used scrap collection.

The total supply of new scrap is a direct function of aluminum production levels. The market supply of new scrap depends on total supply, the amount reused within the generating plant, and the amount of scrap "buy-back" as toll conversion agreements. The scrap "buy-back" and toll conversion agreements are discussed below.

Primary producers enter into agreements to ensure that the scrap generated by the fabricators is resold to (or toll-converted by) them. In times of shortage, the primaries allegedly pressurize the fabricators into entering into such agreements. The fabricators who buy ingots from the primaries are obliged to go along with the primaries' wishes. The capitulation of the fabricators is a result of the oligopolistic power of the primaries. In demand-crunch situations the primary producers ration out their production, and the fabricators who seek continuity of ingot supply do not want to antagonize them.

The potential supply of old scrap is a direct function of the stock of aluminum goods and their age. The actual supply of old scrap is a function of the price of scrap, technological considerations, and transportation costs. The higher the price of scrap, the more feasible is the recovery of aluminum from highly contaminated or low-aluminum content scrap. Similarly, technological breakthroughs or lowered transportation costs would also permit the use of old scrap that is now discarded as useless.

d. Aluminum Scrap Price Behavior

Table III-9 presents prices for scrap clipping and cast scrap for the 1960-1975 period. Both types of scrap are common raw materials for secondary aluminum smelters and their prices naturally move together. Scrap prices are highly volatile, but insofar as they exhibit a trend, it is

TABLE III-6

U.S. SCRAP EXPORTS BY REGION, 1975

	Short Tons	Percentage
Japan	22,558	34.3
West Germany	15,436	23.5
Canada	8,413	12.8
Taiwan	3,343	05.1
Other	15,961	24.3
TOTAL	65,711	100.0

Source: U.S. Bureau of Mines.

TABLE III-7

U.S. SCRAP IMPORTS BY REGION, 1975

	Short Tons	Percentage
Canada	32,239	58.8
West Germany	6,673	12.2
United Kingdom	2,565	04.7
Other	13,329	24.3
TOTAL	54,806	100.0

Source: U.S. Bureau of Mines.

TABLE III-8

INTERNATIONAL SCRAP TRADE, 1960-1975

(Short Tons)

Year	Exports	Imports	Net Exports
1960	79,513	5,042	74,471
1961	82,005	6,002	76,003
1962	65,534	6,496	59,038
1963	71,040	9,306	61,734
1964	68,615	8,152	60,463
1965	38,547	27,026	11,521
1966	48,666	42,982	5,684
1967	54,532	38,609	15,923
1968	49,427	45,751	3,676
1969	86,256	38,155	48,101
1970	57,159	41,122	16,037
1971	30,676	65,876	-35,200
1972	66,040	52,301	13,739
1973	115,120	46,806	68,314
1974	80,159	74,743	5,416
1975	65,711	54,807	10,904

Source: U.S. Bureau of Mines

TABLE III-9

CLIPPING AND CAST SCRAP PRICES, 1960-1975

Year	Clippings (¢/lb)	Castings (¢/lb)
1960	13.5500	10.2500
1961	11.9200	9.40000
1962	11.0500	8.70000
1963	11.5600	8.33000
1964	12.2900	10.1300
1965	14.6800	12.1500
1966	12.7600	10.3000
1967	10.4900	8.40000
1968	10.0800	8.41000
1969	13.0400	11.4800
1970	10.9400	9.79000
1971	8.34000	7.00000
1972	7.52000	5.52000
1973	11.1600	8.5800
1974	16.1800	12.7800
1975	10.3500	8.0100

Source: American Metal Market

TABLE III-10

ALUMINUM SCRAP WHOLESALE BUYING PRICES, CARLOAD LOTS, DELIVERED TO BUYERS' WORKS, MARCH 1971 AND JULY 1973

Types of Scrap	Price, ¢/lb 1971	Price, ¢/lb 1973
Aluminum clips 3003 (3S), 6061 (62S), 1100 (2S), 5052 (52S)	16.75-17.25	17.00-18.50
Aluminum clips 2014 (14S), 2017 (17S), 2024 (24S)	15.50-16.00	16.50-17.00
Aluminum clips 7075 (75S)	12.25-12.75	15.00-15.50
Aluminum clips, mixed	14.50-15.00	15.00-16.00
Old aluminum sheet	13.00-13.50	13.50-15.00
Aluminum cast*	13.00-13.50	13.50-15.00
Aluminum borings, turnings, clean dry basis, less than 1% zinc and less than 1% iron	13.25-13.75	13.00-14.50

*Including clean crankcases and pistons.

Source: American Metal Market, March 10, 1971 and July 16, 1973.

downward. It should be noted that these are prices paid by the scrap dealer and not the smelter.

Table III-10 lists the smelters' wholesale buying prices in 1973 as compared to 1971. There has been substantial increase in scrap prices during the two-year period. Aluminum scrap prices vary, depending on location and type of scrap. Clippings usually carry a premium as they are desirable as raw material for billets. Preparation costs for the scrap dealer are around 2-3¢/lb, and the dealer usually offers 60 percent of that offered by the secondary dealer.

The scrap market is a competitive market and the price is determined by the forces of supply and demand.

2. The Secondary Aluminum Market

The secondary aluminum smelters use the scrap they buy to produce various alloys. The markets of secondary aluminum products, their types, and their price determinants are all described below.

a. Markets for Secondary Aluminum

The major markets for secondary products are castings and extrudings. The characteristics of each of these markets is briefly described.

(1) Castings. Market-casting is the only fabricating process that requires the aluminum to be in a liquid state. In the casting process, liquid aluminum is poured or forced into a mold, which is the shape the metal will take. The metal is allowed to solidify and is then heat treated and aged. The product of these operations is called a "casting."

There are almost 3,000 producers of aluminum castings in the United States. They can be classified on the basis of either ownership or process. There are two ownership structures among foundries--captive shops and custom jobbers. Captive shops produce castings for their own consumption; for example, GM owns foundries that produce castings for use in automobiles. Custom jobbers are independent operations that produce castings for commercial sale.

On the basis of technological process, specialization foundries are classified as sand casting, permanent mold casting, and die casting. Die casting is the most rapidly growing of the three segments.

Of the markets for castings, the transportation industry is the largest. In the transportation sector, the automobile industry is the most important. Other sizable castings markets are machinery, defense, and home appliances.

There is a unique relationship between secondary smelters and the casting industry. The secondaries rely upon the casting industry to consume 90 percent of their output. At the same time, however, the casting industry depends on smelters for the major portion of its supplies. Secondary smelters supply 70-80 percent of the aluminum used by the casting industry; primaries account for the remainder. Of the casting segments, die casting is the important consumer of secondary aluminum.

(2) Extrudings. In the extrusion process, billets are converted into tubing, rod, and bar. The billet is heated and placed in an extrusion process. In the press, the heated billet is forced through a die under great pressure. The aluminum comes out in approximately the same shape as the die opening. Heat treating, stretching, contour rolling, and aging follow the extrusion steps. The building and construction category represent approximately 65 percent of the extrusion market. Transportation and the electrical market also buy significant volumes of extruded products. The extruding industry, which consists of 175 plants, represents a much smaller market for secondary aluminum than does the castings industry.

(3) Other Markets. The only other significant market for secondary production is the steel industry. The steel industry purchases deoxidizers from the secondaries. The characteristics of the steel industry are well documented and will not be presented in this report.

b. Types of Secondary Aluminum Products and Production

In contrast to the primary aluminum product industry, the secondary aluminum product industry has extremely limited product lines. These products can be classified by shape or alloy.

(1) Shape. In terms of shape, secondary aluminum products can be classified as ingot and sows, hot metals, notched bars and shot, and billets.

Ingots are the most important of the shapes produced. Secondaries sell 15-lb and 30-lb ingots to the casting industry with the 30-lb size being the more popular. An ingot has several notches which permit the caster to divide each ingot into smaller segments. Sows which usually weigh 1000 lb. are also a product form designed for the casting industry.

To cast aluminum it has to be in a liquid state. For this reason, casters find it economically advantageous to buy aluminum in molten form (hot metal) rather than buying ingots and having to remelt them. Smelters have supplied foundries with hot metal since 1964.

Billets are product forms designed for the extruding industry. Cylindrical in form, their outside diameter may vary from 3 to 33 inches. Standard lengths for billets run 24 to 72 inches.

Notched and shot bars are used as de-oxidizers by the steel industry. Notched bar is typically produced in 5-lb shapes, while shots are produced as small pellets.

(2) Alloy. In terms of alloy composition, secondary aluminum products can be categorized as aluminum-copper, aluminum-copper-silicon, aluminum-

silicon and other alloys. Table III-11 contains volume and percentage figures on the production (1975) of secondary aluminum smelters disaggregated by major alloy group.

Aluminum-copper alloys include the No. 12 alloy. The No. 12 alloy was the most popular product in pre-World War II times, but has since become much less important. In 1975, No. 12 alloy accounted for 2.6 percent of total secondary smelter production. Other aluminum-copper alloys accounted for 1 percent of total secondary smelter production in 1975.

Aluminum-copper-silicon alloys include No. 380 alloy which is, by far, the most important secondary smelter product. In 1975, No. 380 alloy accounted for 54 percent of total smelter output. Other aluminum-copper-silicon alloys made up 7 percent of smelter production in 1975.

Aluminum-silicon alloys include No. 360. Aluminum-silicon alloys have high fluidity and excellent corrosion resistance. In 1975, No. 360 alloy accounted for 9.3 percent of total smelter production. In the same year, other aluminum-silicon alloys made up 5 percent of smelter production.

The residual category "other" includes pure (97.0%) aluminum and steel deoxidizers, as well as other alloys. In 1975, pure aluminum was 1 percent of total smelter output, while steel deoxidizers accounted for 3 percent of smelter production.

The total amount of secondary aluminum produced in the United States has risen sharply since 1960. The rate of growth has outstripped the overall growth rate in the economy. While growth is rapid, the industry also exhibits highly cyclical patterns. Table III-12 presents secondary aluminum production levels for the 1960-1975 period, and Table III-13 shows the secondary aluminum production as a percentage of primary production for the 1960-1975 period.

c. Secondary Aluminum Prices

Despite the fact that there are many firms in the secondary aluminum industry, it is dominated by a few large firms. The pricing behavior of the primary producers is discussed first as it influences the price the secondaries charge for their products.

(1) Primaries' Price Structure. Discussion of primaries' prices must be made in terms of list, transaction, and effective prices. List prices are the prices quoted by the aluminum product producers. Transactions prices are the prices per unit which appear on the buyers invoice, i.e., the price actually paid. The effective price is an artificial construct that makes allowance for free service, credit conditions, price on scrap buy-back, and all other conditions of sale. It is possible that the transaction prices of two producers may be the same, while their effective prices could differ. From the buyer's point of view, effective price is the one that is most meaningful.

TABLE III-11

SECONDARY ALUMINUM PRODUCTION IN 1975

	Short Tons*	Percentage
No. 12 alloy and variations	13,332	2.6
Other aluminum-copper alloys	4,730	0.9
No. 380 and variations	275,030	53.8
Other aluminum-copper-silicon	36,401	7.1
No. 360	47,418	9.3
Aluminum-silicon alloys	27,897	5.5
Pure (97%) aluminum	4,673	0.9
Deoxidizers	17,098	3.3
Other products	85,196	16.6
TOTAL	511,775	100.0

*Gross weight includes alloying elements.

Source: U.S. Bureau of Mines

TABLE III-12

SECONDARY ALUMINUM PRODUCTION LEVELS, 1960-1975

Year	Short Tons*	Percentage
1960	281,964	100.000
1961	294,976	104.615
1962	383,645	136.062
1963	437,337	155.104
1964	472,291	167.500
1965	500,264	177.421
1966	536,731	190.354
1967	571,578	202.713
1968	635,192	225.274
1969	633,997	224.850
1970	588,820	208.828
1971	606,457	215.083
1972	680,064	241.188
1973	762,096	270.281
1974	679,462	240.975
1975	511,775	181.504

*Weight includes alloying elements.

Source: U.S. Bureau of Mines.

TABLE III-13

SECONDARY PRODUCTION AS A PERCENTAGE OF PRIMARY PRODUCTION, 1960-1975

Year	Percentage
1960	14.00
1961	15.49
1962	18.11
1963	18.91
1964	18.50
1965	18.16
1966	18.08
1967	17.48
1968	19.51
1969	16.71
1970	14.81
1971	15.45
1972	16.50
1973	16.83
1974	13.86
1975	13.19

Source: Aluminum Association and U.S. Bureau of Mines.

List prices of the primary ingot are 'target prices.' Target pricing is a method by which firms estimate the direct and indirect costs of producing a product (based on a normal capacity utilization rate) and add an allowance for profit margin which will generate a target rate of return on investment. List prices are stable and do not respond to market conditions. A list price series is published by the American Metal Market in Metal Statistics.

A transactions price, the price at which the sale actually occurs, is usually lower than the list price, but in times of demand-crunch (for example, September 1973 to November 1974), the transaction price can be greater than list price. Since February 1972, Metals Week has been reporting a transactions price.

No series on effective prices is published. An approximation of movements in effective prices can be obtained by looking at the scrap buy-back agreements the primaries have with the non-integrated fabricators (to whom they sell ingot). During periods of demand-crunch, the primaries pay lower than market prices for the scrap they buy back (or alternatively raise toll conversion charges). By accepting lower than market price for their scrap, the fabricators are, in a sense, raising the effective prices for the ingot they buy from the primaries.

To summarize, list prices are a function of costs and are relatively inflexible, while transaction and effective prices are more responsive to demand conditions.

(2) Relationship of Secondary and Primary Prices. Primary producers do compete in secondary markets. This competition ensures that effective primary and secondary prices for a given alloy are close (list prices, however, can and do differ). Given that the primary producers dominate the industry, the secondary industry is necessarily a price follower of the primary industry.

(3) Secondaries' Price Structure. In the secondary industry, list prices are greater than the transaction prices. In contrast to the primary industry, however, secondary list prices are somewhat sensitive to market conditions. As a consequence, list prices in the secondary industry do provide a reasonable approximation of transaction prices. American Metal Market publishes list prices for secondary producers in Metal Statistics. Published figures for secondary transactions or effective prices are not available.

Table III-14 presents the price series for No. 380 alloy (the most popular secondary product), and for primary 99.5 percent virgin ingot. Comparison of these price series cannot be made directly for the following reasons:

1. The products are different

2. Both the prices are list series and not transactions (or effective) series.

TABLE III-14

SECONDARY AND PRIMARY PRICES, 1960-1975

(¢/lb)

Year	Secondary[1]	Primary[2]
1960	24.67	27.23
1961	22.56	25.46
1962	21.20	23.88
1963	21.10	22.62
1964	22.05	23.72
1965	24.21	24.50
1966	24.74	24.50
1967	24.75	24.98
1968	25.02	25.57
1969	26.82	27.18
1970	27.72	28.72
1971	27.92	29.00
1972	27.72	26.45
1973	30.58	25.33
1974	50.18	34.06
1975	43.87	39.79

[1]No. 380 secondary ingot prices.

[2]Primary (99.5%) ingot prices.

Source: American Metal Market.

It is seen that secondary list prices are lower than primary list prices. In periods of shortage of primary aluminum, secondary list prices exceed primary list prices. However, primary transaction and effective prices, during such periods, are greater primary list price.

F. PRETREATMENT STANDARDS AND THE COSTS OF COMPLIANCE

1. Recommended Preliminary Pretreatment Standards

The Environmental Protection Agency (EPA) is promulgating interim final pretreatment standards for the secondary aluminum industry pursuant to Sections 307(b) of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1317(b), 86 Stat. 816 et seq.; P.L. 92-500). These standards apply to existing sources introducing pollutants into publicly owned treatment works (POTW).

The principal sources of wastewater in the secondary aluminum industry are: ingot and shot cooling, wet scrubbing of fumes from demagging, and the wet million of residues, such as dross and slag.

The pretreatment control levels are presented in Table III-15. Oil and grease are the pollutants limited for metal cooling, aluminum for fume scrubbing wastewater, and aluminum and ammonia for residue million wastewater.

2. Costs of Compliance

Compliance costs for meeting pretreatment standards and achieving zero discharge were provided by the EPA. These costs were provided on a plant-by-plant basis as incremental capital and operating costs based on model treatment plants with two plant sizes: large - 33,600 tons per year; small - 15,265 tons per year. Tables III-16 and III-17 present incremental capital and operating costs for pretreatment and zero discharge. We have not reviewed the costs, as the backup information was unavailable.

One of the POTW dischargers (Plant 17) shows a relatively high level compliance cost for pretreatment as the treatment plant includes ammonia air stripping to take care of ammonia levels in the discharge from this plant. The ammonia air stripper was estimated as requiring capital investment of $250,000.

For a number of plants (Plants 1, 5, 12, 15, 16, and 17) zero discharge was achieved by switching to a dry process such as the Derham process. The incremental costs do not allow for cost advantages that might result from lower material consumption and increased productivity claimed for the process. We understand that, for the remainder of the plants, zero discharge is achieved by total recycle of the water used at the plant.

TABLE III-15

PRELIMINARY PRETREATMENT CONTROL LEVELS

(metric units, mg/l)

Waste Stream	Effluent Characteristic	Pretreatment Levels: Maximum for any 1 day	Pretreatment Levels: Average of daily values for 30 consecutive days shall not exceed
Metal Cooling	Oil and Grease	100.0	100.0
Fume Scrubbing	Aluminum	100.0	50.0
Residue Milling	Aluminum	100.0	50.0
	Ammonia	100.0	50.0

Source: Pretreatment Supplement - Development Document for Secondary Aluminum, EPA, August 1976.

TABLE III-16

COSTS OF COMPLIANCE WITH PRETREATMENT STANDARDS FOR SECONDARY ALUMINUM SMELTERS DISCHARGING TO A POTW

(last quarter 1975)

Plant No.	Capital Investment ($)	Annualized Operating Costs ($)
1	87,900	22,430
2	8,300	3,370
3	8,300	3,370
4	8,300	3,370
5	--	--
6	5,700	2,560
7	5,700	2,560
8	5,700	2,560
9	87,900	22,430
10	9,100	1,760
11	5,700	2,560
12	87,900	22,430
13	5,700	2,560
14	--	--
15	100,800	37,530
16	92,500	34,160
17	349,800	185,570
18	8,300	3,370

Source: EPA

TABLE III-17

COSTS OF ACHIEVING ZERO DISCHARGE FOR SECONDARY ALUMINUM SMELTERS DISCHARGING TO A POTW

(last quarter 1975)

Plant No.	Capital Investment ($)	Annualized Operating Costs ($)
1	173,700	52,200
2	48,200	13,140
3	48,200	13,140
4	48,200	13,140
5	143,800	43,160
6	29,400	9,040
7	29,400	9,040
8	29,400	9,040
9	84,200	23,140
10	--	--
11	29,400	9,040
12	173,700	52,200
13	29,400	9,040
14	29,400	9,040
15	252,900	88,740
16	204,700	75,600
17	204,700	75,600
18	48,200	13,140

Source: EPA

Plants for which no costs were provided by the EPA had the necessary pollution abatement equipment in place.

G. BASELINE ANALYSIS AND PROJECTIONS

In this section, we establish a financial profile for POTW dischargers in the secondary aluminum industry prior to the imposition of pretreatment or zero-discharge standards. We quantified the financial characteristics on a plant-by-plant basis using a deterministic process to simulate conditions as of the last quarter of 1975. We contacted the Aluminum Recycling Association in Washington to verify the baseline financial characteristic generated by our model. The model results were in reasonable agreement. We then made aggregate industry projections to evaluate how much these conditions are likely to change in the future, using a time-series trend analysis.

1. Process Economics Model Structure

ADL has developed a process economics model for the secondary aluminum industry. Given basic characteristics, such as production, corporate structure, product type, scrap type, and demagging practice, the model generates the following financial information: (a) cost by category; (b) revenues; (c) pretax profits; (d) posttax profits; and (e) cash flows.

2. Financial Results

Using data on plant characteristics supplied by the EPA and ADL model we simulated financial conditions in 1975 for 18 POTW dischargers. Table III-18 presents the characteristics of these plants. Plant 7 differs from the other plants in that it produces shot; the other 17 plants produce ingots or ingots and hot metal.

Table III-19 presents, in cents per pound of product (alloy No. 380 ingot or shot), the cost structure for the 18 POTW dischargers. Plants 14, 15, and 17 are dross producers and have the lowest scrap costs--20.49¢/lb. Plant 7 uses higher grade scrap and hence their scrap costs are higher--24.5¢/lb. The remaining plants do not use dross in their scrap mix and have intermediate scrap costs--22.58¢/lb. Alloying element costs include copper and silicon additions and amount to 3.5¢/lb; these costs are included in the other materials cost category which also includes costs for fluxes and maintenance materials. There are no alloying element costs for the shot producers. Production costs range from 31.89 to 35.34¢/lb.

Table III-20 presents baseline profits and cash flow for these 18 plants. We based our analysis on No. 380 alloy being the representative product. The revenues of 38¢/lb taken here make an allowance of 6¢/lb for discounts from list price (approximates 44¢/lb) and freight. Similarly, we assumed a revenue stream of 34¢/lb for shot producer.

TABLE III-18

PLANT CHARACTERISTICS

Plant	Annual Output in Short Tons	Corporate Structure	Product Type	Scrap Type	Demagging Practice
1	9,000	0	0	0	0
2	21,000	1	0	0	1
3	30,000	1	0	0	1
4	21,000	1	0	0	0
5	6,000	0	0	0	0
6	6,000	0	0	0	0
7	12,600	0	2	0	2
8	9,000	0	0	0	0
9	12,000	0	0	0	1
10	24,000	0	0	0	0
11	6,000	0	0	0	1
12	12,000	0	0	0	0
13	15,000	0	0	0	0
14	9,600	1	0	1	0
15	42,000	1	1	1	0
16	60,000	1	1	0	0
17	34,200	1	1	0	0
18	22,800	1	1	1	0

Notes: Corporate Structure Code . . 0 = single plant
1 = part of a multiplant enterprise

Product Type Code . . . . . 0 = ingot
1 = ingot and molten
2 = shot

Scrap Type Code . . . . . . 0 = no dross or minimal dross
1 = dross

Demagging Practice Code . . 0 = CL_2 or Derham
1 = ALF_3 or K_3ALF_6
2 = no demagging

Source: U.S. Environmental Protection Agency.

TABLE III-19

BASELINE COSTS OF PRODUCTION BY MAJOR CATEGORY

(¢/lb)

Plant	Scrap	Other Materials	Labor	Utilities	Selling and Administrative	Interest Expense	Taxes (non-income) and Insurance	Depreciation	Total Cost
1	22.58	4.18	4.05	1.10	0.84	0.28	0.17	0.46	33.66
2	22.58	4.42	2.90	1.10	1.26	0.27	0.15	0.41	33.08
3	22.58	4.49	3.31	1.10	1.26	0.29	0.19	0.53	33.75
4	22.58	4.60	3.94	1.10	1.26	0.31	0.26	0.70	34.74
5	22.58	4.02	3.31	1.10	0.84	0.24	0.07	0.20	32.37
6	22.58	4.02	3.31	1.10	0.84	0.24	0.07	0.20	32.37
7	24.51	0.58	4.47	1.16	0.75	0.26	0.17	0.47	32.27
8	22.58	4.31	4.41	1.10	0.84	0.31	0.25	0.68	34.49
9	22.58	4.59	4.97	1.10	0.84	0.31	0.25	0.69	35.34
10	22.58	4.12	3.15	1.10	0.84	0.26	0.13	0.36	32.53
11	22.58	4.42	4.41	1.10	0.84	0.27	0.15	0.41	34.18
12	22.58	4.27	4.97	1.10	0.84	0.30	0.22	0.61	34.89
13	22.58	4.05	3.00	1.10	0.84	0.25	0.09	0.24	32.15
14	20.49	4.29	4.90	1.27	1.26	0.30	0.23	0.64	33.38
15	20.49	4.15	3.94	1.60	1.26	0.27	0.15	0.41	32.28
16	22.58	4.10	3.31	1.43	1.26	0.26	0.12	0.33	33.39
17	22.58	4.25	4.84	1.43	1.26	0.29	0.21	0.57	35.44
18	20.49	4.20	3.37	1.60	1.26	0.28	0.18	0.49	31.89

Source: Arthur D. Little, Inc., estimates.

TABLE III-20

BASELINE PROFITS AND CASH FLOW

(¢/lb)

Plant	Revenue	Cost	Gross Profit	Net Profit	Cash Flow
1	38.20	33.66	4.54	2.73	3.19
2	38.20	33.08	5.12	3.07	3.48
3	38.20	33.75	4.45	2.67	3.20
4	38.20	34.74	3.46	2.07	2.77
5	38.20	32.37	5.83	3.50	3.70
6	38.20	32.37	5.83	3.50	3.70
7	34.20	32.27	1.93	1.16	1.62
8	38.20	34.49	3.71	2.23	2.91
9	38.20	35.34	2.86	1.72	2.41
10	38.20	32.53	5.67	3.40	3.76
11	38.20	34.18	4.02	2.41	2.82
12	38.20	34.89	3.31	1.98	2.60
13	38.20	32.15	6.05	3.63	3.87
14	38.20	33.38	4.82	2.89	3.53
15	38.20	32.28	5.92	3.55	3.96
16	38.20	33.39	4.81	2.89	3.21
17	38.20	35.44	2.76	1.66	2.23
18	38.20	31.89	6.31	3.79	4.28

Source: Arthur D. Little, Inc., estimates.

3. Industry Projections

The three major determinants of the industry's financial conditions are the price at which it can sell its product, the quantity of the product it can sell, and the price it pays for scrap. The first two variables determine industry revenue and the third variable is a major determinant of cost.

In projecting the future values of these variables, difficulties arise with respect to the data on the price variables. To project a variable, historical time-series data on which to base such predictions must be available. The time-series data available on secondary product prices consist of list prices. These prices generally exceed transaction prices (used in the process model). However, for the secondary ingot, transaction and list prices move together. Therefore, the projected rate of increase in the transactions price should be roughly the same as the projected rate of increase for the list prices.

A different problem occurs in connection with scrap prices. The price series on scrap is based on dealers' prices. To approximate smelters' buying prices (used in the process model), the value added by the dealer must be included. Dealers' buying prices and smelters' buying prices do not always move together. For example, dealers' relative margins increase in times of crunch, and their effect will not appear in the price series. Consequently, there is a possible source of bias in using dealers' prices as the basis for predictions.

To summarize, it should be noted that the prices projected for the product and scrap are not the same as those used in the process model. Nevertheless, since the prices projected are good proxies for those used in the model, the projections are valid.

a. Product Price Projections

The secondaries produce a variety of alloys. Of these alloys, No. 380 is the most important and therefore we chose to project its price. An examination of actual secondary prices showed prices declining slightly in the early years and then rising almost continuously. Given this pattern, we felt that making price a quadratic function of time would be the most appropriate form. Such a form would provide for one inflection in the curve.

We confirmed this hypothesis by statistical experimentation. Using annual data for the 1960-1975 period, we tried a variety of functional formulations and the quadratic proved the most acceptable on the basis of standard statistical criteria. The estimated quadratic trend equation is shown below with the t values placed in the parentheses below the coefficient:

$$\text{PRICE PD} = \underset{(8.04)}{26.62} - \underset{(-2.19)}{1.96}\ \text{TIME} + \underset{(3.73)}{0.19}\ \text{TIME 2} \qquad (3)$$

$R^2 = .80$

where

PRICE PD = list price of No. 380 alloy
TIME = trend variable 1 in 1960, 2 in 1961, 3 in 1962, etc.,
TIME 2 = squared values of the trend variable.

The overall fit of the equation is excellent. The R^2 indicates that 80 percent of the variation in product prices can be explained by the equation. Both the trend variables are significant as demonstrated by their t values.

Utilizing equation (3) we generated price predictions for the 1976-1978 period. The predicted price for No. 380 alloy is presented below (¢/lb).

Year	Price
1976	48.5
1977	53.2
1978	58.3

b. Scrap Price Projections

Data on dealers' buying prices for scrap clippings and cast scrap are available. Both types of scrap are major components of secondaries' consumption, and movements in these prices mirror each other. We decided to project the price for scrap clippings.

Historical scrap prices revealed little variation, except for a sharp rise in 1974. Given the miniscule variation in the data, it is not surprising that, statistically, the scrap trend equation was poor. Because of their relationship to product prices, scrap prices can also be best described as a quadratic function of time. The equation is shown below:

$$\text{PRICES P} = \underset{(7.09)}{13.57} - \underset{(-0.87)}{0.45} \ast\text{TIME} + \underset{(0.68)}{0.02} \ast\text{TIME 2} \qquad (4)$$

$R^2 = 0.09$

where

PRICES P = dealers' buying price for scrap clippings, and
TIME = trend variable.

The overall fit of the equation and the contribution of the individual variables are poor as indicated by the R^2. Only 9 percent of the variation in prices can be explained by the equation. However, scrap price variations have been very small and so errors in prediction are not a matter for serious concern Utilizing Eq. (4), we projected dealers' buying prices (¢/lb) for aluminum clippings:

Year	Price
1976	11.70
1977	11.95
1978	12.24

c. Quantity Projections

We used a number of different trend formulations to determine the best trend equation for projecting the annual production by secondary smelters. Of these formulations, the linear (shown below) was the best:

$$\text{QUANTITY} = \underset{(8.23)}{329{,}411} + \underset{(5.88)}{24{,}309.3} \ {*}\text{TIME} \qquad (5)$$

$$R^2 = .71$$

where

QUANTITY = annual production in short tons by secondary smelters,
TIME = trend variable.

The fit of the equation is good. The equation can explain 71 percent of the variation in annual smelter production. The t value for the trend variable indicates that it is highly significant.

Using equation (5), we predicted quantities (annual short tons) for the 1976-1978 period:

Year	Quantity
1976	742,669
1977	766,978
1978	791,288

d. Analysis of Result

The time-series analysis we conducted provides two types of information: (1) it can indicate whether the base year 1975 was typical; and (2) it can provide growth rates in the key variables.

A comparison of the historical predicted and actual data will indicate whether or not 1975 was a typical year. Deviations of the actual value from the trend value result from the effect of cyclical or irregular forces. Therefore, if the 1975 predicted (or trend) value is considerably different from the actual 1975 value, this indicates that 1975 was an unusual year.

The predicted list price of No. 380 alloy was 44.2¢/lb in 1975. The actual list price in 1975 was 43.9¢/lb. Therefore, as far as product prices are concerned 1975 was a typical year.

The predicted dealer price for scrap clippings was 11.5¢/lb in 1975; the actual price was 10.4¢/lb. Once again, the effect of cyclical irregular forces did not seem to be particularly powerful in 1975.

The predicted production figure for 1975 is 718,400 short tons. The actual production was 511,800 tons. Therefore, 1975 was a year in which production fell considerably below normal due to the effect of cyclical or irregular forces. One would therefore expect industry to enjoy a relatively rapid growth in sales and production as sales picked up from the cyclical low.

In conclusion, therefore, 1975 was in some ways a poor year for the industry. Future conditions should be better in terms of production. Scrap prices, however, may be slightly less favorable (i.e., relatively higher) than they were in 1975.

Turning now to the question of growth rates in the variables, one can see that product prices are predicted to grow at a far more rapid rate than scrap prices. Between 1976 and 1978 (2-year period), product prices are predicted to grow by an amount equal to 20.3 percent versus a 4.6 percent increase for the same period in scrap prices. Quantity is predicted to increase 6.5 percent in the two-year period (1976-1978).

The trend growth rates in prices and quantity seem to indicate very favorable conditions for the industry. These projections, however, do not take into account structural shifts in the industry. The increasing participation of primaries in the secondary markets, for example, will erode secondary sales and reduce product prices below the predictions. Nevertheless, future conditions on the whole are likely to remain favorable for the industry.

H. ECONOMIC IMPACT ANALYSIS

In this section, we have quantified the economic effect of meeting pretreatment or zero-discharge standards. Economic impacts are those deviations from the baseline scenario that result from the standards. The immediate impact of the standards will be on the POTW discharging plants of the secondary aluminum industry. Once the plant and industry effects have been quantified, the resulting secondary effects on communities, trade, and the like, can be quantified recursively.

1. Price Effects

a. Probable Price Increases

While traditionally competitive, the secondary aluminum industry has exhibited a moderate increase in the concentration of market power. In its report on aluminum prices (September 1976), the Council on Wage and Price Stability stated that the secondary aluminum industry is workably competitive. It also indicated that the secondaries are involved in close competition with the primaries, particularly in such markets as deoxidizing material and hot metals, and even in the alloy market, especially the low-copper alloys. Effective secondary and primary prices parallel one another, with the secondaries in the role of price takers.

The secondary aluminum industry, in essence, is a subset of the aluminum industry. Furthermore, not all the plants in the secondary are affected by pretreatment or zero-discharge standards. It is therefore unlikely that prices will increase as a result of compliance.

We note that compliance costs for both pretreatment and zero-discharge are small--less than 0.3¢/lb.

Tables III-21 and III-22 show the compliance costs (on a ¢/lb basis) as a percentage of product price for pretreatment and zero discharge. The compliance costs as a percentage of product price, in all cases, is lower than 1 percent.

b. Secondary Effects

As there is little or no price increase as a result of compliance, the secondary effects are minimal.

2. Financial Effects

As explained earlier, it is unlikely that the impacted plants will pass along the increased costs through price. Therefore, they will have to absorb these costs. We examined the effect of the cost absorption on profits and cash flow, and then considered the sources of funds available to finance the compliance-related investment. Both are discussed below.

a. Profit and Cash Flow Effects

The effects of either pretreatment or zero discharge on cash flow are extremely small. Table III-23 shows the effect of pretreatment on pretax profit and cash flow. Plant No. 17 would suffer the largest impact with profits decreasing 9.8 percent and cash flow 7.3 percent. No other plant would show a decrease in profits or cash flow of more than 4 percent.

Table III-2 shows the effect of zero-discharge compliance on profits and cash flow. In general, the effects here are much more deleterious than

TABLE III-21

PRETREATMENT COMPLIANCE COST IN RELATION TO PRODUCT PRICE

Plant	Compliance Cost (¢/lb)	Product Price (¢/lb)	Compliance Cost as a Percentage of Product Price (%)
1	0.12	38.00	0.33
2	0.01	38.00	0.02
3	0.01	38.00	0.01
4	0.01	38.00	0.02
5	0.0	38.00	0.0
6	0.02	38.00	0.06
7	0.01	34.00	0.03
8	0.01	38.00	0.04
9	0.09	38.00	0.25
10	0.0	38.00	0.01
11	0.02	38.00	0.06
12	0.09	38.00	0.25
13	0.01	38.00	0.02
14	0.0	38.00	0.0
15	0.04	38.00	0.12
16	0.03	38.00	0.07
17	0.27	38.00	0.71
18	0.01	38.00	0.02

Sources: U.S. Environmental Protection Agency and Arthur D. Little, Inc., estimates.

TABLE III-22

ZERO-DISCHARGE COMPLIANCE COST IN RELATION TO PRODUCT PRICE

Plant	Compliance Cost (¢/lb)	Product Price (¢/lb)	Compliance Cost as a Percentage of Product Price (%)
1	0.29	38.00	0.76
2	0.03	38.00	0.08
3	0.02	38.00	0.06
4	0.03	38.00	0.08
5	0.36	38.00	0.95
6	0.08	38.00	0.20
7	0.04	34.00	0.11
8	0.05	38.00	0.13
9	0.10	38.00	0.25
10	0.0	38.00	0.0
11	0.08	38.00	0.2
12	0.22	38.00	0.57
13	0.03	38.00	0.08
14	0.05	38.00	0.12
15	0.11	38.00	0.28
16	0.06	38.00	0.17
17	0.11	38.00	0.29
18	0.03	38.00	0.08

Sources: U.S. Environmental Protection Agency and Arthur D. Little, Inc., estimates.

TABLE III-23

PRETREATMENT COMPLIANCE IMPACTS ON PROFIT AND CASH FLOW

(¢/lb)

Plant	Pretax Profits Baseline	Pretax Profits Impact	Pretax Profits Percent Change	Cash Flow Baseline	Cash Flow Impact	Cash Flow Percent Change
1	4.54	4.42	2.74	3.19	3.11	2.34
2	5.12	5.11	0.16	3.48	3.47	0.14
3	4.45	4.44	0.13	3.20	3.19	0.11
4	3.46	3.45	0.23	2.77	2.77	0.17
5	5.83	5,83	0.0	3.70	3.70	0.0
6	5.83	5.81	0.37	3.70	3.69	0.35
7	1.93	1.92	0.53	1.62	1.62	0.38
8	3.71	3.70	0.38	2.91	2.90	0.29
9	2.86	2.77	3.26	2.41	2.36	2.32
10	5.67	5.66	0.06	3.76	3.76	0.06
11	4.02	4.00	0.53	2.82	2.81	0.45
12	3.31	3.21	2.83	2.60	2.54	2.16
13	6.05	6.04	0.14	3.87	3.87	0.13
14	4.82	4.82	0.0	3.53	3.53	0.0
15	5.92	5.88	0.75	3.96	3.93	0.68
16	4.81	4.78	0.59	3.21	3.20	0.53
17	2.76	2.49	9.83	2.23	2.07	7.30
18	6.31	6.31	0.12	4.28	4.28	0.10

Source: Arthur D. Little, Inc., estimates.

TABLE III-24

ZERO-DISCHARGE COMPLIANCE IMPACTS ON PROFIT AND CASH FLOW

Plant	Pretax Profits			Cash Flow		
	Baseline	Impact	Percent Change	Baseline	Impact	Percent Change
1	4.54	4.25	6.38	3.19	3.02	5.46
2	5.12	5.08	0.61	3.48	3.46	0.54
3	4.45	4.42	0.49	3.20	3.19	0.41
4	3.46	3.43	0.91	2.77	2.76	0.68
5	5.83	5.47	6.17	3.70	3.48	5.83
6	5.83	5.75	1.29	3.70	3.66	1.22
7	1.93	1.89	1.86	1.62	1.60	1.32
8	3.71	3.66	1.35	2.91	2.88	1.04
9	2.86	2.77	3.37	2.41	2.36	2.40
10	5.67	5.67	0.0	3.76	3.76	0.0
11	4.02	3.95	1.87	2.82	2.78	1.60
12	3.31	3.09	6.58	2.60	2.47	5.03
13	6.05	6.02	0.50	3.87	3.86	0.47
14	4.82	4.77	0.98	3.53	3.50	0.80
15	5.92	5.82	1.78	3.96	3.90	1.60
16	4.81	4.75	1.31	3.21	3.18	1.18
17	2.76	3.65	4.00	2.23	2.16	2.97
18	6.31	6.28	0.46	4.28	4.26	0.40

Source: Arthur D. Little, Inc., estimates.

was the case for pretreatment. However, the impacts are still relatively minor. Plant 12 would suffer the largest percentage decrease in profits--6.6 percent, and Plant 5 would suffer the largest percentage decrease in cash flow--5.8 percent.

b. Capital Availability

Funds to finance pretreatment investment can come either from internal sources (cash flow) or external sources (debt). Table III-25 shows capital investment associated with pretreatment as a percentage of a one-year cash flow. In only four cases would the percentage exceed 4 percent. For these four plants, the percentages range from 14.1 percent (plant No. 12) to 23.0 percent (plant No. 17).

Table III-26 provides the same measures for zero-discharge related capital investment. The impact here would be relatively more severe. The highest figure for capital investment as a percentage of annual cash flow is 32.4 percent (plant No. 5). Nevertheless, in both the pretreatment and zero-discharge cases, there would be no capital availability problem according to this criterion.

An alternative way of evaluating the capital availability issue and of examining the possible magnitude of any displacement of productive investment would be to examine the ratio of pretreatment- or zero-discharge-related investment to normal productive investment. Assuming that productive investment is 2 percent of the value of shipments (a figure taken from the *1972 Census of Manufactures*, published by the U.S. Department of Commerce, Bureau of the Census) would imply an annual productive investment of $5.22 million by the impacted plants. Aggregate pretreatment-related investment is $0.88 million, which represents 17 percent of the productive investment figure. If the firms were to make this investment in addition to normal productive investment, the ratio of investment to the value of shipments would rise from 2 to 2.3 percent in the year of the investment.

Zero-discharge-related investment totals $1.61 million, which amounts to 31 percent of the annual productive investment made by the impacted plants. If the firms were to make this investment in addition to productive investment, the ratio of investment to the value of shipments would increase from 2 to 2.6 percent.

3. Production and Employment Effects

In this section, we have examined the effect of proposed standards on production curtailment, plant closures, employment, and industry growth.

a. Production Curtailment

The costs of compliance with pretreatment and zero-discharge standards are minimal. Furthermore, plants in the industry have excess capacity and production curtailment would increase average cost of production. Consequently, we anticipate no production curtailments.

TABLE III-25

CAPITAL INVESTMENT ASSOCIATED WITH PRETREATMENT STANDARDS IN RELATION TO PRECOMPLIANCE CASH FLOW

Plant	Capital Investment to Meet Pretreatment Standards ($)	Cash Flow	Capital Investment Associated with Pretreatment as a Percent of Annual Cash Flow
1	87,900	574,039	15.31
2	8,300	1,460,497	0.57
3	8,300	1,919,010	0.43
4	8,300	1,165,157	0.71
5	0	444,058	0.0
6	5,700	444,058	1.28
7	5,700	409,400	1.39
8	5,700	523,709	1.09
9	87,900	579,125	15.18
10	9,100	1,804,019	0.50
11	5,700	338,571	1.68
12	87,900	623,234	14.10
13	5,700	1,162,447	0.49
14	0	677,295	0.0
15	100,800	3,327,762	3.03
16	92,500	3,856,397	2.40
17	349,800	1,524,856	22.94
18	8,300	1,952,515	0.43

Sources: U.S. Environmental Protection Agency and Arthur D. Little, Inc., estimates.

TABLE III-26

CAPITAL INVESTMENT ASSOCIATED WITH ZERO-DISCHARGE STANDARDS IN RELATION TO PRECOMPLIANCE CASH FLOW

Plant	Capital Investment to Meet Pretreatment Standards ($)	Cash Flow	Capital Investment Associated with Pretreatment as a Percent of Annual Cash Flow
1	173,700	574,034	30.26
2	48,200	1,460,497	3.30
3	48,200	1,919,010	2.51
4	48,200	1,165,157	4.14
5	143,800	444,058	32.38
6	29,400	444,058	6.62
7	29,400	409,400	7.18
8	29,400	523,709	5.61
9	84,200	579,125	14.54
10	0	1,804,019	0.0
11	29,400	338,571	8.68
12	173,700	623,234	27.87
13	29,400	1,162,447	2.53
14	29,400	677,295,	4.34
15	252,900	3,327,762	7.60
16	204,700	3,856,397	5.31
17	204,700	1,524,856	13.42
18	48,200	1,952,515	2.47

Sources: U.S. Environmental Protection Agency and Arthur D. Little, Inc., estimates.

b. Plant Closings

In evaluating shutdowns, plants should be placed in specific categories as follows:

1. those plants which would not cover their variable costs; these plants will shut down since by doing so losses will be avoided;

2. those plants which would cover variable but not fixed costs; they would shut down in the long run, but the timing is difficult to predict; and

3. those plants which would continue to enjoy a profit; these plants may still shut down, but the possibility of these plants shutting down can be evaluated by discounted cash flow analysis.

As demonstrated in Tables III-23 and III-24, all the impacted plants in this study fall into the third category, i.e., even after they met the standards, they would still continue to make a profit. The issue then is whether profits have been reduced to a point low enough to force them to eventually shut down.

When a plant making a profit shuts down, it sacrifices both current and future cash flow, but obtains in return the assets tied up in the business. Therefore, a plant will continue to operate only if the discounted stream of future cash flow and the terminal salvage value exceed the funds that can be released by a shutdown.

The funds released by a shutdown include owner-financed working capital and current salvage value. Current salvage values are relatively low for the plants in the industry. Land values after clearing provide the chief source of their salvage value. Given generally unattractive locations, these salvage values are not particularly high. Given these factors and bearing in mind that the post-impact annual cash flows for the impacted plants, as seen in Tables III-24 and III-25 exceeds $300,000, it is clear that shutdown possibilities as a result of compliance are remote.

c. Employment Effects

The analysis does not indicate production curtailments or plant closures. Consequently, we anticipate no employment effects.

d. Industry Growth

Industry growth could theoretically be reduced as a result of compliance. Reductions in growth could result from the following impact effects:

1. Decreased profits (due to pretreatment-related costs) could reduce the incentive for productive investment; and

2. Increased demands on investment funds (due to pretreatment-related investments) could reduce the amount left.

The secondary aluminum industry baseline growth is likely to be quite rapid. The effect of pretreatment or zero-discharge compliance on this growth will be minimal because productive investment is unlikely to decrease. A decrease in productive investment is improbable because:

1. Pretreatment or zero discharge has little effect on profits; therefore incentive for productive investment is not affected; and

2. Pretreatment or zero-discharge investment is a relatively small percentage of cash flow and so does not significantly decrease the funds available for productive investment.

4. Resultant Effects on the Community

The pretreatment compliance will not cause shutdowns. Furthermore, compliance will have little or no effect on industry production and growth. Given the minimal economic impact of the standards, we concluded that there would be no community effects.

5. Effects on Balance of Payments

There will be no pronounced effects from pretreatment or zero-discharge standards on the domestic industry. Therefore, there is little likelihood that trade and capital accounts on the balance of payments will be affected.

6. Sensitivity Analysis

In this section, we have examined the effect of variations in certain parameters such as pollution-abatement costs and the smelting costs.

Pollution-abatement costs, as provided by the EPA, are applicable to green field sites. We estimate the capital costs could run 50-75% higher and operating costs 10-25% higher than those predicted by the EPA because the treatment plant equipment will have to be retrofitted in many cases in crowded plants. Hence, the effect of an increase of 75% in capital costs and a 25% increase in operating costs on impact parameters was considered (Case 1 of Table III-27).

The costs of production of aluminum alloy ingot are ADL estimates based on models. We have checked our costs with a few plants, and we feel that costs of processing the scrap into ingots (exclusive of scrap

TABLE III-27

SENSITIVITY OF IMPACT PARAMETERS TO POLLUTION ABATEMENT AND PRODUCTION COSTS: SECONDARY ALUMINUM

Standards / Impact Parameter	Base Case	Case 1	Case 2	Case 3
PRETREATMENT				
Price Effects	Price increase unlikely			
Profitability				
(a) Pretax Profits	0-9.8	0-12.3	0-14.3	0-7.5
(b) Cash Flow	0-7.3	0-9.1	0-9.2	0-6.1
Capital Requirements & Availability				
(a) Pollution Abatement Investment/Annual Cash Flow	0-22.9	0-40.1	0-28.9	0-18.2
(b) Total Pollution-Abatement Investment	877,600	1,535,800	877,600	877,600
ZERO DISCHARGE				
Price Effects	Price increase unlikely			
Profitability				
(a) Pretax Profits	0-6.6	0-8.0	0-8.7	0-5.5
(b) Cash Flow	0-5.8	0-7.3	0-6.4	0-4.9
Capital Requirements & Availability				
(a) Pollution Abatement Investment/Annual Cash Flow	0-32.4	0-56.7	0-35.5	0-29.5
(b) Total Pollution-Abatement Investment	1,606,900	2,812,075	1,606,900	1,606,900

Note: Case 1 - Pollution Abatement Costs - Capital costs increased 75%; operating costs increased 25%.
Case 2 - Production costs (exclusive of scrap) increased 10%.
Case 3 - Production costs (exclusive of scrap) decreased 10%.

costs) are within ±10%, for the last quarter of 1975. The effect on impact parameters of a ±10% variation in the costs of processing is covered in cases 2 and 3.

Table III-27 summarizes the effect on impact parameters for variations in pollution abatement and production costs for secondary aluminum.

The maximum reduction in profits as a result of compliance with pretreatment standards for the variation cases range from 7.5-14.3 percent and reduction in cash flow varies from 6.1 to 9.2 percent. Pollution-abatement investment as a percentage of annual cash flow ranges from 18.2 to 40.1 percent. The total capital requirements for POTW dischargers in the secondary aluminum industry ranges from $877,600 to $1,535,800.

For zero discharge, the maximum reductions in pretax profits for the various cases range from 5.5 to 8.7 percent and reductions in cash flow run between 4.9 and 7.3 percent. Pollution abatement as a percentage of annual cash flow ranges from 29.5 to 56.7 percent. The total capital requirements to meet zero discharge range from $1,606,900 to $2,812,075.

7. Limits of the Analysis

The main limitation of this analysis can be attributed to the modelling approach used to quantify impacts. Such an approach was necessitated by the paucity of specific financial data from individual plants. Modelling will not predict the financial characteristics exactly for a particular plant; however, it will allow for basic differences between plants and provide reasonable estimates of financial characteristics against which the impact of compliance can be assessed.

It should be emphasized that the analysis has evaluated impacts due to the proposed pretreatment standards alone.

The costs of compliance with pretreatment and zero-discharge standards were provided by the EPA and are subject to all the limitations of their cost analysis.

IV. SECONDARY COPPER SMELTING AND REFINING

A. INTRODUCTION

In Chapter IV, we assess the economic impact of proposed pretreatment standards on the secondary copper smelting and refining subcategory of the Nonferrous Metals Processing Point Source Category--SIC 3341. These standards are applicable to plants discharging process wastewaters to Publicly Owned Treatment Works (POTW's).

B. TECHNOLOGY

The secondary copper industry is comprised of numerous enterprises which collectively employ many of the recovery and refining processes used in primary plants, as well as many other processes that are unique to the industry. Effective methods are used for identifying and segregating all types of scraps according to widely accepted standard classifications. Segregated scrap and waste materials may require some preliminary processing to remove both valuable and deleterious associated constituents.

Smelting, melting, alloying, pyrorefining and, to some extent, electrorefining are common methods used to produce secondary copper, but specific processing techniques usually depend on the physical and chemical nature of the raw materials being used.

1. Raw Materials

The basic raw material of the secondary copper industry is copper and copper-base alloy scrap. About two-thirds of the amount of secondary copper recovered is in the form of either brass or bronze, while one-third is in the form of copper alone.

Both the secondary copper industry and the American Society for Testing and Materials have made a continuing effort over the past 35 years or so to reduce the number of varieties of copper-base alloys. At one time, there were more than 500 different commercial copper-base alloys made in the United States and the problem of sorting and grading mixed scrap with no uniform standards acquired major importance in the industry. Of the many hundreds of copper-base alloys that become available for reuse through scrap recovery channels, 54 primary types of copper-bearing scrap are now included in the standards published by the National Association of Recycling Industries (NARI, previously NASMI). These are listed in Table IV-1.

Copper sold to manufacturers is returned to the producers either as new scrap or old scrap. New scrap is returned directly from the manufacturers or via collectors and scrap brokers. Old scrap is returned from consumers of copper in used products. Purchased scrap may move from one location to another within the same company, or from one company to another.

TABLE IV-1

TYPES OF COPPER-BEARING SCRAP

1. No. 1 Copper Wire	28. Yellow Brass Rod Ends
2. No. 2 Copper Wire	29. Yellow Brass Turnings
3. No. 1 Heavy Copper	30. Mixed Unsweated Auto Radiators
4. Mixed Heavy Copper	31. Admiralty Brass Condenser Tubes
5. Light Copper	32. Aluminum Brass Condenser Tubes
6. Composition or Red Brass	33. Muntz Metal Tubes
7. Red Brass Composition Turnings	34. Plated Rolled Brass
8. Genuine Babbitt-Lined Brass Bushings	35. Manganese Bronze Solids
9. High-Grade, Low Lead Bronze Solids	36. New Cupro-Nickel Clippings and Solids
10. Bronze Papermill Wire Cloth	37. Old Cupro-Nickel Solids
11. High-Lead Bronze Solids and Borings	38. Soldered Cupro-Nickel Solids
12. Machinery or Hard Red Brass Solids	39. Cupro-Nickel Turnings and Borings
13. Unlined Standard Red Car Boxes (Clean Journals)	40. Miscellaneous Nickel Copper and Nickel-Copper-Iron Scrap
14. Lined Standard Red Car Boxes (Lined Journals)	41. New Monel Clippings and Solids
15. Cocks and Faucets	42. Monel Rods and Forgings
16. Mixed Brass Screens	43. Old Monel Sheet and Solids
17. Yellow Brass Scrap	44. Soldered Monel Sheet and Solids
18. Yellow Brass Castings	45. Soldered Monel Wire, Screen and Cloth
19. Old Rolled Brass	46. New Monel Wire, Screen and Cloth
20. New Brass Clippings	47. Monel Castings
21. Brass Shell Cases without Primers	48. Monel Turnings and Borings
22. Brass Shell Cases with Primers	49. Mixed Nickel Silver Clippings
23. Small Brass Arms and Rifle Shells, Clean Fired.	50. New Nickel Silver Clippings and Solids
24. Small Brass Arms and Rifle Shells, Clean Muffled (Popped)	51. New Segregated Nickel Silver Clippings
25. Yellow Brass Primer	52. Old Nickel Silver
26. Brass Pipe	53. Nickel Silver Castings
27. Yellow Brass Rod Turnings	54. Nickel Silver Turnings

It is evident that copper flows back to the producers along several cyclic paths. Some involve only producers, some manufacturers and producers, and some producers, manufacturers, and consumers. The cyclic period may range from a few days to several decades. Copper consumed in dissipative uses, such as paint bases and chemicals, is permanently consumed and is never returned for processing.

The flow of copper scrap is shown in Figure IV-1 which indicates the channels through which much of the reclaim copper returns to industry from scrap dealers and fabricators. Heavily populated industrial areas are the principal source of copper scrap, and most of the plants that treat secondary materials are located nearby.

2. Sorting Scrap

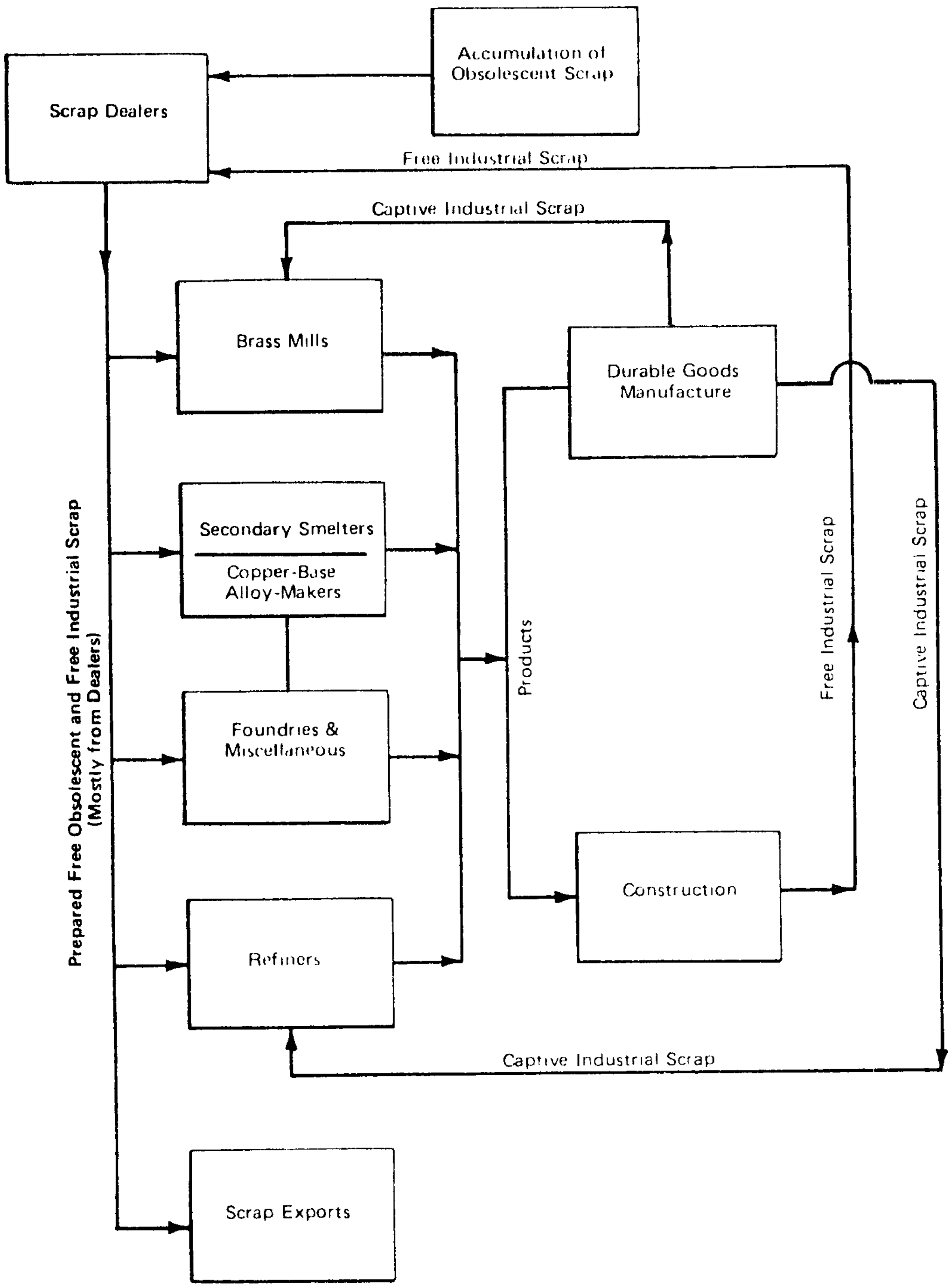
Sorting scrap according to the classification listed in Table IV-1 is one of the most important steps in raw material preparation and the ultimate recovery of secondary copper. Proper sorting of scrap requires quick and accurate methods of identification. Segregation practice varies with the amount and variety of materials involved. Small scrapyards usually segregate scrap to a few basic types, but larger yards find it practicable to segregate their scrap completely, according to all of the common grade specifications. Several methods have been developed for determining the approximate compositions of the thousands of items that pass through the scrapyards. The complexity of the tests ranges from simple recognition of known compositions to chemical analyses. Tradesmen usually acquire a great skill in applying simple tests to identify the common types of scrap. However, the simplest method of segregating scrap is by recognition of its source or previous use. For example, it is easy to classify copper wire, radiator fins, brass fittings, etc., by simple recognition. More nondescript items can often be identified by manufacturers trademark or parts numbers.

3. Scrap Preparation

Before the scrap metal is blended in a furnace to produce the desired ingots, the raw material must be sampled. In addition, removal of some of the non-metallic contaminants or, in some instances, preprocessing the raw material to yield more efficient and economical utilization of the scrap may be desirable. These processes may be either mechanical, pyrometallurgical or hydrometallurgical.

a. Mechanical Preparation

Many types of scrap are prepared for smelting or melting by mechanical methods. Insulation and lead sheathing are removed from electrical conductors by special stripping machines, or occasionally by hand-stripping. Wire, thin-plate, and wire-screen scraps are usually compressed into briquettes, bales, or bundles for convenient handling in subsequent processing



Source: U. S. Bureau of Mines

FIGURE IV-1 FLOW OF COPPER SCRAP IN UNITED STATES (Excluding Industrial Homescrap) operations. Loose materials are usually preferred for chemical recovery processes. Large, solid items are reduced in size by pneumatic cutters, electric shearing machines, or manual sledging. Brittle springy turnings, or borings, and long chips are crushed in hammer mills or ball mills to reduce bulk for easier handling in subsequent operations. Slags, drosses, skimmings, foundry ashes, spills, and sweepings are ground to liberate prills or other metallics from the gangue so that they can be recovered by gravity concentration or other physical means. Small-size materials, such as drillings, clippings, and crushed turnings, are often run over a magnetic separator to remove tramp iron.

b. Pyrometallurgical Preparation

(1) Sweating. Many types of scrap must be given a preliminary furnace treatment before actual melting and refining operations begin. Oil and other organic impurities and moisture are removed by heating in muffle furnaces or kilns. Scrap, such as journal bearings, lead-sheathed cable, and radiators, can be sweated to remove babbitt, lead, and solder as valuable byproducts which would otherwise contaminate a melt. However, if a melt is made requiring a substantial amount of the sweated constituents, the scrap may be added directly to the melt without sweating.

The simplest furnace for sweating is the conventional sloping-hearth, gas-fired furnace. Batches of charge materials are put into the furnace at the highest point on the hearth. Low-melting constituents liquefy and flow to the low end of the hearth and out of the furnace into a collecting pot. Sweated scrap is raked over the hearth until it is free of all low-melting metals and removed from the furnace so that new charge can be added. The process can be a continuous or batch operation. The sweated babbit, lead, or solder may be made into white-metal alloys, used for lead and tin addition to copper-base alloys, or sold as produced to the refiner. Heavy lead-covered cable, railroad journal bearings, and similar bulky scraps are most frequently sweated in stationary sloping-hearth-type furnaces.

Occasionally sweating is done in a pot by dumping the scrap into a pot of alloy which absorbs the low-melting constituents. The sweated scrap is raked from the pot when sweating is completed.

Small-size scrap can be sweated efficiently in a rotary kiln. Scrap is charged continuously at the elevated end of the kiln. The burner is placed at the discharge end so that combustion gases flow counter-current to the scrap. The tumbling action is effective in removing liquefied constituents which flow out of the furnace and collect in a holding pot. Solid scrap discharges through a screen section fastened directly to the discharge end. Heavy scrap is not sweated by this method because of excessive wear to the furnace.

Some types of soldered items are more difficult to sweat completely because much of the solder remains in folds and seams, even when melted. Several types of furnaces have been developed to solve this problem. One is a reverberatory furnace with a shaking grate of steel rails about the size of the furnace floor. The grate is pivoted at one end and the other end is pushed up and down in a fast reciprocating motion by a motor drive connected to the grate through a crank and arm linkage. The reciprocating action moves the scrap over the grate in a series of short, rapid jerks, which also shake the liquid solders from the scrap. The molten solder falls to the floor of the furnace, where it flows to a low corner and into a collecting sump.

Some melters prefer a tunnel furnace in which the scrap is placed in trays or racks and carried through a heated tunnel by an endless conveyor. Some of the solder melts and falls from the scrap while inside the furnace tunnel. The remaining liquid solder is freed when the scrap spills from the conveyor onto a tilted screen. Solder and the metal flowing from the tunnel floor collect in a sump.

(2) Blast Furnace or Cupola. The blast furnace is used extensively in secondary smelters for smelting low-grade copper and brass scraps, refinery slags, drosses, and skimmings to produce black copper (80-90% Cu). When used primarily for melting scrap, with little or no reduction of oxidized materials, it is called a cupola. Operations and equipment are similar to those used for smelting copper ores and concentrates. Differences arise mainly because most of the metals in scrap and wastes are already in metallic form.

The conventional secondary copper blast furnace is a top-charged, bottom-tapped shaft furnace heated by coke burning in a blast of air introduced through tuyeres placed symmetrically around the bottom of the shaft. The upper section of the shaft is cylindrical, but the lower section (the bosh) is an inverted, truncated cone tapering to two-thirds the diameter of the upper shaft. A crucible is located directly below the bosh to collect molten metal and slag produced in the smelting zone above. Refractories for the in-wall, or well, are usually fireclay brick from top to bottom. A layer of chilled slag takes the place of refractories in the water-jacketed steel bosh. The crucible is lined with magnesite or chrome brick.

The charge is normally made up from copper-bearing scrap, a slag, sinter, limestone flux, millscale, and coke. The scrap may contain irony-brass and copper, fine insulated wire, motor armatures, foundry sweepings, slags, drosses, and many other similar low-grade materials. The minimum profitable copper content for the charge is about 30 percent. Fine materials are usually sintered to produce a strong sinter cake or densified by other means, such as briquetting. Coke is used as a fuel and reducing agent. Limestone and millscale are added as fluxes to produce an iron silicate slag. Sulfur in the coke or other charge materials combines with copper. The introduction of sulfur is avoided as much as possible in the secondary blast furnace by using low-sulfur coke.

Charge materials are heated as they descend through rising hot gases, becoming semiplastic and then liquid when they reach the region in the furnace called the smelting zone. Metallic constituents, such as brass and copper, may actually melt above the normal smelting zone. Limestone and iron oxide fuse in the smelting zone and form a molten slag which mixes with the metals in the turbulence of the gases. Molten materials drip through the coke bed and into the crucible below. The coke remains virtually unchanged until it reaches the tuyere zone, where it burns to carbon monoxide and carbon dioxide. Part of the carbon dioxide is reduced to carbon monoxide by the white-hot coke near the tuyeres.

The gases rising through the shaft are composed of CO, CO_2, and N_2. The relative amount of CO_2 increases at higher elevation in the shaft; the coke and air ratio is adjusted to provide a reducing atmosphere. Oxides of the base metals either dissolve in the slag or fume off; many are reduced and dissolved in the copper. The black-copper product of the blast furnace may contain zinc, lead, tin, bismuth, antimony, iron, silver, nickel, or other metals contained in the scrap. Many of these are fumed off and recovered as baghouse dust.

Both slag and metal are usually tapped through a launder into a reverberatory where they are held in a quiescent state to allow more complete separation of metal and slag. Some operators tap metal intermittently and slag continuously.

Some difficulties are experienced with the operation of secondary blast furnaces of conventional design. These difficulties are eliminated by inverting the bosh section of the furnace so that it flares out at its bottom rather than the top. The inverted-bosh design has been adopted by a number of secondary smelters.

(3) Converter. Converters are pear-shaped or cylindrical vessels used for converting copper matte, an impure mixture of iron and copper sulfides, into blister copper. They are made with steel shells lined with calcined magnesite, either in monolithic or brick form. Tuyeres are provided for blowing air into the molten charge when the converter is tilted to the "blow" position.

The converting step transforms the black copper (80-90% Cu) produced in the blast furnace to blister copper. In contrast to the converting operation in a primary copper smelter where two blowing stages are needed, only the second stage, or "blister" blow, is required in secondary copper converting.

c. Hydrometallurgical Preparation

Concentrating is the process by which metallics in materials are recovered through differences in density. Although the total loss of metal is greater than in the blast furnace, this method is well adapted to fines that might be blown out of the furnace. It involves grinding, screening, and gravity separation in a water medium.

4. Melting and Alloying Intermediate Copper Scrap

About two-thirds of the secondary copper production in the United States is used in ingot plants and foundries to make brass and bronze alloys by simple melting and refining methods. The amount of refining is usually small if the scrap is well sorted so that impurities or excess alloy constituents can be diluted to composition specifications with high-grade scrap or virgin metals. These conditions are not easily maintained, however, because of certain impurities, such as aluminum and silicon, which have exceedingly low permissible limits in the product. In the red brass series, for example, maximum acceptable limits for aluminum and silicon are 0.005 and 0.003 percent, respectively. Both aluminum and silicon are difficult to remove by refining. Dilution to specifications is not practicable because of the relatively large proportions of high-grade scrap or virgin metals needed to dilute to these low limits. Impurities such as iron, sulfur, cadmium, bismuth, zinc, phosphorus, and manganese are not so difficult to remove by common refining techniques.

Melting, refining, and alloying procedures are essentially the same regardless of the type of furnace used. Operations are usually controlled by personnel who have acquired considerable skill through years of experience. Although indicating and controlling pyrometers are used extensively, a furnace operator may control the furnace temperature primarily by observing the color and consistency of the slag and metal when stirred with a rod. The degree of refining is indicated by the set of samples taken during various phases of the operation. This technique is common in copper refineries where it is used to indicate the various stages of oxygen and sulfur removal. Progress is also determined quite accurately by other physical changes, such as the appearance of fractured surfaces (hardness, color, grain size, and texture). Experienced operators can estimate alloy compositions very closely and detect the presence of a number of impurities by these methods.

a. Fluxing

Fluxing is an essential part of both melting and refining. The basic functions of fluxes are essentially the same, whether used in reverberatory, rotary, or crucible furnaces.

Two general types of fluxes used for melting and refining scrap copper are: (1) non-metallic fluxes, and (2) fluxing alloys.

Non-metallic fluxes may be solid, liquid, gaseous, or mixtures. Some are used for the sole purpose of protecting the surface of a melt from the prevailing atmosphere. Others refine by mechanical or chemical actions.

Fluxing alloys comprise one or more active agents, such as phosphorous or lithium in a base such as copper. This type is used either to refine the melt by deoxidation, add a definite amount of an alloy constituent, or both.

b. Reverberatory Furnace

Melting, alloying, and refining can be done in any one of several furnaces usually selected for a given application on the basis of quality and quantity of scrap and waste materials to be processed. The reverberatory furnace is a box-like, refractory-lined enclosure designed to heat the charge by both conduction and radiation. The furnace is usually made with magnesite brick walls, fused magnesite bottoms, and suspended magnesite brick roofs. Capacities of stationary reverberatories used in secondary smelters range from a few thousand pounds to 100 tons or more. The side- or end-charged, arched-roof tapping furnace is used most extensively.

Charge materials used in making brass or bronze ingot should contain a minimum of 40% copper to prevent excess slag accumulation, which reacts with the refractories and shortens the life of the furnace lining. Charges comprise batches or lots of scrap selected to produce a melt of the desired composition with a minimum of flux and as little dilution of metal constituents as possible. Scrap is charged at regular intervals until the furnace is filled to capacity. Melting is more efficient if light scrap is densified by balling or briquetting. Oxidation and volatilization losses from copper-base alloys are usually kept to a minimum by rapid melting in a slightly oxidizing atmosphere with a fairly fluid slag cover.

Reverberatory slags usually contain metal values that can be recovered in the blast furnace. Slags produced by small secondary plants are frequently sold to primary smelters on the basis of copper content only. Some plants grind the slag and recover metallic constituents in milling operations before the slag is sold.

c. Rotary Furnace

The rotary furnace is designed to provide efficient melting and refining and convenient pouring of fairly large melts. The capacity of the rotary furnace ranges from several tons to 50 or more tons of non-ferrous metals. Many melters believe that it has a particular advantage over stationary furnaces for melting loose or bailed light scrap, because the rotary mixing action promotes better heat transfer to the melt and causes a more rapid coalescence of melted globules.

The rotary furnace is a cylindrical steel shell with insulating material placed inside next to the shell. Magnesite or chrome-magnesite brick is used for lining. Frequently a monolithic lining of either refractory is used. Brick linings are usually backed with a cushion of grain magnesite.

Linings may last 100 or more heats, and the capacity of the furnace may increase many thousands of pounds, because the lining erodes from slag and by abrasion; heat losses also increase proportionately. The cylinder is mounted with its axis in a horizontal position and is supported by piers and trunnions at each end. It is fired by oil or gas burners inserted through either or both trunnions. The flame is directed lightly on the surface of the flux cover. One or more charging ports, large enough for admitting fairly bulky scrap, are located on the side of the cylinder, and a pouring spout is attached to the furnace at a level slightly higher than the slag level when the furnace is fully charged. Charging, alloying, fluxing, and sampling techniques are essentially the same as for the reverberatory furnace.

d. Crucible Furnace

A fairly large tonnage of secondary copper is produced in crucible furnaces. These may be heated by gas, oil, coke, or electricity. The once popular, coke-fired pit furnace is seldom used today, however.

Crucible furnaces are used in the secondary-copper industry for melting clean, well-segregated scrap--mostly in foundries. Very little fire-refining is performed in crucibles. Non-metallic fluxes are used for a protective covering, but alloy fluxes may be added as a refining agent and as a means of introducing some constituents into the melt.

Scrap is usually melted in crucibles by the puddling method; that is, melting enough scrap to make a liquid puddle, then forcing freshly added scrap below the surface of the melt until it becomes part of the molten body.

Crucible furnaces may be either stationary or tilting; the latter are more convenient and much preferred. The gas- or oil-fired tilting furnace comprises a refractory-line, cylindrical steel furnace shell with a crucible mounted inside. It has two pivot shafts extending horizontally from opposite sides of the cylinder near the top so that the pouring distance, when tilting the furnace, will be as short as possible. The crucible is mounted in the center of the furnace shell and is small enough to provide an annular combustion space between the crucible wall and the refractory lining. Gas or oil burners, with flexible fuel supply lines, are mounted in a position to direct the flame tangentially into the combustion space. This prevents excessive flame erosion of the crucible or furnace lining.

Electric crucible furnaces (including high- and low-frequency induction and resistance types) may be either tilting or stationary, but the tilting type is used now almost exclusively. Electrical resistance furnaces are very seldom used for melting and refining scrap outside of the laboratory. Induction furnaces are particularly well-suited for melting relatively small batches rapidly. Some of the larger low-frequency types are now being made with capacities equal to the larger rotary furnaces. The crucible for a high-frequency induction furnace is placed symmetrically in the center of a hollow helical, water-cooled copper induction coil. The crucible is thermally and electrically insulated from the coil, but the metal charge in the crucible is heated by electrical-eddy currents which are induced into the metal by a high-frequency magnetic field generated in the induction coil. The eddy currents are of such a magnitude that the charge metal actually melts because of its electrical resistance to the heavy current.

Low-frequency or line-frequency induction furnaces generate heat by the same basic principles, but in a slightly different way. Heat is generated in the melt by very high currents induced into the charge metal by the primary winding of a transformer that is coupled magnetically to the melt through an insulated, water-cooled iron core. The furnace crucible is fashioned in such a way that the melt forms in a channel or heating duct which, when filled with molten metal, comprises a short-circuited secondary turn of the transformer. The induced voltage causes very high currents to circulate in the metal. The metal is heated because of its resistance to the flow of electrical currents. Primary and secondary magnetic fields react with each other to produce mechanical forces which may cause considerable turbulence in the melt. The turbulence has the desirable effect of causing rapid mixing and heat transfer to all portions of the melt. Some furnaces are equipped with electromagnetic pumps which can tap metal from the crucible by the same forces which cause the stirring.

e. Furnace Applications

The stationary reverberatory is the most practicable furnace for making very large tonnages of standard alloys from scrap. The rotary furnace is more flexible than the reverberatory, but the capacity is limited to moderate tonnages. Tilting and stationary crucible furnaces, either gas or electric, are used to advantage for making small melts of special alloys. Electric induction furnaces are increasing in popularity at ingot plants and foundries where special high-grade alloys are made. Advantages of electric furnaces include higher melting speed and precise temperature control. These help to defray the relatively higher cost of electrical equipment.

Open-flame stationary or rotary reverberatory furnaces give greater fuel efficiency than furnaces using indirect heating, but oxidation and volatilization losses may be higher if the melt is not protected by a slag or flux cover.

f. Mold Line Equipment

Melting furnaces are always associated with other equipment designed to receive the melt. Melts are usually tapped from reverberatories and rotaries into feeder ladles which transport the metal to a mold line for making conventional ingots. The mold line is a series of ingot molds placed on a rack which may be stationary or movable. If stationary, the molds are filled with metal poured from a portable ladle.

An automatic mold line is an endless mold-conveying system in line with, or on the periphery of, a large circular rack known as a casting wheel. The casting wheel may carry either ingot molds for alloy melts or anode molds, provided that the furnace operation is a step in the production of electrolytic copper.

Melting and refining furnaces are operated frequently in conjunction with a plant or mill to produce items such as rods, tubes, sheet, and similar products. When they are, the furnaces are tapped into special billet molds to make shapes for subsequent milling operations.

Automatic mold lines convey each mold to a position where it is filled from a header or feeder ladle. Some ingot makers use special auxiliary mold-conditioning devices in which the molds are sprayed with a mold wash and then dried thoroughly before the ingot is cast. Automatic devices are often used to sprinkle ground charcoal in the molds to provide a special smooth top on the ingots. In the Kaufman Controlled Process, metal is melted and ingots are cast in an atmosphere of nitrogen to eliminate the need for charcoal topping. Cast ingots are usually cooled by water spray or other means and dumped from molds and racked for shipping.

5. Refining High-Grade Copper Scrap

a. Fire Refining

Copper products smelted from low-grade scrap, slags, drosses, and sludges are eventually brought together with other impure copper products for fire refining. Although some degree of refining is done in smelting and melting furnaces, the final pure copper is made by fire refining.

The refining furnace is either a stationary reverberatory or cylindrical tilting type with a capacity of 20 to 300 tons. The most satisfactory refractory materials are magnesite brick walls, fused magnesite bottoms, and suspended magnesite roofs for the stationary furnace; magnesite brick is used throughout for rotary furnaces. Super-duty firebrick is used extensively in furnace areas that are not in contact with molten metal. Full fire refining is often required to produce billets, slabs, cakes and bars for manufacturing plates, sheets, rods, and so forth. Copper ingots are produced for making copper-base alloys.

Fire refining is only partly completed when the metal is to be cast as anodes for further electrolytic refining; that is, when the copper contains other valuable metals which can be recovered from the cell sludge.

The first step in the refining operation is to melt pigs of black copper, blister copper, and high-grade scrap rapidly in an oxidizing atmosphere, until the melt begins to "work." "Working" is a bubbling action accompanying impurity oxidation.

The melt is skimmed after working has ceased, and a sample is obtained for observing the "set," which is a characteristic shape and appearance of the solidified sample, indicating relative amounts of some constituents within very narrow limits. It may be necessary to saturate the melt with Cu_2O to reduce the amount of other impurities by oxidation. Ordinarily the melt will contain considerable Cu_2O after working stops. The Cu_2O is reduced by skimming the melt; covering the surface with a reducing agent, such as anthracite, charcoal, or coke; and then "poling" the metal. "Poling" is used to reduce the Cu_2O to copper. The ends of green wooden poles are inserted below the surface of the melt, where they decompose and expel gases and carbon and produce much turbulence in the melt. The gases act as a flux to purge some impurities from the melt, and the carbon reduces Cu_2O to copper. The "pitch" is indicated by the appearance of a fracture surface of a sample. The surface exhibits a texture of coarse brownish-red crystals, if the metal still contains large amounts of Cu_2O. As reduction continues, the fracture surface changes to a fine crystalline texture, then to a fibrous appearance, and finally, when poling is finished, it acquires a satiny orange-red sheen. The copper is then "tough pitch" and is ready for casting ingots, slabs, wire bars, and billets.

b. Electrolytic Refining

Some silver and gold may still remain in the copper after fire refining. These metals and others cannot be refined by oxidizing and poling, and, if present in substantial amounts, require electrolytic refining. The impure copper is cast in the shape of anodes which will contain about 99 percent copper and small amounts of silver, gold, lead, selenium, tellurium, and other metals. During electrolytic refining, the copper from the anodes is deposited on copper cathodes, and impurities are either dissolved in the electrolyte or deposited as a sludge.

The electrolytic purification is carried out in a spacious tankhouse containing a great many rectangular cells through which the electrolyte, composed of sulfuric acid and copper sulfate, is circulated and in which the anodes are hung. Thin, copper starting sheets, produced in a separate circuit by electrodeposition on stainless-steel blanks, alternate with the anodes and cathodes dissolves the impure anodes and deposits purer copper anodes and become the cathodes. Passage of the electric current between the anodes and cathodes dissolves the impure anodes and deposits purer copper on the cathodes. The latter are usually removed after 14 days when they are about 0.375 inch thick. Anodes remain in the tanks twice as long. Impurities, such as silver and other precious metals, remain in the slimes which settle to the tank bottom and are recovered when the tanks are drained and cleaned. Copper and other impurities tend to build up in the electrolyte and are controlled by purification in special circuits.

Refined cathodes are withdrawn from the cells, washed, melted, alloyed, or otherwise treated in a holding furnace and cast as wirebars, cakes, billets, or other special shapes. "Tough pitch" conditions are controlled by oxidation, poling and atmospheric control within the furnace to produce an oxygen content of 0.025% to 0.030%. Other types of deoxidation are also practiced. Considerable No. 1 scrap (99% copper) can be melted and refined in the cathode refining furnace.

C. INDUSTRY SEGMENTATION

There are approximately 70 producers of either brass and bronze ingots or secondary refined copper in the United States. Most of these producers are small, individually owned plants, and thus it is difficult to obtain accurate information concerning their operations. As a result, in this section of the analysis we have concentrated on 45 of the larger plants, which represent in excess of 95% of the production and 90% of the employment in the industry.

It seems best to segment the industry into groups of plants which may have similar processing problems. The most effective way of accomplishing this is to classify each plant on the basis of the major raw material input and the final product produced, since these two factors combined determine the process or processes used.

Based on the above considerations and for the purpose of industry characterization, we have classified the U.S. secondary copper and brass and bronze smelters and refineries into two segments in terms of type of product:

1. producers of brass and bronze ingot, billet, or con-cast ingot, and

2. producers of unalloyed copper.

With this segmentation method, the type of raw material input has to be specified, since the type of material produced normally determines this. For example, the raw material input to segment 1 is brass and bronze scrap and that to segment 2 is copper scrap.

Another benefit is gained from this particular segmentation scheme, that is, most of the plants in segment 1 are small, individually owned operations while the plants in segment 2 are usually much larger and are usually integrated forward into producing finished products for market.

1. Types of Firms

a. Concentration Ratios

Most of the firms are small, individually owned operations having only one plant, and only a few of the firms are publicly held. A minority of the firms, yet a number still representing a large fraction of the production, are either subsidiary operations of large mining companies or are subsidiaries of conglomerates. Most firms in both the alloyed copper ingot segment and the unalloyed copper segment have only one plant with only a few exceptions.

Table IV-2 presents concentration ratios for the secondary copper industry based on the 1963, 1967, and 1972 surveys of manufacturing industries taken by the U.S. Bureau of Census. Concentration ratios represent the value of shipments accounted for by the largest companies. High ratios indicate oligopolistic market power in an industry.

For the 1963-1972 period, the 4 largest firms accounted for about 40 percent of the value of shipments, the 8 largest companies accounted for 69 percent; the 20 largest for about 85 percent, and the 50 largest for almost all of the value of shipments.

TABLE IV-2

PERCENT OF VALUE OF SHIPMENTS OF COPPER AND COPPER-BASE ALLOYS ACCOUNTED FOR BY THE LARGEST COMPANIES IN THE SECONDARY COPPER SMELTING AND REFINING INDUSTRY

		Percent Accounted for by:			
Year	Value of Shipments (Million Dollars)	4 Largest Companies	8 Largest Companies	20 Largest Companies	50 Largest Companies
1963	247.2	42	62	85	99
1967	364.8	40	60	84	99+
1972	510.9	39	62	88	100

Source: U.S. Bureau of the Census, 1972.

b. Integration

In the normal sense of production, the secondary brass and bronze ingot-making segment of the industry is non-integrated. None of the smaller smelters is integrated to the point of producing a finished or semi-finished product, but basically each continues producing alloy ingots. On the other hand, many of the firms in segment 2 are completely integrated, using copper scrap as a raw material and turning out a salable finished product, such as electrical wire, valve fittings, and copper tubing.

c. Diversification

In almost all cases, the firms having plants in segment 1 have established in a moderate level of diversification. In many cases these plants are also processors of secondary aluminum and frequently secondary lead- and zinc-based materials. Oftentimes they are combined with scrap steel yard operations.

The producers of unalloyed copper (segment 2) are generally not so diversified. It must be noted, however, that many of these firms produce a number of precious metals as a byproduct or coproduct. These precious metals are derived from sources such as printed circuit boards and electrical contacts.

d. Products

The brass and bronze producers (segment 1), by and large, manufacture a wide variety of specification alloys. These alloys generally fit a series of specifications which have been outlined by both ASTM and by the Brass and Bronze Ingot Institute (BBII). The general product of segment 1 is in the form of 30-pound brass or bronze ingots. Some of these smelters also produce a series of materials in the form of shot which are sold to factories for the inoculation of gray iron. The shot may be pure copper or copper nickel alloys of various types.

The major product of segment 2 is unalloyed copper. This can be in the form of blister copper, fire-refined copper, cathode copper, wire bar, continuous cast, or as a finished product, depending on both the production scheme and the needs of the customer. Also, several precious metals are usually recovered as a result of the electrorefining to produce cathode copper.

2. Types of Plants

a. Production Levels

Plants in segment 1 vary in size from small operations producing as few as 50 tons of brass and bronze alloy per month with as few as 10 employees to large operations producing more than 1000 tons per month and employing more than 500 people. These plants are located near heavily industrialized areas which give them proximity to both a supply of scrap and a host of customers. The plants vary in age with some facilities being 40 to 50 years old with additions having been made over the years and in some cases currently underway. Plants in segment 2 are, in general, much larger than those in segment 1, producing 1500 to 18,000 tons of copper per month and employing 100 to 1800 workers.

b. Location

Plants in segment 1 are located mostly in the northeastern states, the Pacific Coast states, and the east north central states. A few plants are located in the southern and west central states. As with plants in segment 1, segment 2 plants are also located in heavily industrialized areas and are of about the same age. Most of the plants in segment 2 are located in the northeastern states with one in the South and two in Illinois.

c. Technological Level

Most plants in segment 1 generally function at relatively low technological levels as compared to other manufacturing industries. Techniques for smelting basically have not changed for 50 years, although furnaces today are much larger and are equipped with much greater heat input capability. Thus they are able to generate more output per man-hour. Techniques for preparation of scrap by means of crushers and hand-sorting are reasonably general. In some plants, turnings are prepared by crushing and drying. Slag processing to separate the metallic from the glassy components is carried out by a number of smelters who remelt their slag in cupolas, blast furnaces, or shaft furnaces.

The general efficiencies of the plants in segment 1 are low in terms of technology and energy utilization (fuel, electricity, and manpower). Heat recoveries from the furnaces are low, and many operations which could be automated are still accomplished by manual labor. By and large the reason that new companies can enter the brass and bronze business segment so readily is that the general level of operations is reasonably labor-intensive and not capital-intensive. This further tends to indicate the lack of high-level technology in the operation of this segment of the secondary copper smelting and refining industry.

The levels of technology of plants in segment 2 are generally higher than those of plants in segment 1. The plants in segment 2 are larger on the average, and thus employ larger and more advanced types of equipment.

As opposed to plants in segment 1, the general efficiencies of the plants in segment 2 are higher due to many of the operations being highly automated. The utilization of labor, power, and fuel are considerably better than in plants in segment 1.

d. Integration

In general, as with the firms, the plants in segments 1 and 2 are not integrated to any great extent, with the same exceptions as those which applied to the firms.

3. Characteristics of POTW Dischargers*

a. Production

Production levels of Publicly Owned Treatment Works (POTW) dischargers range from 300 to 15,600 tons per year. The production levels of POTW dischargers reflect the entire range of production levels for the industry. Of the 16 POTW dischargers, 12 produce brass and bronze ingots; 2 produce brass and bronze ingot and phosphor copper; 1 produces copper shot, and 1 plant produces unalloyed copper cathodes and billets. Thus, of the 16 POTW's, 15 belong to segment 1 and 1 plant to segment 2. Of the brass and bronze segment, 2 plants produce less than 100 tons a month, 9 plants between 100-500 tons a month; 3 plants 500-1000 tons a month and 1 plant produces 1000-5000 tons a month. The plant in the unalloyed copper segment produces 3500 tons of cathodes a month and 4000 tons of billets a month.

b. Location

No significant differences in location exist between POTW dischargers and non-POTW dischargers in the industry. The distribution of POTW dischargers by state is as follows: Illinois (5), New York (2), Massachusetts (2), Ohio, New Jersey, Texas, Michigan, Utah, Indiana, and Kansas (1 each).

c. Technology

With respect to technology, POTW dischargers are representative of the industry.

4. Percent of Industry Represented by Each Segment

Table IV-3 presents a breakdown of production and numbers of plants and employees represented by each segment, as well as the percentages of total industry represented by each. The table indicates the relative sizes of the plants in both segments. Segment 1 data is based on a sample of 37 large plants out of about 63 plants in the brass and bronze ingot segment. This data indicates that segment 1 represents 53 percent of the plants in the industry, 46 percent of the employees and 32 percent of the production. Segment 2 contains only 10% of the plants in the industry, but accounts for about 65% of the production and 44% of the employment. It should be noted that the plants being considered in segment 2 represent 100% of the U.S. secondary copper smelting and refining plants producing unalloyed copper.

*Based on Supplemental for Pretreatment to the Development Document for the Secondary Copper Segment of the Nonferrous Metals Manufacturing Point Source Category, EPA, August 1976.

TABLE IV-3

PLANTS, EMPLOYEES, AND PRODUCTION AND PERCENTS OF INDUSTRY TOTALS REPRESENTED BY EACH SEGMENT

Segment*	Plants: Number	Plants: Percent of Industry	Employees: Number	Employees: Percent of Industry	Production: Short Tons/Month	Production: Percent of Industry
1	37	53	4,100	46	21,000	32
2	7	10	4,000	44	43,000	65
Totals	44	63	8,100	90	64,000	97

*Segments: 1 - Producers of brass and bronze ingot, billet or con-cast.
2 - Producers of unalloyed copper.

Source: Arthur D. Little, Inc., estimates.

The POTW dischargers in segment 1 comprise 15 plants, or 41 percent of the plants in the segment on which we have information. They account for a production of 6300 tons per month or 30 percent of the segment production and employ approximately 900 people, i.e., 22 percent of the segment's employment.

The POTW dischargers in segment 2 account for 14 percent of the plants in the segment, 17 percent of the production, and approximately 17 percent of the employment.

D. FINANCIAL PROFILES

As most of the firms are either privately held or subsidiary operations of larger corporations, specific financial information on the annual profits, cash flow, or cost structures of each plant is not available. However, we have utilized the most recent data on the secondary copper smelting and refining industry (as developed in the 1972 Census of Manufactures) to assess the financial profiles of the industry. The Census data provide the following financial information on the industry:

- Value of shipments (VS) represents the net selling values, f.o.b. plant, after discounts and allowances and excluding freight charges and excise taxes.

- Cost of materials includes:

  a. the total delivered cost of all raw materials, semifinished goods, parts, components, containers, scrap and supplies consumed or put into production;

  b. the amount paid for electric energy purchased;

  c. the amount paid for all fuels consumed for heat, power, or the generation of electricity;

  d. the cost of work done by others on materials or parts furnished by the reporting establishment (contract work); and

  e. the cost of products bought and resold in the same condition.

- Capital expenditures include the cost of plant and equipment for replacement purposes, as well as for additions to productive capacity. Costs associated with plants under construction, but not in operation during the year, are also included. Capital expenditures do not include plant and equipment furnished to the manufacturer without charge by governmental or private organizations. The value of rented facilities is also excluded.

- The payroll total includes the gross earnings paid in calendar year 1967 to all employees on the payroll of reported establishments. It is based on the definition of payrolls used for calculating the federal withholding tax, and includes all forms of compensation, such as salaries, wages, commissions, dismissal pay, bonuses, vacation, and sick leave pay, and compensation in kind. It does not include employers' Social Security contributions or other non-payroll labor costs such as employees' pension plans, group insurance premiums, and workmen's compensation.

- The "value added by manufacture" figure is derived by subtracting the total cost of materials (including materials, supplies, fuel, electric energy, cost of resales and contract work done by others) from the value of shipments, including resales, and other receipts and adjusting the resulting amount by the net change in finished products and work-in-process inventories between the beginning and end of the year.

These data can be utilized to derive the following information shown in Table IV-4.

- Value added (VA)/Value of Shipments (VS). This is equivalent to value added per dollar of sales. Since the value of shipments is a measure of tonnage produced by each segment, this is also proportional to value added per ton.

- VA - Payroll (including supplementary expenses)/(VS). If local taxes, insurance, and interest charges are subtracted from this column, we obtain an estimate of pretax profit.

- Capital Expenditures (CI)/VS. This is proportional to the average rate of capital investment per ton of production.

- Variable Out-of-Pocket Costs (CV)/VS. CV is equal to cost of materials plus payroll (including supplemental expenses such as welfare and Social Security contributions). When divided by value of shipments, this gives an estimate of the out-of-pocket variable costs per dollar of sales.

Interpretation of Ratios:

VA/VS - A low ratio indicates that the difference between the value of the raw material used and that of the product produced is small.

CI/VS - A low ratio shows that there is not much capital investment, or perhaps it consists of used equipment installed by in-house labor costs, and that most capital expenditures are paid for via retained income without the use of long-term financing. It may also indicate a tendency to write off as current expenses what are really capital items.

TABLE IV-4

MEASURES OF FINANCIAL PERFORMANCE OF SECONDARY COPPER SMELTING AND REFINING INDUSTRY BASED ON BUREAU OF CENSUS DATA

Year	Payroll[1]	Materials[1]	VA[1]	VS[1]	CI[1]	VA/VS[2]	(VA - Payroll)/VS[2]	CI/VS[2]	CV/VS[2]
1967	30.3	410.9	52.7	464.3	3.5	0.11	0.05	0.01	0.95
1972	49.4	539.2	87.5	692.6	12.2	0.13	0.06	0.02	0.85

NOTE: VA - Value Added by Manufacturer
VS - Value of Shipments
CI - Capital Expenditure
CV - Variable Out-of-Pocket Costs

See text for interpretation of the ratios derived.

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[1]Million Dollars

[2]Ratio of $/$

Source: 1967 and 1972 Census of Manufactures.

CV/VS - A high ratio means low fixed charges, i.e., low book value of assets; depreciation is low; small long-term debt.

1. Profits

Table IV-4 shows that (VA-payroll)/VS is 0.05 or, in other words, value added minus payroll is about 5% of value of shipments or sales. As mentioned earlier, if local taxes, insurance, and interest charges are subtracted from this value, one can obtain an estimate of the pretax profit.

2. Annual Cash Flow

Again annual cash flow is very difficult to determine since company figures are not made public. Transactions in the secondary smelting industry are complicated and can change dramatically from month-to-month and even day-to-day.

Secondary smelters usually pay up to 75% of the purchase price of scrap in cash at the time of confirmation of shipment and the balance in 30 days. However, it may be days or even weeks before the scrap arrives at the smelter. In the meantime, smelter products are always sold on credit with payment required in 30, 60, or 90 days. Thus, a secondary smelter generally buys for cash and sells on loan credit. This financial arrangement generates a tremendous need for liquid capital and has been a powerful motivation in convincing the small family-owned smelter operators to either merge or go public.

The inventory of scrap that each smelter strives to maintain is determined by scrap availability, storage capacity, and operating cash on hand. Since the scrap material is bulky, large volumes of storage space are required. While some smelters operate with as much as a month of scrap in inventory, others operate with as little as a two-day supply. A normal scrap inventory, however, is about a two-week supply. Smelters operating with a small inventory can influence local prices when in danger of running out of scrap. When scrap does not arrive at the smelter on schedule, the operator must buy quickly from a local supplier by offering a premium price. This practice can--and often does--raise general scrap prices within the area.

3. Market Value of Assets

The market value of the assets of the large plants producing unalloyed copper (segment 2) can be reasonably high since most of these plants are quite well maintained and the technologies utilized in the plants are reasonably good. On the other hand, the assets of the secondary brass and bronze ingot makers (segment 1) are quite low unless the plant can be maintained as an operating unit. In general, the smaller plants in this segment and many of the larger ones as well have been fairly negligent in the maintenance and upkeep of their facilities. Much of the equipment is single-purpose equipment. On this basis, we believe that the larger plants can be sold at a substantial portion of book value, while many of the smaller plants would be hard-pressed to get very much more than the value of the land and buildings. In fact, if the plant were not to continue production, this value would be somewhat less than the local land costs since the land values would have to be depressed by the cost of clearing up the sites. On the other hand, if the plant can be turned over to another operator who can operate it, the value can be substantially higher.

4. Cost Structure

Cost structures vary dramatically in the industry depending on the type of scrap being utilized and the volume of operation, the diversity of the operation, and the type of overhead load. As an example, a plant utilizing a high percentage of slag metallics and breakage will have considerably higher operating costs, excluding raw material costs. However, in general, the costs of raw materials will be low enough to offset these higher operating costs and return a better-than-average profit much of the time. Typically the brass and bronze segment of the industry, in 1975, required 10-13¢ per pound for processing brass and bronze scrap into ingot (on a finished weight basis). The distribution of costs between fixed costs (such as rent, taxes, commercial and sales expenses) and variable costs (such as labor, fuel, fluxes, refractories, and maintenance) is split, so that the essentially fixed costs represent about 40 percent of the total cost or 10 to 13¢ per pound. In certain operations where relatively expensive scrap is used (which minimizes in-plant production costs) total conversion costs can be as low as 7¢, the fixed-cost expenses of which would represent about 40 percent. In plants that utilize high percentages of low metallics, the variable costs may go as high as 14 or 15¢ per pound.

In general, the sales expenses in the brass and bronze segment of the industry, except for the smallest plants, are quite similar. In the case of the small plants, they tend to be somewhat less since the plant owner often will be selling relatively small quantities of material locally, reducing his sales expenses, possibly even completely eliminating his need for a sales force. Since many of these small plants are operated by "graduates" from the scrap industry, they have excellent commercial contacts and minimize their buying expenses to an extent that the larger companies cannot.

In the case of secondary producers of unalloyed copper, smelting and refining costs are on the order of 10-15¢ per pound of copper product. Their selling expenses are held to a minimum since their product is more often "bought" than sold.

5. Constraints on Financing Additional Capital

The general constraints on financing relate to the dollars needed for a particular project. In the past several years, the larger companies with a number of claims on their capital dollars from many divisions have been reluctant to spend large sums of money for plant improvements, pollution controls, and the like. On the other hand, many of the small companies which are privately owned have been able to find the capital to make at least minimal improvements, though most capital expenditures are paid for via retained income without the use of long-term financing.

The small companies tend to do things on a less formal basis, to do a lot of "horseback" engineering, and are adept at acquiring information and technology without great expense. These people have oftentimes been able to "home-make" quite capable machinery which would have cost several times its acquired cost if it had been purchased from normal commercial sources, or if it had been engineered to their specific requirements.

In general, the larger companies and subsidiaries of conglomerates or mining companies are able to acquire the necessary funds if the profitability of the overall operation appears to warrant it in the view of the management of the company. These funds can oftentimes be raised internally, but it must be recognized that many times the call for more profitable divisions minimizes the capital investments that can be put into these secondary operations. For example, some of these secondary metals operations are owned by larger companies which also have primary metals operations. In this case, the secondary metals operation very seldom gets many opportunities to call on the capital dollars of the corporation. Basically, this is because the profit from their primary metals operation is generally better than that from their secondary metals operation. Therefore, when faced with a capital investment in their secondary metals operation, they can either close it down and absorb the fixed costs with the profit from their primary metals operation or, if the required capital investment is reasonable, they can choose to make the necessary modifications to keep the secondary metals operation running.

E. PRICE DETERMINATION

1. Scrap Market

The price of scrap is a fundamental determinant of the financial conditions of the secondary unalloyed copper and brass and bronze ingot makers accounting, as it does, for about 65 percent of the product price. The price of copper and copper-base scrap is determined by the interaction of demand and supply. The market is competitive with many participants on both the demand and supply sides. International trade in scrap, which affects supply conditions, also has an influence on scrap price levels.

a. Scrap Demand

Copper and copper-base scrap can be classified into the following categories: No. 1 wire and heavy copper; and No. 2 wire and mixed heavy and light copper; brasses; bronzes; auto radiators; and low-grade scrap and residues.

No. 1 wire and heavy copper scrap consists of high-grade scrap with a copper content greater than 99 percent. Such scrap does not have to be refined; it has to be melted. Because of its high quality it is demanded chiefly by brass and bronze ingot-makers and brass mills. This scrap category represents an important component of scrap consumed by smelters, accounting for 17 percent of smelter scrap consumption in 1974. Of the No. 1 copper scrap consumed by smelters, 45 percent was new scrap and 55 percent old.

No. 2 wire and mixed light and heavy scrap has a 96 percent copper content. This type has to be refined before it can be used to make shapes. The producers of unalloyed copper are major users of this type of scrap; other major users (chiefly new scrap) are brass mills. In 1974, this category of scrap accounted for 28 percent of scrap consumed by smelters, 61 percent of which was new.

The brasses represent a generic category that includes red brass scrap, yellow brass scrap, low brass scrap, and others. Brass scraps are consumed mainly by brass and bronze ingot-makers and brass mills. In 1974, this category of scrap accounted for 14 percent scrap consumed by smelters, 19 percent of which was new scrap.

Bronze scrap is also consumed chiefly by brass and bronze ingot-makers and brass mills. In 1974 bronze scrap accounted for 3 percent of scrap consumed by smelters. Eighteen percent of the bronze scrap consumed was new.

Radiator scrap is consumed chiefly by brass and bronze ingot-makers. A considerably smaller amount is consumed by foundries. In 1974 radiators accounted for 6 percent of scrap consumed by smelters. All radiator scrap is old.

Low-grade scrap and residues are consumed almost entirely by producers of unalloyed copper. In 1974, this category of scrap accounted for 18 percent of the total scrap consumed. Thirty-eight percent of this scrap category was new and 62 percent was old.

Table IV-5 shows scrap consumption patterns in 1974, with data broken down by scrap type and scrap consumer. Table IV-6 presents the amount of scrap consumed by smelters as well as the total amount of scrap consumed.

The quantities of copper and copper base scrap consumed have stagnated over the last 10 years. In 1965, 1,026,897 tons of scrap were consumed by producers of unalloyed copper and brass and bronze ingots, and in 1974,

TABLE IV-5

BREAKDOWN BY TYPE OF COPPER SCRAP CONSUMPTION IN 1974

(short tons)

Type of Scrap	Smelters*	Total
No. 1 - Wire and Heavy Copper	169,534	411,343
No. 2 - Wire and Mixed Copper	274,832	345,083
Brass Scrap	131,020	557,006
Bronze Scrap	26,695	33,650
Radiators	60,426	69,215
Others**	4,203	40,140
Low-Grade Scrap and Residues	320,449	321,092
Total	987,159	1,777,529

*This category includes producers of an alloyed copper and brass and bronze ingot.

**Nickel silver and cupro-nickel.

Source: U.S. Bureau of Mines.

TABLE IV-6

SCRAP CONSUMPTION LEVELS, 1965-1975

(short tons)

Year	Smelters*	Total	Percentage
1965	1,020,897	1,735,131	59
1966	1,119,072	1,867,940	60
1967	902,620	1,541,484	59
1968	963,590	1,661,574	58
1969	1,102,844	1,891,305	61
1970	1,075,052	1,749,656	62
1971	939,557	1,659,649	57
1972	962,811	1,781,274	54
1973	1,005,953	1,863,129	54
1974	987,159	1,777,529	56
1975**	672,724	1,255,541	54

*This category includes producers of unalloyed copper and brass and bronze ingot.

**Preliminary.

Source: U.S. Bureau of Mines.

987,159 tons were consumed. Preliminary figures for 1975 indicate that scrap consumption by smelters was 672,724 tons. The percentage of total scrap consumed by smelters has remained stable.

b. Scrap Supply

The supply of new domestic scrap is a function of the level of the fabricating operations in which this scrap is generated. The potential supply of old domestic scrap is a function of the stock of copper goods and their age. The actual supply is largely a function of scrap price. The higher the price of scrap, the more feasible the gathering of poorly accessible scrap.

The availability of scrap is affected in part by international trade. Exports decrease and imports increase the supply available.

Exports of unalloyed copper scrap exceed imports. In 1974, 41,342 tons of scrap were exported versus 31,109 tons imported. The major export markets are Korea, Japan, Canada, and the industrialized nations of Western Europe. The major import sources are Canada and Mexico.

Exports of copper alloy scrap also exceed imports of scrap. In 1974, 118,198 tons were exported versus 15,890 tons imported. The major export markets are the same as those for unalloyed scrap. The major source of imports is Canada.

c. Scrap Prices

The price of copper and copper-base scrap is determined by the interaction of supply and demand. The prices of various scrap types move in the same direction. Published data on scrap prices, at best, are indicative and do not pinpoint the level at which transactions actually occur.

For unalloyed copper a published price series on refinery buying prices for category 2 copper scrap is published by the American Metal Market. These are purportedly the prices the smelters pay the scrap dealers for delivered scrap. However, they usually understate actual transaction prices. This price series for the 1965-1974 period is reproduced in Table IV-7.

A published series on prices paid for brass and bronze scraps by the scrap dealer is also available. To approximate prices charged by the smelters, the dealers' processing costs, profits, and freight expenses must be included. Table IV-7 also contains a dealer price series for category 1 red brass, the scrap category most heavily consumed by brass and bronze ingot-producers.

TABLE IV-7

COPPER SCRAP PRICES

Year	Refinery Prices No. 2 Copper Scrap (¢/lb)	Dealer Prices No. 1 Red Brass Scrap (¢/lb)
1965	38.91	27.87
1966	50.09	33.06
1967	37.28	29.95
1968	38.73	27.25
1969	49.13	37.04
1970	49.19	36.27
1971	38.43	29.92
1972	31.38	29.54
1973	60.20	40.87
1974	67.75	113.76
1975	41.12	32.47

Source: American Metal Market.

2. Brass and Bronze Ingot Market

a. Demand

The major market for the brass and bronze ingot-makers is represented by the foundries which cast the ingots into various shapes. Foundry products have numerous applications among the most important of which are plumbing supplies, industrial pumps, bearings, and high-voltage switching gear.

The brass and bronze ingot-makers produce a wide range of alloys. The most popular are red brass, tin bronze, and yellow brass.

1. Red Brass - This is the most important product and includes the popular alloy 85-5-5-5 (85 percent copper, 5 percent zinc, 5 percent tin, and 5 percent lead). The red brasses accounted for 49 percent of brass and bronze ingot production in 1974.

2. Tin Bronze - This category ranks next in importance. It includes tin bronze and high lead tin bronze. In 1974, it accounted for 29 percent of total brass and bronze ingot production. Due to the tin content, it is higher priced than red brass.

3. Yellow Brass - This alloy is typically made up of 60 percent copper, 38 percent zinc, 1 percent tin, and 1 percent lead. In 1974, it accounted for 6 percent of total ingot production. Due to the high zinc content, it is a relatively low-value product, priced beneath the red brass.

4. Other Products - This category, which includes manganese bronze, aluminum bronze, silicon bronze and conductor bronze, accounted for 16 percent of the total brass and bronze production in 1974.

Table IV-8 contains the production levels for the major brass and bronze ingot categories in 1974.

The market for brass and bronze ingot has exhibited a sharp decline since the mid-1960's. Table IV-9 presents production levels for brass and bronze ingots in the United States for the 1965-1975 period. The table shows that production declined from a high of 347,127 tons in 1966 to 261,553 tons in 1974. The preliminary production figures for brass and bronze ingot in 1975 show a significant drop in production to 186,420 tons.

b. Supply

The supply of ingots is competitive. The brass and bronze ingot-makers are numerous and small. The amount they supply is tied to the price they pay for scrap and the price their ingots can command.

TABLE IV-8

BREAKDOWN BY TYPE OF BRASS AND BRONZE INGOT PRODUCTION IN 1974

Category	Short Tons
Red Brass	126,836
Tin Bronze	73,977
Yellow Brass	15,460
Other	40,132
TOTAL	256,405

Source: American Metal Market.

TABLE IV-9

BRASS AND BRONZE INGOT PRODUCTION LEVELS (1965-1975)

Year	Production (Short Tons)
1965	328,952
1966	347,127
1967	309,900
1968	316,073
1969	321,336
1970	258,732
1971	262,588
1972	268,067
1973	284,482
1974	261,553
1975*	186,420

*Preliminary.

Source: U.S. Bureau of Mines.

c. Prices

Published price series for major brass and bronze ingots are available. These series reveal close correlation between ingot and scrap prices. The published prices are list prices. Transactions usually take place at about a 5 percent discount from the list price.

Table IV-10 contains price series for No. 115, the popular red brass ingot, and No. 405, the popular yellow brass ingot. These are list prices. Transaction prices are usually discounted from list prices.

3. Market for Unalloyed Copper Ingot

a. Demand

The immediate market for unalloyed copper is constituted by the semi-fabricating industries. The major semifabricating markets are the wire and brass mills. In 1974 wire mills consumed 67 percent of total refined copper, and the brass mills consumed 31 percent.

Demand by semifabricators is, in turn, linked to demand by the end-use industries. The end-use industries include electrical and electronic products, building construction, transportation, consumer, and general products, industrial machinery and equipment, and ordnances and accessories. The fact that these sectors are highly cyclical is reflected by fluctuations in refined copper consumption.

b. Supply

There are two supply sources for unalloyed copper products--primary and secondary. Primary unalloyed copper is produced from blister, while secondary copper is produced from scrap. The large copper producers mainly use blister, although they may smelt and refine scrap in their operations. This group, referred to as the primary producers, includes Anaconda, ASARCO, Kennecott, Phelps Dodge, Magma, White Pine, and Inspiration. There is a second group of producers who predominantly use scrap. They are referred to as the secondary producers and include Amax, Cerro, Southwire, Reading, and Chemetco.

Table IV-11 presents the amount of refined copper produced from scrap in comparison with the total refined copper production for the 1965-1974 period. Refined copper from scrap accounted for 20-30 percent of the total refined copper production.

c. Prices

During the post-World War II period selling of refined copper, most of the sales and purchases of refined copper have been made directly or indirectly on the basis of one of two price regimes: the domestic producers' price and the London Metal Exchange (LME) price.

TABLE IV-10

BRASS INGOT PRICES
(¢/lb)

Year	No. 115	No. 405
1966	50.34	40.29
1967	44.79	35.24
1968	44.26	35.62
1969	51.92	44.88
1970	56.35	46.51
1971	52.94	44.08
1972	51.90	42.19
1973	66.02	56.28
1974	84.49	72.64

Source: American Metal Market.

TABLE IV-11

REFINED COPPER PRODUCED FROM SCRAP
(1965-1974)

Year	Produced from Scrap (Short Tons)	Total	Percent
1965	445,209	1,882,172	24
1966	490,743	1,869,027	26
1967	406,614	1,282,758	32
1968	416,579	1,607,499	26
1969	499,122	1,985,202	25
1970	511,609	2,003,681	26
1971	400,662	1,787,005	22
1972	423,243	2,026,846	21
1973	465,123	1,997,032	23
1974	496,908	1,741,481	29

Source: American Metal Market.

The domestic producers' price is a set of nearly uniform price quotations used for sales in the United States by the major U.S. primary producers and, for a good portion of the post-war period, by Noranda, one of the Canadian producers. The LME price, spot and forward quotations prevailing on the London Metal Exchange, is used as the basis of sales outside North America.

During the post-war period, 76 percent of the average annual consumption of refined copper in the United States has been sold by U.S. primary producers at the domestic producers' price. About 11 percent of the average annual consumption of refined copper consisted of imports from foreign producers. The copper handled by LME and U.S. metal merchants is mostly sold at the LME price or a price closely reflecting that price. The principal secondary or custom refiners, on the average, accounted for about 13 percent of the average annual consumption of refined copper. They sold this supply at their own established prices which generally reflected the prevailing scrap prices.

Figure IV-2 presents trends in copper prices for the period 1965-75. The primary producers have maintained a price that was generally below the international LME price. In 1975, however, the Free World price dropped below the primary producer price. While the primary producers' price was below the LME price, the secondary group charged prices higher than the producers', but still lower than the LME. In recent times, with the LME below the producer price, the larger secondaries have been able to maintain prices above the LME, but below that of the primaries.

F. PRETREATMENT STANDARDS AND THE COSTS OF COMPLIANCE

1. Recommended Preliminary Pretreatment Standards

The EPA is promulgating interim final pretreatment standards for the secondary copper industry pursuant to Section 307(b) of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1317(b), 86 Stat. 816 et seq; P.L. 92-500). These standards apply to existing sources introducing pollutants into Publicly Owned Treatment Works (POTW).

The principal sources of wastewater in the secondary copper industry are: metal cooling, slag quenching and granulation, furnace exhaust scrubbing, and electrolytic refining. Slag million and classification can generate an effluent; such as operation was not found at plants discharging to POTW's.

The pretreatment control levels are presented in Table IV-12. The pollutant parameters to be limited include copper, zinc, lead, cadmium, mercury, and oil and grease.

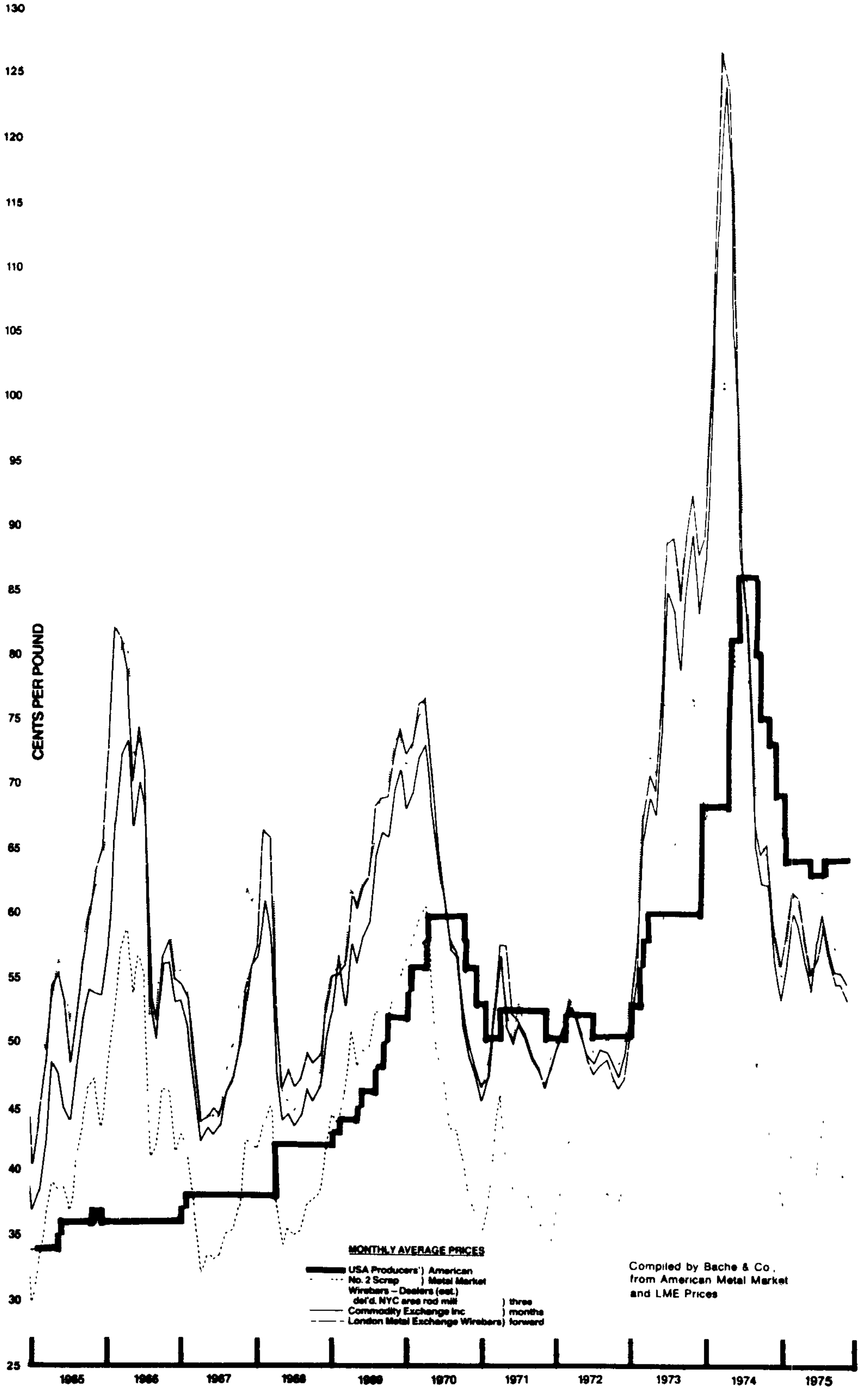

FIGURE IV-2 TRENDS IN COPPER PRICES, 1965-1975

Source: Metal Statistics, 1976.

TABLE IV-12

PRELIMINARY PRETREATMENT CONTROL LEVEL

(Metric units, mg/1)

Effluent Characteristic	Pretreatment Levels: Maximum for any 1 day	Pretreatment Levels: Average of daily values for 30 consecutive days shall not exceed
Copper	0.50	0.25
Zinc (dissolved)	2.0	1.0
Lead	1.0	0.5
Cadmium	1.0	0.5
Mercury	0.18	0.09
Oil and Grease	100	100

Source: Pretreatment Supplement - Development Document for Secondary Copper, EPA, August 1976.

2. Compliance Costs

The compliance costs associated with pretreatment standards and the recycling costs for POTW dischargers were provided by the EPA and are summarized in Tables IV-13 and IV-14. The cost of replenishment water is not included in these costs. These costs were provided on a plant-by-plant basis as incremental capital and operating costs derived from model treatment plants. We have not reviewed these costs as the relevant back up information was not available.

In general, pretreatment costs are lower than recycle costs. The differences between the two costs are more significant when pretreatment costs are low. In such a case, it means going from a simple pretreatment scheme (such as settling, using gravity flow) to more elaborate recycle systems involving pumps for recycle, additional piping, and the like. According to the EPA, plants 6 and 7, earlier listed as POTW dischargers, were later found not to discharge to a POTW and are therefore not considered further in the analysis.

G. BASELINE ANALYSIS AND PROJECTIONS

In this section, we establish a financial profile for POTW dischargers in the secondary copper industry prior to compliance with pretreatment or zero-discharge standards. A deterministic process economics model is used to simulate the financial condition of POTW dischargers on a plant-by-plant basis. We verified the financial data generated by the modelling with some plants in the segment and found reasonable agreement for the plants that responded. We also tried to obtain industrywide cost structure information from the Brass and Bronze Institute, but could not get information as of the writing of this report. Aggregate industry projections are made to evaluate how much these conditions are likely to change in the future using a time series trend analysis.

1. Process Economics Model Structure

ADL has developed a process economics model for the secondary copper industry. Given basic characteristics, such as production, product type, and scrap type, the model generates the following financial information: (a) production costs by category; (b) pretax profits; (c) posttax profits; and (d) cash flow.

2. Financial Results

Using data on plant characteristics supplied by the EPA and the ADL model, we simulated financial conditions in 1975 for 16 out of 17 POTW dischargers. No data on production were available on the 17th plant. Table IV-15 presents the characteristics of these plants. Plant 5 is a producer (segment 1) of unalloyed copper, making cathodes and billets. The remaining plants belong to segment 2. Plant 3 is a copper shot producer.

TABLE IV-13

COSTS OF COMPLIANCE WITH PRETREATMENT STANDARDS FOR THE SECONDARY COPPER INDUSTRY

(last quarter 1975 $)

Plant Code	Pretreatment Costs Capital	Pretreatment Costs Annual Operating
1	13,200	5,360
2	13,200	5,360
3	2,200	640
4	8,000	3,170
5	547,500	278,320
8	13,200	5,360
9	13,200	10,310
10	13,200	10,310
11	147,600	76,090
12	74,400	32,890
13	8,000	3,170
14	152,100	43,300
15	8,000	6,470
16	8,000	3,170
17	13,200	10,310
18	21,200	11,830
19	4,600	880

Source: EPA

TABLE IV-14

COSTS FOR RECYCLE (ZERO DISCHARGE)
FOR THE SECONDARY COPPER INDUSTRY

(last quarter 1975 $)

Plant Code	Pretreatment Costs	
	Capital	Annual Operating
1	24,200	8,040
2	24,200	8,040
3	10,200	2,110
4	14,000	4,650
5	641,900	318,790
8	24,200	8,040
9	24,200	15,400
10	24,200	15,400
11	199,900	89,740
12	80,300	34,260
13	14,000	4,650
14	176,400	59,250
15	13,300	7,810
16	14,000	4,650
17	24,200	15,400
18	37,500	15,850
19	4,600	880

Source: EPA

TABLE IV-15

PLANT CHARACTERISTICS OF SECONDARY COPPER POTW DISCHARGERS

Plant No.	Product Type	Scrap Type	Monthly Output in Short Tons
1	10	3	400
2	10	3	500
3	12	1	35
4	10	3	200
5	21,22	1,2	3500 cathodes 4000 billets
8	10	3	300
9	10	3	725
10	10	3	400
11	11	3	1300
12	10	3	170
13	10	3	25
14	11,12	3	270
15	10	3	250
16	10	3	270
17	10	3	700
18	10	3	750

Product Type Code: 10 = brass and bronze ingot and phosphor copper
11 = brass and bronze ingot
12 = copper shot
20 = unalloyed copper, cathodes
21 = unalloyed copper, billets

Scrap Type Code: 1 = No. 1 copper scrap
2 = No. 2 copper scrap
3 = Brass and bronze scrap mix

Source: U.S. Environmental Protection Agency

Plant 11, besides producing brass and bronze ingot, also produces phosphor copper, and Plant 14, besides producing brass and bronze ingots, also produces phosphor copper and shots.

Table IV-16 presents production costs in cents per pound of product for the POTW dischargers. The variation in scrap costs is due to the type of scrap consumed. Plant 3 consumes No. 1 copper scrap and has the highest scrap costs (48¢/lb). The bronze and brass scrap producers consume a brass and bronze scrap mix comprised of red brass scrap, yellow brass, auto radiators, and the like. We have assumed Alloy 115 (85:5:5:5, i.e., 85% Cu, 5% Sn, 5% Pb, 5% Zn) to be the representative alloy produced by the brass and bronze ingot makers. The scrap mix costs are the lowest (37.4¢/lb). Plant 5, which refines No. 2 scrap to produce electrolytic copper, has intermediate scrap costs--43.2¢/lb. The principal components of other materials costs are those for alloying, fluxes, and maintenance materials. These costs are highest for the brass and bronze producers, mainly because of tin addition--approximately 4¢/lb. Labor costs vary from 3.4-7¢/lb. Total costs range from 52.18-55.8¢/lb for the brass and bronze ingot producers and around 55¢/lb for unalloyed copper and copper shots.

Table IV-17 presents baseline profits and cash for the secondary copper POTW dischargers. The analysis is based on No. 115 alloy (85:5:5:5 group), being the representative product for the bronze and brass ingot-makers. For plants making products other than brass and bronze ingots, such as phosphor copper and shots, we have assumed that their products would be minor in volume, and consequently we treated them as brass and bronze ingot-producers. For the revenue stream, from the list price of 64¢/lb, we have subtracted 7¢/lb to cover discounts and freight. For unalloyed copper products, the revenue was taken to be 58¢/lb which is the LME price. The producer price, 64¢/lb, was much higher.

3. Industry Projections

In the impact analysis we performed in this study, we evaluated financial plant conditions during 1975. To the extent that 1975 is an atypical year, our conclusions are biased. We used trend analysis to gauge how normal 1975 was and the extent to which future conditions will differ from those prevailing in 1975. We then fitted all trend equations to annual data for the 1960-1975 period.

The three major determinants of an industry's financial condition are the price at which it can sell its product, the quantity of the product it can sell, and the price it has to pay for scrap. The first two variables determine industry revenue and the third variable is a major determinant of cost.

We have projected these three determinants for brass and bronze, and unalloyed copper below.

a. Brass and Bronze

The production projection equation is a cubic function of time. The estimated equation is shown below. The time (t) values are placed in parentheses beneath the coefficients.

TABLE IV-16

BASELINE COSTS OF PRODUCTION BY MAJOR CATEGORY FOR SECONDARY COPPER POTW DISCHARGERS

(¢/lb)

Plant	Scrap	Other Materials	Labor	Utilities	Selling and Administrative	Interest Expense	Taxes (non income) and Insurance	Depreciation	Total Cost
1	37.42	4.50	5.33	1.16	1.50	1.42	0.22	0.62	52.18
2	37.42	4.50	5.64	1.16	1.50	1.42	0.22	0.62	52.49
3	48.00	0.20	3.40	1.00	1.00	1.00	0.10	0.30	55.00
4	37.42	4.48	7.00	1.16	1.50	1.42	0.22	0.60	53.80
5	43.20	1.00	4.00	2.50	1.20	1.50	0.50	1.00	54.90
8	37.42	4.83	6.83	1.16	1.50	1.42	0.37	1.04	54.58
9	37.42	4.85	7.00	1.16	1.50	1.42	0.38	1.06	54.80
10	37.42	4.53	5.49	1.16	1.50	1.42	0.24	0.66	52.42
11	37.42	4.44	7.00	1.16	1.50	1.42	0.20	0.55	53.70
12	37.42	5.23	7.00	1.16	1.50	1.42	0.55	1.53	55.81
13	37.42	5.00	7.00	1.16	1.50	1.42	0.45	1.25	55.20
14	37.42	4.43	5.79	1.16	1.50	1.42	0.19	0.53	52.44
15	37.42	4.46	5.48	1.16	1.50	1.42	0.21	0.57	52.23
16	37.42	4.43	6.37	1.16	1.50	1.42	0.19	0.53	53.02
17	37.42	4.48	7.00	1.16	1.50	1.42	0.21	0.60	53.79
18	37.42	4.67	5.09	1.16	1.50	1.42	0.30	0.83	52.39

TABLE IV-17

BASELINE PROFITS AND CASH FLOW
FOR SECONDARY COPPER POTW DISCHARGERS

Plant	Revenue	Cost	Gross Profit	Net Profit	Cash Flow
1	57.00	52.18	4.82	2.89	3.51
2	57.00	52.49	4.51	2.70	3.33
3	58.00	55.00	3.00	1.80	2.10
4	57.00	53.80	3.20	1.92	2.52
5	58.00	54.90	3.10	1.86	2.86
8	57.00	54.58	2.42	1.45	2.49
9	57.00	54.80	2.20	1.32	2.38
10	57.00	52.42	4.58	2.75	3.40
11	57.00	53.70	3.30	1.98	2.53
12	57.00	55.81	1.19	0.71	2.24
13	57.00	55.20	1.80	1.08	2.33
14	57.00	52.44	4.56	2.73	3.27
15	57.00	52.23	4.77	2.86	3.44
16	57.00	53.02	3.98	2.39	2.92
17	57.00	53.79	3.21	1.93	2.52
18	57.00	52.39	4.61	2.76	3.60

Source: Arthur D. Little, Inc., estimates.

$$\text{BBPD} = \underset{(9.11)}{217688} + \underset{(9.95)}{34854.8}\ \text{TIME} - \underset{(-2.28)}{3614.0}\ \text{TIME 2} + \underset{(1.60)}{98.35}\ \text{TIME 3}$$

$$R^2 = 0.68$$

where

BBPD = annual brass and bronze ingot production in short tons,

TIME = trend variable which is 1 in 1960, 2 in 1961, etc.,

TIME 2 = squared values of the trend variable, and

TIME 3 = cubed values of the trend variable.

The equation explains 68 percent of the variation in production. The variables are significant at the 80 percent level according to the two-tailed t test.

The predicted value for 1975 from this equation was 252,980 short tons. The actual value was 249,134 short tons. The trend value is close to the actual value, indicating that cyclical or irregular forces were minimal in that year.

Utilizing the production equation, we generated predictions for the 1976-1978 period. The predicted values are 248,966 tons in 1976; 247,718 tons in 1977; and 249,863 short tons in 1978.

We next fitted a linear trend equation to data on No. 115 alloy. This is the most important of the brass and bronze ingots. The equation is shown below:

$$\text{BBPP} = \underset{(7.03)}{23.00} + \underset{(8.72)}{2.95}\ \text{TIME}$$

$$R^2 = 0.84$$

where

BBPP = price of No. 115 alloy (¢/lb), and

TIME = trend variable.

The estimated equation explains 84 percent of the variation in the price; the trend variable is significant at the 99 percent level.

In 1975, the predicted price of No. 115 alloy was 70.2¢/lb; the actual price was 65.9¢/lb. Therefore, cyclical or irregular forces exerted a downward pressure on prices in that year.

We generated predictions from the price equation for the 1976-1978 period. The predicted prices for No. 115 alloy are 73.1¢/lb in 1976, 76.1¢/lb in 1977 and 79.0¢/lb in 1978.

We also fitted a quadratic trend equation to the dealers' price for red brass scrap. This is one of the important scrap varieties consumed by brass and bronze ingot-makers. The estimated equation is shown below:

$$\underset{}{BBSP} = \underset{(4.01)}{14.24} + \underset{(2.67)}{2.56}\ TIME - \underset{(-1.28)}{0.07}\ TIME\ 2$$

$R^2 = 0.75$

where

BBSP = dealer's price for red brass scrap (¢/lb),

TIME = trend variable, and

TIME 2 = squared values of trend variable.

The estimated equation explains 75 percent of the variation in scrap prices. The trend variable is significant at the 95 percent level. The squared trend variable is significant at the 70 percent level.

The predicted value for 1975 was 37.2¢/lb, and the actual value was 32.5¢/lb. This implies that cyclical or irregular effects had a depressive effect in that year.

Using the scrap equation, we generated predicted values for the 1976-1978 period. The predicted values for red brass scrap price are 37.5¢/lb in 1976; 37.6¢/lb in 1977; and 37.6¢/lb in 1978.

The trend analysis indicated that 1975 was a slightly depressed year for brass and bronze ingot-makers. Production and prices were below the trend (or normal) values. Trend projections indicate that production and prices (product and scrap) will grow at slow rates over the 1976-1978 period. Actual growth, however, will probably exceed trend values, given the probable positive contributions of cyclical forces. In summary, future industry conditions are likely to be somewhat better than those prevailing in 1975.

b. Unalloyed Copper

The production trend equation for secondary copper production was:

$$CUPD = \underset{(8.94)}{390737} + \underset{(2.99)}{10727.2}\ TIME$$

$R^2 = 0.39$

where

CUPD = production of copper from scrap in short tons, and

TIME = trend variable.

The equation can explain 39 percent of the variation in secondary copper production. The trend variable is significant at the 99 percent level.

The predicted value for 1975 was 481,580 short tons and the actual value was 342,580 tons. The actual value is considerably below the trend value. This indicates that the cyclical or irregular forces had a pronounced depressive effect in 1975.

We made projections from the production equation for the 1976-1978 period. The projected values are 492,096 tons in 1976; 502,823 short tons in 1977; and 513,550 short tons in 1978.

There is no published series for secondary copper prices. That portion of the secondary copper produced by the primary producers sells at the U.S. producer price. The secondary copper produced by the secondaries sells at prices between the U.S. producer price and the international LME price. We fitted a linear trend equation to the U.S. producer price series. The estimated equation is:

$$\underset{}{CUPP} = \underset{(7.11)}{21.40} + \underset{(8.87)}{2.76}\ TIME$$

$$R^2 = 0.85$$

where

CUPP = U.S. producer price for electrolytic copper (¢/lb), and

TIME = trend variable.

The equation can explain 85 percent of the variation in the price series. The trend variable is significant at the 99 percent level. The predicted value for 1975 was 65.6 cents and the actual value was 64.5¢/lb. The closeness of the trend and actual values indicates that 1975 was a normal year for copper prices.

We generated projections for the 1976-1978 period. The predicted values are 68.3 cents in 1976; 71.1 cents in 1977; and 73.9¢/lb in 1978.

We then fitted a linear trend equation to the refinery buying prices for No. 2 copper scrap--the most important variety consumed in the production of secondary unalloyed. A dummy variable was used to take into account the effect of abnormally high prices. The dummy variable has the effect of shifting up the equation intercept in those two years. The estimated equation is shown below:

$$CUSP = \underset{(6.40)}{25.91} + \underset{(2.87)}{1.32}\ TIME + \underset{(2.93)}{18.86}\ DUMMY$$

$$R^2 = 0.72$$

where

CUSP = refinery buying prices for No. 2 copper scrap, and

TIME = trend variable.

The equation can explain 72 percent of the variation in scrap prices. The trend and dummy variables are significant at the 95 percent level.

The predicted value for 1975 was 47.1¢/lb and the actual value was 41.1¢/lb. Cyclical and irregular forces therefore had a depressive effect that year.

We used the scrap price equation to generate predicted values for the 1976-1978 period. The predicted values are 48.4¢/lb in 1976; 49.8¢/lb in 1977; and 51.1¢/lb in 1978.

Trend analysis indicated that 1975 was, in some ways, an unusual year for secondary copper producers as production was depressed. It is not possible to make any strong statements about prices as the reported series are only proxies. Over the next few years, production should rise sharply from the 1975 levels for the industry. Profit margins, however, may be squeezed, given that the LME has fallen beneath the producer's price.

H. ECONOMIC IMPACT ANALYSIS

In this section we have quantified the economic impact of compliance with pretreatment or zero-discharge standards on the secondary copper industry. The immediate impact of implementing these standards will be on the POTW discharging plants. Once we quantified the plant and industry effects, we then estimated recursively the resultant effects on communities, employment, trade, and the like.

1. Price Effects

a. Probable Price Increases

Copper and copper-base scrap are largely sold at spot prices in both the domestic and world markets. Scrap prices are determined in the "free" or "outside" market which, in general, is described as a complex conglomeration of secondary refiners, importers, commodity exchanges, and merchants. Prices for U.S.-refined copper are quoted by producers (U.S. producers' price), while the world market price for refined copper is quoted on the London Metal Exchange (LME).

Under normal conditions, each type of scrap sells at a fairly constant discount from the free market price and the U.S. producers' price for refined copper. The amount of the discount depends on the amount of copper content and the cost of turning the scrap to a usable secondary product. Custom refiners producing unalloyed copper from scrap (segment 2) are an important element in the pricing of copper scrap because they pruchase substantial quantities of obsolete and prompt industrial scrap. Much of this scrap is also used by brass and bronze ingot-makers and other scrap consumers, such as brass mills.

In the case of brass and bronze ingot-producers, only about 24 percent of the plants, representing about 30 percent of the production, are affected by these standards. To a large extent, the market for the product is competitive. For the producers of unalloyed copper, the product cathodes and shapes compete with all refined copper. Only one out of seven plants is a POTW discharger, representing about 17 percent of the secondary production. Therefore, the probability of passing on the increased costs of pollution abatement by secondary copper POTW dischargers through increased product price is low.

Tables IV-18 and IV-19 show compliance costs (on a ¢/lb basis) as a percentage of product price. For the brass and bronze producers, compliance costs as a percentage of product price for pretreatment and zero discharge are in all cases, less than 1.6%. Plants 12, 13, and 14 show compliance costs in the range of 1.0-1.6 percent. For unalloyed copper (plant 5), compliance costs are 0.6 percent of product price for pretreatment and 0.7 percent of product price for zero discharge.

b. Secondary Effects

Since price increases due to compliance are unlikely, there will be no secondary effects.

2. Financial Effects

It is unlikely that the impacted plants will be able to pass along the increased costs by increasing prices. Therefore, they will have to absorb the compliance costs. In this section, we have examined the effect of such cost absorption on profits and cash flow, and also considered the capital requirements and sources of funds available to finance the compliance cost-related investment.

Profits and Cash Flow Effects

Table IV-20 shows the effect of compliance with pretreatment standards on pretax profits and cash flow. For the brass and bronze segment, Plant 12 exhibits the largest decrease in pretax profits (68%) and cash flow (22%). Pretax profits are reduced from 1.2¢/lb to 0.4¢/lb. Plant 13 shows a decrease in pretax profits of 30 percent and a decrease in cash flow of 14 percent. Plant 14 has its pretax profits reduced 15 percent and its cash flow reduced 12 percent. The remaining plants show a less than 10 percent decrease in pretax profits and cash flow. For the unalloyed copper segment (Plant 7), the decrease in pretax profits is 11 percent and the decrease in cash flow 7 percent.

Table IV-21 shows the effects of achieving zero discharge on pretax profits and cash flow. In the brass and bronze segment, Plant 12 shows a 71 percent reduction in pretax profits and a 22 percent reduction in cash

TABLE IV-18

PRETREATMENT COMPLIANCE COST IN RELATION TO PRODUCT PRICE FOR SECONDARY COPPER POTW DISCHARGERS

Plant	Compliance Cost (¢/lb)	Product Price (¢/lb)	Compliance Cost as a Percentage of Product Price (%)
1	0.06	57.00	0.10
2	0.04	57.00	0.08
3	0.08	58.00	0.13
4	0.07	57.00	0.12
5	0.33	58.00	0.57
8	0.07	57.00	0.13
9	0.06	57.00	0.10
10	0.11	57.00	0.19
11	0.24	57.00	0.43
12	0.81	57.00	1.41
13	0.53	57.00	0.93
14	0.67	57.00	1.17
15	0.11	57.00	0.19
16	0.05	57.00	0.09
17	0.06	57.00	0.11
18	0.07	57.00	0.12

Sources: U.S. Environmental Protection Agency and Arthur D. Little, Inc., estimates.

TABLE IV-19

ZERO-DISCHARGE COMPLIANCE COST IN RELATION TO PRODUCT PRICE FOR SECONDARY COPPER POTW DISCHARGERS

Plant	Compliance Cost (¢/lb)	Product Price (¢/lb)	Compliance Cost as a Percentage of Product Price (%)
1	0.08	57.00	0.15
2	0.07	57.00	0.12
3	0.25	58.00	0.43
4	0.10	57.00	0.17
5	0.38	58.00	0.65
8	0.11	57.00	0.20
9	0.09	57.00	0.16
10	0.16	57.00	0.28
11	0.29	57.00	0.50
12	0.84	57.00	1.47
13	0.77	57.00	1.36
14	0.91	57.00	1.60
15	0.13	57.00	0.23
16	0.07	57.00	0.13
17	0.09	57.00	0.16
18	0.09	57.00	0.15

Sources: U.S. Environmental Protection Agency and Arthur D. Little, Inc., estimates.

TABLE IV-20

PRETREATMENT COMPLIANCE IMPACTS ON PROFIT AND CASH FLOW FOR SECONDARY COPPER POTW DISCHARGERS

Plant	Pretax Profits Baseline	Pretax Profits Post Compliance	Pretax Profits Percent Change	Cash Flow Baseline	Cash Flow Post Compliance	Cash Flow Percent Change
1	4.82	4.76	1.16	3.51	3.48	0.95
2	4.51	4.46	0.99	3.33	3.30	0.81
3	3.00	2.92	2.54	2.10	2.05	2.18
4	3.20	3.14	2.06	2.52	2.48	1.57
5	3.10	2.77	10.69	2.80	2.66	6.95
8	2.42	2.34	3.08	2.49	2.45	1.79
9	2.20	2.14	2.69	2.38	2.35	1.49
10	4.58	4.48	2.34	3.40	3.34	1.89
11	3.30	3.06	7.39	2.53	2.39	5.77
12	1.19	0.38	67.91	2.24	1.76	21.55
13	1.80	1.27	29.42	2.33	2.01	13.62
14	4.56	3.89	14.68	3.27	2.86	12.28
15	4.77	4.67	2.26	3.44	3.37	1.88
16	3.98	3.93	1.23	2.92	2.89	1.01
17	3.21	3.15	1.91	2.52	2.48	1.46
18	4.61	4.54	1.43	3.60	3.56	1.10

Source: Arthur D. Little, Inc., estimates.

TABLE IV-21

ZERO-DISCHARGE COMPLIANCE IMPACTS ON PROFIT AND CASH FLOW FOR SECONDARY COPPER POTW DISCHARGERS (¢/lb)

Plant	Pretax Profits			Cash Flow		
	Baseline	Post Compliance	Percent Change	Baseline	Post Compliance	Percent Change
1	4.82	4.73	1.74	3.51	3.46	1.43
2	4.51	4.44	1.49	3.33	3.29	1.21
3	3.00	2.75	8.37	2.10	1.95	7.18
4	3.20	3.11	3.03	2.52	2.46	2.23
5	3.10	2.72	12.24	2.86	2.63	7.96
8	2.42	2.30	4.62	2.49	2.42	2.69
9	2.20	2.11	4.02	2.38	2.33	2.23
10	4.58	4.42	3.50	3.40	3.31	2.82
11	3.30	3.01	8.71	2.53	2.36	6.81
12	1.19	0.35	70.73	2.24	1.74	22.45
13	1.80	1.02	43.15	2.33	1.86	19.98
14	4.56	3.64	20.07	3.27	2.72	16.80
15	4.77	4.64	2.73	3.44	3.36	2.27
16	3.98	3.90	1.80	2.92	2.87	1.48
17	3.21	3.12	2.86	2.52	2.47	2.18
18	4.61	4.52	1.91	3.60	3.54	1.47

Source: Arthur D. Little, Inc., estimates.

flow. Plant 13 shows a reduction in pretax profits of 43 percent and a reduction in cash flow of 20 percent. Plant 14 shows a reduction in pretax profits of 20 percent and reduction in cash flow of 17 percent. The remaining plants show a less than 10 percent decrease in pretax profits and cash flow. In the unalloyed copper segment, Plant 5 shows a decrease of 12 percent in pretax profits and an 8 percent decrease in cash flow.

3. Capital Availability

The funds to finance pollution-abatement investment come either from internal sources (cash flow) or external sources (debt). Except for the plants that are subsidiaries of large corporations, most of the firms look to cash flow as their principal source of funds. In this analysis, we compare pollution-abatement investment to annual cash flows.

Table IV-22 shows the capital investment for pretreatment as a percentage of annual cash flows. For the brass and bronze segment, the capital requirements of Plant 12 for pretreatment amount to 81 percent of annual cash flow. The capital requirements of Plant 3 amount to 72 percent of annual cash flow and 57 per cent of annual cash flow for Plant 14. For the unalloyed copper segment, the capital requirements of Plant 5 for pretreatment are 23 percent of its annual cash flow.

Capital requirements for zero discharge as a percentage of annual cash flow are presented in Table IV-23. In the brass and bronze segment, these percentages are 100 percent for Plant 13, 88 percent for Plant 12, and 83 percent for Plant 14. The shot producers' (Plant 3) capital requirements amount to 58 percent of annual cash flow. Plant 11 shows capital requirements amounting to 25 percent of annual cash flow. Plant 5, unalloyed copper, requires capital for pretreatment amounting to 27 percent of annual cash flow.

The possible magnitude of the displacement of productive investment can be assessed by examining the ratio of pretreatment or zero discharge-related investment to normal productive investment. If one assumed that productive investment were 1.8 percent of the value of shipments (1972 Census of Manufactures, Bureau of Census, U.S. Department of Commerce), it would imply that annual productive investment for the POTW dischargers in the brass and bronze segment would be $1.55 million. Aggregate pretreatment-related investment would be $508,700, which would represent about 33 percent of the productive investment figure.

If the firms involved were to make this investment in addition to normal productive investment, the ratio of investment to the value of shipments would increase from 1.8 to 2.4 percent. For the unalloyed copper segment, we estimate the normal productive investment would be $1.88 million. The pretreatment related-investment would be $547,500; i.e., 29 percent of the annual productive investment by the impacted plants. If the firms were to make this investment in addition to productive investment, the ratio of investment to value of shipments would increase from 1.8 to 2.3 percent in the year of investment.

TABLE IV-22

CAPITAL INVESTMENT ASSOCIATED WITH PRETREATMENT STANDARDS IN RELATION TO PRECOMPLIANCE CASH FLOW FOR SECONDARY COPPER POTW DISCHARGERS

Plant	Capital Investment to Meet Pretreatment Standards ($)	Cash Flow	Capital Investment Associated with Pretreatment as a Percent of Annual Cash Flow
1	13,200.00	337,400.00	3.91
2	13,200.00	399,429.06	3.30
3	2,200.00	17,640.13	12.47
4	8,000.00	120,973.00	6.61
5	547,500.00	2,402,425.00	22.79
8	13,200.00	179,370.19	7.36
9	13,200.00	414,618.38	3.18
10	13,200.00	327,221.06	4.03
11	147,600.00	790,582.06	18.67
12	74,400.00	91,560.81	81.26
13	8,000.00	13,965.43	57.28
14	152,100.00	211,635.19	71.87
15	8,000.00	206,362.06	3.88
16	8,000.00	189,084.75	4.23
17	13,200.00	423,591.19	3.12
18	21,200.00	647,442.50	3.27

Sources: U.S. Environmental Protection Agency, and Arthur D. Little, Inc., estimates.

TABLE IV-23

CAPITAL INVESTMENT ASSOCIATED WITH ZERO-DISCHARGE STANDARDS IN RELATION TO PRECOMPLIANCE CASH FLOW FOR SECONDARY COPPER POTW DISCHARGERS

Plant	Capital Investment to Meet Pretreatment Standards ($)	Cash Flow	Capital Investment Associated with Pretreatment as a Percent of Annual Cash Flow
1	24,200.00	337,400.00	7.17
2	24,200.00	399,429.06	6.06
3	10,200.00	17,640.13	57.82
4	14,000.00	120,973.00	11.57
5	641,900.00	2,402,425.00	26.72
8	24,200.00	179,370.19	13.49
9	24,200.00	414,618.38	5.84
10	24,200.00	327,221.06	7.40
11	199,900.00	790,582.06	25.29
12	80,300.00	91,560.81	87.70
13	14,000.00	13,965.43	100.25
14	176,400.00	211,635.19	83.35
15	13,300.00	206,362.06	6.44
16	14,000.00	189,084.75	7.40
17	24,200.00	423,591.19	5.71
18	37,500.00	647,442.50	5.79

Sources: U.S. Environmental Protection Agency, and Arthur D. Little, Inc., estimates.

Similarly zero-discharge investment for the brass and bronze segment would be $704,800; i.e., 45.5 percent of the annual productive investment by the impacted plants. This represents an increase in the ratio of investment to value of shipments from 1.8 to 2.6 percent in the year of investment. For unalloyed copper, the zero-discharge-related investment would be $641,900; i.e., 34 percent of the annual productive investment by the impacted plants. The ratio of investment to value of shipments would increase from 1.8 to 2.4 percent in the year of investment.

4. Production and Employment Effects

In this subsection we have examined the effect of the proposed standards on production curtailment, plant closures, employment, and industry growth.

a. Production Curtailment

In the secondary copper industry, especially brass and bronze, there is an excess of capacity. We estimate that the industry is currently operating a. about 60-65 percent of its capacity. Production curtailments would increase marginal and average costs. Consequently, such curtailments would not be likely.

b. Plant Closures

In evaluating shutdowns, we first categorized the industry's plants. First, there are plants that do not cover their variable costs. Then plants will shut down since by so doing, they will be able to avoid losses. Second, there are those plants which cover their variable costs, but not fixed costs. These too will shut down in the long run, but the timing is difficult to predict. Finally, there are those plants which will conitnue to enjoy a profit, but these plants may still shut down. The possibility of shutdown can be determined on the basis of a discounted cash flow analysis.

All plants in both the brass and bronze and unalloyed copper segment fall into the third category; i.e., even after compliance with the standards, they will still make a profit. The issue then is whether their profits will be reduced to the point where they decide they must close down after all.

When a plant making a profit shuts down, it sacrifices current and future cash flow but, in return, obtains the assets tied up in the business. Hence, a plant will continue to operate only if the value of the discounted stream of future cash flow and terminal salvage value exceeds the funds that can be released by a shutdown.

The funds released by a shutdown fall into two categories; owner-financed working capital and current salvage value. Current salvage values are relatively low in the industry. Land values after clearing provide the chief source of salvage value. Given generally unattractive locations, these land values are not particularly high.

The brass and bronze as well as the unalloyed copper segments can still make a profit and a positive cash flow, even after compliance. As seen earlier in Tables IV-20 and IV-21, Plant 12 shows a pretax profit of 1.19¢/lb and cash flow of 2.24¢/lb. As a result of compliance with pretreatment standards, pretax profits are reduced to 0.38¢/lb and cash flow to 1.75¢/lb. The pretax profits after compliance with zero-discharge standards would be 0.35¢/lb and the cash flow 1.74¢/lb. Plant 13 would have a pretax profit of 1.8¢/lb and cash flow of 2.33 ¢/lb prior to compliance. By meeting pretreatment standards, the pretax profit would be reduced to 1.27¢/lb and cash flow to 2.01¢/lb. Compliance with zero-discharge standards could cause pretax profits to be reduced to 1.02¢/lb and cash flow to 1.86¢/lb. All other plants show past compliance profits of at least 2.0¢/lb.

Tables IV-22 and IV-23 show that the ratios of capital investment for pretreatment or zero-discharge to annual cash flow would be in the range of 80 to 90 percent. For Plant 13, these percentages are 60 percent for pretreatment and 100 percent for zero-discharge. For Plant 14, capital requirements would be in the range of 70 to 80 percent. For Plant 5, pollution abatement capital to annual cash flow would be in the range of 20-25 percent. For the copper shot producer (Plant 3), zero-discharge capital requirements would be about 60 percent of annual cash flow.

From the above discussion, we can see that Plant 12 producing 170 tons per month of brass and bronze ingots would be impacted heavily in terms of adverse effects of profits and capital requirements, and thus would be a potential candidate for closure. Plant 13, which has a very small production of only 25 tons per month, would also be heavily impacted and could possibly close as well. It is to be noted that this plant, besides brass and bronze ingots, is also involved in precious metals. Plant 14 has significant pollution-abatement capital requirements (due to emissions from phosphor copper production); i.e., 70 to 80 percent of one year's cash flow. We do not believe that this plant is likely to close. Plant 3 makes 35 tons of copper shot a month, and its capital requirements for zero-discharge would be significant. However, this plant produces other products such as secondary aluminum ingot, precious metals, bismuth, and lead tin alloys. Here again, we believe closure as a result of pretreatment standards is unlikely.

For the unalloyed copper producer (Plant 5), pretax profits would decrease 11-12 percent and cash flow decrease 7-8 percent as a result of compliance with pretreatment and zero-discharge standards. Capital requirements would be 23 percent of annual cash flow for pretreatment and 27 percent of annual cash flow for zero-discharge standards. Closure is not anticipated. It is also to be noted that the POTW to which this plant discharges its wastewater is likely to build a secondary treatment facility. If that is done, it is likely that Plant 5 will not have to meet pretreatment standards.

c. Employment Effects

Our analysis indicates that two plants in the brass and bronze segment would face potential closure. This translates to an employment loss of 20-30 people, around 1 percent of the industry's employment level.

d. Industry Growth

Theoretically, as a result of compliance, industry growth could be curtailed. Reductions in growth could result from the following impact effects:

1. Decreased profits (due to pretreatment-related costs) could reduce the incentive for productive investment; and

2. Increased demands on investment funds (due to pretreatment-related investments) could reduce the amount left.

The secondary copper industry baseline growth has been fairly stagnant in the past, although we anticipate that secondary copper production will pick up above 1975 levels. However, growth rates are likely to be low. There is a potential for the closure of two plants, accounting for 200 tons/month, or less than 1 per cent of the industry production. As the industry has sufficient slack (operating at 60-65 percent of capacity), pretreatment (or zero-discharge standards) are unlikely, to any great extent, to contribute to any curbing of growth in the industry.

5. Resultant Effects on the Community

The two plants where there is a potential for closure are located on urban sites, and 20-30 persons are involved. The community impacts are not likely to be significant.

6. Balance-of-Payment Effects

The overall effect of pretreatment or zero discharge on the domestic industry is small. Therefore, there is little likelihood that the impacts would trickle over to affect trade and capital accounts of the balance of payments posture.

7. Sensitivity Analysis

In this section, we have analyzed the effect of variations in certain parameters such as pollution-abatement costs and the costs of smelting. The pollution-abatement costs, as anticipated by the EPA, are applicable to greenfield sites. We estimate that the capital costs can be 50-75 percent higher, and operating costs 10-25 percent higher than those anticipated by the EPA, because the treatment plant equipment will have to be retrofitted in many cases in crowded plants. Hence, we considered the effect of an increase of 75 percent in capital costs and a 25 percent increase in operating costs on impact parameters (Case 1).

The costs of production of brass and bronze ingot and unalloyed copper are ADL estimates, based on models. We have checked our costs with a few plants and we feel that the costs of processing scrap into ingots or cathodes (exclusive of scrap costs) are within ± 10 percent, for the last quarter of 1975. The effect on impact parameters of a ± 10 percent variation in the costs of processing is covered in Cases 2 and 3.

Tables IV-24 and IV-25 summarize the effect on impact parameters caused by variations in pollution-abatement and production costs for brass and bronze and unalloyed copper, respectively.

For segment 1, brass and bronze ingot-makers' compliance with pretreatment standards would result in maximum reductions in pretax profits of 32-620 percent and cash flow from 15.9 to 57.9 percent. Pollution-abatement investment as a percentage of annual cash flow, on the high end, would range from 60 to 130 percent. The capital requirements for this segment for compliance with pretreatment standards, would range from $508,700 to $890,225.

Increasing production costs (exclusive of scrap) by 10 percent (Case 2) would cause Plant 12 to show a loss of 0.12¢/lb precompliance. The compliance costs would be 0.81¢/lb, which would further increase the loss of 0.93¢/lb (620 percent change in profits). Plant 13 shows a profit (Case 2) of 0.52¢/lb. Compliance costs of 0.53¢/lb would result in the plant (100 percent change in profits) breaking even. It is to be noted that the impact on cash flow of these plants would be less severe, and that post-compliance cash flow of these plants would be positive. This means that, although immediate closure might not result, the potential would exist that these plants might close.

Compliance with zero-discharge standards would result in maximum reductions in profit of 33.5 to 150 percent and cash flows of 16.6 to 60 percent. Pollution-abatement investment as a percentage of cash flow would range from 74.4 to 175.4 percent. The capital requirements for achieving zero-discharge would range from $704,800 to $1,233,400.

For the unalloyed copper segment, the decrease in pretax profit due to compliance with pretreatment standards would range from 7.9 to 16.3 percent, and cash flow decreases would range from 5.7 to 9.0 percent. Pollution-abatement capital requirements as a percentage of annual cash flow would vary between 18.6 to 39.9 percent. The capital requirements for compliance with pretreatment standards would range from $547,500 to $958,125.

Compliance with zero-discharge standards would result in a decrease in pretax profits of 9.1-18.7 percent, and cash flow decreases would range from 6.5-10.3 percent. Pollution-abatement capital requirement as

TABLE IV-24

SENSITIVITY OF IMPACT PARAMETERS TO POLLUTION ABATEMENT AND PRODUCTION COSTS SECONDARY COPPER: BRASS AND BRONZE (SEGMENT 1)

(Percent)

Standard / Impact Parameter	Base Case	Case 1	Case 2	Case 3
PRETREATMENT				
Price Effects	Price increase unlikely			
Profitability				
(a) Pretax Profits	1.0-67.9	1.2-84.9	1.3-62	0.8-32.2
(b) Cash Flow	0.8-21.6	1.0-26.9	1.0-57.9	0.7-15.9
Capital Requirements & Availability				
(a) Pollution Abatement Investment/Annual Cash Flow	3.1-81.3	5.5-142.2	4.1-13.0	2.4-60.2
(b) Total Pollution-Abatement Investment	508,700	890,225	508,700	508,700
ZERO DISCHARGE				
Price Effects	Price increase unlikely			
Profitability				
(a) Pretax Profits	1.5-70.7	1.9-88.4	1.9-64.6	1.2-33.5
(b) Cash Flow	1.2-22.5	1.5-28.1	1.5-60	1.0-16.6
Capital Requirements & Availability				
(a) Pollution Abatement Investment/Annual Cash Flow	5.7-100.3	10.0-175.4	7.0-149.5	5.1-74.4
(b) Total Pollution Abatement Investment	704,800	1,233,400	704,800	704,800

Note: Case 1 - Pollution Abatement Costs - Capital costs increased 75%; operating cost increased 25%.
Case 2 - Production costs (exclusive of scrap) increased 10%.
Case 3 - Production costs (exclusive of scrap) decreased 10%.

TABLE IV-25

SENSITIVITY OF IMPACT PARAMETER TO POLLUTION ABATEMENT AND PRODUCTION COSTS SECONDARY COPPER: UNALLOYED COPPER (SEGMENT 2)

(Percent)

Standard / Impact Parameter	Base Case	Case 1	Case 2	Case 3
PRETREATMENT				
Price Effects	Price increase unlikely			
Profitability				
(a) Pretax Profits - % change in pretax	10.7	13.4	16.3	7.9
(b) Cash Flow - % change in cash flow	7.0	8.7	9.0	5.7
Capital Requirements & Availability				
(a) Pollution-Abatement Investment/Annual Cash Flow (%)	22.8	39.9	29.4	18.6
(b) Total Pollution-Abatement Investment ($)	547,500	958,125	547,500	547,500
ZERO DISCHARGE				
Price Effects	Price increase unlikely			
Profitability				
(a) Pretax Profits	12.2	15.3	18.7	9.1
(b) Cash Flow	8.0	10.0	10.3	6.5
Capital Requirements & Availability				
(a) Pollution-Abatement Investment/Annual Cash Flow	26.7	46.8	34.5	21.8
(b) Total Pollution-Abatement Investment ($)	641,900	1,123,325	641,900	641,900

Note: Case 1 - Pollution Abatement Costs - Capital costs increased 75%; operating cost increased 25%.
Case 2 - Production costs (exclusive of scrap) increased 10%.
Case 3 - Production costs (exclusive of scrap) decreased 10%.

a percentage of annual cash flow would range from 21.8 to 46.8 percent. The total capital requirements for achieving zero discharge would vary between $641,900 and $1,123,325.

8. Limits of the Analysis

The main limitation of this analysis would be due to the use of a modeling approach to quantify the impacts. Such an approach was necessitated by the paucity of specific financial data on each plant modeling will not predict the financial characteristics exactly for a particular plant; however, it can allow for basic differences between plants and provide reasonable estimates of financial characteristics against which the impact of compliance can be assessed.

It should be emphasized that in our analysis we evaluated only those impacts due to the proposed pretreatment standards.

The costs of compliance with pretreatment and zero-discharge standards were provided by the EPA and are subject to all limitation of their cost analysis.

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