EPA-450/3-80-011

# Source Category Survey: Secondary Copper Smelting and Refining Industry

Emission Standards and Engineering Division

Contract No. 68-02-3059

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
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PREFACE

This Source Category Survey Report is submitted in partial fulfillment of EPA Contract No. 68-02-3059. The purpose of the report is to determine the need for New Source Performance Standards for air emissions for selected industries. The source category surveyed by this report is the Secondary Copper Smelting and Refining Industry.

This study was performed by Midwest Research Institute for the Emission Standards and Engineering Division of the U.S. Environmental Protection Agency at Research Triangle Park, North Carolina. The EPA lead engineer for this study was Mr. Reid Iversen. Principal Midwest Research Institute contributors to this study included: Mr. Michael K. Snyder (project leader), Associate Environmental Scientist; Dr. A. D. McElroy, Senior Advisor; Mr. Franklin Shobe, Associate Environmental Analyst; and Mr. Tim Arnold, Junior Analyst. This project was conducted in the Environmental and Materials Sciences Division under the supervision of Mr. A. R. Trenholm, Head, Environmental Control Section.

Midwest Research Institute expresses its appreciation to the industrial and governmental personnel who provided technical input and advice.

Approved for:

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# 1. SUMMARY

The term "secondary copper" describes not the quality of product but the origin of the copper, which is new and used copper-bearing scrap or other copper-bearing wastes. Primary copper is produced from ores and concentrates. This study examines plants that smelt and refine copper scrap to produce pure copper or copper alloy (other than brass and bronze). The Standard Industrial Classification (SIC) 3341 category includes these plants and brass and bronze smelters and refiners. The study also excluded the secondary copper foundries as their processes are only melting and casting operations and do not involve any refining. Their emissions are also substantially less than emissions from the secondary smelters and refiners.

Currently, there are only seven plants in the United States that fit the definition of producing pure copper from copper-bearing scrap. These secondary smelters are usually located close to urban areas or near inexpensive transportation. Georgia, New Jersey, and South Carolina have one plant each; Illinois and Pennsylvania have two plants each.

Production of secondary copper is estimated to be 323,000 Mg (356,000 tons) in 1979. Production figures in past years have shown that the industry is easily influenced by economic recessions and its growth rate is very volatile. Upper level management personnel in the industry indicated that they have no plans to expand their existing operations or build a new plant. This is supported by projections of less than 2 percent growth in production.

At present, the industry is operating at approximately 84 percent of capacity. Increases in production through plant expansion, adding additional work shifts, or new plant construction, are limited by several factors. Among them are limited availability of scrap and rising fuel and production costs. The scrap market is highly competitive with a large amount of scrap being sent to foreign markets. The quality of scrap or its copper content has decreased over the years resulting in higher production costs and energy consumption rates. At least one plant listed as producing at capacity could double its capacity by increasing its electrolytic refining capacity. But, because of the influences described above, they are discouraged from doing so.

Secondary copper is manufactured from all grades of copper scrap and copper bearing wastes. Preparation of scrap for processing is usually accomplished before it is received at the smelters and refineries. Sorting and baling of the scrap are usually the only preparations performed by the plants. Low grade scrap and slags are smelted in a cupola furnace using a coke charge for fuel. Black copper, from a cupola, ranging from 75 to 88 percent copper, proceeds to a converter furnace where it is blown to remove metallic impurities. The resulting blister copper is high in copper content (98 percent) and can be cast and sold or sent to fire refining or anode furnaces. Fire refined copper is cast into ingots and sold. Anode copper is cast into anodes and electrolytically refined. The resulting cathode copper is melted in shaft furnaces and cast into billets, wirebar, wire rod, etc. One plant processes part of its cathode copper into an oxygen-free copper of 99.99 percent purity.

The major sources of emissions are from the furnaces in the smelting and refining processes. Other miscellaneous sources involve processes or furnaces located only at one or two plants, such as a holding furnace between the cupola and converter operations or a Kaldo furnace instead of cupola, converter, and anode furnaces.

The most significant emission source is the cupola furnace. Uncontrolled particulate emissions from this source at a typical plant are about 1,140 Mg/year (1,260 tons/year), but actual emissions would be controlled to approximately 34 Mg/year (38 tons/year) to comply with the typical State Implementation Plan (SIP). All cupolas are controlled with baghouses.

Other significant particulate emission sources are the converting operation and the fire refining/anode operations. Emissions from the converter at a plant controlled to meet a typical SIP would be about 19 Mg/year (21 tons/year). All converters are controlled with baghouses. Fire refining furnaces and anode furnaces of comparable size emit about 15 Mg/year (17 tons/year) particulates. Most furnaces are controlled with baghouses, although one plant uses venturi scrubbers with a mist eliminator. One plant did not control its fire refining and anode furnaces, but because it is in violation of standards in the SIP, the company plans to install a baghouse.

Shaft furnaces are not a major source of emissions. Uncontrolled emissions from a typical plant were only about 9 Mg/year (10 tons/year). Only one plant controlled its shaft furnace, by using a settling chamber.

Sulfur emissions from the industry were not found to be a problem primarily because the use of low sulfur fuels predominated. Another reason for low $SO_2$ emissions is the low average sulfur content of the copper-bearing scrap that is processed. One plant, however, had a scrubber on its converter furnace. No plant was in violation of $SO_2$ standards in its respective SIP.

If the secondary copper smelting and refining industry had been operating at full capacity in 1979, it is estimated that the following quantities of particulates would have been emitted nationwide.

| Process source | Particulate emissions Mg/year (tons/year) |
|---|---|
| Cupola | 253 (279) |
| Converters | 83 (92) |
| Anode and fire refining | 592 (652) |
| Shaft | 45 (50) |
| Other | 259 (285) |
| Total | 1,232 (1,358) |

The "other" process source category includes holding furnaces and Kaldo furnaces.

The "best system" of control on all major sources of emission is a fabric filter system (baghouse). One problem with wet scrubbers is the production of a wastewater which must be treated.

States regulate the secondary copper industry under general process emission regulations. In Georgia and South Carolina, the formula for determining allowable particulate emissons is $E = 4.10 \times P^{0.67}$, where E is the allowable emissons in pounds/hour and P is the process weight rate in tons/hour. In Illinois, the formula used is $2.54 \times P^{0.534}$. In New Jersey and Pennsylvania, the state standards for particulate emissions are 0.046 g/dscm (0.02 gr/scf) and 0.092 g/dscm (0.04 gr/scf), respectively.

The standard method of sampling and analyzing pollutants from the process sources is EPA Method 5.

It is not recommended that a NSPS be developed for the secondary copper smelting and refining industry at this time because the rate of introduction of new sources is expected to be negligible and there would be a small potential impart of a NSPS on air pollution. Chapter 3 presents the rationale for this recommendation.

## 2. INTRODUCTION

The authority to promulgate standards of performance for new sources is derived from Section 111 of the Clean Air Act. Under the Act, the Administrator of the United States Environmental Protection Agency is directed to establish standards relating to the emission of air pollutants and is accorded the following powers:

1. Identify those categories of stationary emission sources that contribute significantly to air pollution, the emission of which could be reasonably anticipated to endanger the public health and welfare.

2. Distinguish among classes, types, and sizes within categories of new sources for the purpose of establishing such standards.

3. Establish standards of performance for stationary sources which reflect the degree of emission reduction achievable through application of the best system of continuous emission reduction, taking into consideration the cost, energy, and environmental impacts associated with such emission reduction.

The term "stationary source" means any building, structure, facility, or installation which emits or may emit any air pollutants. A source is considered new if its construction or modification is commenced after publication of the proposed regulations. Modifications subjecting an existing source to such standards are considered to be any physical change in the source or change in methods of operation which results in an increase in the amount of any air pollutant emitted.

The Clean Air Act amendments of 1977 require promulgation of the new source standards on a greatly accelerated schedule. As part of that schedule, a source category survey was performed to determine if development of new source performance standards for the secondary copper smelting and refining indutry was justified and to identify what processes and pollutants, if any, should be subject to regulation.

The secondary copper industry includes all institutions manufacturing copper and copper alloys from copper scrap and other copper-bearing wastes. This report concerns itself only with those institutions smelting and/or refining copper scrap into pure copper and copper alloy other than brass and bronze. The final product produced by these plants is the same as copper from primary producers (those that produce copper from ore and concentrates).

In a typical process, low grade scrap is smelted in a cupola furnace that uses coke as a fuel. The molten "black copper" product from this operation is blown in a converter furnace to remove metallic impurities. The resulting blister copper can be sent to a fire refining furnace where it undergoes reduction and further refining and is then cast into ingots or billets; or the blister can be sent to an anode furnace where it undergoes fire refining and is then cast into anodes. The anodes are put into electrolytic refining cells and cathode copper is produced. The pure cathode copper is melted in a shaft furnace and can be cast into wirebar, wire rod, cakes, etc.

Those emission sources primarily examined during this study were the exhausts from the cupola, converter, fire refining, anode, and shaft furnaces and from less common emission sources such as holding and Kaldo furnaces and incinerators.

Information necessary for development of the secondary copper smelting and refining source category survey was gathered through the following activities:

1. Collection of process and emission data from literature searches and contacts with State and local air pollution control agencies.

2. Visiting several secondary copper plants to develop an understanding of smelting and refining processes, and to collect data on operating air pollution control equipment.

3. Contacting representatives of industry, trade associations, and government agencies to gather information on current secondary copper smelting and refining production and projected industry expansion.

# 3. CONCLUSIONS AND RECOMMENDATIONS

## 3.1 CONCLUSIONS

The number of plants that produce secondary refined copper has decreased from 20 identified plants in 1965 to 8 in 1979. The plants that stopped producing generally never produce more than 454 Mg/year (500 tons/year). Of the eight plants that produce secondary copper in 1979, seven are considered major plants and were involved in the study. The other plant produces less than 454 Mg/year (500 tons/year) of refined copper in addition to the variety of other metals it refines.

The probability that any new plants will be built is low at this time due to the following circumstances:

1. Past and projected growth rate for the industry does not suggest expansion of the industry. Projected long-term growth based on total copper consumption and the index of durable manufactures is 1.0 to 1.9 percent. These projections must be viewed with skepticism since past figures for secondary copper production show a widely fluctuating market.

2. The high costs of fuels and uncertainty of their availability do not encourage expansion of the industry.

3. The scrap market is highly competitive and the ability to obtain copper-bearing scrap at a reasonable price influences industry decisions to expand. Some plants could increase plant capacity by increasing their electrolytic refining capacity, but the availability of scrap and high fuel costs are two factors that have discouraged this capital investment thus far.

There are factors that could stimulate the industry into expansion. An oil embargo or other restriction of fuel supplies would probably hurt the primary producers more than the secondary refiners because secondary smelting operations are more energy efficient. Of course, increasing production would still involve obtaining a large share of the scrap market. Government inducements to reduce export of scrap would probably be needed to increase scrap availability to the secondary producers. Finally, a step up of military equipment and ammunition production would also stimulate the secondary copper industry.

On the other hand, there has been a definite trend in many manufacturing industries, such as the automobile indutry, to decrease the amount of copper in their final products or to substitute lower grade copper, copper alloys, or other metals for pure copper. The decrease in average copper content of the secondary copper smelters' scrap charge results in increased production costs and efforts to obtain even more scrap to maintain current production.

The most significant emission source in the secondary copper smelting and refining industry is the cupola furnace. A typical uncontrolled particulate emission from a cupola is about 1,143 Mg/year (1,260 tons/ year). Assuming an average control efficiency of 97 percent for a baghouse, controlled emissions are about 34 Mg/year (38 tons/year).

Other significant emission sources are the converter, fire refining, anode, and shaft furnaces. Typical controlled particulate emissions from the converter operation are about 19 Mg/year (21 tons/year). Typical emissions from fire refining furnaces and anode furnaces of equivalent size are about 15 Mg/year (17 tons/year). The control method most commonly used on these three operations is a baghouse, although one plant successfully uses a venturi scrubber with a mist eliminator on each of its fire refining and anode furnaces. The shaft furnace emissions are much less than from the above processes. Only one plant was controlling this process and they use a settling chamber. Typical controlled emissions from the shaft furnace are about 11 Mg/year (13 tons/year).

Sulfur emissions from the above furnaces were not a serious problem, i.e., no plant was in violation of standards in its State Implementation Plan (SIP). One plant had a scrubber on its converter to control sulfur emissions released during conversion of black copper to blister copper. Sulfur emissions were generally low because of the use of low sulfur fuels at plants located in states that had $SO_2$ standards. There were no data available on $SO_2$ emissions from the plant in South Carolina, a state that does not have a $SO_2$ standard that applies to this industry. Th potential for sulfur emissions does exist should high sulfur fuels be used by plants not subject to stringent $SO_2$ state standards.

Good particulate emission data were available in only a few instances. Some form of particulate emission data was available for every plant, but often they were not up-to-date or were incomplete. Complete sulfur emission data were available for only one plant. Emission data for nitrogen oxides, hydrocarbons, and carbon monoxide were sometimes available, but these pollutants are emitted in minor quantities. No violations of SIP's were encountered. All data used in the study were provided by State and local control agencies or the National Emission Data System (NEDS).

There are standard EPA methods for evaluation of particulates and sulfur oxides, the two pollutants for which standards are considered in this study.

## 3.2 RECOMMENDATIONS

It is not recommended that an NSPS be developed for the secondary copper smelting and refining industry at this time. The factors supporting this recommendation are:

* It is unlikely that a new plant will be built in the next 5 years because the copper scrap market is so competitive and because fuel costs have risen so sharply.

* Growth in production is likely to be slow at best. Growth projections show a 1.0 to 1.9 percent growth rate. Considering the fluctuating behavior of secondary copper production the past 14 years, any growth projection is suspect.

* Currently plants are operating at approximately 84 percent of capacity. At a growth rate of 1.9 percent, the plants would reach 90 percent of capacity in 1983 and 100 percent in 1986. At a growth rate of 1.0 percent, the plants would reach 90 percent of capacity in 1985, and would not reach 100 percent by 1989.

* The results of the Model IV calculation yielded a maximum estimated national impact of 17 Mg/year (19 tons/year) in 1984 and 35 Mg/ year (39 tons/year) in 1989. These impacts are not large because the industry is small and the projected rate of growth is low. The most likely impact is zero, based on indications from industry personnel that no new furnaces will be built.

# 4. INDUSTRY DESCRIPTION

## 4.1 SOURCE CATEGORY

The secondary copper industry is defined in this report as that portion of SIC 3341 (Secondary Smelting and Refining of Nonferrous Metals) that consists of industries recovering copper metal from new and used copper-bearing scrap. This definition excludes industries engaged in secondary brass and/or secondary bronze production because these industries were covered in another EPA report.[1] It also excludes secondary copper foundries (SIC 3362, Brass, Bronze, Copper, Copper Base Alloy Foundries (Castings)) for reasons which will be discussed later. Included are those industries that smelt and/or refine copper-bearing scrap to produce copper or copper alloys (other than brass or bronze).

The industry, by this definition, does not include the scrap industry itself where scrap is collected, graded, and prepared for sale; nor are the primary copper producers included who process scrap along with their primary copper ores and concentrates.

The terminology associated with the secondary copper industry requires clarification. "Secondary" refers only to the origin of the copper and not to the quality of the finished product. Secondary metal is rerefined metal as opposed to primary metal, which is produced from ores. The term "new scrap" refers to materials produced in manufacturing plants such as turnings, borings, and defective goods and metal residues such as slags. "Old scrap" consists of obsolete, worn out, or damaged materials containing copper, such as automobile generators and radiators, wire, pipe, bearings, and other used metal materials.

Depending on the copper content of the processed scrap, the scrap can enter secondary metal production at a number of points. Low grade scrap (i.e., its copper content is low) will enter the recovery process at the beginning where smelting operations are carried on. The average copper content of the scrap entering the cupola furnaces commonly ranges from 30 to 50 percent. Clean scrap consisting of pure copper will enter relatively late into the metal refining process, possibly only requiring melting and casting. Scrap containing alloying constituents can be classified as intermediate grade scrap and will enter the refining process at some point after the cupola operations.

Secondary copper smelters and refiners are generally found close to their source of scrap materials, such as urban areas, or near inexpensive transportation in the northeastern and east-north central states. At present, the number of secondary copper smelting and refining plants is seven. Table 4-1 is a listing of secondary copper smelters and refiners operating in the United States.

TABLE 4.1. SECONDARY COPPER SMELTING AND REFINING PLANTS

| Company | Location | Employees | Production Mg/month | Production Tons/month | Estimated capacity Mg/month | Estimated capacity Tons/month | Approximate[a] annual operation (hr) | Final Product |
|---|---|---|---|---|---|---|---|---|
| Southwire | Georgia | 200[b] | 2,720[b] | 3,000[b] | 2,720[b] | 3,000[b] | 8,400 | Cathode copper |
| Cerro Copper Prod. | Illinois | 900 | 3,990 | 4,400 | 3,990[d] | 4,400[d] | 5,280 | Cathode copper |
| CHEMETCO | Illinois | 200 | 2,270 | 2,500 | 2,720 | 3,000 | 8,400 | Cathode copper |
| U.S. Metals Refining | New Jersey | 1,600 | 14,440 | 15,920 | 14,440[d] | 15,920[d] | 8,400 | Cathode and OFHC copper |
| Franklin Smelting and Refining | Pennsylvania | 150 | 1,360-1,500 | 1,500-1,650 | 1,500 | 1,650 | 8,400 | Black and blister copper |
| Reading Metals Refining | Pennsylvania | 100 | 4,540 | 5,000 | 6,350 | 7,000 | 6,000 | Copper billets |
| Nassau Recycling | South Carolina | 1,200 | 6,350[c] | 7,000[c] | 9,450 | 10,420 | 8,400 | Cathode and fire refined copper |

a Hours for melting or fire refining operations.

b Estimate (1975 data).2

c Approximate.

d Capacity limited by electrolytic refining capacity.

The secondary metal industry 75 years ago consisted of a group of independent scrap dealers who gathered and sold scrap to a variety of markets. Some of these dealers remelted their scrap to increase their profits. However, the demand for a higher grade of product gave the industry impetus to improve its technology. It was not until World War I and copper shortages that the use of large quantities of secondary metals gained general acceptance. This resulted in rapid growth in the industry and during World War II growth was boosted once again.[3]

Since the middle 1960's, secondary copper production has been very cyclical. It is a volatile industry, easily influenced by national economic recessions. Because of this, it is difficult to forecast more than 1 or 2 years into the future. Quantitative information on production is provided in the next section.

Secondary copper foundries were not included in the study for one reason: they do not refine copper scrap, but carry out only melting and casting operations. Their scrap charge consists predominantly of No. 1 and No. 2 copper scrap, which are the highest two grades. Alloying industries will add a particular metal during the melting operation to make a copper alloy. Emissions from these industries are considerably lower than emissions from the secondary copper smelting and refining industry, and emission control problems are not as difficult to deal with. This is because they only perform melting and casting operations. The number of secondary copper foundries was not determined, but some emissions data are available.

## 4.2 INDUSTRY PRODUCTION

In this section, secondary copper production is discussed, and the future demand is projected. Current and past market conditions are also discussed and an estimation of industry expansion is made.

### 4.2.1 Secondary Refined Copper Production

Secondary copper production in 1979 is estimated by MRI to be 323,000 Mg (356,000 tons) based upon a telephone survey of the indstry. Precise production data for the past are unavailable. The statistical series from the Copper Development Association (CDA) does not distinguish primary from secondary production and the Bureau of Mines classifies the industries in a different way from that used in this study. The CDA statistics on copper recovery from scrap list the copper content smelted from scrap and refined from scrap and the copper content of scrap which is consumed directly in brass mills and other industries. The total production of smelted and refined copper from scrap consists of four parts: (a) smelted at primary plants, (b) smelted at secondary plants, (c) refined at primary plants, and (d) refined at secondary plants. The secondary copper industry as defined here consists of b and d.

To establish the trend of secondary copper production since 1966, the production of refined copper from scrap was used as a surrogate. This figure from the CDA statistical series[4] equals b+c+d, because the CDA production figure for copper smelted from scrap consists only of production from primary smelters (a) while the total production equals a+b+c+d. Thus the production statistics in this section are overstated by an amount equal to c. The magnitude of c is unknown but is small enough for the use of b+c+d as a surrogate for b+d to be valid. A comparison of the industry survey with CDA and Bureau of Mines statistics[5,6] shows that as a percent of total production of smelted and refined copper from scrap (a+b+c+d), b+d is more than 80 percent in 1979 while b+c+d is never more than 87 percent in the 1966 to 1978 period.

The estimated production of the secondary copper industry for 1966-1979 with a projection to 1989 is shown in Figure 4-1. By the reasoning above, the historical series should be accurate to within ± 10 percent.

#### 4.2.2 Projection of Secondary Refined Copper Production

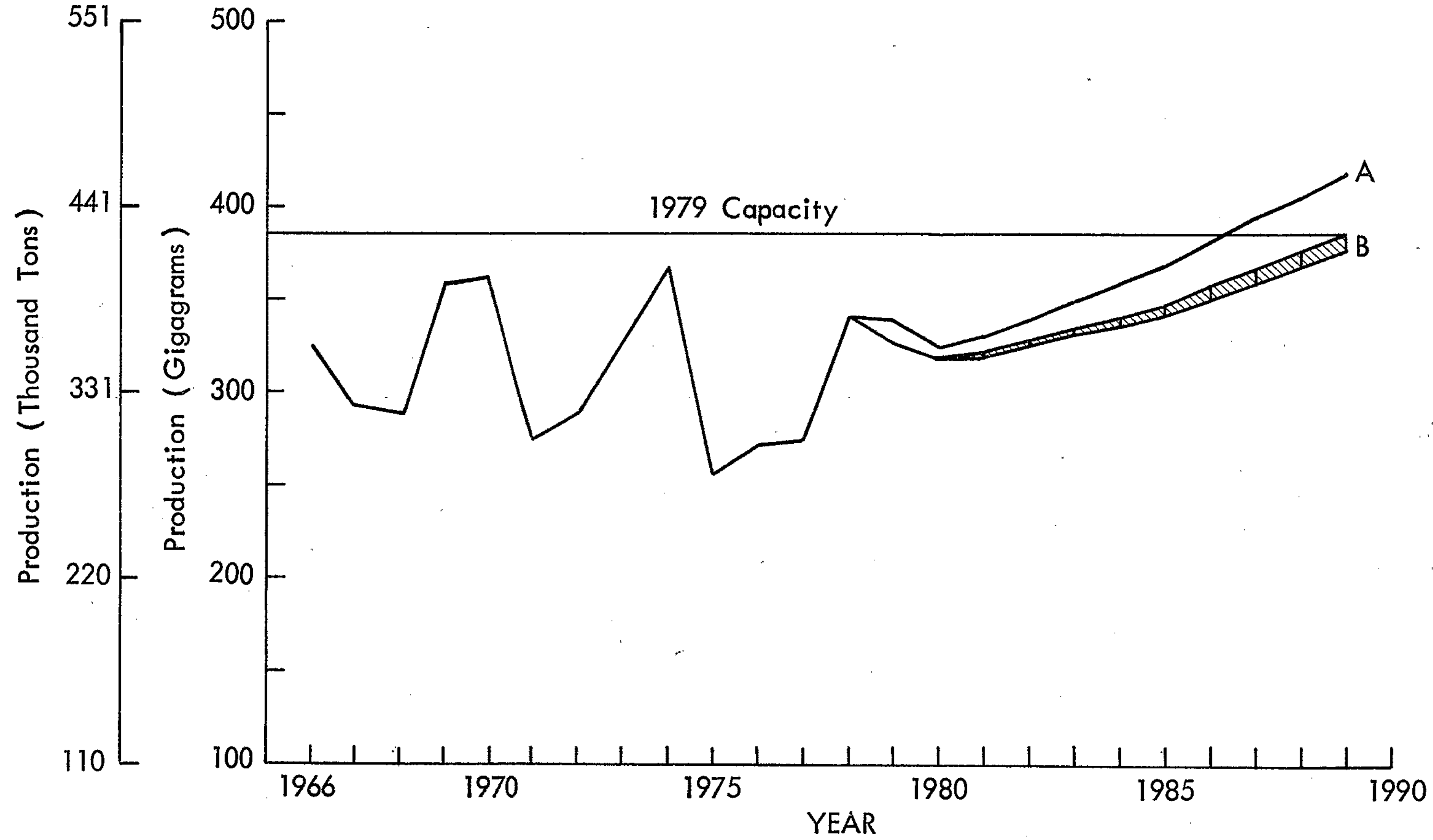
The projection of secondary refined copper production was based on a regression on time, the total consumption of copper in the United States,[4] and the index of durable manufactures.[7] The index of durable manufactures represents the demand for copper, 85 percent of which was consumed in building and construction, transportation, industrial machinery and equipment, or electrical and electronic products in 1978.[4] Total copper consumption was used as a quantitative indicator of the supply of copper scrap, since the source of scrap is copper which was consumed in the past. The new copper scrap, in fact, comes immediately from the copper-using industries. On the other hand, there is usually a considerable time lag between copper consumption and its recovery as old scrap. The data base for the projection is shown in Table 4-2. A trilinear regression of secondary copper production on the year, the index of durable manufactures, and the total U.S. copper consumption yeilded the equation:

$$S = 14.732.4 - 7.48049\ y + 0.0421744\ c + 2.03111\ m$$

where S is the secondary copper production in thousand short tons, y is the year (1966 to 1978), c is the total U.S. copper consumption in thousand short tons, and m is the Federal Reserve Board index of durable manufactures (1967 = 100). The index of determination, $R^2$, is 0.42, so the independent variables "explain" 42 percent of the variation in secondary copper production. This shows only a moderate degree of correlation between the variables, and it means that estimates based on them are of "ballpark" precision.

Five projections of secondary copper production were calculated from the regression equation, using a forecast of the index of durable manufactures and five forecasts of total copper consumption.

The 1979 and 1980 forecasts of the index of durable manufactures are the Predicasts Composite Forecasts:[8] 146 in 1979 and 142 in 1980. The Predicasts annual growth rate for 1976 to 1990 (4.3 percent) was used to project the index through 1989. The projected 1989 value is 207. The index is presented in Figure 4-2.




LEGEND

A. Based on Bureau of Mines and ITA Forecast of Total Copper Consumption

B. Based on CRA Forecasts of Total Copper Consumption

Figure 4-1. Past and projected production of the secondary copper smelting and refining industry.

TABLE 4-2. DATA BASE FOR SECONDARY COPPER GROWTH PROJECTION[4,8]

| Year | Total U.S. copper consumption | | Index of durable manufactures 1967=100 | Secondary copper production | |
|---|---|---|---|---|---|
| | Gigagrams | Thousand tons | | Gigagrams | Thousand tons |
| 1966 | 3053.9 | 3366.3 | 99 | 324.5 | 357.7 |
| 1967 | 2581.8 | 2852.6 | 100 | 292.9 | 322.9 |
| 1968 | 2555.0 | 2816.4 | 106 | 287.4 | 316.8 |
| 1969 | 2892.1 | 3188.0 | 110 | 358.2 | 394.8 |
| 1970 | 2671.9 | 2945.3 | 102 | 361.7 | 398.7 |
| 1971 | 2693.1 | 2968.6 | 102 | 276.1 | 304.3 |
| 1972 | 2976.1 | 3280.6 | 114 | 286.9 | 316.3 |
| 1973 | 3177.7 | 3502.8 | 127 | 332.3 | 366.3 |
| 1974 | 2873.1 | 3167.0 | 126 | 366.9 | 404.4 |
| 1975 | 2059.0 | 2269.7 | 109 | 255.9 | 282.1 |
| 1976 | 2611.0 | 2828.1 | 122 | 272.3 | 300.2 |
| 1977 | 2832.9 | 3122.7 | 130 | 274.9 | 303.0 |
| 1978 | 3115.2 | 3433.9 | 140 | 340.2 | 375.0 |

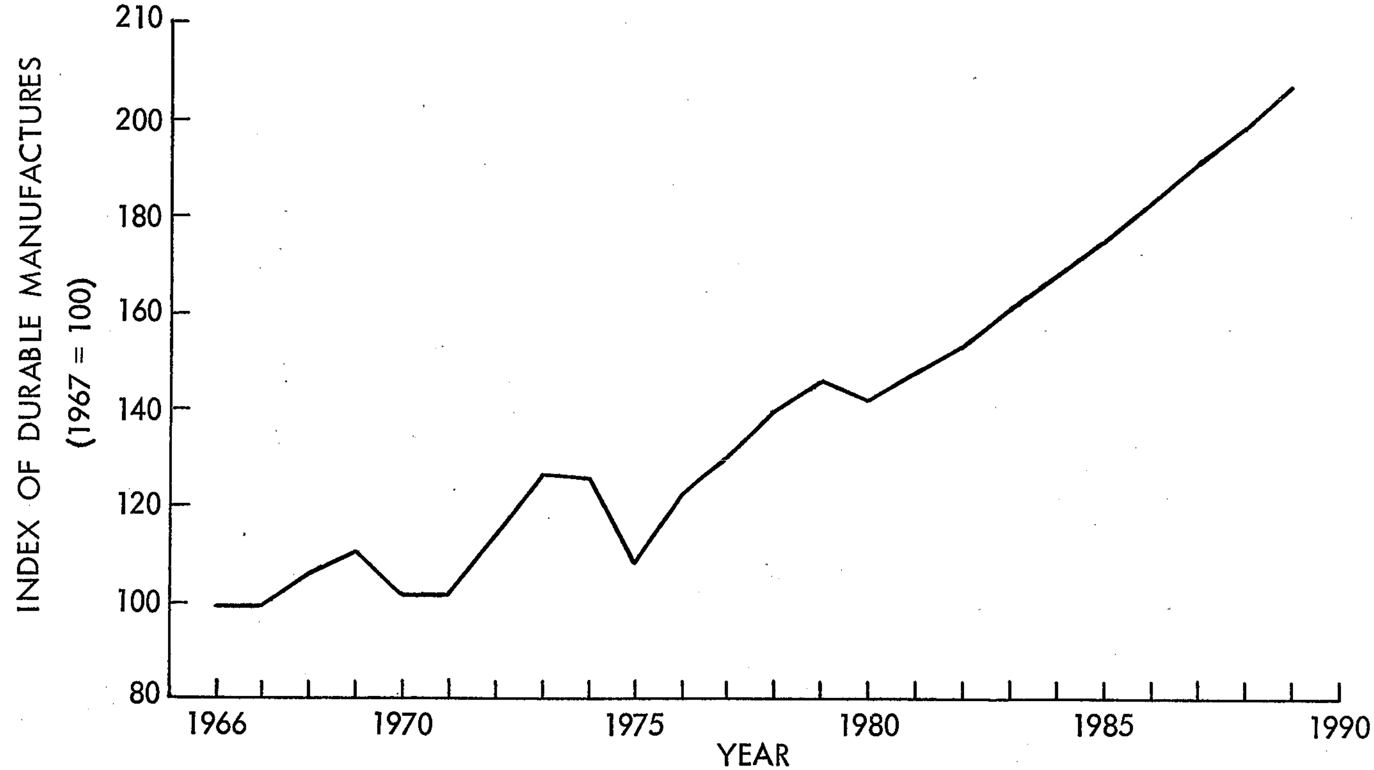



Figure 4-2. Index of durable manufactures.

The five forecasts of total U.S. copper consumption are presented in Table 4-3. The series labeled "Bureau of Mines and ITA" is based on 1979 and 1983 forecasts from the U.S. Bureau of Mines and the Industry and Trade Administration.[9] These forecasts were extended to the other years as follows. The consumption in 1980 is assumed to equal the 1979 consumption because of the present state of the economy. The average annual growth rate which is necessary to reach 3,447 Gg (3,800,000 short tons) in 1983 from 3,175 Gg (3,500,000 short tons) in 1980 is 2.8 percent. This 2.8 percent rate was used to forecast consumption in 1981 and 1982 and to extrapolate the forecast to 1989.

The other four forecasts are from the exercise of a detailed model of the world copper industry constructed by Charles River Associates (CRA).[10] CRA forecast prices, production and consumption of copper through 1985 under four scenarios involving each combination of rapid or moderate growth rates for the world economy and rational disposition or rapid disposition (blow-out) of the present world copper stocks. The rapid growth scenario assumes the 4 percent economic growth which is forecast by most macroeconomic forecasting services and models. The moderate growth scenario assumes a 3 percent economic growth, "which appears more consistent with recent economic experience."[10]

Copper production generally exceeded demand in the mid-1970's. Consequently there is a large overhang of refined copper stocks, approximately 1.3 Tg (1.4 million short tons) of excess copper stocks in the world at the end of 1977.[10] This is approximately 20 percent of annual world production. The rational stock disposal assumption is that holders of stocks will dispose of them in a manner which will maximize their rate of return. Realistically, deviatians from this pattern of stock disposal would occur because of imperfections in the ability of stockholders to predict future price movements and the price responses to different rates of stock disposal. Also the holders of the stocks may have other objectives than maximizing return. For example, an earlier inflow of cash may be needed. The stock blow-out scenario assumes that the excess stocks are disposed of rapidly. The stock blow-out depresses prices and stimulates consumption in the short run, but results in higher prices and lower consumption after the excess stocks have been depleted. The CRA forecasts were extrapolated to 1989 by assuming continuation of the average 1979 to 1985 growth rate.

These five forecasts of total U.S. copper consumption can be compared in Figure 4-3. For the historical data base used with the Bureau of Mines and ITA forecast, MRI used the statistical series from the Copper Development association.[4] CRA used the series from Metal Statistics, an annual publication of Mettalgesellschaft, A.G. The two are in exact agreement prior to 1975 and are in general agreement from 1975 to 1977. The forecast by MRI, the Bureau of Mines, and ITA is probably the most accurate for 1979 and 1980, since it was made significantly closer to the time of the events being forecast. For 1981 to 1985, the growth trend of the CRA forecasts is probably more accurate since these forecasts resulted from a more detailed examination of the relevant factors. The CRA forecast for 1978 is below the actual 1978 results.

TABLE 4-3. TOTAL U.S. COPPER CONSUMPTION[4,9,10]
(GIGAGRAMS)

| Year | Bureau of Mines and ITA | Charles River Associates: Stock: Blow-out, Rapid growth | Charles River Associates: Stock: Blow-out, Moderate growth | Charles River Associates: Stock: Rational, Rapid growth | Charles River Associates: Stock: Rational, Moderate growth |
|---|---|---|---|---|---|
| 1966 | 3054 | 3054 | 3054 | 3054 | 3054 |
| 1967 | 2588 | 2588 | 2588 | 2588 | 2588 |
| 1968 | 2555 | 2555 | 2555 | 2555 | 2555 |
| 1969 | 2892 | 2892 | 2892 | 2892 | 2892 |
| 1970 | 2672 | 2672 | 2672 | 2672 | 2672 |
| 1971 | 2693 | 2693 | 2693 | 2693 | 2693 |
| 1972 | 2976 | 2976 | 2976 | 2976 | 2976 |
| 1973 | 3178 | 3178 | 3178 | 3178 | 3178 |
| 1974 | 2873 | 2873 | 2873 | 2873 | 2873 |
| 1975 | 2059 | 2048 | 2048 | 2048 | 2048 |
| 1976 | 2611 | 2563 | 2563 | 2563 | 2563 |
| 1977 | 2833 | 2810 | 2810 | 2810 | 2810 |
| 1978 | 3115 | 2951[a] | 2951[a] | 2951[a] | 2951[a] |
| 1979 | 3175[a] | 2951 | 2892 | 2937 | 2880 |
| 1980 | 3175 | 3089 | 3011 | 3052 | 2979 |
| 1981 | 3266 | 3062 | 3012 | 3030 | 2963 |
| 1982 | 3357 | 3059 | 3039 | 3064 | 2996 |
| 1983 | 3447 | 3046 | 3034 | 3097 | 3032 |
| 1984 | 3547[b] | 3004 | 2984 | 3092 | 3034 |
| 1985 | 3638 | 3039 | 2992 | 3127 | 3079 |
| 1986 | 3737 | 3054[b] | 3009[b] | 3160[b] | 3113[b] |
| 1987 | 3846 | 3069 | 3026 | 3193 | 3148 |
| 1988 | 3955 | 3084 | 3044 | 3227 | 3183 |
| 1989 | 4064 | 3099 | 3061 | 3160 | 3219 |

[a] Forecast begins.
[b] Extrapolation begins.

TABLE 4-3. TOTAL U.S. COPPER CONSUMPTION[4,9,10]
(THOUSAND TONS)

| Year | Bureau of Mines and ITA | Charles River Associates — Stock: Blow-out — Rapid growth | Charles River Associates — Stock: Blow-out — Moderate growth | Charles River Associates — Stock: Rational — Rapid growth | Charles River Associates — Stock: Rational — Moderate growth |
|---|---|---|---|---|---|
| 1966 | 3366 | 3366 | 3366 | 3366 | 3366 |
| 1967 | 2853 | 2853 | 2853 | 2853 | 2853 |
| 1968 | 2816 | 2816 | 2816 | 2816 | 2816 |
| 1969 | 3188 | 3188 | 3188 | 3188 | 3188 |
| 1970 | 2945 | 2945 | 2945 | 2945 | 2945 |
| 1971 | 2969 | 2969 | 2969 | 2969 | 2969 |
| 1972 | 3281 | 3281 | 3281 | 3281 | 3281 |
| 1973 | 3503 | 3503 | 3503 | 3503 | 3503 |
| 1974 | 3167 | 3167 | 3167 | 3167 | 3167 |
| 1975 | 2270 | 2258 | 2258 | 2258 | 2258 |
| 1976 | 2828 | 2825 | 2825 | 2825 | 2825 |
| 1977 | 3123 | 3097 | 3097 | 3097 | 3097 |
| 1978 | 3434 | 3253[a] | 3253[a] | 3253[a] | 3253[a] |
| 1979 | 3500[a] | 3253 | 3188 | 3237 | 3175 |
| 1980 | 3500 | 3405 | 3319 | 3364 | 3284 |
| 1981 | 3600 | 3375 | 3320 | 3340 | 3266 |
| 1982 | 3700 | 3372 | 3350 | 3377 | 3303 |
| 1983 | 3800 | 3358 | 3344 | 3414 | 3342 |
| 1984 | 3910[b] | 3311 | 3289 | 3408 | 3344 |
| 1985 | 4010 | 3350 | 3298 | 3447 | 3394 |
| 1986 | 4130 | 3366[b] | 3317[b] | 3483[b] | 3432[b] |
| 1987 | 4240 | 3383 | 3336 | 3502 | 3470 |
| 1988 | 4360 | 3400 | 3355 | 3557 | 3509 |
| 1989 | 4480 | 3416 | 3374 | 3594 | 3548 |

[a]Forecast begins.
[b]Extrapolation begins.

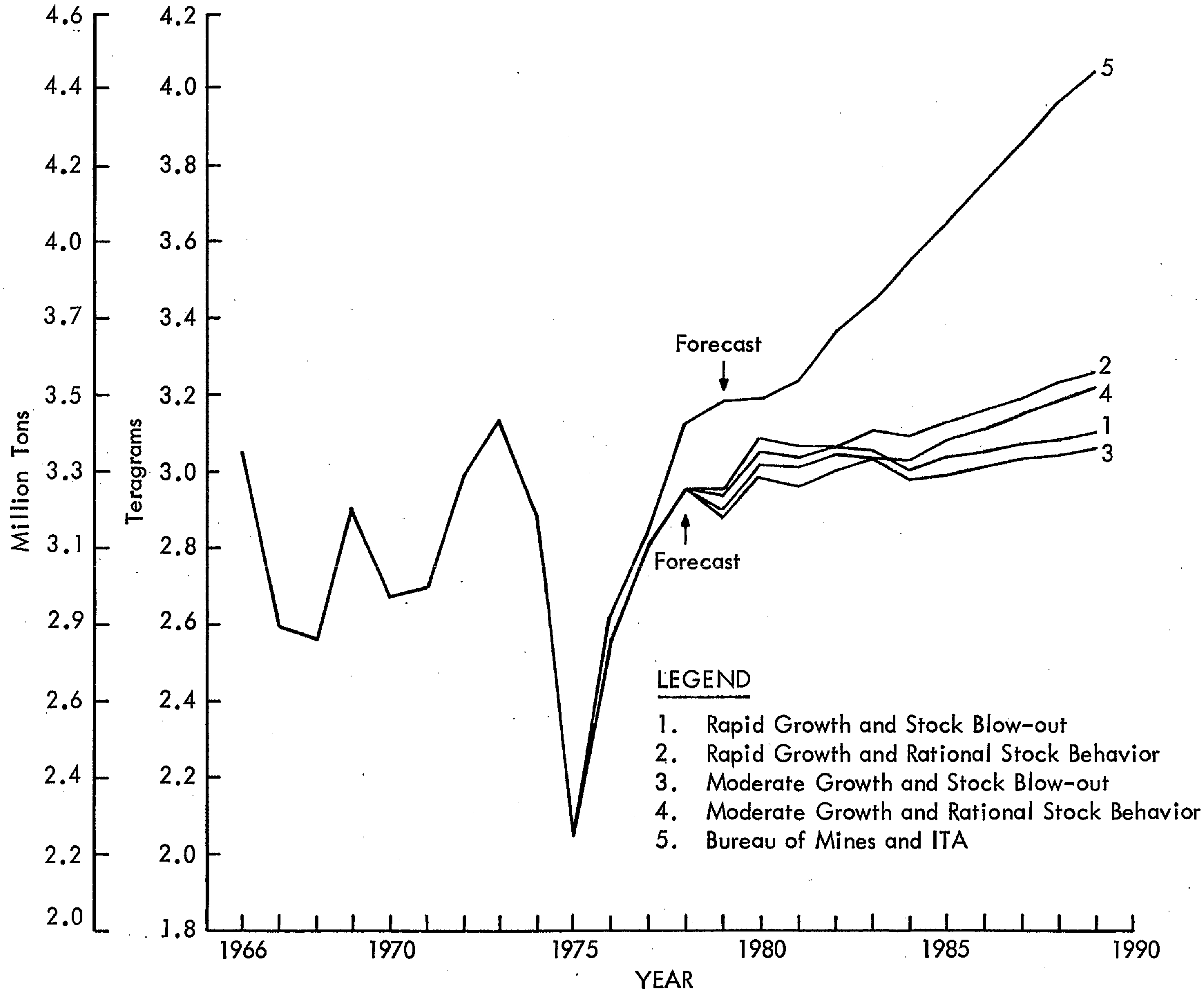



Figure 4-3. Total U.S. copper consumption.

Five projections of the production of the U.S. secondary copper smelting and refining industry were made using the regression equation, the projected index of durable manufactures, and the five forecasts of total U.S. copper consumption. The results are shown in Table 4-4 and Figure 4-1. The four projections which use the CRA forecasts are nearly the same, and Figure 4-1 shows their range. The average annual compound growth rates from 1978 to 1989 range from 1.0 to 1.9 percent.

As Figure 4-1 shows, the industry is extremely volatile. As an illustration of the pitfalls in forecasting the copper industry, Battelle Columbus Laboratories, in a classic 1972 study on solid waste,[11] wisely discounted the 4 to 4.5 percent annual growth commonly mentioned in the press literature and estimated a 2 percent annual growth for total copper consumption through 1979. The actual growth for 1972-1979 was 0.9 percent, but the rate for 1971-1978 was 2.1 percent. This is partly because 1971-1973 was a period with rather high growth in copper consumption, but primarily it reflects the general volatility of the industry. In the same study, the total copper recovered from scrap was projected to grow at 2.15 percent annually for 1969-1979. The actual shrinkage rate for 1969-1979 was 0.1 percent, but the 1968-1978 period averaged a 0.9 percent compound annual growth.

For comparison, the consumption of copper scrap is forecast to increase at a 2.4 percent annual rate for 1978-1987.[12]

### 4.2.3 Past, Present, and Future Market Trends

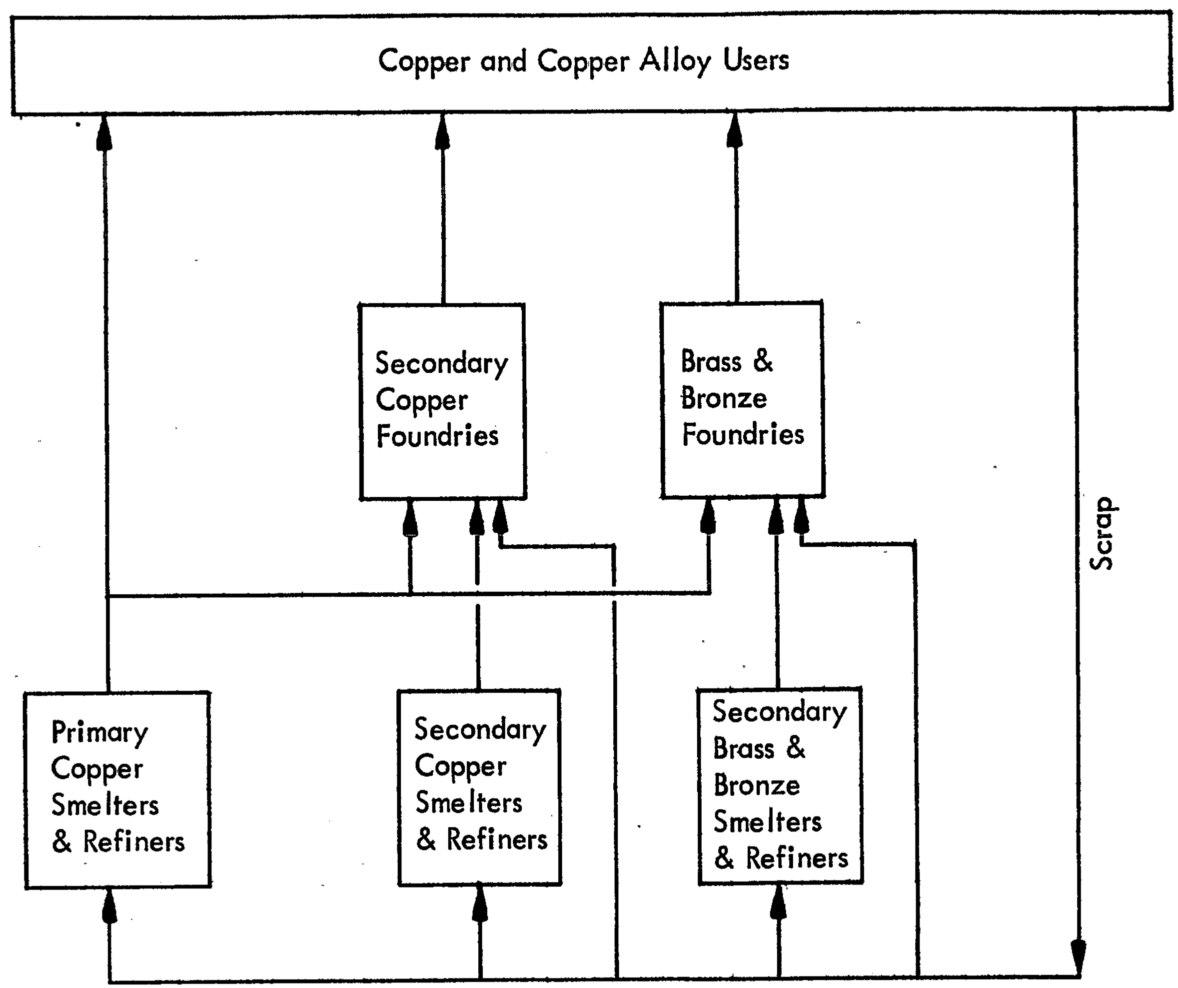
When examining production and growth of the secondary copper smelting and refining industry, it is important to consider other metals and materials that compete with copper for the existing market and to consider the scrap market itself. Copper markets have undergone assault from the aluminum industry in the past, but on the whole, copper has been able to hold its own in the competition. However, in certain industries such as the automobile industry, the use of copper in manufacturing has steadily decreased over the years. The use of copper in automobiles has decreased from 15 kg (34 lb) per car in the 1975 model year to 13 kg (29 lb) per car in the 1979 model year, and it is expected to be 11 kg (25 lb) per car in 1985.[13] This is an annual shrinkage rate of 3.0 percent, but the number of cars produced is expected to grow at an annual rate of 2 to 2.5 percent.[14]

There has also been a trend toward the use of lower grade copper and copper alloys where pure copper was used before. This results in a lower grade of copper-bearing scrap becoming available for the secondary smelters to process and in higher processing costs.

Competition for scrap can also be one of the limiting factors to increased production by a plant. Secondary copper smelters compete for scrap with secondary brass smelters, primary copper producers, and overseas buyers. Figure 4-4 is a simplistic schematic of the flow of copper-bearing scrap in the United States. Figure 4-5 shows a breakdown of the copper scrap consumption and secondary refined copper production in the United States.[15] The market was made even more competitive by the removal of telephone scrap by Western Electric for processing in Nassau Recycling Corporation's new plant in South Carolina.

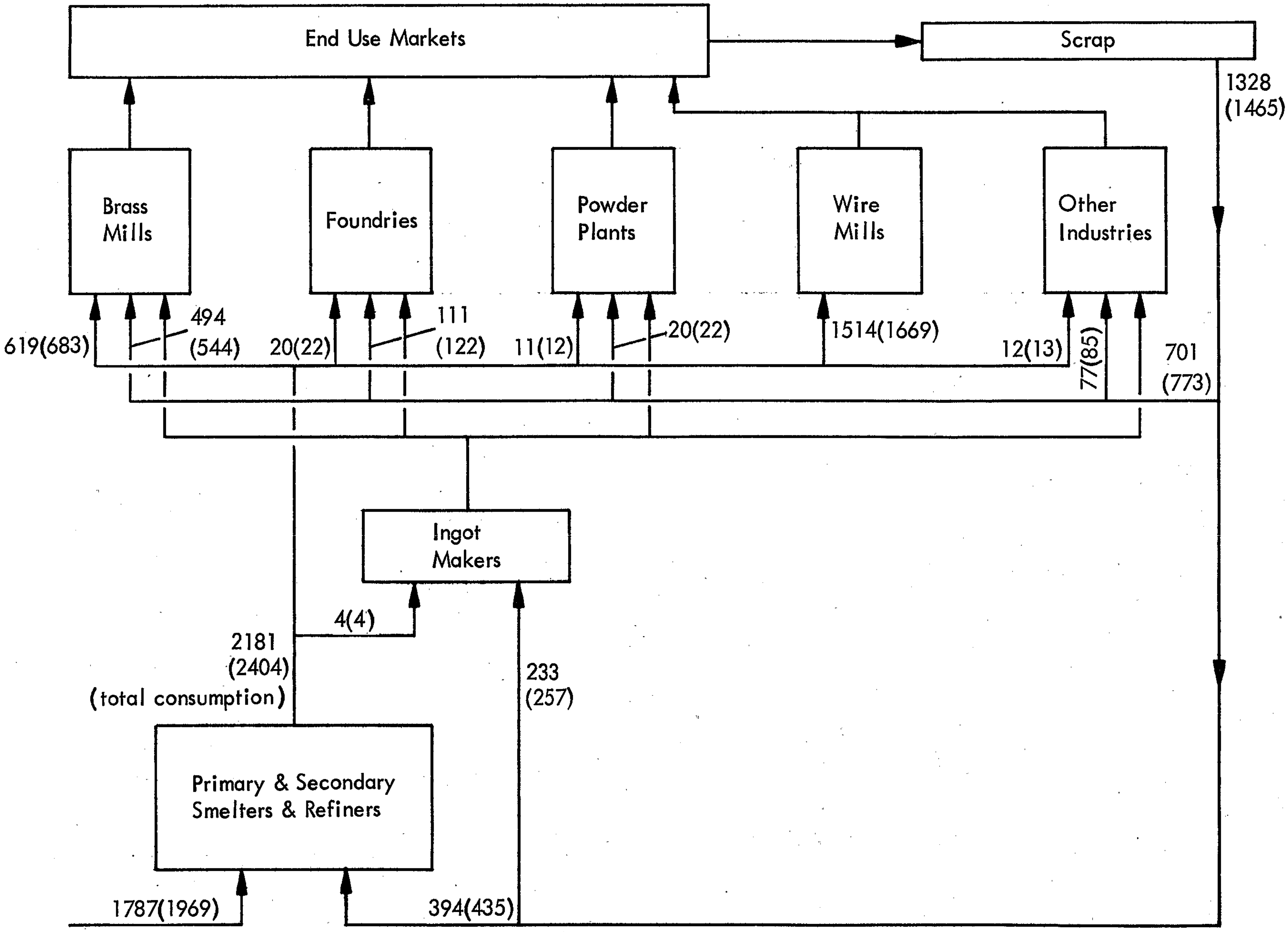
TABLE 4-4. PROJECTED PRODUCTION OF THE SECONDARY COPPER SMELTING AND REFINING INDUSTRY (GIGAGRAMS (THOUSAND TONS))

| Year | Bureau of Mines and ITA | Stock: Blow-out | | Stock: Rational | |
|---|---|---|---|---|---|
| | | Rapid growth | Moderate growth | Rapid growth | Moderate growth |
| 1979 | 338 (373) | 328 (362) | 327 (360) | 328 (362) | 326 (359) |
| 1980 | 324 (357) | 320 (353) | 317 (349) | 318 (351) | 316 (348) |
| 1981 | 332 (366) | 323 (356) | 321 (354) | 322 (355) | 319 (352) |
| 1982 | 340 (375) | 327 (360) | 327 (360) | 327 (360) | 325 (358) |
| 1983 | 350 (386) | 333 (367) | 333 (367) | 336 (370) | 333 (367) |
| 1984 | 360 (397) | 337 (371) | 337 (371) | 341 (376) | 338 (373) |
| 1985 | 370 (408) | 345 (380) | 343 (378) | 348 (384) | 347 (383) |
| 1986 | 383 (422) | 354 (390) | 352 (388) | 358 (395) | 357 (394) |
| 1987 | 395 (435) | 362 (399) | 360 (397) | 367 (405) | 366 (403) |
| 1988 | 407 (449) | 371 (409) | 369 (407) | 376 (414) | 375 (413) |
| 1989 | 420 (463) | 379 (418) | 377 (416) | 386 (425) | 385 (424) |
| Annual growth rate 1978 to 1989: | 1.9% | 1.0% | 1.0% | 1.2% | 1.1% |




Source: MRI (from Copper Development Association)

Figure 4-4. Flow of copper scrap in the United States.




Source: MRI (1978, Copper Development Association)

Figure 4-5. Flow of refined copper and copper scrap in the United States (gigagrams (thousand tons)).

The industry survey indicated that there were seven major plants operating at an average capacity of 84 percent in 1979. Of the major plants, no plans for expansion of any kind were revealed and industry and trade association personnel seem very cautious about even considering expansion. In the past 10 years, statistics from the Bureau of Mines show that there have been no plant closings and only one plant addition in the secondary copper fire-refining industry.[16] Bureau of Mines statistics also show that there were nine plants refining secondary metals that stopped producing secondary refined copper and copper alloy (other than brass and bronze) between 1968 and 1979. Production from each of these plants was usually never more than 454 Mg/year (500 tons/year). The new major plant that was opened belonged to Nassau Recycling Corporation, a subsidiary of Western Electric, which is a major producer of telephone and electrical equipment.

The demand for copper comes mostly from the manufacturers of durable goods. Because of this, the copper market is volatile and very sensitive to national economic recessions. Demand also rises sharply during wars because of the use of copper in ammunition and military equipment. Typically, the copper industry expands to meet wartime demand and is in a state of over-capacity during peacetime.

Copper prices in the United States are set by the primary producers at a level which they believe will give them a reasonable long-term profit without encouraging excessive imports or excessive substitution of other metals. Copper demand is first met by that scrap which can be collected and processed at a cost below the cost of primary production. The remaining demand is filled by primary copper. During copper shortages, the domestic primary producers usually ration their sales instead of raising the price. When the price of scrap increases, the copper scrap supply increases. This is because lower quality and more dispersed scrap can be gathered and processed at a price copper consumers are willing to pay in order to meet that part of their needs which the primary industry is not filling. This process is limited by the cost of imported copper, which is well above the domestic price during times of shortage. During normal times, the primary producers have considerable excess capacity, as they have had since 1975.[17-21]

### 4.2.4 Estimated Expansion

If the secondary copper industry grows in the next decade at the higher rate forecast in Figure 4-1, it will reach 90 percent of present capacity in 1983 and 100 percent in 1986. This would indicate the need for additional production capacity of approximately 82,000 Mg/year (90,000 tons/year) over the 1979 production capacity by 1989. Compared to the primary copper industry, the secondary copper industry is characterized by relative ease of entry and relatively short lead times for expansion of capacity. Also, the volatility of the copper industry gives every incentive to delay decisions to expand as long as possible, and because the industry has been so volatile in the past, growth projections of more that a couple of years must be looked upon with skepticism.

Another problem in making an expansion estimate is that current (1979) plant capacities are not easy to assess. For example, one plant could easily double its fire refining capacity without any capital investment but is limited by its electrolytic refining capacity, by fuel supply costs, and by scrap availability. Thus, the plant is really operating at capacity now, but under the right conditions it could greatly increase production without adding a new source of emissions, if there were a market for the copper anodes the plant produced. With some capital investment, the plant could modify its existing facility to increase its electrolytic refining capacity and consequently its overall production.

One outside influence that would strongly influence the secondary copper industry is an oil embargo or other action restricting oil supplies. The secondary smelters are more energy efficient than primary producers and would be better able to immediately meet the copper demand. This would also depend on their being able to obtain an adequate supply of copper scrap, a requirement that could be eased through government incentives to keep scrap from being shipped overseas to foreign markets.

There is some potential for additional plants, but expansion is unlikely to occur for the following reasons:

1. The industry can meet increased demand by expanding electrolytic refining capacity without adding a significant new emissions source.

2. The industry is reluctant to expand because of the volatility of the market.

3. The anticipated growth in production is too low to place strong expansionary pressure on the industry.

4. The industry survey did not reveal any plans for expansion.

## 4.3 PROCESS DESCRIPTION

The first step in secondary copper smelting involves scrap preparation. Most of the secondary plants in this study do little preparation of scrap other than some sorting and possibly some baling. A couple have incinerators to burn off insulation from copper wire, but the majority of the plants buy their scrap from dealers who do much of the preparation work.

Scrap is charged to a blast or cupola furnace at plants that carry on smelting operations. Charged with the copper bearing scrap are low sulfur coke fuel and fluxes. The copper bearing scrap usually ranges from 30 to 50 percent copper. The product of the smelting operation is black copper, a low grade copper ranging from 75 to 88 percent copper. The black copper might be cast into convenient shapes for later use; shapes can be in the form of shot, pigs, sows, or any mold shape available. Contaminants in the black copper can be common alloying elements such as tin, lead, zinc, nickel, and iron phosphorus, or sometimes precious metals such as gold, silver, and platinum.

During the cupola and blast furnace processes, metallic constituents melt, while the limestone and iron oxides fuse in the smelting zone to form a molten slag. Coke reduces the copper compounds. The molten materials flow downward through the coke bed and are collected in a crucible below. After a period of time, the molten slag and metal form separate layers and are tapped.

A typical slag from a blast furnace has the following approximate composition:[22]

| | Percent |
|---|---|
| FeO | 29 |
| CaO | 19 |
| $SiO_2$ | 39 |
| Zn | 10 |
| Cu | 0.8 |
| Sn | 0.7 |

Flow rates and exhaust temperatures from cupola furnaces vary from plant to plant depending on furnace capacity and process design. An example for one cupola is a flow rate of 944 $m^3$ STP/min (33,000 scfm), gas temperature (at the baghouse) of 93°C (200°F), and 16.0 Mg/hr (17.6 tons/hr) total charge rate.

Unless the black copper is the secondary copper smelter's salable product, the material must undergo further smelting. This is accomplished in furnaces called converters; most commonly used are the reverberatory and rotary furnaces. These furnaces produce blister copper, a semirefined copper. The off gases containing lead, tin, and zinc oxides are collected with a hood, cooled, and sent to a baghouse for recovery of the oxide dust. This dust, like the cupola dust, is sold principally for its zinc and tin content. Typical operating rates for a reverberatory furnace at one plant are: 716 $m^3$ STP/min (25,294 scfm) gas flow rate; 73°C (163°F) gas temperature; 9.1 Mg/hr (10.0 tons/hr) total charging rate. Typical operating rates for a rotary furnace at one plant are: 1,133 $m^3$ STP/min (40,000 scfm) gas flow rate; 127°C (260°F) gas temperature; 1.9 Mg/hr (2.1 tons/hr) total charging rate.

One plant uses Kaldo furnaces instead of cupola and converter furnaces. The scrap charge to the Kaldo averages about 50 percent copper. Anode copper is the end product from the furnace. Typical operating data for the Kaldo furnace are: 734 $m^3$ STP/min (25,924 scfm) gas flow rate; 68°C (155°F) gas temperature; and 12.3 Mg/hr (13.5 tons/hr) operating rate.

Molten blister copper in some plants is conveyed to an anode furnace where it is fire refined. If blister production is out of phase with the fire-refining operation, the molten copper can be cast into any available mold shape. Fire refining is accomplished in a reverberatory or rotary furnace. The process removes most metallic oxide impurities that are undesirable in high purity copper. Most of these impurities are trapped in the slag cover. Once the slag cover is removed, the refined copper is deoxidized with green wood poles under a charcoal or coke cover. The molten deoxidized copper is cast into anodes for electrolytic refining or into copper billets, wire bar, etc. Emissions from the anode and fire-refining operations are not as substantial as those from the smelting operation.

The anodes are taken to electrolytic refining tankhouses where they are placed into cells in an alternating fashion with thin copper starter sheets. The electrolytic deposition on the sheets produces cathodes of refined copper. No significant emissions were identified from this operation.

The cathodes are melted in shaft or reverberatory furnaces and the refined copper is cast into the desired product shapes such as cakes, billets, and wirebar as well as ingots.

The shaft furnace, which uses natural gas as a fuel and operates on the principle of the cupola furnace, continuously melts cathodes, with reduction accomplished by poling or charcoal in a small reverberatory holding furnace before casting. The particulate emissions from this operation are not substantial and can be controlled by any of a number of control systems.

Throughout the smelting and refining operation, the slags generated are sent to landfills, sold, or (depending on metals content) recycled. Recoverable particulates captured in emission control systems are recycled or sold for their metals content. Figure 4-6 is a flow diagram for the materials and products of the secondary copper smelting and refining industry.

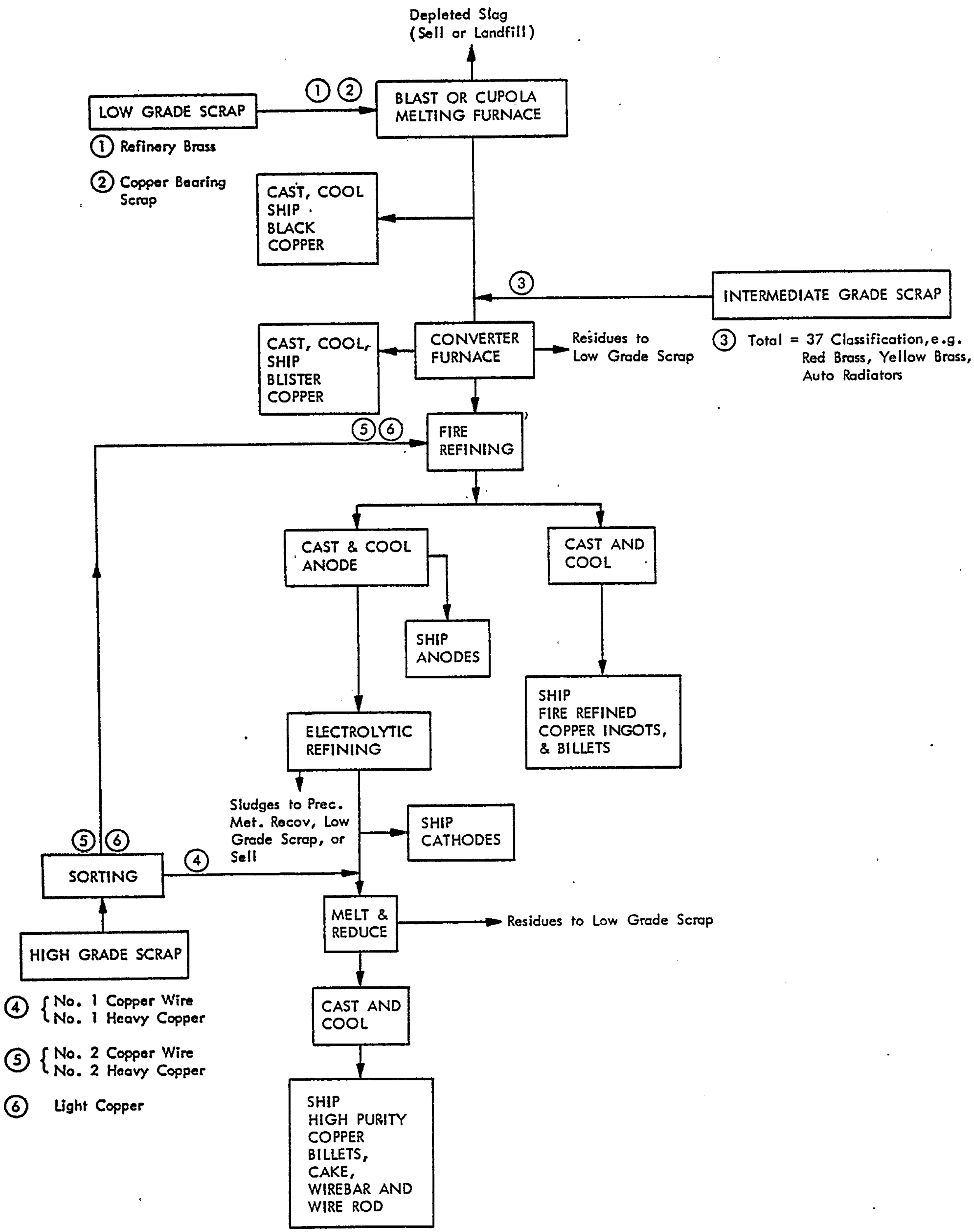



Figure 4-6. Raw material and product flow diagram of the secondary copper industry.

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# 5. AIR EMISSIONS DEVELOPED IN THE SOURCE CATEGORY

## 5.1 PLANT AND PROCESS EMISSIONS

This chapter identifies the types and quantities of emissions from several potential emission points within secondary copper smelting and refining plants. Emission test data were requested from all local and state control agencies having jurisdiction over existing secondary copper smelting and refining plants. Data were also requested for several secondary copper alloying industries and several secondary copper foundries from the control agencies. The agencies for the States of New York, Pennsylvania, Illinois, and Georgia, the City of Philadelphia, and the South Coast Air Quality Management District of California furnished data for this study. In many cases, the data were fragmentary and the study was generally hampered by a scarcity of good, current data.

Available emission data from the above agencies and from the National Emission Data System (NEDS) Point Source Listing were used to develop emission factors for an uncontrolled plant and a typical plant controlled to meet requirements of a typical State Implementation Plan. These plants are hypothetical in that each of the major plants studied is different in some respect in their secondary copper processing operations. For instance, some plants do not have blast or cupola furances, another does no fire-refining.

### 5.1.1 Particulate Emissions from the Source Categories

The cupola furnace is the first step in the smelting of low grade copper bearing scrap. The emission rate from this source is the highest of any operation in the smelting and refining process. The emissions consist of metal oxide fumes as well as particulate matter from dusty charge materials, limestone, or fluorspar, and coke ash or coke breeze. The metal oxides, especially zinc oxide, are very small in particulate size (usually less than 1 μm (0.00004 in.). Some fine particulate is also produced from combustion of coke and organic wastes in the charge materials. The following is a typical composition of the collected dusts:

| | Percent |
|---|---|
| Zn | 58-61 |
| Pb | 2-8 |
| Sn | 5-15 |
| Cu | 0.5 |
| Sb | 0.1 |
| Cl | 0.1-0.5 |

As an example of the quantity of emissions from a cupola, at one plant 5.4 to 6.4 Mg/day (6 to 7 tons/day) of particulates are removed by the pollution control system. This cupola furnace produces approximately 2.2 Mg/day (2.4 tons/day) of black copper. Controlled particulate emissions from this operation are approximately 4.8 kg/hr (10.5 lb/hr). The amount of particulates removed depends on several factors including the amount of fine material in the scrap charge, the composition of the scrap charge, and the efficiency of the pollution control device. In addition to emissions from the cupola stack, there are also fugitive emissions that many plants occasionally have trouble controlling. These occur primarily during tapping of the furnace and are in the form of fine particulates or steam containing particulates when the molten copper is poured into a shot pit.

Between the cupola and converter operations, some plants have a holding furnace which keeps the black copper from the cupola in a molten state until it is loaded to the converter. Emissions from this furnace are fugitive, metal oxide fumes which occur during tapping of the furnace. One plant with a holding furnace taps the furnace approximately 12 times during a converter cycle and averages two converter cycles a day. Fugitive emissions can also be emitted from the furnace's emergency slagging hole and primary slagging hole.

One plant sends its cupola melt to a settler where slag and molten copper are allowed to separate. The copper rich slag is sent to an electric arc furnace where coke and limestone are added and the slag is cleaned to recover its copper content. The molten copper layer in the settler and the copper from the arc furnace are tapped and this black copper is sent to the converter. Emissions from the electric arc furnace are similar to those from the cupola. The fugitive emissions occurring during tapping are metal oxide fumes.

Exhausts from converters contain metal oxides of all of the metals present in the molten copper and other pollutants. Included are copper, zinc, sulfur, and phosphorus. Emissions are less than those from the cupola. However, the amount of particulates emitted depends on the converter used and composition of the melt. For the above plant, 0.9 Mg/day (1 ton/ day) of particulates are removed by the control system on a rotary converter producing approximately 34 Mg/day (37 tons/day) of blister copper. Controlled particulate emission data for this operation were not available. Fugitive emissions from the converters also can be a problem at the converter outlet and charge door.

Reverberatory and rotary furnaces doing fire-refining of blister copper for casting into anodes or billets produce fumes of metal oxides when the molten metal is blown with air to remove metallic impurities, or when green wood poles are inserted into the furnace to deoxidize the melt. Fine particulate due to incomplete combustion can be produced, particularly if oil-fired furnaces are used or if the charge is not pretreated to remove organic wastes. An example of controlled and uncontrolled particulate rates for a reverberatory anode furnace are 1.7 kg/hr (3.7 lb/hr) and 54 kg/hr (119 lb/hr), respectively. Production rate from this furnace is approximately 55 Mg/day (61 tons/ day). Fugitive emissions can come from the charge doors during poling operations.

A natural gas fired shaft furnace or reverberatory furnace is most commonly used to melt cathode copper so that it can be cast into wirebar, billets, or cakes. Particulate emissions from this operation are low, however, some form of control is often employed.

Emissions from the above operations are summarized for a typical plant on Table 5-1. The emission rates were obtained from industry furnaces of comparable size to those in the typical plant.

### 5.1.2 Sulfur Emission from the Source Category

Sulfur emissions from the secondary copper smelting and refining industry do not pose a particularly large problem. The sulfur content of the scrap or copper bearing charge is very low, the sulfur having been removed during primary metal refining. Sulfur emissions may become a problem when moderate to high content sulfur fuels and coke charges are used in smelting and refining operations.

Sulfur emissions are generally highest during the cupola and converter operations for two reasons: these operations use more fuel or charge than subsequent operations and any sulfur in the copper bearing charge is removed in these operations. Fuel consumption in the anode and fire-refining furnaces is less and consequently sulfur emissions are less. Sulfur emissions from the shaft furace melting cathode copper are not a problem as natural gas is the fuel most commonly used in this operation. See Table 5-1 for typical plant uncontrolled and controlled emissions.

### 5.1.3 Other Emissions from the Source Category

Other minor emissions from the smelting and refining process operations include nitrogen oxides, hydrocarbons, and carbon monoxide, but very few measurements have been made, and no measurements are available for some types of furnaces. Table 5-2 presents the available data. Information on the sources of these data are presented in Chapter 7. These emissions were either not considered a problem by the state regulatory agencies, or were ot covered by a state regulation.

Some plants that perform scrap preparation have an incinerator to burn insulation from scrap wire. Emissions from this operation can be in the form of hydrocarbons and other organics and chloride compounds; however, proper operation of the incinerator (temperature) should keep these emissions at a minimum. Also in the area of scrap preparation is the possibility of dust emissions during various crushing and size reduction processes. However, of the plants questioned during the study none were found to be carrying on scrap preparation operations other than sorting, baling, and some incineration.

One operation with potential emissions is the crushing of slag that is sold, sent to a landfill, or smelted (if the copper content is high). However, this is only a source of emissions if dry crushing operations are conducted; of the plants questioned, all were using a wet crushing process.

TABLE 5-1. OPERATING SPECIFICATIONS AND UNCONTROLLED AND CONTROLLED EMISSION RATES FOR THE TYPICAL SECONDARY COPPER SMELTING AND REFINING PLANT

| | Cupola | Rotary converter | Reverberatory anode furnace No. 1 | Reverberatory anode furnace No. 2 | Reverberatory fire refining furnace | Shaft furnace |
|---|---|---|---|---|---|---|
| Production (net Cu content) Mg/year (tons/year) | 22,680 (25,000) | 22,680 (25,000) | 22,680 (25,000) | 22,680 (25,000) | 9,070 (10,000) | 54,430 (60,000) |
| Process rate (total charge) Mg/hr (tons/hr) | 8.2 (9.0) | 3.4 (3.7) | 4.5 (5.0) | 4.5 (5.0) | 1.1 (1.2) | 6.5 (7.1) |
| Total hours of operation | 8,400 | 8,400 | 4,200 | 4,200 | 8,400 | 8,400 |
| Gas effluent rate $m^3$STP/min (SCFM) | 1,698 (60,000) | 1,132 (40,000) | 682 (24,100) | 682 (24,100) | 566 (20,000) | 730 (25,800) |
| Gas temperature °C (°F) | 93 (200) | 127 (260) | 78 (173) | 78 (173) | 78 (173) | 247 (476) |
| Stack height m (ft) | 23 (75) | 23 (75) | 17 (55) | 17 (55) | 17 (55) | 17 (55) |
| Fuel or charge | coke | fuel oil | 1. fuel oil<br>2. natural gas<br>3. coke | 1. fuel oil<br>2. natural gas<br>3. coke | 1. fuel oil<br>2. natural gas<br>3. coke | natural gas |

TABLE 5-1. (continued)

| | Cupola | Rotary converter | Reverberatory anode furnace No. 1 | Reverberatory anode furnace No. 2 | Reverberatory fire refining furnace | Shaft furnace |
|---|---|---|---|---|---|---|
| Burning rate[1] GJ/Mg ($10^6$ Btu/ton) of Cu content | 23.45 (20.16) | 3.99 (3.43) | 1. 1.42 (1.22)<br>2. 0.27 (0.23)<br>3. 0.33 (0.28) | 1. 1.42 (1.22)<br>2. 0.27 (0.23)<br>3. 0.33 (0.28) | 1. 1.42 (1.22)<br>2. 0.27 (0.23<br>3. 0.33 (0.28) | 2.27 (1.95) |
| Uncontrolled particulates emission factor kg/Mg (lb/ton) of charge | 17 (33) | 22 (45) | 12 (24) | 12 (24) | 20 (40) | 0.5 (1.0) |
| Uncontrolled particulates kg/hr (lb/hr) | 136 (300) | 76 (167) | 54 (119) | 54 (119) | 22 (48) | 2.6 (5.7) |
| Controlled particulates kg/hr (lb/hr) | 4.1 (9.0) | 2.3 (5.0) | 1.8 (4.0) | 1.8 (4.0) | 0.5 (1.0) | 1.1 (2.4) |
| Sulfur emissions kg/hr (lb/hr) | 3.6 (8.0) | 23 (50) | 4.5 (10) | 4.5 (10) | 1.8 (4.0) | 0 |

TABLE 5-2. SUMMARY OF AVAILABLE EMISSION DATA BY PLANT AND EMISSION SOURCE

| Plant | Type of furnace | Particulates | Emissions with existing controls kg/hr (lb/hr) | | | |
|---|---|---|---|---|---|---|
| | | | $SO_2$ | $NO_X$ | HC | CO |
| USMR | Cupola | 16.3 (35.9) | 2.3 (5.0) | 1.3 (3.0) | | |
| | Slag cleaning | 4.9 (10.8) | | | | |
| | Converter | 2.8 (6.2) | | | | |
| | Reverberatory | 0.6 (1.4) | | | | |
| | Reverberatory | 4.5 (9.8) | | | | |
| | Reverberatory | 2.9 (6.4) | | | | |
| | Reverberatory | 0.3 (0.7) | | | | |
| | Reverberatory | 1.1 (2.5) | | | | |
| | Shaft | 1.5 (3.2) | | | | |
| Franklin Smelting and Refining | Cupola | 4.6 (10.1) | 1.3 (3.0) | 0.4 (0.9) | 0.1 (0.2) | 0.1 (0.2) |
| CHEMETCO | Holding | 0.3 (0.6) | | 5.9 (12.9) | 0.1 (0.2) | 0.5 (1.0) |
| | Kaldo | 8.1 (17.8) | | | | |
| | Kaldo | 8.1 (17.8) | | | | |
| | Kaldo | 8.7 (19.2) | | | | |
| Cerro Copper Products | Reverberatory | 1.7 (3.7) | | 5.2 (11.5) | 0.1 (0.2) | 0.4 (0.8) |
| | Reverberatory | 4.3 (9.4) | | 5.2 (11.5) | 0.1 (0.2) | 0.4 (0.9) |
| | Billet | 4.8 (10.5) | | 3.9 (8.6) | | 0.3 (0.6) |
| | Shaft | 1.2 (2.7) | | 6.3 (13.8) | 0.1 (0.2) | 0.5 (1.0) |

TABLE 5-2. (continued)

| Plant | Type of furnace | Particulates | Emissions with existing controls kg/hr (lb/hr) | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | | $SO_2$ | $NO_x$ | HC | CO |
| Southwire | Cupola | 4.1 (9.0) | 3.6[a] (8.0) | | | |
| | Converter | 2.3 (5.0) | 272.0[b] (600.0) | | | |
| | Reverberatory | 4.5 (10.0) | 22.7[a] (50.0) | | | |
| Nassau Recycling | Reverberatory | 15.1 (33.4) | | | | |
| | Reverberatory | 30.2 (66.6) | | | | |

[a] $SO_2$ emission measurements are for when operations are using standby fuel oil; these operations normally use natural gas.

[b] This figure is the average $SO_2$ emission rate for a blow; the plant averages two blows per day, each blow lasting from 30 to 90 min. $SO_2$ emissions are determined by a material balance analysis before and after a converter cycle.

### 5.1.4 Typical Secondary Copper Smelting and Refining Plant

This section describes a typical plant that is meeting the requirements of a typical State Implementation Plan. The plant is typical only in the sense that all smelting and refining operations described previously are employed in the production of refined copper. It should be noted that none of the plants surveyed have identical processes to those employed by the typical plant. In addition, only two plants of those surveyed have all the processes employed by the typical plant in their own production scheme. The others employ only certain of the processes; for instance, one plant has only the cupola and converter operations.

Two operations not shown are a holding furnace and electrolytic refining. The plant also has no scrap preparation other than sorting and baling. The table shows two anode furnaces, but only one furnace is operating at a time because electrolytic refining capacity is 45,300 Mg/year (50,000 tons/year). Therefore, the plant capacity could be increased by adding electrolytic capacity. This is a situation that exists with at least two plants. Operating time is based on 24 hr/day, 50 weeks/year or 8,400 hr/year. Entry of scrap copper into the production flow is based upon its copper content. Copper production is 9,070 Mg/year (10,000 tons/year) of fire-refined copper and 54,430 Mg/year (60,000 tons/year) of cathode copper, a total of 63,500 Mg/year (70,000 tons/year) of finished copper. Sulfur emissions were not controlled, but use of low sulfur fuels was assumed. Figure 5-1 is a production flow diagram of the typical plant.

The typical plant specifications will be used in Chapter 8 to summarize the state and local emissions regulations that apply to new and modified sources in the source category.

The uncontrolled particulate emission factor was calculated by dividing uncontrolled particulates in kilograms per hour (pounds per hour) by the process weight rate (total charge) in megagrams per hour (tons per hour). The process weight includes all metal bearing charge, solid fuel charge, and other materials that are fed into a furnace.

## 5.2 TOTAL NATIONAL EMISSIONS FROM SOURCE CATEGORY

Total potential nationwide emissions for the secondary copper smelting and refining industry are shown in Table 5-3. Only particulate emissions are shown because there were insufficient data to determine a national sulfur emission estimate. Sulfur emission data were available for only one plant. In addition, fuel consumption data were not available from which the quantity of $SO_2$ emissions could be estimated.

Total controlled particulate emissions is the sum of existing or estimated particulate emissions for each emission source based on data obtained from the NEDS, state regulatory agencies, or local regulatory agencies. Emission data had to be estimated for Nassau Recycling Corporation's cupola and converter furnaces because these operations were not on line the entire year in 1979. Emissions data from a plant with similar cupola and converter capacity were substituted for the missing data. Nassau's cupola and converter

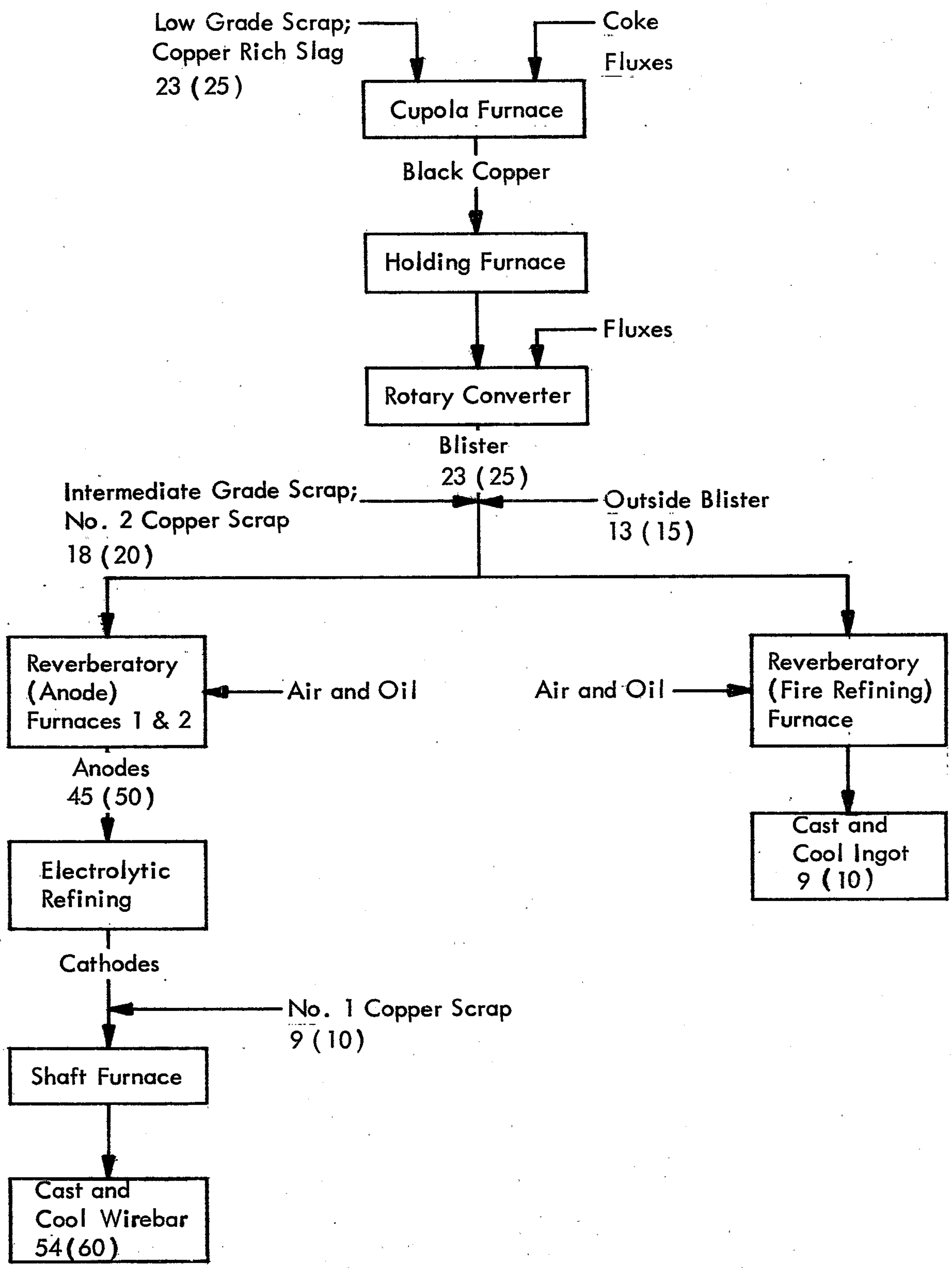


Figure 5-1. Production flow from the typical copper smelting and refining plant (Gg/year (thousand tons per year) net copper content).

TABLE 5-3. NATIONWIDE POTENTIAL EMISSIONS FROM THE SECONDARY COPPER SMELTING AND REFINING INDUSTRY FOR 1979 ASSUMING COMPLIANCE WITH SIP'S (Mg/year (tons/year))

| Process source | Control devices | Particulates | |
|---|---|---|---|
| Cuplas | Fabric filters | 253 | (279) |
| Converters | Fabric filters | 83 | (92) |
| Fire refining and anode furnaces | Fabric filter or wet scrubber | 592 | (652) |
| Shaft furnaces | Settling chamber or none | 45 | (50) |
| Other[a] | Fabric filter, wet scrubber, or none | 259 | (285) |
| Total | | 1,232 | (1,358) |

[a]Slag cleaning furnace, Kaldo furnaces, and holding furnaces.

furances are expected to be operating full time in 1980. Therefore, the total national emissions for 1979 really represents the approximate emissions from all sources assuming they were operating full time (or at plant capacity). Nassau also had no controls on its fire-refining and anode furnaces, which is the reason total emissions from this source are so high. The plant will probably install controls in the near future.

In other cases where emission rates from a plant process had to be estimated, enough data about the source (e.g., flow rates, charge rates, etc.) were available to make an emissions estimate. The category, "other," contains holding furnaces at two plants, a slag cleaning furnace, and three Kaldo furnaces. The three Kaldo furnaces contribute 209 Mg/year (230 tons/year) to the emissions total for the "other" category.

REFERENCES: Section 5.

1. Kusik, C. L., and C. B. Kenahan. Energy Use Patterns for Metal Recycling. U.S. Bureau of Mines Information Circular 8781. Washington, D.C. 1978. pp. 31-56.

2. Battelle Memorial Institute, Columbus, Ohio. Development Document for Interim Final Effluent Limitations Guidelines and Proposed New Source Performance Standards for the Secondary Copper Subcategory of the Copper Segment of the Nonferrous Metals Manufacturing Point Source Category. U.S. Environmental Protection Agency, Washington, D.C. Publication No. EPA 440/1-75/ 032-c. February 1975. 221 p.

# 6. EMISSION CONTROL SYSTEMS

## 6.1 CURRENT CONTROL TECHNOLOGY PRACTICES

Several sources of information were used to obtain data on the types and operation of commonly used control systems for each emission source at each plant. These were primarily telephone contacts with plant personnel and state and local control agencies. The usual process emission points where controls were applied were cupolas, converters, anode and fire-refining furnaces, and shaft furnaces. Other sources included Kaldo furnaces, holding furnaces and incinerators and were found in only one or two plants in the industry.

### 6.1.1 Cupola Emission Control Systems

The pollutant of concern in this process is particulates. Of the four plants that had a cupola furnace, all use fabric filtration to control particulate emissions. Information obtained on three of the four installations showed that the fabric filtration system (baghouse) was of the shaker variety. The filter bags consist of graphite/silicon treated fiberglass. The periodic shaking of the bags gradually breaks the glass fibers and causes higher maintenance costs. However, the glass bags are capable of withstanding higher temperatures than conventional wool, cotton, and synthetic fiber filter media.[1]

The gases from the cupola are cooled before reaching the fabric filters by an indirect water cooling system. All systems provided adequate control to easily meet requirements of a typical State Implementation Plan (SIP).

Problems with fugitive emissions usually occur at the charging door and at the tapping port of the cupola. Plants that have the best system of control provide hooding over the tapping port with ducts to carry emissions to the baghouse. One plant that has problems with fugitive emissions at its charge door is committed to installing a "double door-evacuated chamber charging system" to eliminate the problem.[2] This appears to be the most advanced technology in the industry for control of fugitives from the cupola furnace.

Sulfur emissions apparently are not a serious problem as no violations of existing state standards were identified. For the plant in South Carolina, there was no applicable sulfur emission standard.[3] The other three plants with cupolas use low to moderately low sulfur fuels to meet state sulfur emission standards.

### 6.1.2 Converter Emission Control Systems

The same four plants that have cupolas also have converter furnances. Again, all operations were controlled by baghouses. Of three plants surveyed, two had shaker baghouses. All four plants were meeting state standards for particulates and would easily meet requirements of a typical SIP.

Fugitive emissions from converter operations are not a big problem. Indications from state control agencies were that problems with fugitive emissions do sometimes occur, particularly during the charging operations of the converting cycle and again during discharge of the molten blister. Fugitive emission rates must be estimated and only one state, Georgia, had an estimate; 4 kg/cycle (8 lb/cycle) with approximately 2 cycles/day. The state does not think this quantity of emissions is a problem.

The uncontrolled sulfur emissions from the converter furnaces are higher than those from the cupolas (two plants had only incomplete sulfur emission data). Any sulfur in the black copper is released during the converting processes. One of the plants had a scrubber following its baghouse system that is apparently operating efficiently. Old data (NEDS 1975) show a controlled emission rate of 11 Mg/year (12 tons/year) of $SO_2$ with 153 Mg/year (169 tons/year) allowed.

### 6.1.3 Anode and Fire-Refining Emissions Control Systems

Five of the seven plants have anode and/or fire-refining furances. Three of those plants have baghouse systems on their operations; one was installed within the last year. These plants had particulate emission rates that are well below a typical SIP.

One of the five plants has no air pollution control on its fire-refining and anode furnaces. Available emissions data show that the plant is in violation of state standards.[4] The plant indicated that they were considering fabric filtration as the method of control of their particulate emissions. Preliminary uncontrolled emissions for this plant are 30.2 kg/hr (66.6 lb/hr) for their fire-refining furnace and 15.1 kg/hr (33.4 lb/hr) for their anode furnace. Allowable rates are 8.3 kg/hr (18.4 lb/hr) and 13.6 kg/hr (30.0 lb/hr), respectively.

The fifth plant has a gas quencher, high energy venturi scrubber with mist eliminator control system on each of its anode furnaces and is achieving a 97% reduction in particulate emissions. The plant also has a medium energy venturi scrubber with mist eliminator on its fire-refining furnace and is obtaining 87% control efficiency.[5] Its controlled emission rate also meets the requirements of a typical SIP.

Fugitive emissions are a potential problem; however, indications from the plants surveyed and from the state control agencies are that these emissions appear to be minimal. No data on fugitive emissions from these processes were uncovered during the study.

Sulfur emissions are not a serious problem during fire-refining and anode production operations unless a high sulfur fuel is used. None of the plants surveyed indicated usage of a high sulfur fuel in any of their operations. No information was obtained on the plant in South Carolina with respect to the type of fuel it was using.

### 6.1.4 Shaft Furnace Emission Control System

Four plants have shaft furnaces to melt their cathode copper and cast the final product. Emissions from this source are not usually a problem. In fact, only one of the four furnaces has any form of control. In order to comply with state standards in New Jersey, U.S. Metals Refining installed a settling chamber to partially control particulate emissions from its shaft furance. The system operates at a listed efficiency of 58.6% and controlled emissions are listed at 1.5 kg/hr (3.3 lb/hr). The allowable rate is 6.0 kg/hr (13.3 lb/hr) (1976 NEDS data).

There are no sulfur emissions from the shaft furances.

### 6.1.5 Miscellaneous Operations Emission Control Systems

6.1.5.1 Kaldo Furnace Emission Control. CHEMETCO in Illinois uses three Kaldo furances in its refining operations. Each furnace is equipped with a gas quencher, high energy venturi scrubber, and mist eliminator control system. Illinois EPA has estimated that CHEMETCO is achieving a 99.5% reduction in emissions with these systems.[6]

No data on fugitive emissions or sulfur emissions from the Kaldos were available.

6.1.5.2 Holding Furnace Emission Control System. No emission control systems were found on holding furnaces. Although average hourly emission rates on these furnaces are low, fugitive emissions can be substantial when the furnace is tapped. The Southwire plant in Georgia has committed to hood the tapping hole of its holding furnace and duct the emissions to a baghouse. This is the only pollution control system on a holding furnace that was encountered in the study.[7]

No sulfur emission data were available on holding furnaces. However, emissions should be very low because this is not a refining step. One plant is using natural gas to fire its furnace, thus eliminating the main source of potential sulfur emissions.

6.1.5.3 Incinerator Emission Control Systems. Only one plant surveyed had an incinerator operating which burned insulation from scrap wire. Emissions were controlled with an afterburner. No current emission data on the afterburner were available. There is potential for problems with emissions when PVC is incinerated which would emit HCl and possibly chlorinated hydrocarbons; thus, some type of control of chloride compounds would be necessary.[8]

## 6.2 ALTERNATIVE CONTROL TECHNIQUES

The process steps that could be considered for NSPS investigation are the cupola, converter, anode/fire-refining, shaft, Kaldo, and holding furnace emission points. The methods of control for these processes are listed in Table 6-1 as alternatives. All the alternatives address only particulate control since this was the major pollutant emitted and also one for which data exist. Sulfur control alternatives are only low sulfur fuel usage or a sulfur scrubber.

Because so many combinations are possible, all process/control alternative combinations are not listed, but such combinations can be selected from Table 6-1.

## 6.3 "BEST SYSTEMS" OF EMISSION REDUCTION

The plants that are candidates for initial consideration as "best systems" are listed below with plant location and contact indicated.

Southwire Company
Box 1000
Carrollton, Georgia 30117

Mr. William Burson
404-832-5130

| Cupola | Holding | Converter | Anode/Fire-Refining | Shaft |
|---|---|---|---|---|
| Fabric filter - evacuIted chamber on charge door | Hooded tapping hole - fabric filter | Fabric filter | Fabric filter | None |

Comments: This plant was not visited but its planned controls are the most advanced in the industry. Double door-evacuated chamber on cupola charge door and hood on holding furance tapping hole have not been installed yet. Cupola controlled by two baghouses in parallel.

Cupola emissions: Approximately 4 kg/hr (9 lb/hr) particulate not including fugitives; $SO_2$ emissions approximately 3.6 kg/hr (8 lb/hr) when furnace is on standby fuel oil.

Holding: No estimate on fugitive emissions.

Converter: Approxiamtely 2.3 kg/hr (5 lb/hr) particulate not including fugitives (estimated at 3.6 Kg/cycle (8 lb/cycle)); $SO_2$ emissions approximately 272 kg/blow (600 lb/blow) and blow lasts about 45 min, 2 blow/day.

Anode: Approximately 4.5 kg/hr (10 lb/hr) particulate. $SO_2$ emissions approximately 22.7 kg/hr (50 lb/hr) when furance on standby oil fuel.

Shaft: No estimate; in compliance.

TABLE 6-1. CONTROL ALTERNATIVES FOR EACH PROCESS IN THE SECONDARY COPPER SMELTING AND REFINING INDUSTRY

| | Control Technology[a] | | | | | |
|---|---|---|---|---|---|---|
| | Cupola | Converter | Anode/ fire-refining | Shaft | Kaldo | Holding |
| Alternative 1 | FF | FF | FF | SC | FF | FF |
| Alternative 2 | FF-LSF | FF-S | VS-ME | None | VS-ME | None |
| Alternative 3 | FF-LSF-EC | - | - | - | FF-LSF | - |
| Alternative 4 | FF-EC | - | - | - | VS-ME-LSF | - |

[a] FF - fabric filter; LSF - low sulfur fuel; EC - evacuated chamber on charge door; S - scrubber; VS-ME - high energy venturi scrubber with mist eliminator; SC - settling chamber.

U.S. Metals Refining
400 Middlesex Avenue
Carteret, New Jersey 07008

Mr. M. J. Hauser
Plant Metallurgist
Mr. Tony Filiaci
Director of Environmental and Metallurgical Control
201-541-9600

| Cupola | Settler | Arc Furnace (Slag Cleaning) | Converter | Anode/ Fire-Refining | Shaft |
|---|---|---|---|---|---|
| Fabric filter | Fabric filter hooded tapping hole | Fabric filter hooded tapping hole | Fabric filter | Fabric filter | Settling chamber |

Comments: Cupola controlled by two baghouses in parallel. Sulfur emissions are not a problem because of usage of low sulfur fuels. 1976 NEDS data particulate emissions.

Cupola: 142 Mg/year (157 tons/year)
Arc: 43 Mg/year (47 tons/year)
Converter: 24 Mg/year (27 tons/year)
Anode/Fire-Refining: 2.7 Mg/year (3 tons/year) to 39 Mg/year (43 tons/year)
Shaft: 13 Mg/year (14 tons/year)

Franklin Smelting and Refining Company
Castor Avenue and Richmond Street
Philadelphia, Pennsylvania 19134

Mr. Walter Pickwell
Plant Engineer
215-634-2231

| Cupola | Converter | Incinerator |
|---|---|---|
| Afterburner and fabric filter; hooded tap | Fabric filter and scrubber | Afterburner |

Comments: Emissions from the cupola baghouse must be estimated because of the difficulty in testing. No current emissions data on the converter baghouse since it is new. No data on the incinerator.

Cupola: 1975 data - 40 Mg/year (44 tons/year)
No change in system since 1975; estimates are constant.

REFERENCES: Section 6.


1. U.S. Environmental Protection Agency. Air Pollution Engineering Manual. 2nd Edition. Compiled and edited by J. A. Danielson. Research Triangle Park, North Carolina. May 1973. pp. 279-282.

2. Letter and attachments from Cutrer, E. A., Jr. Air Pollution Compliance Program, Georgia Department of Natural Resources to M. K. Snyder, MRI. January 7, 1980. p. 3. Response to request for emission and emission control data on Southwire Copper Division.

3. Telecon. Culler, William. Bureau of Air Quality Control, Department of Health and Environmental Control, South Carolina. November 28, 1979. Emission data on Nassau Recycling Corporation.

4. Reference 3.

5. Letter and attachments from Montney, W. A., Division of Air Pollution Control, Illinois EPA, to M. K. Snyder, MRI. December 27, 1979. Surveillance report for CHEMETCO and Cerro Corporation.

6. Reference 5.

7. Reference 2.

8. Telecon. Scott, Robert. Air Management Services, Philadelphia. January 4, 1980. Process and emission data on Franklin Smelting and Refining Company.

# 7. EMISSION DATA

## 7.1 AVAILABILITY OF DATA

The emission data obtained from state and local control agencies and the National Emission Data System during the conduct of this study are identified in Table 7-1. The data were incomplete for most of the plants. In some instances, particulate emission data were available for one plant process but not for another. Availability of uncontrolled emission data was poor. Good process rate information for the various smelting and refining operations was difficult to obtain. Sulfur emission data were available for only one plant, although an estimate was available for another plant.

## 7.2 SAMPLE COLLECTION AND ANALYSIS

EPA Method 5 is an applicable standard method for sample collection and analysis of particulates emitted from secondary copper smelting and refining processes. Information on the test methods used to collect data analyzed in this study was not obtained. The adequacy of available test methods for fugitive emissions needs to be studied further.

TABLE 7-1. AVAILABILITY OF EMISSION TEST RESULTS

| Plant name and city | Date | Process source | Control equipment | Pollutant(s) sampled |
|---|---|---|---|---|
| GEORGIA - DEPARTMENT OF NATURAL RESOURCES | | | | |
| Southwire Carrollton, GA | 9/79 | Cupola | Baghouse | Particulate $SO_2$ |
| Southwire Carrollton, GA | 9/79 | Converter | Baghouse | Particulate $SO_2$ |
| Southwire Carrollton, GA | 9/79 | Anode | Baghouse | Particulate $SO_2$ |
| Southwire Carrollton, GA | 9/79 | Holding furnace | None yet | Not sampled |
| ILLINOIS ENVIRONMENTAL PROTECTION AGENCY | | | | |
| Cerro Copper Products East St. Louis, IL | 10/79 | Anode (2) | HE wet scrubber with mist eliminator | Particulates $NO_x$ HC CO |
| Cerro Copper Products East St. Louis, IL | 10/79 | Fire-refining | ME wet scrubber with mist eliminator | Particulates $NO_x$ HC CO |

TABLE 7-1 (continued)

| Plant name and city | Date | Process source | Control equipment | Pollutant(s) sampled |
|---|---|---|---|---|
| ILLINOIS - ENVIRONMENTAL PROTECTION AGENCY | | | | |
| Cerro Copper Products<br>East St. Louis, IL | 10/79 | Shaft | None | Particulates<br>$NO_x$<br>HC<br>CO |
| CHEMETCO<br>Alton, IL | 11/79 | Kaldo (3) | HE wet scrubber wtih mist eliminator | Particulate |
| CHEMETCO<br>Alton, IL | 11/79 | Holding furnace | None | Particulate<br>$NO_x$<br>HC<br>CO |
| NATIONAL EMISSION DATA SYSTEM (NEDS) | | | | |
| U.S. Metals Refining<br>Carteret, NJ | 1976 | Cupola | Baghouse | Particulate |
| USMR<br>Carteret, NJ | 1976 | Slag cleaning | Baghouse | Particulate |
| USMR<br>Carteret, NJ | 1976 | Anode (3) | Baghouse | Particulate |

TABLE 7-1 (continued)

| Plant name and city | Date | Process source | Control equipment | Pollutant(s) sampled |
|---|---|---|---|---|
| NATIONAL EMISSION DATA SYSTEM (NEDS) | | | | |
| USMR<br>Carteret, NJ | 1976 | Fire-refining (2) | Baghouse | Particulate |
| USMR<br>Carteret, NJ | 1976 | Shaft | Settling chamber | Particulate |
| Franklin Smelting and Refining<br>Philadelphia, PA | 1975 | Cupola | Baghouse | Particulate<br>$SO_2$<br>$NO_x$<br>HC<br>CO |
| SOUTH CAROLINA - DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL | | | | |
| Nassau Recycling Corporation<br>Gaston, SC | 12/79 | Anode | None | Particulate |
| Nassau Recycling Corporation<br>Gaston, SC | 12/79 | Fire-refining | None | Particulate |

# 8. STATE AND LOCAL EMISSION REGULATIONS

State and local emission regulations that apply to new sources in the secondary copper industry are summarized in this section. Only the regulations of the five states where secondary copper plants are located were examined. It is believed that these five states are representative of the eastern United States where the secondary copper industry is concentrated. (The supply of processible scrap is concentrated in the heavy manufacturing areas.) These regulations were primarily taken from the Environment Reporter[1] with supplemental information from contacts with state air pollution control agencies.

The emission regulations are presented in Table 8-1. The allowable emissions for each state are compared for a hypothetical plant, considered typical of a new plant which might be built. The plant is described in Section 5.1.4. It has six significant emission sources: a cupola, a rotary converter, two reverberatory anode furnaces, a reverberatory fire refining furnace, and a shaft furnace. Only one reverberatory anode furnace is operated with the other on standby. All three reverberatory furnaces use the same stack, but each of the other sources has its own stack. Table 5-1 lists the plant parameters used to determine the state regulations which would apply to this plant. The parameters for the reverberatory anode furnace apply to each anode furnace when it is operating.

To make this comparison, it is assumed that each state considers each source to be a separate process. However, the reverberatory furnaces are treated as a single process when the emission standard is based on stack height or gas exit velocity. (Note that gas exit velocity is not the same as the gas effluent rate. The gas effluent rate, as listed in Table 5-1, is a volume of gas leaving the stack per unit of time. The gas exit velocity is the gas effluent rate divided by the area of the stack opening.)

The major pollutant emitted from the secondary copper industry is particulates. Particulate emissions from the cupola, rotary furnace, and reverberatory furnace are typically controlled by fabric filters. Particulate emissions from the shaft furnace are typically controlled by a settling chamber.

Sulfur dioxide emissions are minor. The uncontrolled emissions from the model plant do not exceed the emission limit of any of the five states because the plant uses a low sulfur fuel.

There are some other regulations in the five states which would apply to secondary copper plants with different configurations. Illinois limits carbon monoxide emissions from cupolas to 200 ppm corrected to 50 percent

TABLE 8-1. SUMMARY OF EMISSION REGULATIONS FOR NEW SECONDARY COPPER PLANTS

| State | Number of plants | General process regulation[a] | Visible emission percent opacity | Cupola kg/hr | Cupola lb/hr | Rotary converter kg/hr | Rotary converter lb/hr | Reverberatory anode furnace kg/hr | Reverberatory anode furnace lb/hr |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Particulates | | | | | |
| Georgia | 1 | $E = 4.1P^{0.67}$ | 20 | 8.1 | 17.9 | 4.5 | 9.9 | 5.5 | 12.1 |
| Illinois | 2 | $E = 2.54P^{0.534}$ | 30 | 3.7 | 8.2 | 2.3 | 5.1 | 2.7 | 6.0 |
| New Jersey | 1 | 0.02 gr/scf | 20 | 4.7 | 10.3 | 3.1 | 6.9 | 1.9 | 4.1 |
| Pennsylvania | 2 | 0.04 gr/scf | 20 | 9.3 | 20.6 | 6.2 | 13.7 | 3.7 | 8.3 |
| South Carolina | 1 | $E = 4.1P^{0.67}$ | 20 | 8.1 | 17.9 | 4.5 | 9.9 | 5.5 | 12.1 |
| | | | | Sulfur Dioxide | | | | | |
| Georgia | | 1.2 h[b] | | 41 | 90 | 41 | 90 | 30 | 66 |
| Illinois | | 2,000 ppm | | 542 | 1,194 | 361 | 796 | 218 | 480 |
| New Jersey | | c | | 37 | 82 | 37 | 82 | 17 | 37 |
| Pennsylvania | | 500 ppm | | 135 | 299 | 90 | 199 | 54 | 120 |
| South Carolina | | None | | - | - | - | - | - | - |

TABLE 8-1. (continued)

| State | Reverberatory fire refining furnace kg/hr | Reverberatory fire refining furnace lb/hr | Shaft furnace kg/hr | Shaft furnace lb/hr | Date of last revision |
|---|---|---|---|---|---|
| | | Particulates | | | |
| Georgia | 2.1 | 4.6 | 6.1 | 13.5 | Apr. 9, 1979 |
| Illinois | 1.3 | 2.8 | 3.0 | 6.6 | May 3, 1979 |
| New Jersey | 1.6 | 3.4 | 2.0 | 4.4 | Mar. 18, 1977 |
| Pennsylvania | 3.1 | 6.9 | 4.0 | 8.8 | Apr. 9, 1979 |
| South Carolina | 2.1 | 4.6 | 6.1 | 13.5 | Jan. 10, 1978 |
| | | Sulfur Dioxide | | | |
| Georgia | Included with anode furnaces | | 30 | 66 | Apr. 9, 1979 |
| Illinois | 181 | 398 | 233 | 513 | May 3, 1979 |
| New Jersey | Included with anode furnaces | | 20 | 45 | Aug. 10, 1978 |
| Pennsylvania | 45 | 100 | 58 | 128 | Apr. 9, 1979 |
| South Carolina | - | - | - | - | Jan. 10, 1978 |

a E = allowable emissions (lb/hr).
P = process weight rate (tons/hr).
gr/scf = allowable concentration of particulate matter in grains per standard cubic foot of exhaust gas.
h = is stack height in feet.
ppm = parts per million by volume.

b Applies for h = 90 ft if the type of plume is typical of a noncombustion source.

c Based on gas exit velocity (linear ft/sec), stack height, and gas exit temperature, with a maximum of 2,000 ppm.

excess air if the melt rate exceeds five tons per hour. Georgia limits nitrogen oxide emissions from general manufacturing processes. Illinois also limits emissions of $H_2SO_4$ and $SO_3$. New Jersey limits emissions of all sulfur compounds. None of these other pollutants are known to be emitted in sufficient quantities that would require the secondary copper industry to install emission controls.

It should be noted that the crucible furnace, which is used in some secondary copper plants, is an indirectly heated emissions source. There are separate effluent streams from the combustion chamber and the melting chamber. The former would be regulated as a fuel-burning source and the latter as an industrial process.

The particulate emission limits are based on the process weight rate in Georgia, Illinois, and South Carolina and on the concentration of particulates in the effluent gas in New Jersey and Pennsylvania. The Illinois and New Jersey limits are the most stringent. They are in rather close agreement as applied to the model plant, although they have a different basis for establishing limits. The Illinois limits are the most stringent for the cupola, rotary converter, and fire refining furnace. The New Jersey limits are the most stringent for the anode furnaces and the shaft furnace. The Illinois limits are the most stringent for the plant as a whole.

There is more variation among the states in the basis for sulfur dioxide emission limits. Illinois and Pennsylvania limits are based on the concentration of sulfur dioxide in the effluent gas. The Georgia limit is based on stack height. The New Jersey limit is based on stack height, gas exit velocity, and gas exit temperature, but there is also a concentration limit which must not be exceeded. South Carolina does not regulate sulfur dioxide emissions from secondary copper plants. The New Jersey limit is the most stringent.

A Model IV calculation[2] was made to estimate the impact of new source performance standards in 1984 and 1989. The calculation was based on the upper limit of the probable increase in capacity, so the result is an estimated maximum impact. The new source performance standards were assumed to equal the Illinois standards for particulates. The calculation was not made for sulfur dioxide because the uncontrolled emissions meet the standards of each of the five states. The particulate emissions under state regulation were assumed to equal the state emission limits. The calculation was done for each of the five states and the results were added to give an estimated impact for the nation. The fractional utilization of existing industry capacity was assumed to be 1.00 for Georgia, Illinois, and New Jersey; 0.77 for Pennsylvania; and 0.67 for South Carolina. The baseline year production capacity is 383 Gg (422 thousand tons) in 1979. The construction and modification rate to replace obsolete capacity was assumed to be zero. The construction and modification rate to increase industry capacity was assumed to be 0.009. This is a decimal fraction of baseline capacity per year. If the industry expands capacity so that it produces at 90 percent of capacity and if the higher growth projection (1.9 percent) is realized, it would reach an annual capacity of 465 Gg (513,000 tons) in 1989 for an increase of 82 Gg (90,000 tons) the 10 years. Some of the new capacity, however, can come from expansion of electrolytic refining capacity, without the introduction of significant new emissions sources. Such latent capacity is at least 46 Gg (51,000 tons). Thus 36 Gg (40,000 tons) is the maximum likely expansion which would result in new sources. A capacity growth from 383 (442,000 tons) to 419 Gg (462,000 tons) in 10 years averages 0.9 percent per year (compound).

The results are an estimated national impact of 17 metric tons (19 short tons) per year in 1984 and 35 metric tons (39 short tons) per year in 1989. These impacts are not very large because the industry is rather small and its expected growth rate is rather slow.

REFERENCES: Section 8.


1. Bureau of National Affairs. Environment Reporter. State Air Laws. Washington, D.C.

2. Monarch, M. R., R. R. Cirillo, B. H. Cho, G. A. Concaildi, A. E. Smith, E. P. Levine, and K. L. Brubaker. Priorities for New Source Performance Standards under the Clean Air Act Amendments of 1977. EPA-450/3-78-019. Research Triangle Park, N.C. April 1978. pp. 9-13.

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**16. ABSTRACT**
This report presents the results of a survey of the secondary copper smelting and refining industry to determine the probable impact of the development of new source performance standards under Section 111 of the Clean Air Act. The surveyed industry processes copper scrap to produce pure copper or copper alloy, other than brass and bronze. Secondary copper foundries, which melt and cast high-quality copper scrap without refining it, are excluded. Primary copper smelters and refiners, which produce copper from ore, are also excluded, although they also process copper scrap. Process, emissions, and economic data were gathered by literature searches, contacts with representatives of the industry, trade associations, federal government agencies, and state and local air pollution control agencies, and visits to two plants. The industry's production processes, actual and allowable air emissions, and emission control systems are described. State and local emission regulations are compared. Production and capacity are projected to 1989 and the impact of new source performance standards is assessed.


**17. KEY WORDS AND DOCUMENT ANALYSIS**

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|---|---|---|
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