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April 7, 2004

By Hand

Mr. Bernard Kritzer
Bureau of Industry and Security
U.S. Department of Commerce
P.O. Box 273
14th Street and Constitution Avenue, N.W.
Washington, D.C. 20044

Re: Petition for the Imposition of Monitoring and Controls With Respect to Exports From the United States of Copper Scrap and Copper-Alloy Scrap

Dear Mr. Kritzer:

As requested, please find enclosed the original and ten copies of the referenced petition that is being filed today on behalf of the Copper & Brass Fabricators Council, Inc., and its member companies and the Non-Ferrous Founders' Society and its member companies. Please contact the undersigned with any questions concerning this submission. Thank you for your attention to this matter.

Very truly yours,

Jeffrey S. Beckington

DAVID A. HARTQUIST
JEFFREY S. BECKINGTON
JENNIFER E. McCADNEY

Counsel to Petitioners

Enclosures

PUBLIC DOCUMENT

BEFORE THE
BUREAU OF INDUSTRY AND SECURITY
U.S. DEPARTMENT OF COMMERCE

PETITION FOR THE IMPOSITION OF MONITORING AND CONTROLS WITH RESPECT TO EXPORTS FROM THE UNITED STATES OF COPPER SCRAP AND COPPER-ALLOY SCRAP

ON BEHALF OF

THE COPPER & BRASS FABRICATORS COUNCIL, INC.
AND ITS MEMBER COMPANIES

AND

THE NON-FERROUS FOUNDERS' SOCIETY
AND ITS MEMBER COMPANIES

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April 7, 2004

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PETITION FOR THE IMPOSITION OF MONITORING AND CONTROLS WITH RESPECT TO EXPORTS FROM THE UNITED STATES OF COPPER SCRAP AND COPPER-ALLOY SCRAP

I. INTRODUCTION

This petition is filed on behalf of the Copper & Brass Fabricators Council, Inc. ("CBFC"), and its member companies and the Non-Ferrous Founders' Society ("NFFS") and its member companies.[1] The CBFC and the NFFS are trade associations that are representative of an industry that processes metallic materials capable of being recycled, specifically copper scrap and copper-alloy scrap ("copper-based scrap"), within the meaning of section 7(c) of the Export Administration Act of 1979, as amended ("the Act" or "the EAA"), 50 U.S.C. App. § 2406(c)(1)(A) and section 754.7 of the Export Administration Regulations ("EAR") of the U.S. Department of Commerce, 15 C.F.R. §§ 754.7(a) and (b) (2003).[2]

This petition presents evidence that copper scrap and copper-alloy scrap, which are more fully described in section II. A., infra, have experienced significant increases in the volumes of exports from the United States in relation to domestic supply and demand within a specific period of time and that these increases have resulted in significant increases in domestic prices, and domestic shortages of these materials relative to demand, within the meaning of section 7(c)(3)(A) of the Act, as amended, 50 U.S.C App. §§ 2406(c)(3)(A)(i) and (ii). Furthermore, this

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[1] A list of the CBFC's member companies and a list of the NFFS's brass and bronze foundries are appended at Exhibit 1.

[2] The EAA of 1979, as amended (50 U.S.C. App. § 2401 et seq.), remains in force pursuant to the International Emergency Economic Powers Act ("IEEPA") (50 U.S.C. § 1701 et seq.) and Executive Order 13,222. See Exec. Order No. 13,222, 66 Fed. Reg. 44,025 (Aug. 22, 2001) (declaring a national emergency under IEEPA with respect to the expiration of the EAA and continuing the EAA, as well as its implementing regulations, the EAR). The national emergency declared in Executive Order 13,222 was continued by President Bush's Notice of August 7, 2003. See Notice of August 7, 2003 – Continuation of Emergency Regarding Export Control Regulations, 68 Fed. Reg. 47,833 (Aug. 11, 2003).

petition demonstrates that the large and growing volumes of exports of these materials are as important as any other cause of the domestic price increases and shortages relative to demand, and that these conditions have significantly adversely affected the domestic industry consuming these materials within the meaning of section 7(c)(3)(A) of the Act, as amended, 50 U.S.C. App. §§ 2406(c)(3)(A)(iii) and (iv). Based on this evidence, the petitioners submit that both monitoring and restrictive export controls are necessary in order to protect the domestic economy from the excessive drain of scarce copper scrap and copper-alloy scrap and to reduce the serious inflationary impact of foreign demand within the meaning of sections 3(2)(C) and 7(c)(3)(A) of the Act, as amended, 50 U.S.C. App. §§ 2402(2)(C) and 2406(c)(3)(A)(v), respectively.[3]

This petition sets forth the information reasonably available to petitioners and is filed in conformity with the requirements of section 7(c)(1)(B) of the Act, 50 U.S.C. App. § 2406(c)(1)(B) and section 754.7 of the EAR, 15 C.F.R. § 754.7 (2003). In addition, the petitioners respectfully request a public hearing on the merits of this petition pursuant to section 7(c)(2) of the Act, 50 U.S.C. App. § 2406(c)(2) and section 754.7(c) of the EAR, 15 C.F.R. § 754.7(c) (2003).

II. GENERAL AND BACKGROUND INFORMATION

A. Description of the Subject Merchandise

Exports of copper-based scrap, the metallic recyclable materials that are the subjects of this petition, are classified under subheadings 7404.00.0020, 7404.00.0045, 7404.00.0062, and 7404.00.0080 set forth in Schedule B of the Statistical Classification of Domestic and Foreign

[3] These conclusions are supported and reinforced by a series of recent press articles and other papers that are found in the Attachment to this petition. Some, but not all, of these documents are referred to specifically in the balance of this petition.

Commodities Exported from the United States.[4] Additional information about the subject merchandise, as well as the copper industry in general, is provided below.

1. Properties and Applications of Copper and Copper Alloys

Copper and its alloys constitute one of the major groups of commercial metals. See American Society of Metals, Metals Handbook Desk Edition at 7-1 (1997) ("Metals Handbook"), appended at Exhibit 2. Copper and copper-alloys generally fall within one of six categories: (1) coppers; (2) dilute copper-alloys; (3) brasses; (4) bronzes; (5) copper nickels; and (6) silver nickels. Id. at 7-15. The first category includes essentially pure copper, which is typically soft and ductile, and contains less than about 0.7 percent total impurities. Id. Dilute copper-alloys contain small amounts of various alloying elements that modify one or more of the basic properties of copper. Id. Each of the remaining categories -- brasses, bronzes, copper nickels and copper silvers -- contains one of five major alloying elements as its primary alloying ingredient (zinc in the case of brasses, tin in the case of bronzes, and so forth). Id.

Given its unique combination of properties, including high ductility, malleability, thermal and electrical conductivity, resistance to corrosion, and the ability to be recycled, copper and its alloys are widely used in a variety of industries. Building construction is the single largest market for these metals, followed by electronics and electronic products, transportation, industrial machinery, and consumer and general products. Id. at 7-19. Copper has also been a key component in emerging technologies. According to the United States Geological Service, copper ranks third among major industrial metals after iron and aluminum in terms of quantities

[4] The commodity descriptions associated with these classifications within Schedule B are as follows: 7404.00.0020: Waste and scrap of refined copper; 7404.00.0045: Waste and scrap of copper-zinc base alloys (brass) containing more than 0.3 percent lead; 7404.00.0062: Waste and scrap of copper-zinc base alloys (brass) containing 0.3 percent or less lead; and 7404.00.0080: Waste and scrap of other copper-alloys.

consumed. See United States Geological Service, Copper Statistics and Information, available at www.minerals.usgs.gov, appended at Exhibit 3.

Pure copper is generally produced through a multi-stage process, beginning with the mining and concentrating of low-grade ores containing copper sulfide minerals, followed by smelting and electrolytic refining to produce pure copper cathode. Id. An increasing share of copper is produced from leaching of oxidized ores. Id. Copper by-products from manufacturing and obsolete products, or copper scrap, are readily recycled and contribute significantly to the copper supply. Id.

2. Properties and Applications of Copper Scrap and Copper-Alloy Scrap

The U.S. copper industry relies heavily on scrap copper as a raw material. Notably, copper-based scrap has constituted about half of the copper consumed in the United States for the past 20 years. See Copper Development Association, Trends in U.S. Copper and Scrap Effects of Product Shifts, available at www.copper.org, appended at Exhibit 4. In 1995, roughly two-thirds of copper scrap and copper-alloy scrap were re-melted directly by brass mills, wire-rod producers, foundries and ingot producers. Id. The remaining third went back into the production stream at the smelting and refining stages. Id. Copper-based scrap historically has made a significant contribution to the United States' self-sufficiency with respect to overall copper consumption versus production. Id.; see also Metals Handbook at 7-20 (Exhibit 2).

In order to monitor and analyze consumption, the copper industry has divided scrap into two broad classifications – "old scrap" and "new scrap." See Copper Development Association, Copper Applications in General Interest: Scrap Terminology and Classifications (1999) ("Scrap Terminology") available at www.copper.org, and appended at Exhibit 5. Old scrap is material that has been used by a consumer and, as such, is sometimes referred to as "post-consumer scrap." Id. New scrap is material that is generated during the manufacturing process when copper is cast into shapes, converted into semi-fabricated products, and manufactured into products sold in consumer end-use markets. Id.

New scrap is also further divided into "prompt-industrial scrap" and "return scrap." Prompt-industrial scrap is generated by toll producers that convert semi-fabricated copper products into parts. The turnings, stampings, and cuttings generated by this manufacturing process are then "returned" to the mill that supplied the semi-fabricated product. See Scrap Terminology (Exhibit 5). This "return scrap" may be reused by the mill or sold. Id. Prompt-industrial scrap and return scrap are generally recorded in recycling statistics, because the material is sold or toll processed. Id. Another division of new scrap, which is called "home scrap" or "run-around" scrap, is normally generated and re-melted in the same facility, which is usually owned by a fully-integrated copper producer. Id. This scrap generally is not recorded in scrap statistics. Id.

In addition to the old and new designations, copper scrap and copper-alloy scrap are further classified and monitored by scrap type and processor. For example, scrap may be classified by copper content or composition (e.g., No.1 wire and heavy, No. 2 mixed heavy and light, red brass, leaded-yellow brass, yellow and low brass, nickel-based, and other alloy scrap). Id. It can also be classified by use (e.g., refinery, smelter, or brass-mill scrap), by source (e.g., turnings, borings, cartridge cases, old radiators), or by appearance (e.g., bare bright, burnt wire, mixed heavy or light scrap).

B. The Domestic Industry

The Copper & Brass Fabricators Council represents U.S. manufacturers of a wide variety of products fabricated from copper and copper-alloys. The three main classifications of these products are flat-rolled products (such as sheet, strip, and foil), tubular products (such as pipe and tube), and long products (such as copper bar). Individual producers are known as "brass mills," and the industry as a whole is typically referred to as the "brass mill industry."[5] The members of the CBFC represent an estimated 80-85 percent of the total production of the U.S. brass mill industry.[6]

The Non-Ferrous Founders' Society was founded in 1943 during World War II to ensure that non-ferrous foundries could meet all their production demands and, as relevant, includes the principal brass and bronze foundries in the United States.[7] These foundries by and large are consumers of copper-alloy ingot that typically is 95 percent derived from copper-alloy scrap and annually recycle millions of pounds of brass and bronze scrap. The art of making castings is quite old, and non-ferrous castings have been part of nearly every new technological development since the Industrial Revolution. The U.S. brass and bronze foundries produce a wide variety of castings.

The U.S. brass mill industry and brass and bronze foundries are not the sole consumers of copper-based scrap within the United States, but do account for a substantial majority of all copper scrap and copper-alloy scrap consumed in the United States. According to the data of the U.S. Geological Survey, in 2002, the U.S. brass mill industry (in conjunction with the copper

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[5] These terms are somewhat misleading in that the industry manufactures products of pure copper and copper-alloys other than brass as well. However, because of the widespread and long-standing use of the shorthand terminology, the domestic industry will be referred to in this petition as the "brass mill industry."

[6] The member companies of the CBFC are listed at Exhibit 1. Because many of the members of the U.S. brass mill industry are privately held (and thus do not publicly disseminate sales or financial information), a precise calculation of the share of the overall industry represented by the CBFC members cannot be provided.

[7] As noted earlier, the NFFS's brass and bronze foundries are listed in Exhibit 1.

wire rod industry) accounted for 74.0 percent of copper-based scrap consumed within the United States, while smelters, refiners and ingot makers accounted for 19.1 percent and foundries, chemical plants, and miscellaneous manufacturers accounted for 6.9 percent of consumption.[8] See Exhibit 7.

Although both industries use some form of copper as their main input materials, metal consumption patterns within the U.S. brass mill industry are notably different from those of the U.S. wire rod mill industry. Indeed, there are numerous distinctions between the wire rod mill industry and the brass mill industry. Copper wire rod is produced as an intermediate product to be drawn into copper wire, primarily for application in electronics and communications equipment. To the best of the petitioners' knowledge, there is no overlap between U.S. brass mills and wire rod mills, as no company produces both brass mill products and copper wire rod.

Because copper wire is produced exclusively from pure copper (copper-alloy wire is produced in very small quantities and is not used in electrical applications), the vast majority of metal input used by copper wire rod producers is in the form of copper cathode. Indeed, as noted, supra, the volume of copper scrap used by wire rod mills is so small that the U.S. Geological Survey does not provide a separate reporting of copper scrap used by wire rod mills, but rather includes such volumes with those consumed by brass mills, for fear of disclosing proprietary information from the wire rod industry. Further, copper wire rod mills do not consume copper-alloy scrap, because the industry's metal input is limited to pure copper.

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[8] The USGS does not separately report copper scrap consumption by the U.S. copper wire rod industry, but rather includes such data with the figures for the brass mill industry. This convention is followed in order to avoid disclosing wire rod mill company proprietary data. See USGS Copper Annual Mineral Commodity Summary ("USGS Copper Annual") at Table 4.

In contrast to the wire rod mill industry, brass mills have traditionally used copper-based scrap for the majority of their metal input. According to the USGS statistics, copper scrap accounted for 61.1 percent and refined copper (primarily copper cathode) accounted for 39.9 percent of U.S. brass mills' consumption of copper metal input in 2002.[9] See USGS Copper Annual Table 4. Further, the consumption of refined copper (primarily cathode) by the U.S. brass mill industry was only about one-third that of the copper wire-rod mill industry (593,000 metric tons as compared to 1,710,000 metric tons). Id. In addition, while copper wire rod mills do not consume copper-alloy scrap, brass mills consume copper-alloy scrap in large volumes. Indeed, consumption of copper-alloy scrap by the brass mill industry typically exceeds its consumption of copper scrap.[10] See USGS Copper Annual at Table 10.

The structure of the U.S. brass mill industry also contrasts with that of the wire rod mill industry. The U.S. brass mill industry is not integrated backward, meaning that it does not produce its own raw materials and must obtain those materials from non-affiliated sources. While some members of the U.S. brass mill industry have the capability to move back and forth between copper-based scrap and copper cathode as raw materials, other producers rely on copper-based scrap for 100 percent of their raw material inputs. In contrast, wire rod mills in the United States by and large are integrated backward, meaning that they are owned by the same companies that mine copper ore and refine it into cathode. Thus, copper wire rod mills primarily

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[9] Non-copper metals consumed by the industry included slab zinc and hardeners and master alloys.

[10] Consumption of unalloyed copper scrap in the United States totaled 540,400 metric tons in 2002, with brass mills accounting for 386,000 metric tons, or 71.4 percent of the total (the figure includes the small amount consumed by wire rod mills). USGS Copper Annual at Table 10. Consumption of copper-alloy scrap in the United States in 2002 totaled 716,400 metric tons, of which 544,000 metric tons (75.9 percent) were consumed by brass mills (no wire rod mill consumption is lumped in with the brass mill figure because wire rod mills do not consume copper-alloys). Id.

source raw materials from affiliated sources, are much less dependent on outside, unaffiliated sources for their metal input needs, and consume very little copper-based scrap.

The vast majority of copper scrap and copper-alloy scrap consumed in the United States is generated within the country. In 2003, 90,581 metric tons of copper scrap and copper-alloy scrap were imported into the United States, representing just 4.7 percent of the total U.S. supply of copper-based scrap (defined as consumption plus exports). See Exhibit 6. In that year, exports of copper scrap totaled 753,541 metric tons, meaning that exports were more than eight times as large as imports. Indeed, as is discussed in greater detail below, U.S. exports of copper-based scrap have increased dramatically in recent years, while imports of the product have actually been declining. While U.S. exports of copper-based scrap increased by 138.2 percent between 1999 and 2003, imports declined by 33.6 percent over the same period. Id.

In summary, the brass mill industry is the largest consumer of copper scrap and copper-alloy scrap in the United States, and the industry relies on copper-based scrap for the majority of its raw material needs. Because the U.S. brass mill industry is not integrated back to the mine level, it is dependent upon access to a reliable and consistent supply of copper-based scrap from independent scrap suppliers. The vast majority of copper-based scrap consumed by the industry is generated within the United States, and the brass mill industry has been structured to make use of these recyclable materials as its main source of supply. Indeed, many members of the U.S. brass mill industry rely on copper-based scrap as their sole source of supply of raw materials.

While the brass-mill industry's structure has developed as a logical means of taking advantage of the lower cost of scrap materials (and has provided the further benefit of recycling what would otherwise be waste materials headed for landfill), the dependence on scrap materials has also made the U.S. brass mill industry extremely vulnerable to any interruptions in the supply of copper-based scrap materials. As discussed in further detail below, while the U.S. brass mills have traditionally had sufficient indigenous sources of copper-based scrap to supply their raw materials needs, increasing exports of the materials in recent years have resulted in critical supply shortages in the U.S. market. The result has been insufficient supplies and stocks of raw materials, dramatically increased prices for copper-based scrap, short-term production interruptions, higher production costs, and reduced profitability for the U.S. brass mill industry. The same conditions are being experienced by the brass and bronze foundries. If recent trends are allowed to continue, the end result will be industry shutdowns, bankruptcies, and shortages within the U.S. economy of the critical products manufactured by the brass mill industry and by the brass and bronze foundries.

III. THERE HAS BEEN A SIGNIFICANT INCREASE IN EXPORTS OF COPPER SCRAP AND COPPER-ALLOY SCRAP IN RELATION TO DOMESTIC SUPPLY AND DEMAND

Exports of copper and copper-alloy scrap from the United States have increased quickly and significantly in recent years. From a level of 316,342 metric tons ("MT") in 1999, exports of copper-based scrap increased to 494,284 MT in 2000, 559,699 MT in 2001, and 566,838 MT in 2002, before jumping to 753,541 MT in 2003.[11] See Exhibit 7. Thus, between 1999 and 2003, U.S. exports of copper-based scrap grew by 138.2 percent. In the single year between 2002 and 2003, copper-based scrap exports grew by 32.9 percent.

Exports of copper-based scrap have increased to a highly significant part of U.S. scrap supply. While exports represented just 16.2 percent of total U.S. copper-based scrap supply in

[11] Copper scrap and copper-alloy scrap (copper-based scrap) exports at Exhibit 7 are defined as the sum of classifications 7404.00.0020, 7404.00.0045, 7404.00.0062, and 7404.00.0080 under the Schedule B Statistical Classification of Domestic and Foreign Commodities Exported from the United States ("Schedule B").

1999, that figure increased to 23.7 percent in 2000, 28.9 percent in 2001, and 31.1 percent in 2002, before surging to 39.4 percent in 2003.[12] See Exhibit 6.

Exports of copper-based scrap have also grown rapidly in relation to U.S. demand (consumption). As shown at Exhibit 6, U.S. consumption of copper-based scrap declined consistently from 1999 through 2003 (from 1,630,900 metric tons in 1999 to 1,159,254 metric tons in 2003) and by 28.9 percent overall. Given that exports of copper-based scrap were increasing significantly during this period, exports as a percentage of U.S. consumption jumped from 19.4 percent in 1999 to 31.0 percent in 2000, 40.6 percent in 2001, 45.1 percent in 2002, and 65.0 percent in 2003. See Exhibit 6. Thus, from 1999 to 2003, U.S. exports of copper-based scrap more than tripled in relation to consumption of the product within the United States.

Exports of copper-based scrap have also grown significantly in relation to the consumption of the brass mill industry. The consumption of copper-based scrap by U.S. brass mills and wire rod mills[13] moved from 1,050,000 metric tons in 1999 to 1,070,000 MT in 2000, 919,000 MT in 2001, 930,000 MT in 2002, and 842,182 MT in 2003. In relation to brass mill consumption, exports of copper-based scrap from the United States increased from 30.1 percent of consumption to 46.2 percent in 2000, 60.9 percent in 2001, 61.0 percent in 2002, and 89.5 percent in 2003, based of total exports of the material.[14] See Exhibit 6. Thus, while brass mill

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[12] Total copper-based scrap supply at Exhibit 6 is defined as U.S. consumption of purchased copper-based scrap plus total exports of copper-based scrap.

[13] As discussed, supra, the USGS statistics include consumption of copper scrap by wire rod mills with that of brass mills so as not to divulge proprietary information in relation to the relatively small consumption by wire rod mills.

[14] Petitioners provide these data for informational purposes only and do not advocate the comparison of total scrap exports to the consumption of the brass mill industry as a means of assessing the impact of increased exports on the industry, because some element of the product exported is not of sufficient quality for use by the brass mill industry. However, because the export (and import) statistics do not distinguish among types or quality of copper-based scrap (...continued)

consumption of copper-based scrap declined by 19.8 percent between 1999 and 2003, exports of these materials increased by 138.2 percent.

Monthly statistics show that export volume increases in 2003 in particular have been noteworthy, pervasive, and dramatic. As shown at Exhibit 8, total exports of copper-based scrap were higher in each of the twelve months of the year than in any of the four previous years. Monthly exports in 2003 were at a minimum 89.9 percent higher than those in 1999 and a maximum of 171.6 percent higher. See Exhibit 8. Monthly exports in 2003 were higher than those in 2002 by a minimum of 17.6 percent and a maximum of 63.9 percent.

Even within the year of 2003, exports of copper-based scrap increased significantly over the course of the year. While monthly exports averaged 55,601 metric tons in the first quarter of 2003 (already higher than the average shown for any quarter in the 1999-2002 period), that figure increased to 62,528 MT in the second quarter, 64,343 MT in the third quarter, and 68,709 MT in the fourth quarter of the year. See Exhibit 8. Exports in January 2004 were higher than in any January of 1999-2003. Clearly, the most recent export data for copper-based scrap show consistent and dramatic increases, and the growth in volume for 2003 as a whole has been due to ongoing export expansion, rather than any seasonal surges that have already peaked.

The growth in copper-based scrap exports in recent years has not been limited to any particular alloy form of the product. As shown at Exhibit 9, each of the four tariff headings under which copper scrap and copper-alloy scrap are classified has shown almost consistent export growth in the 1999-2003 period. Volume growth in this period ranged from a minimum

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(...continued)
materials, there is no means of discerning how much of the exported product could actually be used by the U.S. brass mill industry. For this reason, petitioners believe that the most meaningful comparison of exports to consumption is that performed on the basis of total U.S. exports and total U.S. scrap consumption.

of 91.2 percent for "other" copper-alloy scrap to 247.0 percent for brass scrap. See Exhibit 9. In 2003, total exports of copper-alloy scrap slightly exceeded those of copper scrap.

Essentially all of the growth in U.S. exports of copper-based scrap in recent years has been attributable to rising demand in China. In 1999, exports to China of copper-based scrap stood at 86,601 MT and accounted for just 27.4 percent of total U.S. exports. See Exhibit 7. That volume more than doubled in 2000 and tripled in 2001, as exports to China accounted for 43.3 percent of all exports in 2000 and 56.6 percent in 2001. Copper-based scrap exports to China increased moderately in 2002 to 332,110 MT (58.6 percent of exports) before jumping to 532,901 MT in 2003, representing 70.7 percent of total U.S. exports. Id. Thus, in the single year from 2002 to 2003, exports to China of copper-based scrap increased by 60.5 percent, and between 1999 and 2003, such exports grew more than six-fold. Further, the increase in volume of copper-based scrap exports to China from 1999 to 2003 (an expansion of 446,300 MT) was just slightly more than the entire expansion of overall U.S. exports of the product during the period (which increased by 437,199 MT).[15]

IV. THERE HAS BEEN A SIGNIFICANT INCREASE IN THE DOMESTIC PRICE OF COPPER SCRAP AND COPPER-ALLOY SCRAP

Rapid increases in exports of copper-based scrap have acted to reduce domestic supplies of scrap and increase prices for the product. Because brass mills rely on copper-based scrap as their most important raw material, these trends have resulted in increased costs for the domestic industry, costs which the industry has not been fully able to pass through in the costs of its finished products. Further, even to the extent that U.S. brass mills have been able to pass

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[15] As shown at Exhibit 9, the growth in exports to China occurred in relation to each of the four tariff classifications of copper-based scrap, and China dramatically increased its share of total U.S. exports for each of the tariff classifications as well.

through increased raw-material costs to their customers, increases in prices of copper and copper-alloy input products and of finished products act to reduce consumption of these products as users begin to substitute competing products for copper-based products. In some instances of customers purchasing the copper-based product as an input for further processing, user industries have added rising prices to their calculus of continued U.S. production viability and have concluded that relocation of their manufacturing facilities to low-priced non-market economies, notably China, has been their best option.

U.S. prices for copper-based scrap have jumped upward significantly in recent years, most notably since the beginning of 2003. While these price increases have generally reflected increasing prices for copper cathode, growing exports of copper-based scrap have also had a substantial effect by reducing U.S. supply and increasing U.S. prices for copper-based scrap.

As shown in the table attached as Exhibit 10, average U.S. prices for Number 1 copper scrap have been increasing almost consistently since 2001. While the average buying price per pound of No. 1 copper scrap by U.S. brass mills stood at 69.62 cents per pound in 2001, that figure increased to 70.23 cents in 2002 and jumped to 78.14 cents per pound in the first 11 months of 2003.[16] Thus, on the basis of annual averages, prices paid for No. 1 copper scrap increased by 12.2 percent between 2001 and 2003.

Monthly average prices for No. 1 copper scrap have shown even more dramatic increases over the course of 2003 and into 2004. As shown at Exhibit 10, average monthly prices for No. 1 copper scrap stood at 74.16 cents per pound through the first six months of 2003, and then

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[16] No. 1 copper scrap is 99.9 percent pure copper and is the most common form of scrap purchased by the brass mill industry as a whole. The prices shown at Exhibit 10 are as reported by the American Metal Market magazine and the U.S. Geological Survey and represent brass mills' estimated buying prices for delivered carload lots.

increased to an average of 85.69 cents per pound in the second-half of the year. In the first nine weeks of 2004, average prices jumped to $1.1883 per pound for the period overall. Thus, between the first-half of 2003 and the first nine weeks of 2004, average prices for No. 1 copper scrap in the U.S. market grew by 60.2 percent. Indeed, to date in 2004, No. 1 copper scrap prices reached a peak daily price of $1.3700 per pound on March 1, 2004, a price more than 100 percent higher than that shown as recently as October 2002.

Prices for Number 2 copper scrap have similarly shown substantial increases. As summarized at Exhibit 10, annual prices paid for No. 2 copper scrap increased from 58.96 cents per pound in 2001 to 59.45 cents in 2002 and 68.38 cents per pound in the first 11 months of 2003.[17] This amounted to an increase in annual average prices of 16.0 percent between 2001 and 2003.

Monthly average prices for No. 2 copper scrap have soared in the second-half of 2003 and the first weeks of 2004. From an average price of 64.05 cents per pound in the first six months of 2003, No. 2 copper scrap prices increased to an average of 76.38 cents per pound in the second-half of the year. <u>See</u> Exhibit 10. In the first nine weeks of 2004, average prices for No. 2 scrap have risen dramatically to $1.0778 per pound. Thus, in relation to the first-half of 2003, prices for No. 2 copper scrap to date in 2004 have increased by an average of 68.3 percent.

V. THERE HAS BEEN A DOMESTIC SHORTAGE OF COPPER SCRAP AND COPPER-ALLOY SCRAP

Increasing exports of copper-based scrap have reduced U.S. supplies of scrap and have caused shortages of the material. Because many producers can use both copper scrap and copper

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[17] No. 2 copper scrap is 94.0 percent pure copper at a minimum and is purchased and used by brass mills, but is more commonly used by copper refiners. No. 2 copper scrap is typically less pure and requires more processing than No. 1 copper scrap and, hence, reflects a relatively lower price.

cathode as inputs into their production process, the result of shortages of copper scrap has not been widespread production interruptions, but rather, increased use of copper cathode by brass mills in place of copper scrap. Because copper cathode generally sells at prices in excess of those for Number 1 copper scrap, the forced replacement of cathode for scrap acts to increase input and production costs for these manufacturers. This increased demand for copper cathode within the U.S. market (from demand that has traditionally been supplied by copper scrap) has the concomitant effect of pushing up transaction prices for copper cathode.

For those producers that can only use copper scrap (and cannot use copper cathode), the result of increasing supply shortages has been large increases in scrap costs and periods of dangerously low scrap stocks on hand. In some instances, due to extreme supply shortages (and the fact that some producers can use only scrap as their raw material input), prices of copper scrap in some regions have increased <u>above</u> those for copper cathode, a purer and normally more "valuable" and expensive raw material than any form of scrap. In other words, recent supply trends for copper-based scrap have turned market logic and pricing upside-down. While supply shortages to date have generally resulted in only short-term production shutdowns of one or two days, it is only a matter of time until scrap shortages reach the point of forcing prolonged production interruptions at these facilities.

Increasing exports of copper-based scrap have resulted in reduced consumption and decreased stocks of copper scrap in the United States. Data compiled by the U.S. Geological Survey show that consumption of copper scrap has consistently and rapidly been declining in recent years, from a level of 1,630,900 metric tons in 1999, to 1,593,000 metric tons in 2000, to

1,377,500 MT in 2001, to 1,256,900 MT in 2002, and to 1,159,264 MT in 2003.[18] See Exhibit 6. Thus, from 1999 to 2003, U.S. consumption of copper-based scrap declined by 471,636 metric tons, or 28.9 percent.

Stocks of copper-based scrap within the United States have also shown major declines. From a level of 91,070 metric tons at year-end 1999, stocks declined to 82,010 MT at the end of 2000, 67,770 MT in 2001, and 66,520 MT in 2002. See Exhibit 6. While year-end 2003 stock data are not currently available, stocks and scrap supplies are understood to have contracted even more dramatically in 2003. As noted in the most recent report of the U.S. Geological Survey, "{b}rass mill production and shipments declined, however, owing to a sharp drop in scrap consumption. The consumption of refined copper at the expense of copper scrap is indicative of the tight scrap supply and narrow discounts reported by the industry. According to the Institute of Scrap Recycling Industries (2003), copper scrap remained difficult to source."[19]

VI. EXPORTS OF COPPER SCRAP AND COPPER-ALLOY SCRAP ARE THE PRIMARY CAUSE OF DOMESTIC PRICE INCREASES AND SUPPLY SHORTAGES

A. Exports of Copper Scrap and Copper-Alloy Scrap Are the Primary Cause of U.S. Supply Shortages

The shortages in supplies of copper-based scrap have largely come about as a result of rising exports of the product. As U.S. copper-based scrap consumption declined by 471,636 metric tons from 1999 to 2003, exports of the product increased by 437,199 metric tons over the same period. See Exhibit 6. The increase in exports of copper-based scrap during this period, therefore, represented 92.7 percent of the overall decline in scrap consumption. Thus, declining

[18] 2003 figure estimated based on January – November data.

[19] U.S. Geological Survey Mineral Industry Surveys, Copper in November 2003, February 2004 at 1.

scrap supplies in the United States have been largely attributable to increasing exports of the product.

Review of the other determinants of U.S. supply and demand for copper-based scrap shows that there are no factors other than increasing exports that have caused recent supply shortages. Consumption data for the U.S. market as a whole and for the brass mill industry specifically demonstrate that insufficient scrap supply is not attributable to any increased demand for the product in the United States. Total U.S. consumption of copper-based scrap declined in each of the years from 1999 through 2003, and by 28.9 percent for the period overall. See Exhibit 6. In 2003, the year of the greatest shortages of scrap supply and most rapid price increases, U.S. consumption of copper-based scrap fell by 97,636 metric tons, or 7.8 percent. Id.

Consumption of copper-based scrap by brass mills similarly showed large declines during this period. Between 1999 and 2003, consumption of copper-based scrap by the brass mill and wire rod mill (primarily brass mill, as noted, supra) industries declined by more than 200,000 metric tons, or 19.8 percent. Id. In the single year of 2003, brass mill consumption fell by 87,818 metric tons, or 9.4 percent.

Clearly, consumption trends within the brass mill industry and the U.S. market generally have not caused recent supply shortages. Indeed, had the output of the U.S. brass mill industry not been depressed and the U.S. economy not been in recession during 2001-2003, demand for copper scrap in the United States likely would have increased, rather than decreased, and the shortfall in the supply of copper-based scrap would have been far more pronounced than was the case. Now that the U.S. economy is showing signs of improvement, demand for copper-based scrap can be expected to increase. Unless controls on exports of this critical material are put into place, the supply shortages that have been experienced to date (and the related price increases) are likely to become far more severe and widespread in the coming months.

Nor is the shortage of copper-based scrap attributable to a shortage of the amount of scrap material generated in the United States. As shown at Exhibit 6, the total U.S. supply of copper-based scrap (defined as U.S. scrap consumption plus exports) has changed only marginally since 1999. Between 1999 and 2003, total U.S. scrap supply declined by just 34,437 metric tons, or 1.8 percent. See Exhibit 6. Over this same period, exports of copper-based scrap increased by 437,199 metric tons, or 138.2 percent. Id. As a result of these trends, exports increased from 16.2 percent of total U.S. copper-based scrap supply in 1999 to 39.4 percent in 2003. Clearly, exports -- not a decline in U.S.-generated copper-based scrap -- accounted for the shortfall of scrap supply in relation to domestic demand.

In fact, in 2003, the year of the most severe scrap shortage, total U.S. supply of copper-based scrap actually increased by 89,067 metric tons or 4.9 percent, in relation to 2002. Id. Unfortunately, scrap exports in that year increased by 186,703 metric tons, meaning that exports grabbed not only the entire increase in scrap in that year, but an additional 100,000 tons of existing supply.

B. Exports of Copper Scrap and Copper-Alloy Scrap Are the Primary Cause of Increasing Scrap Prices in the United States

Increased demand for U.S. copper scrap and copper-alloy scrap for export has acted to push up prices paid by U.S. consumers of the product, most notably brass mills, in two significant ways. First, as noted above, exports have increased their volumes and their share of U.S.-generated scrap, thereby reducing supplies of copper-based scrap available to U.S. consumers of the product. Second, agents working in the United States on behalf of foreign consumers of copper-based scrap, most notably in China, have been paying prices at above-market levels and agreeing to preferential sales terms to U.S. scrap dealers in order to obtain sufficient supplies of scrap for export. These two types of price effects are discussed in detail below.

As increasing exports have reduced U.S. copper-based scrap supplies, prices for available supplies have risen. In order to fully appreciate the way in which increased exports of copper-based scrap have affected prices for the commodity in the U.S. market, it is first important to understand the manner in which the price of copper-based scrap is set.

Copper-based scrap is normally sold at a discount off the prevailing market price for pure, refined copper, which is most typically sold in the form of copper cathode. Prices for copper cathode, as tracked by exchanges such as the London Metals Exchange (LME) and the Commodity Exchange, Inc. (Comex), fluctuate daily (and within the day), reflecting both world supply and demand conditions and, secondarily, local supply and demand conditions within the United States. Depending on the copper content and relative purity of the scrap supply, various types and gradations sell at differing discounts from the prevailing market prices for copper cathode on the exchanges. The discounts at which copper-based scrap is sold reflect the fact that scrap typically requires more processing than copper cathode and runs the risk of containing impurities.[20]

As with the exchange prices for copper cathode, selling prices for copper-based scrap fluctuate daily. While copper-based scrap prices are certainly related to prices for copper

[20] Examples demonstrating the pricing disparity between Number 1 copper scrap and the Comex cathode price and Number 2 copper scrap and the Comex cathode price are provided at Exhibit 10. These data show that in 2000, for example, the buying price for Number 1 copper scrap averaged 69.62 cents per pound, a discount of 2.95 cents per pound in relation to the average Comex copper cathode price of 72.57 cents per pound. In the same year, the buying price for Number 2 copper scrap averaged 58.96 cents per pound, a discount of 13.61 cents per pound in relation to the Comex copper cathode price of 72.57 cents per pound. See Exhibit 10.

cathode (with the price of copper cathode typically acting to define the logical upward limit of the price of scrap), scrap discounts from the price of copper cathode may increase or decrease as supply and demand for scrap fluctuate. Evidence from recent years shows that expanding exports of copper-based scrap have acted to increase the prices (reduce discounts) of scrap in relation to copper cathode.[21]

As shown at Exhibit 10, the discount in prices paid by U.S. brass mills for Number 1 copper scrap in relation to the Comex price for copper cathode has declined from an average of 3.3 cents per pound in 2000 and 2.95 cents per pound in 2001 to just 1.44 cents per pound in 2002 and 1.21 cents per pound in the first 11 months of 2003. This means that between 2000 and 2003, the average discount for Number 1 copper scrap from the Comex cathode price has declined by 63.3 percent. Over the same period, the discount for lower-quality Number 2 copper scrap has fallen from an average of 18.98 cents off Comex in 2000 to 13.61 cents per pound in 2001, 12.22 cents in 2002, and just 10.97 cents per pound in 2003. This trend amounts to a 42.2-percent decline in the discount for Number 2 copper scrap from 2000 to 2003. See Exhibit 10.

Monthly pricing data show that average scrap discounts have been extremely small in the second half of 2002 and the whole of 2003. In eight of the months during this period, the monthly average discount for Number 1 copper scrap has been less than one cent per pound, and in September 2003 the average scrap price actually exceeded the Comex cathode price. See Exhibit 10. The major declines in discounts for copper scrap were recognized in a recent report of the U.S. Geological Survey, which stated that due to declining supplies of scrap in the United

[21] It also should be noted that, while futures markets exist in relation to copper cathode as a means of controlling the risk of price volatility in that market, no comparable futures markets exist in relation to copper-based scrap. Essentially all purchases of copper-based scrap are made on a spot basis.

States, "{t}he consumer buying price for bare bright copper was reported to be level with the spot COMEX price for refined copper, and the price {sic} for burnt No. 1 scrap and No. 2 scrap were reportedly discounted by only 3 cents per pound and 9 to 10 cents per pound, respectively."[22]

Scrap prices have soared in 2004 as stocks have continued to dwindle. Between the first week of December 2003 and the last week of February 2004, average prices for Number 1 scrap increased from 97.00 cents per pound to $1.3250 per pound, an increase of 36.6 percent. See Exhibit 10. Discounts on copper-based scrap have remained depressed during this period and, on several occasions, average prices for Number 1 copper scrap have again gone above the Comex copper cathode price.

While the overall price of copper-based scrap is, to a significant extent, driven by the price of copper cathode, the discount at which copper-based scrap sells in relation to copper cathode is essentially completely driven by the supply and demand for copper-based scrap. Distinguishing the price effects of rising copper (cathode) prices from the effects of declining copper-based scrap supplies is, therefore, a relatively straightforward exercise.

In a typical market, reduced activity within the U.S. economy has the effect of reducing demand for copper-based scrap, as reductions in output by brass mills result in reduced demand for raw materials. Historically, therefore, in periods of economic slowdown, the price of copper-based scrap has tended to decline. Such was not the case during the 2001-2003 period of recession, however. From an average price of 69.62 cents per pound in 2001, Number 1 copper scrap increased in price to 70.23 cents per pound in 2003 and 78.14 cents in the first 11 months of 2003 (prices since that point have reached levels well in excess of $1.00 per pound). See

[22] U.S.G.S. Mineral Industry Surveys, Copper in February 2004 at 1.

Exhibit 10. Further, the discount at which Number 1 copper scrap sold in relation to copper cathode fell from an average of 2.95 cents per pound in 2001 to just 1.21 cents per pound in 2003, a 59.0 percent decline. Thus, the higher pricing for copper-based scrap in the 2001-2003 period has been contrary to historical trends during a downturn in the U.S. economy. These price trends have not been due to an expansion of consumption of copper-based scrap in the U.S. market, as total consumption of the product declined in each year from 2001 to 2003 and by 15.8 percent for the period overall. See Exhibit 6.

Nor was the increase in the price of copper-based scrap due to declines in the amount of scrap generated within the U.S. market. Total U.S. supply of copper-based scrap (consumption plus exports) declined only marginally (1.3 percent) between 2001 and 2003 and actually increased (by 4.9 percent) in 2003 in relation to 2002. See Exhibit 6. Thus, from 2002 to 2003, a period during which overall U.S. copper-based scrap supply showed a large increase and U.S. consumption showed a substantial decline, overall scrap prices went up dramatically and the scrap discount in relation to cathode prices diminished further. This upward trend in the price of copper-based scrap during this period was completely illogical in relation to developments in U.S. supply and demand for the product. What was driving prices during this period was not U.S. demand for copper-based scrap, but foreign demand for U.S. scrap, as exports increased their share of total U.S. supply from 28.9 percent in 2001 to 39.4 percent in 2003. See Exhibit 6.

The causal connection between increased exports of copper-based scrap and increased prices for the product in the U.S. market has been widely reported by the metals industry trade press. As noted in one recent summary, "{s}upplies of copper scrap also have grown tight due to Asian demand, particularly from China. 'They've been buying it way over the market price, and it's sucked the United States dry ... that's putting a lot of pressure on the market,' one merchant told Platts. The low amount of copper scrap being produced by manufacturers in the US was adding to the problem, another merchant said."[23]

The recent weakening of the U.S. dollar has only added to foreign demand for U.S. copper-based scrap supply, thereby exacerbating supply shortages. As noted in a March 1, 2004 article in the American Metal Market,

> Copper scrap pricing is setting records and experts throughout the industry say the secondary market is still heating up rather than cooling down as the winter season ends.
>
> A weak U.S. dollar and domestic supply shortages have fueled rising scrap prices recently, but several sources believe overseas demand will drive the current feeding frenzy for material well into the summer....
>
> With tensions mounting in the copper scrap industry and competition for domestic supplies escalating, prices have soared to record levels throughout the winter, a time of year usually noted for inactivity and seasonal shutdowns....
>
> "We've seen copper scrap at $1.50 before, but you could very well see these prices next year," a Chicago-based buyer said. "All of the evidence points to a sustained run up. Unless the Chinese stop buying material, these prices aren't going away anytime soon."
>
> Copper scrap spreads have remained virtually unchanged since February last year, with one notable exception: During the past month, dealers and brokers reported that Bare Bright was being sold for 1 cent more than the March Comex price.
>
> "There are two types of supply right now: tight and tighter. And the competition for material has forced guys to pay premiums," a Midwest scrap broker said. "These guys have to get scrap into their furnaces right away so they can get their products out to market."...
>
> The weak U.S. dollar also has attracted new buyers to the market since the beginning of the year, and brokers reported renewed interest from European buyers recently.

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[23] Platts Metals Week, Dec. 22, 2003 at 6.

> "Europe has really stepped up in the last month and we're finding more and more metal headed to Europe," Weintraub said. "It's really making it hard on the brass business."
>
> One scrap dealer noted that warmer weather on the U.S. East Coast should draw out more scrap material in the coming weeks. But several other industry sources said that, aside from new demolition work, the material just wasn't there.[24]

Clearly, expanded demand for U.S. copper-based scrap from foreign buyers has had the effect of reducing scrap supplies, thereby pushing up prices for the product. Further, the high prices that buyers from countries such as China have been willing to pay to source U.S. scrap have in themselves acted to increase prices in the U.S. market (that is to say, even if supplies were adequate, the prices the Chinese purchasers are willing to pay would be having the effect of increasing prices in the U.S. scrap market).[25]

Agents purchasing U.S. scrap on behalf of the Chinese industry have not only offered above-market prices for copper-based scrap, but have also reportedly been willing to pay cash to U.S. scrap dealers for their purchases and to arrange their own transportation of this scrap. Chinese agents have actually established their own scrap purchasing agencies on the West Coast of the United States in order to take direct control of the sourcing of copper-based scrap.

Thus, users of copper scrap and copper-alloy scrap in the United States have been doubly injured by recent trends in copper-based scrap prices: global shortages of copper cathode and extremely strong demand for the product in China have pushed up prices for copper cathode

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[24] "Hot copper market growing still hotter," American Metal Market, Scrap, March 1, 2004 (Monday Edition), at 10.

[25] Chinese purchasers of copper-based scrap are believed to be able to purchase the material in the United States at above-market prices because Chinese governmental programs reimburse Chinese brass mill producers for some element of their raw-material costs on exported finished products. Chinese purchasers are also understood to receive preferential ocean freight rates on the transport of these materials from the United States to China.

rapidly (thereby pushing up copper-based scrap prices), while declining supplies of copper-based scrap in the U.S. market have all but erased scrap discounts and pushed prices of the product toward or above cathode prices. The current situation is injurious and untenable.

VII. DOMESTIC PRICE INCREASES AND SHORTAGES OF COPPER SCRAP AND COPPER-ALLOY SCRAP HAVE HAD AND WILL HAVE A SIGNIFICANT ADVERSE EFFECT ON THE NATIONAL ECONOMY AND THE DOMESTIC COPPER AND BRASS INDUSTRY

As exports have expanded and U.S. supplies of copper-based scrap have dwindled, prices both in absolute terms and in relation to copper cathode have increased. This activity has had a particularly dramatic effect on the U.S. brass mill industry. U.S. brass mills rely on copper-based scrap for a high percentage of their basic raw materials. Indeed, a survey of industry members shows that as recently as 2001, brass mills consumed more Number 1 copper scrap than copper cathode, with Number 1 copper scrap accounting for 53.5 percent of the total of these inputs.[26] Due to declining scrap availability, by 2002 consumption of copper cathode by brass mills exceeded consumption of Number 1 copper scrap, with scrap falling to 46.7 percent of the total of these raw materials. By 2003, scrap's share had declined even further, with Number 1 copper scrap accounting for just 39.8 percent of total consumption of the two products.[27]

[26] Number 1 copper scrap is the most-consumed form of copper-based scrap by volume by the industry, but the industry also consumes significant volumes of other copper-based scrap, notably C.D.A. 300-series leaded-brass scrap, C.D.A. 200-series brass scrap, and Number 2 copper scrap.

[27] On the basis of overall raw materials consumption by the brass mill industry, copper-based scrap (including copper-alloy scrap) accounted for the majority of metal inputs. In 2003, copper-based scrap consumption by the industry (including the small amount consumed by wire rod mills) totaled an estimated 842,182 metric tons (58.9 percent of total metal consumed), while consumption of refined copper (predominantly cathode, but also including ingot, cakes and slabs, and wire bar and billet) is estimated at 586,909 metric tons (41.1 percent of metal consumption). USGS Mineral Industry Survey, Copper in February 2004 (data through November annualized).

The move away from scrap and toward cathode has been driven by two factors. First, declining availability of scrap has forced brass mills to source more-expensive cathode, because adequate stocks of scrap are simply not always available. Second, as the price of copper scrap has approached that for cathode (or, as noted above, exceeded the price for cathode in some instances), the natural price advantage of copper scrap has diminished to insignificance, and copper cathode has become relatively more attractive.

However, not all brass mills can use copper cathode as an input material, as some production operations have been expressly designed to use copper scrap as their sole raw material. For these facilities, even as the price of copper scrap has approached, or indeed exceeded, the price of copper cathode, a transition to copper cathode has not taken place. It is because of this total reliance on scrap that prices of copper scrap in some instances can exceed prices for the purer copper cathode. Further, while copper cathode can in many instances be used in lieu of copper scrap, it is <u>not</u> a meaningful substitute for copper-alloy scrap (<u>e.g.</u>, for a product such as brass scrap). As noted, <u>supra</u>, the majority of copper-based scrap consumed by the U.S. brass mill industry is copper-alloy scrap, not copper scrap, so in the majority of applications copper cathode cannot even be used as a direct substitute.

Regardless of whether a brass mill has the ability to move back and forth between cathode and scrap, increasing prices for scrap have had detrimental effects on the production costs of manufacturers. Obviously, if a brass mill has historically used Number 1 copper scrap for a significant portion of its overall raw-material needs but is forced to increase its purchases of copper cathode due to scrap shortages, its raw-material costs will increase as relatively less expensive scrap is replaced with relatively more expensive cathode. For brass mills that cannot switch their raw-material source and can only employ scrap, declining discounts and rising prices for scrap directly increase their raw-material costs. As raw-material costs have increased, finished brass product prices have not kept pace, and so the industry's operating margins have declined.

The impact on the U.S. brass mill industry of increasing costs for copper-based scrap resulting from increased exports and reduced U.S. supply is extremely significant. In 2003, the brass mill industry consumed 842,182 metric tons of copper-based scrap (including some small amount consumed by the wire rod industry). Given that the discount for Number 1 copper scrap dwindled from 2.95 cents per pound below the Comex cathode price in 2001 to just 1.21 cents per pound in 2003 (see Exhibit 10), it is estimated that the increase in exports and reduction in the supply of scrap available to the U.S. industry acted to push up the effective price for copper-based scrap by a minimum of 1.74 cents per pound.[28] Applying this cost increase to the annual consumption figure, it can be estimated that the reduced scrap discounts due to lower supply of copper-based scrap resulted in a direct cost to the brass mill industry of $32,306,135 annually.[29]

While pricing of copper and copper-alloy finished products by brass mills generally takes account of prevailing market prices for copper cathode (such that the "metal" element of the price of the end-product will be based on the prevailing market price as established by the LME or Comex), the ability to "pass through" increased costs to purchasers is limited in three ways. First, to the extent that a producer employs scrap, rather than cathode, as its input, the discount

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[28] The change in the discount for Number 2 copper scrap was even greater, as it fell from 13.61 cents per pound off Comex in 2001 to 10.97 cents per pound in 2003, a decline of 2.64 cents per pound. See Exhibit 10. However, because Number 1 copper scrap is the form of scrap employed in the largest amounts by the brass mill industry, it will be used for purposes of estimating the price impact of increased exports in the period.

[29] 842,182 metric tons = 1,856,674,437 pounds x 1.74 cents per pound = $32,306,135.

from the prevailing market price has generally accrued to the producer. As the copper scrap discount evaporates, an important element of industry cost savings disappears as well.

Second, because prices for copper-based scrap have been increasing so quickly and supplies are so tight, in many instances brass mills have set contractual price terms with customers that reflect Comex copper prices as of a specific date, only to find that when production takes place after that referenced date, the actual price paid for the copper-based scrap is substantially higher than the price referred to in the agreement. When such an occurrence takes place, the brass mill cannot pass through the increased cost for raw materials, and the profit margin on the sale suffers accordingly.

Finally, as prices for copper and copper-alloy products rise, those products become less attractive relative to substitute products. For example, if the price of copper roofing materials becomes prohibitive, a builder might decide to use a cheaper substitute material such as aluminum. This shift has the effect of reducing overall demand for copper and copper-alloy products. Further, to the extent that U.S. brass mills are placed at a cost disadvantage on scrap inputs vis-à-vis producers in Asia or Europe, brass mill imports from those countries become more attractive to U.S. purchasers, or processors of brass mill products simply cease U.S. operations in favor of foreign production. Thus, the ramifications of increasing scrap exports are far broader than the immediate supply shortages and higher prices they engender.

Current trends in copper-based scrap exports do not bode well in relation to future supply availability. Copper-based scrap continues to be exported from the United States in large quantities, and, as noted above, demand for scrap by Chinese producers is forecast only to accelerate. According to one recent article concerning China's consumption of various types of scrap metals, "most analysts don't foresee any decline in {China's} scrap imports before

2010."[30] Further, largely because of China's unprecedented recent growth, world supply of mined copper and copper concentrates has not kept pace with global demand, and cathode stocks have also been dwindling. Recent press reports indicate that world supplies of copper cathode are well below demand and that stocks of copper cathode within the United States are at perilously low levels:

> "I could see all of the stockpiles in the LME going to zero by the end of this year," said Peter Sellars, the 52-year-old chief executive of Liverpool, England-based Henry Bath & Son Ltd., the metals warehouse division of San Diego-based Sempra Energy.
>
> "So far the real demand has been taken to the Far East, particularly China," Sellars said in a telephone interview. "As the U.S. economy continues to pick up, then I think the supply will get even tighter."
>
> Stockpiles in warehouses in Long Beach, California, have dropped 56 percent this year alone. Inventories have declined in warehouses along the West Coast, including Los Angeles, which supplies copper to Asia.
>
> "All the metal in the Long Beach warehouse has gone to China," said Tim Strelitz, chief executive of Los Angeles-based California Metal-X Inc., which produces about 3 million pounds of copper-based ingots a month used in the manufacture of faucets and valves.
>
> "We've had to change the way we do our business, so we can be ahead of the rising market and historically, that's something nobody ever did," Strelitz said.
>
> California Metal-X has had to seek new supplies because some scrap dealers the company used to buy from are selling scrap at a premium of 7 cents a pound over the price of copper on the Comex in New York, he said. "I can't do that. It's too expensive."[31]

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[30] "China's Huge Hunger for Scrap," The Wall Street Journal, A15, March 25, 2004.

[31] "Pacorini Copper Supply Dwindles as Codelco Sells More to China," RBC Capital Markets, Feb. 25, 2004.

Thus, the short-term prospect is that supplies of copper cathode will tighten even further. This pressure will make the use of copper cathode by brass mills even more expensive than it has been and will place corresponding pressure on the supply and pricing of copper-based scrap. Barring some meaningful action on the part of the U.S. government to reduce the export outflow of U.S. copper-based scrap, a massive supply shortage is looming. If such a shortage is allowed to come to pass, production interruptions in the U.S. brass mill industry will be widespread, and the financial impact on the industry will be immense.

From the earliest days of the founding of the United States, the importance of copper as an essential raw material has been recognized. In the words of Alexander Hamilton in his report in 1791 as Secretary of the Treasury to Congress on manufacturing, "The manufactures of which this article {copper} is susceptible are also of great extent and utility."[32] As time has gone by and industrialization has accelerated and expanded, the accuracy of Hamilton's statement has been reinforced time and time again. The properties and versatility of copper make it invaluable in a wide range of settings.

The numerous and critical applications to which copper is put are illustrated by the list in Exhibit 2 at 7-5 through 7-14. The excerpts there from the "Metals Handbook" give a good sense of how far-reaching the uses of copper are and of how vital copper-based scrap is. In the production of electrical connectors, ammunition components, marine hardware, forgings and pressings of all kinds, condenser tube and piping systems, bushings, gears, building hardware, aircraft parts, valve bodies and parts, rivets and bolts, heat exchanger tubing, communications systems, welding rod, optical goods, keys and locks, lead frames, plumbing fixtures, and

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[32] A. Hamilton, "Report on the Subject of Manufactures" (Dec. 5, 1791), in "Alexander Hamilton – Writings" 647, 714 (The Library of America ed. 2001).

bearings, the role played by copper scrap and copper-alloy scrap is central. It is reasonable to say that these raw materials are essential work horses in the day-to-day maintenance of the U.S. economy and national defense.

VIII. MONITORING AND EXPORT CONTROLS ON COPPER SCRAP AND COPPER-ALLOY SCRAP ARE NECESSARY TO PROTECT THE DOMESTIC ECONOMY FROM THE EXCESSIVE DRAIN OF SCARCE MATERIALS AND TO REDUCE THE SERIOUS INFLATIONARY IMPACT OF FOREIGN DEMAND

The unprecedented increase in exports from the United States of copper scrap and copper-alloy scrap and current supply shortages mandate a substantial and powerful response. Based on the seriousness of the current situation, the petitioners request the imposition of a volume-based annual quota on U.S. exports of copper scrap and copper-alloy scrap of 380,139 metric tons. Such quota should be allocated evenly over a 12-month period, resulting in a monthly export quota of 31,678 metric tons, with an option of extending such quota beyond 12 months in the event of continued supply shortages.

While exports of copper-based scrap have averaged 626,693 metric tons over the years 2001-2003, in the previous five-year period of 1996-2000, such exports averaged just 380,139 metric tons. See Exhibit 11. Because the 1996-2000 period predates the substantial surge in exports of copper-based scrap over the last three years, it constitutes a valid timeframe for purposes of establishing what "normal," non-injurious levels of exports might be.

Examination of the 1996-2000 period to establish a quota is also logical because it pre-dates the slowdown in the U.S. economy and brass mill production that has taken place in the 2001-2003 period. Given that the current trend is toward a rebounding economy and increased output in U.S. manufacturing, the level of input material required by U.S. consumers of copper-based scrap in the year ahead is more likely to be comparable to that during the 1996-2000 period of relatively strong output rather than that of the 2001-2003 period of relatively weak output. Indeed, given the volumes of copper-based scrap exported during the 2001-2003 period, supply shortages within the U.S. market would have been far more severe had the brass mill industry then been undergoing a period of expansion, rather than one of contraction. As brass mill output increases over the course of 2004, unless a significant limitation on the volume of copper-based scrap to be exported is put into place, shortages of this raw material in the U.S. market will become widespread and extreme.

Moreover, given that the proposed quota is based on the average export volume over five calendar years, the period is sufficiently long to overcome any anomalies in the data that might be reflected in a shorter timeframe. Significantly, for four of the five years in the 1996-2000 period, exports were within the relatively narrow range of 300,000 – 400,000 MT (only in 2000 did exports exceed 400,000 MT), indicating that the average is representative of the actual volumes exported within any given year. See Exhibit 11. Indeed, the median volume of exports during this period (383,742 MT in 1997) is very close to the mean volume of 380,139 MT, the proposed volume quota.

The proposed quota represents a reduction in exports of copper-based scrap of 373,402 metric tons in relation to 2003 exports and 186,699 metric tons in relation to 2002 export volumes. These reductions are actually very conservative in relation to the actual decline in U.S. consumption of copper-based scrap during the recession years from 2000-2003, which contracted by 471,636 MT from 1,630,900 MT in 1999 to 1,159,264 MT 2003. See Exhibit 6. Given the growing strength of the U.S. economy, it is clear that demand for copper-based scrap within the U.S. market is likely to start to increase once again. A significant reduction in exports of copper-based scrap is the only means by which current supply shortages can be remedied and future economic growth can be accommodated.

A strict volume quota on exports is also necessitated by the nature of copper-based scrap supply. Copper-based scrap is not responsive to increased prices (that is to say, copper-based scrap supply is extremely price-inelastic), because this scrap is not "produced," but rather is a by-product from the manufacture of other products or is simply waste material. Thus, unlike some materials, including copper cathode, which will eventually respond to price signals by expanded production, the supply of copper-based scrap is largely set independently of its price. For this reason, it cannot be assumed that the market forces of supply and demand will naturally and timely act to overcome current supply shortages; rather, controls on exports of copper-based scrap are the only means of augmenting U.S. scrap supply.

In addition to the volume-based quota on U.S. exports of copper-based scrap, petitioners request that a system of monitoring such exports and export contracts be put in place under section 7(b) of the Act, 50 U.S.C. App. § 2406(b). More specifically, petitioners ask that such a system track (a) the volume and value of all exports of copper-based scrap and (b) the quality of scrap and its origin within the United States. It is further requested that such information be gathered and reported on a weekly basis and that a non-confidential version of each report be released on an expedited, hopefully weekly basis as well. It is envisioned that the specifics of such a monitoring system can be further identified in consultations by the petitioners with the Department of Commerce and any other relevant federal agencies. The information developed through the monitoring program could also be used in reviewing the need for an extension of the quota program beyond the 12-month period currently requested.

IX. CONCLUSION

The roles played by the brass mill industry and the brass and bronze foundries in the U.S. economy are important ones. The circumstances in which the petitioners find themselves, through no fault of their own, are dangerously serious and threaten to become worse. Central to the petitioners' ability to meet the U.S. economy's needs successfully are adequate volumes and reasonable prices for the essential raw materials of copper scrap and copper-alloy scrap. Such scrap, however, is now in very short supply and obtainable only at high and rising prices. It is just this sort of predicament that Congress intended to address in the Export Administration Act by means of temporary export controls and monitoring of exports and contracts for exports. Based upon the data presented in this petition and for the foregoing reasons, petitioners urge the Department of Commerce to implement as quickly as possible the relief sought.

Respectfully submitted,

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Attachment and Exhibits

Dated: April 7, 2004

ATTACHMENT

While demand for copper remains lacklustre, there is some hope that the North American market is about to discover better times. But there is also concern over the migration abroad of manufacturing industries, says **Myra Pinkham.**

US picture still flat

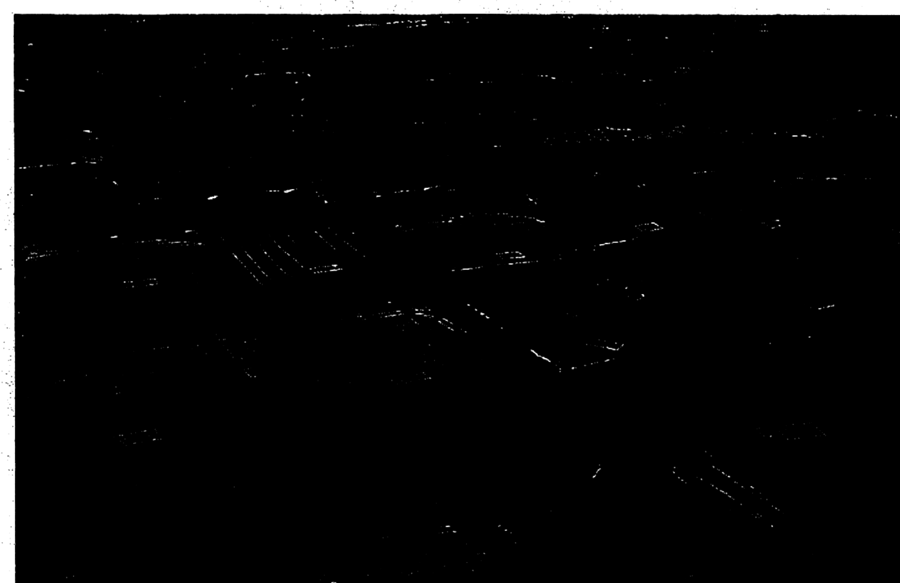
"If there ever was a question that has people scratching their heads, it is when business will get better," Donald Commerford, senior vice president of Revere Copper Products, Rome, NY, declares. While it is likely the worst is over, North American producers are not yet seeing any measurable, positive changes, he adds.

"Demand has remained flat over the last four to five months, which isn't good, as it remains at a low level. In fact the first five months of the year were not as strong as the first five months of last year," maintains Tom Baker, vp of marketing for the Olin Brass unit of Olin Corp, East Alton, Illinois. "I would like to think that demand should pick up in the second half, but I don't know if it will dramatically increase this year."

The road to recovery has so far felt rather like a roller-coaster ride. While the US market appears to be reaching a turning point, says Andy Cole, metal analyst for Metal Bulletin Research, London, it has not turned around quite yet: "The first half was very poor – more disappointing than a lot of expectations."

George Cheveley, research manager for copper for CRU International, London, notes that while there appeared to be a recovery in North American copper demand earlier this year, "the general feeling is that since the first quarter things got weaker. Car companies have quite a bit of stock. Construction isn't growing. Commercial construction is not doing well this year. Also, other things continue to be problematic, including increased competition from the Far East, particularly China, for finished goods."

Ingrid Sternby, base metals analyst for Barclays Capital, London, expresses some optimism that the extremely low interest rates could start to have a positive effect on US manufacturing. However, she notes that while US industrial production rose by 0.1% month-on-month in May compared with a 0.5% month-on-month decline in April, May output was down 0.8% from a year earlier, marking the second consecutive negative reading after nine consecutive months of improvement.



Phelps Dodge

The copper stockpile has fallen by 20% in the first half of this year, while end-use inventories are also low

Still, Sternby declares: "We see the possibility that low interest rates will boost production in the second half of the year and that should feed through to higher metal demand." In the first four months, US copper demand fell to 768,600 tonnes from 797,100 tonnes a year earlier, according to the UK-based World Bureau of Metal Statistics.

Arthur R. Miele, senior vp, marketing, for Phelps Dodge Corp, Phoenix, Arizona, also believes that copper demand will gradually start to pick up in the second half of this year and then accelerate further next year. "Much of the recovery will be related to normal cycles," he says.

"Companies have been quite careful about their capital spends and as we go through this period of adjustment, inventories are being kept at extraordinarily low levels as there has been a dramatic drawdown of finished goods and manufactured goods inventories. With manufacturers operating at about 74.5% capacity, they can quickly turn orders around and do not need to have the same pipeline of inventory that they need during more normal times," Miele points out.

"Once the market starts to pick up – and it will pick up as companies need to invest in technology, in maintenance and in some new capacities – then

Idled copper mine capacity*

[illegible]

immediately you will see manufacturing capacity move up. Companies will also need to pick up their material to put into the pipeline so that they can serve their customers effectively," he declares. The result will be a dual effect of order input for movement out to customers as well as movement of copper cathode out of exchange inventories to go back to where it is normally held – in the manufacturing distribution chain.

Less stock

Sternby also notes that copper has seen the largest inventory drawdowns in percentage terms among all base metals during the first half of this year with the total copper stockpile falling 170,000 tonnes, or 20%. Likewise, she adds, end-use inventories are estimated to be very low and any stronger-than-anticipated pickup in demand is likely to accelerate the declining trend in refined copper inventories.

Many copper producers, however, are not nearly as optimistic, concerned that the North American manufacturing base is migrating to China. In fact, one US copper producer states that this rate of migration, at least for strip, sheet and plate, has offset any current recovery. "Right now there is nothing other than a blip of recovery here and there. It will probably not be until the end of next year, or even 2005 or 2006 before we see a sustained recovery," he laments.

Andrew G. Kireta Sr, president and ceo of the New York-based Copper Development Assn, echoes that concern, stating: "The US copper industry continues to atrophy, with curtailment of operations, layoffs and movement of several base-manufacturing operations abroad. As a result of lower domestic consumption and decreased export activity, overall belt-tightening is the rule today and will be for the near term."

Todd Heusner, vp and general manager of regional products, Americas, for Outokumpu Copper, Buffalo, NY, points out that US manufacturing has lost over 2.3m jobs since the recession started in 2001. But he still expresses some optimism that while this year will be another difficult year, 2004 will be better, although he admits this is only based on an apparent improvement of consumer confidence echoed in certain government reports. "I've got to think that time is on our side," he says.

Miele also notes that short-term disruptions to the copper market are due to changes in the manufacturing base for products that use the metal. "A number of end-use manufacturers are now moving from the United States, western Europe and Japan into China and other places like eastern Europe and Mexico, which is a significant change in pattern and is resulting in some short-term disruption of some of the markets for some of the companies on the manufacturing side of the business. But in the medium term it should result in bringing to these developing countries a manufacturing base that will allow them to increase their standard of living, and copper growth is very much related to standards of living," he says.

Another producer agrees, noting that the industry went through a similar migration of business to Japan several years ago. "I don't think we will ever see another year like 2000 again. It was an unbelievable year with all the stars lined up right. We could, however, get to levels of the mid- or late-1990s," he says.

In the past several years of downturn, there has been considerable rationalisation and idling – in the US and globally – of capacity, both on the mining side and further downstream.

Barclays Capital estimates that as of the end of June, approximately 670,000 tpy of copper mine capacity has been idled *(see table)*. In addition, there have been some permanent closures. For example, Grupo Mexico has closed its Mission mine in Arizona, which produced about 50,000 tpy of copper-in-concentrate, according to Hector Garcia, corporate director for planning for the Mexico City-based company, because it was too high cost, especially in light of weak copper prices.

Likewise several downstream copper operations have been closed, including: Olin Brass's Indianapolis facility; Outokumpu American Brass's Kenosha, Wisconsin, operation; PMX Industries' Euclid, Ohio, plant; and Wolverine Tube's Fergus, Ontario, Wolverine Ratcliffs joint venture.

There is, however, some concern that now LME and Comex copper prices are firming – they have gone into the mid-70s ¢/lb as of press time, and are expected to further improve next year – that some of the idled mine capacity could be restarted soon. In fact, Barclays Capital says that approximately 375,000 tpy of currently idled capacity is vulnerable to restart, including 85,000 tpy at Phelps Dodge's Sierrita and Bagdad mines in Arizona and 290,000 tpy idled by BHP Billiton at Escondida in Chile and Tintaya in Peru. In particular, there is fear that a restart announcement could be imminent from BHP Billiton, which has stated that it will issue an update about its 2003 production plans mid-year.

Phelps Dodge would not say whether or not they are considering restarting any of their idled capacity. A spokesman would only say that the company's first half production will be about the same as the first half of 2002. "I can't speculate about the second half or beyond. We will look at all the factors affecting the market."

"If they don't restart their idled capacity it would be of extreme help to the copper market," Sternby says. "It shows that copper producers have discipline – that even though they could personally benefit from restarting capacity they won't because the market isn't strong enough yet."

Expansions pending

This is especially true, MBR's Cole adds, since there are a number of expansions in the pipeline for 2004-05, including BHP Billiton's Escondida Norte project in northern Chile. There is some fear that the combination of these factors, plus lacklustre demand, could cause the copper market to be in oversupply again, he says.

According to the International Copper Study Group, the global copper market was in a 73,000-tonne deficit during the first quarter of this year compared with a surplus of 213,000 tonnes a year earlier. That deficit could grow by the end of the year, Cole says, especially if US demand does indeed start picking up.

"That should mean increased prices," he adds, noting that MBR predicts an LME copper price of 79 ¢/lb by the end of 2003, followed by a further increase to about 86 ¢/lb by the end of next year.

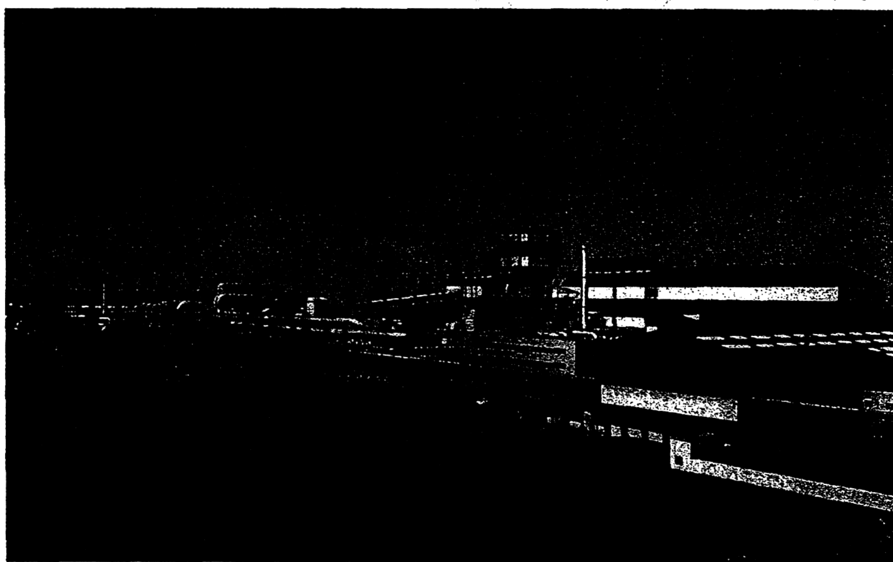
But all in all, Olin Brass's Baker says, 2003 will be much like 2002. "It will be the third straight year that it has been very difficult." However, he notes, "I am more optimistic about 2004. I think there will be increased demand. The economy has to start coming back and that will be positive."

Meanwhile, confirms Garcia, several producers – including Grupo Mexico – are making whatever internal changes they can to ensure that once the market does pick up they will be in a better position to benefit from it. ■

The author is a metals industry writer based in New York

Full steam ahead

India is being quickly transformed from a net importer to a net exporter of copper, and current smelter expansions are intended to pave the way for a globally competitive industry, writes **Gilbert Lobo.**



Birla Copper

Birla Copper is adding 100,000 tpy of capacity at Dahej by 2004

Economic liberalisation has worked like magic for India's refined copper capacity, which has risen from 47,500 tpy in 1997 to 447,500 tpy in 2002, the International Copper Study Group's 11th general session in Lisbon was told recently.

The two custom primary smelters, Birla Copper of the Aditya Birla Group and Sterlite Industries, are in the process of adding another 100,000 tpy and 120,000 tpy respectively to their existing capacity. So by the end of 2003 or early 2004 India will have a refined copper capacity of around 650,000 tpy. This may increase further, for Birla is talking of taking their capacity to 400,000 tpy eventually.

India's refined copper production was 60,737 tonnes in 1997-98 but grew to 325,000 tonnes in 2001-02 and 339,000 tonnes in 2002-03, and it is rising every year. Imports of refined copper were 176,797 tonnes in 1996-97 and 149,506 tonnes in 1997-98, but fell to just 10,640 tonnes in 2000-01 and 9,183 tonnes in 2001-02; these may yet fall further.

In the current copper race, the public sector Hindustan Copper Ltd (HCL) is making heavy losses and is in the process of being privatised, with a likely sale either to Birla Copper or Sterlite Industries.

The private sector copper processor Swil initiated a 50,000 tpy secondary smelter and refinery project in Gujarat, handling a feed of scrap, waste, residues and concentrates, but there was a big cost overrun – from about Rs6bn to over Rs11bn (US$238m) – and long delays. The project has now been taken over by financial institutions, which have brought in professional management, completed the project and conducted cold trials.

However, they have been waiting for a suitable buyer for some time and none has come forward so far. Birla Copper was interested in the plant but has reportedly backed out.

Indian companies, except for HCL, depend mostly or entirely on imported copper concentrates. The two custom smelters now need more than 1m tpy of concentrates from the world market, which will rise to 1.5m-2m tpy in the near future. Both Birla Copper and Sterlite have long-term frame contracts to import their concentrates and are said to be getting favourable terms, on a par with the Japanese smelters, for the bulk of their requirements.

The domestic market for refined copper is around 320,000 tpy and over 200,000 tpy will have to be exported after the current expansions are complete. Birla Copper and Sterlite both already export cathodes and wire rod.

Since most concentrate needs to be imported and treatment/refining charges (TC/RCs) are currently low, how do the custom smelters manage to be profitable?

Birla Copper and Sterlite have both invested in large, competitive plants and they also get a good price for sulphuric acid by-product. An additional advantage for Birla Copper is an industrial development fiscal incentive of tax exemption on sales for a 14 year period, up to 90% of assets.

There is also a net tariff protection in India – concentrates carry an import duty of 5% while finished copper is charged an import duty of 25%.

Assured supply

Birla Copper and Sterlite have both realised that they must ensure their concentrate supplies not only through long-term contracts but also by buying and operating mines abroad. Sterlite took the first initiative and bought two mines in Australia two years ago (Copper Mines of Tasmania and Thalanga Copper Mines) which can supply about 35% of its requirements.

Birla Copper has followed suit and last year acquired Straits (Nifty) Pty Ltd (SRL), which owns the Nifty copper mine in Australia, for A$79.80m (US$52.5m). "The acquisition of Nifty will elevate us to an integrated copper producer. Ownership in upstream mines is a strategic imperative for a smelter of our size, which we intend to scale up further to a global size in the foreseeable future," says Kumara Mangalam Birla, chairman of the Aditya Birla Group.

Nifty currently has a capacity of 27,500 tpy of copper cathodes via SX-EW. It is a low-cost open pit mine with oxide ore as the top layer, but it also has a large undeveloped sulphide resource, capable of producing up to 100,000 tpy of copper concentrate over an extended period. The project has a total resource of 148m tonnes of ore grading 1.3% copper.

There is now a feasibility study for the mining project and concentrator, and it will take about two years before concentrates from this mine start flowing to the smelter in India.

The Nifty project is located in the eastern Pilbara region of Western Australia, 350km from Port Hedland and less than 70km from the Telfer gold mine, according to Birla Copper. The acquisition comprises the Nifty mine and rights to explore in the Paterson range, both being located in the richly mineralised Paterson province that hosts high-class copper and gold orebodies.

In addition the 50% interest of SRL in the Maroochydore exploration joint venture is being acquired by Birla for A$10m. This has proven resources of 51m tonnes grading 1% copper.

Sterlite built a 150,000 tpy Isasmelt smelter at Tuticorin, Tamilnadu, in 1996 costing around Rs11bn, and another 30,000 tpy of capacity was added through some additional facilities costing some Rs1bn.

Now it is adding another 120,000 tpy of smelter capacity at Tuticorin as a separate plant which should be complete by the end of the year. A refinery with a capacity of 127,000 tpy is being built next to the smelter. The company's existing refinery is at Silvassa, a central government enclave near Mumbai which enjoys tax concessions and which is close to the main markets. The new refinery is also scheduled to be completed by the end of the year. The smelter and refinery together will cost Rs3.5bn.

Sterlite is using Isasmelt technology for the smelter and the IsaRefine process for refining, both supplied by MIM. The entire 300,000 tpy site is probably one of the lowest cost copper complexes in the world.

Birla Copper's first complex of 100,000 tpy at Dahej, Gujarat, later expanded to 150,000 tpy, cost around Rs15.5bn, and uses Outokumpu flash smelting and Pierce-Smith converting. For the refinery it uses MIM's Isa process.

For its 100,000 tpy expansion the company is investing in Ausmelt technology. According to Ausmelt it has signed two contracts: the first is worth more than A$12m for the smelter and separate converter to produce blister copper. The second contract is for the design and supply of Ausmelt's state-of-the-art copper cooling panel technology which takes the total contract value to A$15m. The expansion will be operational in fiscal 2003-04.

Sterlite and Birla Copper both realise that customs duties on refined metal imports will be reduced in the course of time and they therefore have to build up their companies to meet the coming competition.

Sterlite is planning to grow into a non-ferrous giant, as apart from the present 180,000 tpy copper capacity to which it is adding 120,000 tpy, it has in the group 170,000 tpy of zinc capacity (as a result of buying control of Hindustan Zinc) plus 100,000 tpy of aluminum capacity in one unit (Balco) and another 35,000 tpy of aluminium in another (Malco). In each of these sectors it wants to expand and become more competitive, and it hopes to delist in India and list its shares in London and New York to raise capital for expansion.

Restructuring

Birla Copper was part of Indo Gulf Corp, an Aditya Birla company, along with a fertiliser company. Birla also acquired Hindalco Industries, India's biggest aluminium producer, and the management then decided to demerge the copper business of Indo Gulf and merge it with Hindalco.

Comments Kumar Mangalam Birla: "This restructuring exercise is an important step in our ongoing endeavours to create a business that is both focused and has the financial capability to become a global player. The non-ferrous metals sector is integral to our future growth plans. We would like to bring in maximum focus and harness all possible synergies to make it truly world class."

Birla and Sterlite give similar answers when asked the reasons for the rapid expansion of their copper capacities – domestic demand for copper is about 320,000 tpy now but is likely to grow by around 8% annually. Import tariff protection is expected to be reduced, and so their strength is being built up through globally competitive units in terms of size and efficiency.

In fact there is a deficit in copper in west Asia and the Far East of around 2m tpy, and therefore the Indian producers have a growing regional demand as well as a freight cost advantage. It is perhaps not surprising that they feel optimistic about the future of their business. ■

The author is a specialist writer based in Mumbai.

After several years of misfortune, WMC hopes for a better outlook at Olympic Dam in 2004. **Jo Clarke** reviews troubled times for the Australian miner and outlines its reasons for optimism now.

WMC prays for better fortunes at Olympic Dam

No-one could have known back in October 2001 when WMC said that the then recent fire at its Olympic Dam solvent extraction plant would have a minimal impact on production, that by mid-2003 the associated rebuild would be running around A$200m over budget. Now all fingers are crossed at WMC Resources that 2004 will see a turn around in the company's fortunes from the previous four years and that production will finally reach the nameplate capacity of 235,000 tpy of copper.

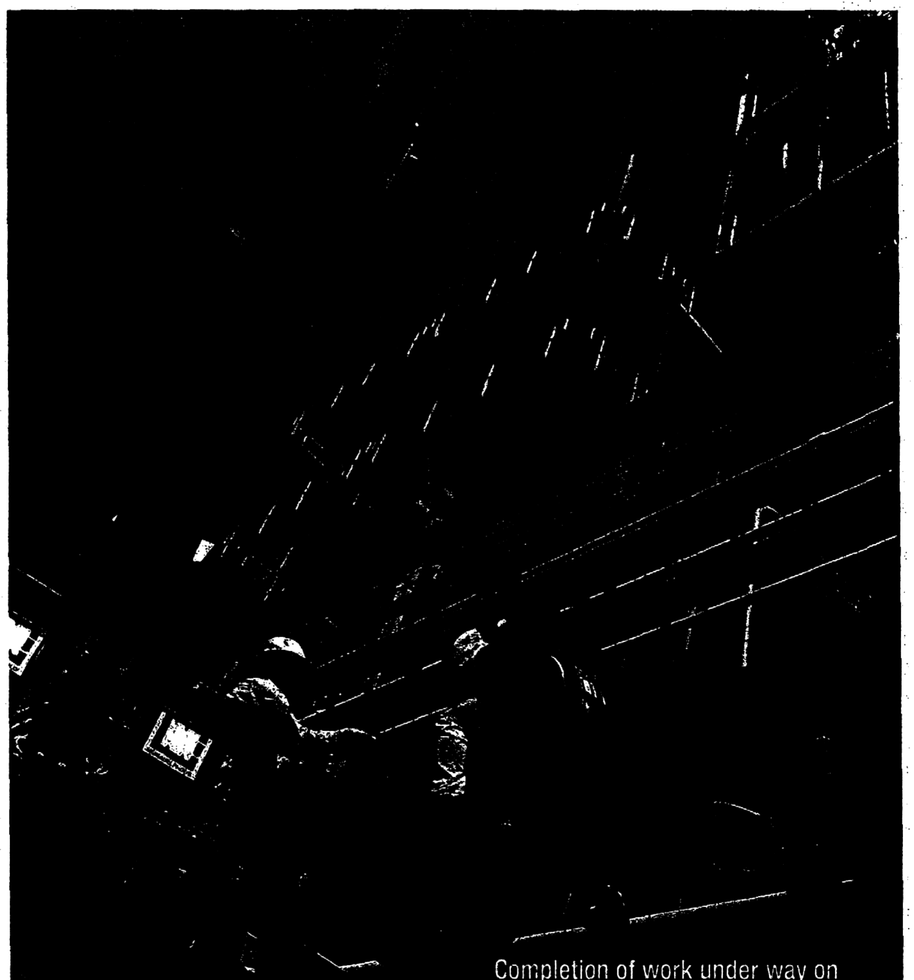
The first fire at Olympic Dam's solvent extraction (SX) unit – important as part of the production process for all of the mine's uranium and, at 10,000 tpy, a significant contributor to its copper output in recent years – occurred just before Christmas 1999 and was blamed on a fault in a pump valve. Six months later the plant was back on line and the second half of 2000 was a good year for the company. However, disaster struck again on 21st October 2001 with the second fire, the cause of which is still baffling WMC and independent experts to this day.

Eighteen months on and the rebuild of the uranium section of the SX plant has been completed and is running at full production, but the copper SX plant is only in the very early stages of construction. It will not be completed before the fourth quarter of this year and ramp-up is due for Q1 2004.

Over budget

In June this year WMC announced the latest budget over-run of an additional 25%, taking the total cost of the rebuild of the combined copper and uranium SX plant to A$375m (US$247m). A spokesman at the company said at the time that the excess spend was due to a lack of integrity in the original cost estimate, the fast tracking of the project and the inclusion of additional safety features. He added that WMC was unhappy with the performance of the contractors on the rebuild, which it blames for the original underestimate of the project cost. WMC decided, therefore, that with the uranium section of the rebuild completed, it would take over the project management role itself for the remaining six months of the copper SX plant rebuild.

WMC has not ruled out court action over the SX project, which was originally budgeted at below A$200m and had been scheduled to achieve commissioning of the uranium plant for November 2002 and the copper plant for March 2003. The company also hopes that the additional safety features incorporated into the rebuild will be paid for by its insurers and that the reduced risks they



Completion of work under way on Olympic Dam's new solvent extraction plant should mark an upturn in the mine's fortunes

provide will be reflected in future insurance premiums.

To add to WMC's copper-related woes, this year it has been forced to shut the smelter at Olympic Dam for 40 days from 20th August to conduct a reline. The maintenance work had been scheduled for 2004, but the company brought it forward by a year following a technical review conducted in 2002

The review, which was commissioned following 17,000 tonnes of lost copper production in May and June 2002 due to two leaks in the smelter's cooling jacket, found that the refractory in the furnace roof and walls had degraded. The smelter reline, which is usually needed every four to five years, is currently estimated to cost around A$120m. Replacement of the refractory bricks will cost around A$50m, with an additional A$40m to be spent on associated repairs to the smelter, while the remaining A$30m will be used to improve the gas handling system.

WMC expects that, once the SX rebuild and the smelter reline are completed, its refined copper production will rise to 235,000 tonnes in 2004, up from a predicted 185,000 tpy this year, which would be above the 170,000 tonnes produced in 2002. A company spokesman said that WMC has already sold forward the hoped-for extra production, the majority of which is cathode. The last year in which WMC produced more than 200,000 tonnes of refined copper was 2001, when it just scraped past the milestone with 200,523 tonnes.

By 2006 WMC hopes to have increased production at Olympic Dam to 250,000 tonnes by a series of small-scale de-bottlenecking projects that will see an incremental increase in production with no large capital expenditure. Looking further into the future, WMC is conducting an internal study into the feasibility of expanding Olympic Dam to a massive 600,000 tpy of refined copper. This study is in the very preliminary stages and is unlikely to see light of day for several years.

Majority exported

One-third of Olympic Dam's refined copper goes to the domestic Australian market, with the remainder destined for export, mainly to Asia and particularly to Malaysia. Some experts believe, however, that takeover by Xstrata of WMC's main domestic rival Mount Isa Mining will reduce the focus on MIM's domestic customers and could allow WMC to increase its share of the Australian market.

Olympic Dam owns and operates the mine, smelter and refinery on the one site and oversees production from mine to cathode. The plant, which is in the middle of the state of South Australia, is a long way from the rest of WMC's operations in Western Australia, where it operates the Kalgoorlie nickel smelter, the Kwinana nickel refinery and the Mount Keith, Leinster and Kambalda nickel ore mines. Olympic Dam is the company's only copper resource and, according to WMC, is in the lowest quartile of per unit production costs for copper cathode in the world.

Around 80,000 oz of gold are also produced annually from the Olympic Dam ore, along with a small amount of silver. The main by-product, however, is uranium. The difficulties with the SX plant mean that this year Olympic Dam will produce around 3,000 tonnes of uranium, but it hopes to reach its nameplate capacity of 4,700 tonnes in 2004.

The cost over-runs at Olympic Dam, combined with higher-than-expected unit costs in the company's nickel operations, have pushed the share price of WMC Resources, which is Australia's last independent mining house, down. Analysts believe this has left the company wide open to an opportunistic takeover bid, similar to that made by Xstrata for Queensland's MIM Holdings.

Last year WMC Resources, which includes Olympic Dam as well as the company's nickel assets, split from Alumina Ltd, which owns the 40% stake in Alcoa World Alumina and Chemicals. This demerger was seen by analysts at the time as an attempt by WMC to get a fair price should the company be subject to a takeover bid. ■

China's strong appetite for US copper and brass scrap – US$229m worth last year – is eclipsing the more conventional role played by destinations such as South Korea, India, Canada and Germany, reports **Paul Schaffer**.

China soaks up US scrap

By physical quantity, China probably takes roughly 19% of copper and brass shipments from US scrapyards. The country's interest in US copper and brass scrap has continued through the first half of this year. Other foreign destinations probably account for 16%. Domestic brass mills, wire rod mills and ingot makers account for most of the rest.

President of Steelbro International Co, Oyster Bay, NY, Andy Goenka runs a trading firm that ships scrap to India and China, both countries with low-wage labour for sorting and processing scrap. In his view, India behaves less brashly in western scrap markets because of its longer experience of them. Back in 1989, for example, India's share of US copper and brass scrap exports was 7%, compared with China's 4%.

"They are not as experienced in metal scrap quality," he says, regarding Chinese enterprises. "They accept much lower-graded material at the same prices."

In Goenka's view, what comes across as a Chinese willingness to overpay is sometimes the result of failing to bargain aggressively on pricing to adjust for shortcomings in quality. He expects the Chinese to develop greater sophistication as negotiators. Such an evolution may soften how they are perceived at companies bidding against them.

Administrative deadlines also complicate the lives of Chinese buyers, Goenka says. When the expiration date on a Chinese import licence looms, taking advantage of unused quota allotments can become a high priority, even when pricing cues call for a break in buying.

Traditionally, domestic consumers have taken the premium grades of US copper and brass scrap. "The higher-end products stay domestic. There are enough ingot makers and copper mills left in this country," George Ostendorf, from the Rochester, NY, branch of United Alloys & Steel Corp, Buffalo, says. "The lower-grade products go to China and India."

Ostendorf says there is even a traditional pecking order among the foreign destinations. "India has been the primary buyer of yellow brass for many years, at least from this region. The Chinese used to buy just the copper-bearing odds and ends. But now they're becoming more aggressive with yellow brass. They're paying the same price as the Indian guys," he says.

The disappearance of the last standalone US secondary copper smelter in 2001 shifted the market. "With no custom smelters buying No. 2 copper, that opened the way for that metal to go somewhere else," Scott Tauben, a trader with Metalsco Inc, St. Louis, says. "You've had less people buying domestically."

Waning domestic demand for No.2 copper scrap has interacted oddly with the Chinese willingness to pay well for insulated wire. That development has left US wire choppers with minimal supplies of reasonably priced raw material. "When they can't afford to chop insulated wire, some of the wire choppers have been shredding No. 2 copper to make a product that can go into a brass rod mill," Tauben says. "It's a creative way to keep your equipment going. But it wasn't designed to chop No. 2 copper scrap. So you run into issues with equipment maintenance," he adds.

They accept much lower-graded material at the same prices

Canada was once an extremely important destination for copper scrap. As recently as 1997, the export tally to Canada (including brass grades) was roughly 160,000 tonnes, or 42% of the US export total. Last year, it was only 40,000 tonnes. One scrap executive suggests that shifting currency rates may soon boost Canada's role as a buyer of US scrap. Some of Canada's waning role, he says, was due to weakened purchasing power for the Canadian dollar.

Mexico's role in the market has been erratic. After peaking at 22,300 tonnes in 1999 and 17,500 tonnes in 2000, that country's receipts of US copper and brass scrap dropped to 2,500 tonnes in 2002. However, that too may change, according to Tauben of Metalsco. "The west coast of Mexico has some US plants opening that are trying to buy scrap," he says. "It has the potential to grow." He also reports some inquiries from South America. "But it's mostly just talk at the moment," he points out.

Exports of copper scrap surged in March, driving exports to their highest level in a decade. According to the US Commerce Department, copper and brass scrap exports registered 63,375 short tons during March, a level that spurred overall exports between January and March to 171,396 tons, a 27.8% increase from the tonnage exported during the first quarter of 2002.

It was no surprise that China was the top buyer in March, taking in 39,642 tons, or 62.5% of the export market. Purchases in March pushed China to a grand total of 107,386 tons of red-metal scrap imported from US suppliers in the first quarter – almost 70% more than they brought ashore in the comparable 2002 period.

But China was not the only country buying in large amounts earlier this year – Canada, India and South Korea showed renewed interest in US copper and brass scrap too.

Canadian consumption, which had been waning through much of last year and during the first two months of 2003, jumped to 4,697 tons in March, a rise of close to 1,500 tons from the 3,198 tons purchased in February. India boosted its intake to 4,633 tons in March, a 1,100-ton rise from the prior month's pace. Korean smelters, which barely averaged 3,000 tons a month for much of the past year, took in more than 5,000 tons a month in both February and March.

In a separate development, the Washington-based Institute of Scrap Recycling Industries (ISRI) has announced that it will launch a comprehensive review of copper-based scrap definitions that could rewrite some industry designations. ISRI said the review could revise, delete or possibly add new red-metal scrap specifications that are used as business designations throughout the world. ■

The author is secondary materials reporter for *MBM's* sister title *American Metal Market*.

Regulations are hitting the ability of Europe's scrap industry to operate profitably, with the result that much of its copper and other non-ferrous scrap is being diverted to Asia. **Klaus Vollrath** reports German dismay.

Sucking Europe dry

Europe is losing valuable scrap resources, and the situation is particularly worrying in the case of non-ferrous metals. "Too many regulatory handicaps concerning waste handling and environmental protection are resulting in a re-routing of material streams away from Europe and towards Asia," laments Hans P. Münster, newly-elected chairman of the German Metal Traders Assn (VDM).

An opinion poll recently carried out among VDM members has shown that in the past few years, the situation has markedly worsened. Two-thirds of all companies complained that scrap availability on the market has declined, whereas only a small minority of 5% remained optimistic.

The increasing drain of metallic secondary raw materials out of Europe and towards Asia is affecting not only traders, but also industries themselves – it must be remembered that recycled scrap already contributes as much as 50% to the production of non-ferrous metals in Europe.

"It is easier to export cable scrap from Switzerland to Asia than to send it to Munich," explains Rita Dapont, VDM board member and md of Metall-Verwertung München Hans Gschwendtner in Oberschleißheim, Germany. Even after it has been separated for recycling, such materials remain classified as waste to be monitored, which means that treatment, shipment and stocking is subjected to a multitude of strict regulations.

These regulations are often different and partly even contradictory between the German Bundeslands as well as between individual European nations. While this makes it difficult to ship such materials within Europe, exports to Asia are often much simpler due to significantly lower bureaucratic hurdles in many countries of the region. As a consequence, the Hans Gschwendtner scrap processor, working under the high environmental protection standards applied in Germany, is currently only operating at 40-45% capacity.

According to Dapont, valuable scrap raw materials are leaving Europe for good, which is damaging not only for the region's industry but can also be bad for the environment: "Just recently, the German magazine *Focus* described how in some developing countries, cables are simply burned without any pollution control measures in order to reclaim their copper content," she observes.

"Additionally, competition in the international raw materials markets is distorted to our disadvantage by unfair practices," says Hans-Gerhard Hoffmann, executive board member of Hüttenwerke Kayser in Lünen, Germany, a company annually processing some 300,000 tonnes of copper-containing residues to high-grade electrolytic copper.

For example, Russia has imposed a 50% tax on the export of copper scrap, Ukraine has also discouraged scrap exports by high taxes, and China exerts its own influence on the market through high import taxes on refined metal, whereas raw materials – including scrap – are largely exempt. Such practices are of course aimed at protecting domestic metallurgical industries, although this is hardly in line with the rules of the World Trade Organisation.

If Europe does not respond, it may well follow developments in the United States, where there is virtually no domestic copper recycling any more *(see page 29)*. In the copper sector alone, China currently exerts a "vacuum cleaner effect" by annually sucking in some 3m tonnes of material from the international markets, which amounts to a significant share of all available scrap copper. But faced with such threats, the German sector does not get adequate support from its politicians, who are not doing enough to ensure fair international competition.

During the past few years, the situation has worsened to a degree where many German companies now feel their existence is at risk. In a ranking of burdens, environmental protection prescriptions, changes in taxation rules, takeovers and EU decisions are leading the way. More and more firms have been leaving the country or have been taken over.

"Law makers should finally recognise that the sector has been pushed to the limit," says Münster. Every new regulation – specifically those aiming at the protection of the environment – adds to the bureaucratic expenditures the companies are already burdened with, without tangible additional ecological benefits.

Metal traders are forced to spend more and more time and money on superfluous administrative tasks at the expense of the productivity they urgently need. While the industry agrees in principle with the necessity of control mechanisms to preserve the environment, their extent should not exceed a reasonable limit.

Another problem for the scrap sector is the subsidising of so-called renewable energy through a levy on electrical energy consumed. This is leading to a cost burden that increases year after year, further hampering the secondary metal industry's position in international markets. ■

A MYSTERIOUS SECTOR

Metal and scrap trading companies in Germany form a sector with traditionally a very wide range of structures. Very large mixed-purpose combines can be found as well as a multitude of small- to medium-sized companies, and the trading of scrap or metals is often only a small part of a portfolio of other activities.

Since many of the firms involved do not have to publish their accounts and the activities of the sector are not monitored statistically, reliable data are scarce. According to an estimate published some years ago, the combined associations of the steel and non-ferrous metals recycling industries (Gesamtverband Stahl- und NE-Metall-Recycling), which groups the German association of steel collection and recycling companies (Bundesverband Deutscher Stahlrecycling- und Entsorgungsunternehmen, BDSV) and the association of German metal traders (Verein Deutscher Metallhändler, VDM), represent about 1,300 companies with some 15,000 employees. These have an annual turnover of about €7.5bn. With about 140 members, the VDM is clearly the smaller partner.

The author is a specialist writer based in Herne, Germany. This article is based on presentations at the German Metal Traders Assn (VDM) annual general meeting in Mainz in May.

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US Exports of Copper Scrap
(in short tons)

	Aug.	July	June	Year to date 2003	Year to date 2002	Percent change
Belgium	511	997	911	5,360	5,707	–6.1
Canada	3,671	4,395	3,886	30,584	31,374	–2.5
China	48,786	43,193	41,259	319,558	189,489	+68.6
Germany	1,858	791	1,444	12,952	25,479	–49.2
Hong Kong	1,454	1,067	1,007	8,141	12,229	–33.4
India	4,364	4,735	6,169	40,107	36,980	+8.5
Japan	1,470	1,806	1,436	13,176	15,303	–13.9
Mexico	283	460	415	2,522	2,048	+23.1
S. Korea	3,230	3,928	4,377	32,418	25,565	+26.8
Taiwan	1,728	993	1,543	12,957	14,440	–10.3
Others	1,021	1,843	1,171	14,685	11,386	+29.0
Totals	**68,376**	**64,208**	**63,618**	**492,460**	**370,000**	**+33.1**

Source: Compiled by *AMM* from data released by the U.S. Commerce Department.

China lifts US copper exports to new record

PHILADELPHIA — U.S. exports of copper and brass scrap continued to break new ground in August, jumping significantly in the waning days of summer.

Shipments of copper and brass scrap to overseas customers climbed 6.5 percent from the previous month to 68,376 short tons, the largest monthly total in the past 12 years. Year-to-date exports are 33.1 percent ahead of last year's pace and closing in on the 500,000-ton mark after only eight months, according to U.S. Commerce Department statistics.

Once again, Chinese smelters were the primary customers, taking 48,786 tons in August, up 12.9 percent from July to the largest one-month total in the past decade. China's appetite for secondary red metals has grown nearly 69 percent over last year, reaching 319,558 tons in the first eight months. For most of 2003, refined copper scrap has been the metal du jour for Chinese buyers, who purchased 24,420 tons of the material in August. Since the beginning of the year, more than a third of all Chinese copper scrap purchases have been higher-quality refined copper scrap.

India's steady consumption of brass scrap remained in line with previous purchases. Indian smelters took 4,364 tons of both copper and brass scrap from U.S. scrap processors and traders in August to remain the second-largest consumer of red metal scrap from the United States. Two-thirds of that tonnage is brass.

South Korean buyers continued a return to form. Last year, copper and brass scrap shipments to the Korean peninsula fell to its lowest level in four years, but exports have rebounded this year, increasing 26.8 percent to make Korean smelters the third-largest consumers of U.S. red metal scrap.

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The current situation and prospects for the Chinese copper scrap industry

China's secondary copper industry began in the early 1950's. In the decade of the 1950's to the 1960's, the production of secondary copper made up 65 percent of China's total production of copper. With the development and construction of large-scale copper mines and copper smelters, the proportion of secondary copper in China's total copper production showed a decline through the period from the late 1950's to the early 1970's. After China adopted the reform and opening to the outside world policy, China's secondary copper industry has experienced rapid growth. Over the last twenty-odd years, the production of secondary copper has kept a rising trend and the proportion of secondary copper in the production of refined copper has increased from 19 percent in the early 1970's to 33 percent in the mid 1990's. There is no doubt that secondary copper and the related products have played an important role in China's copper industry.

The Importance of Developing the Secondary Copper Industry

A. China's Primary Copper Resources Are Seriously Running Short

China has always been a poor country in terms of copper resources. Due to limited resources of copper mines, difficult conditions in copper mining, as well as a lack of new discoveries of copper resources and a severe shortage of backup reserves, China has been an importer of great amounts of copper concentrates, refined copper, raw copper, fabricated copper and other copper products so as to make up the shortage of domestic copper resources. In respect of copper concentrates, the proportion of domestic copper concentrates (copper content) is very small. Take 2002 for example, domestic production of copper concentrates for the year was about 550,000 tons (copper content), which accounted for 34 percent of the production of electrolytic copper of the year and about 20 percent of China's total consumption of refined copper. In the same year, China's total import of copper concentrates was about 600,000 tons (copper content), which accounted for 36.8 percent of China's total production of electrolytic copper and is more than double of the copper concentrates produced by domestic copper producers. The situation of China's copper mine resources is getting really stringent. See Table 1 for China's production and import of copper concentrates for the year of 2002.

Table 1 Domestic and Imported Copper Concentrates (1997-2002)

Unit: 10,000 tons

Year	Production of electrolytic copper	Copper content in domestic copper concentrates	Share in electrolytic copper (%)	Import of copper concentrates	Copper content converted	Share in electrolytic copper (%)
1997	117.94	49.55	42	93.777	28.14	23
1998	121.13	48.68	40	118.27	35.4	29
1999	117.4	52.01	44	186.63	55.9	47.6
2000	137.1	59.26	43	181.33	54.39	39.6
2001	142.6	56	39	225.52	67.65	47.4
2002	163	55.61	34	206	60	36.8

We see from Table 1 that domestic production of copper concentrates has not seen a rapid increase in recent six years, whereas in the same period, the import of copper concentrates has increased significantly.

In view of China's potential resources of copper mines, there is the possibility that China has a big reserve of primary copper deposits, which, however, are not yet discovered up to date. Even if new copper deposits may be explored, a series of issues such as the construction of mining and smelting facilities will have to be solved and a long construction cycle will be required, and thus it is unlikely to increase the production of refined copper solely relying on the domestic market for copper concentrates.

B. A Huge Consumption Market

(1) The last decade has seen a big growth in copper consumption: Over the last decade, copper consumption has experienced rapid growth in China. China's consumption of refined copper has increased from 1.5 million tons in 1995 to 2.684 million tons in 2002, presenting a growth of 78 percent. Statistics of 2002 show that China's apparent production of copper of the year was about 3.5 million tons, and if we omit the factors of inventories and etc., the consumption of copper in 2002 should be around 3.5 million tons. However, as the production of secondary copper and related products produced by the private companies and the village and township enterprises were not included in the statistics, the consumption of domestic copper (fabricated copper included) must be greater than 3.50 million tons. See Table 2 for China's consumption of refined copper in the period from 1995 to 2002.

Table 2 China's Consumption of Refined Copper (1995-2002)

Unit: 10,000 tons

Year	Consumption	Year	Consumption
1995	114.76	1999	150.77
1996	116.1	2000	188.76
1997	102.48	2001	232.06
1998	142.19	2002	268.44

We see from Table 2 that China's consumption of copper has shown an upward trend over the last eight years.

In respect of the growth rate of copper consumption, China's rate has exceeded those of the developed countries by far. Take the consumption growth rates of refined copper over the six-year period (1995-2000) for example, the growth rate of Germany was up 22 percent, the US 17 percent, France 7.5 percent, Japan down by 4 percent, whereas China's growth rate over the period saw an increase of 64 percent.

(2) Evaluate China's potential consumption capacity from consumption per capita: Even though China's consumption of copper has increased sharply over the last decade, it is still at a low level in terms of consumption per capita. In view of the consumption of refined copper per capita, we see that China's consumption of refined copper per capita is far behind those of the developed countries. See Table 3 for the consumption of refined copper per capita in some developed countries.

Table 3 The Consumption of Refined Copper Per Capita of Different Years in Certain Countries

Unit: 1,000 kilograms

Year	USA	Japan	Germany	France	China
1995	9.7	11.3	13.1	9.3	0.94
2000	11.4	11.2	16	9.8	1.4

Although the consumption of refined copper per capita cannot represent the overall consumption of copper of a state, it does reflect the level of copper consumption from one aspect.

Table 3 shows a big gap between China's consumption of copper per capita and those of the developed countries. However, with the rapid development of such industries as electrics, machinery, electronics and automobiles, we will see rapid growth of copper consumption per capita in China. If the consumption of copper is to increase by 1,000 kilograms per capita, China'stotal consumption of copper will increase by 1.30 million tons. Therefore, China's copper consumption market bears a great potential for growth.

(3) Evaluate the potential of China's copper consumption by steel outputs: From the experience of the developed countries, we see different ratios of copper production to steel production in different periods. Such ratios can provide a reflection of the level of development and copper consumption of a certain country. For instance, the ratio of copper production and steel production of the US was 1.03 percent in 1980, and it had once reached a peak level of 2.3 percent in 1995, and the ratio of copper production to steel productions of Japan in 2001 was 1.4 percent. Table 4 shows the ratios of copper production to steel production of three countries when their steel productions reached 100 million tons.

Table 4 Ratios of Copper Production to Steel Production

Unit: 10,000 tons

	1980			1995			2001		
	Production of Steel	Production of Copper	%	Production of Steel	Production of Copper	%	Production of Steel	Production of Copper	%
China	3,712	38.36	1.03	9,536	107.97	1.1	15,226	142.6	0.9
USA	10,146	168	1.6	9,519	227.99	2.3	9,010	171.4	1.9
Japan	11,017	101.4	0.92	10,164	118.8	1.1	10,286	144.9	1.4

We see from Table 4 that the ratio of copper production to steel production of current China is only 0.9 percent, which is only about the level of Japan in 1980 (0.92%), a big gap from the US and Japan. So, we can see a great potential for growth in terms of both copper production and consumption in the Chinese market.

C. Developing Secondary Copper Provides a Shortcut Solution for China's Copper Industry

The market potential for copper consumption is huge in China. However, as a result of insufficient copper resources, there is a big divide between supply and demand. The solution for this problem is fourfold: first, stepping up the efforts on prospecting copper resources to find new copper mines, so that domestic production of copper concentrates can be increased; second, increasing the import of copper concentrates; third, importing refined copper and fabricated copper; forth, fully developing and utilizing the resources of copper scrap.

It requires time to increase domestic production of copper concentrates and, even if domestic production of copper concentrates has increased in the next few years, it will not be made ready to serve the instant demand of the domestic market. So, it is unlikely to solve the issue solely relying on domestic production of copper concentrates. In respect of import of copper concentrates, there is little room for profit as we have seen from the practice of import of copper concentrates over the last few years even though a good number of copper producers are importing copper concentrates in great amounts. It is even less profitable to import refined copper and fabricated copper from abroad. In particular, the import of fabricated copper will leave a substantial part of the profit in overseas states, which is economically unreasonable.

By fully developing and utilizing the resources of copper scraps in the home and overseas markets to increase the production of secondary copper and related products, we get a shortcut solution in making up the insufficiency of copper resources in China. It saves the construction of mines and mining and dressing of ores, as well as a part of the smelting process, so that copper production can be largely increased in a short time. In addition, much environmental efficiency can also be achieved. Considering the advantage and disadvantage of the four approaches aforementioned from the aspects of resources, environmental protection, economy, etc., it is self-evident that developing secondary copper industry is a far more apposite solution in China. It provides us with a shortcut in the development of our copper industry and is well in compliance with the strategy of sustainable growth of the national economy.

The Basic Structure of China's Secondary Copper Industry

China's secondary copper industry consists of two major sectors: the copper scrap salvage sector and the copper scrap recycle sector. The salvage sector involves a domestic copper scraps collection system and a system for processing the seventh category waste materials and the sixth category of copper scraps. The recycle sector consists of companies engaged in the production of secondary copper. This sector was mainly composed by state-owned enterprises at times of planned economy, when some collective-owned ventures also engaged in the production and processing of secondary copper. In the late 1970's, the village and township enterprises that had engaged in the production of secondary copper gained fast growth, however, as compared to those of state-owned enterprises, their outputs were limited because their business operations often ran down for shortages of raw materials, backward technologies and marketing and sales problems. The 1990's saw rapid growth of the secondary copper industry in China. Through intense competitions, many of the small-scale village and township enterprises were eliminated in the process. Those that survived the competitions were private companies, which had established themselves in the late 1990's. At present, the state-owned companies and the large-scale private companies are now the major actors of China's secondary copper industry, which have been playing an important role in the development of China's copper industry.

An Analysis of the Current Situation of China's Resources of Copper Scraps

China's resources of copper scraps consist of domestic and imported copper scraps. Since China's industrial foundation is relatively weak, the reserve of copper products is not so large, and since all copper wares are subject to a long term of usage cycle, the generation of waste copper is slow. Therefore, of the copper scraps being used in current China, import of copper scraps has taken a large share in addition to domestic copper scraps.

An analysis of the quantity of domestic copper scraps

As the collection of copper scraps in China is subordinated to different systems, it is hard to make an effective counting on the actual generation of copper scraps. To get a relatively accurate figure of the generation of copper scraps, a common practice is by way of reasonable reckoning. Presently, domestic copper scraps are mainly produced from wastes and scraps generated from the processing industry (i.e., scraps and rejected products), as well as discarded machines and equipment, and together they make the total generation of domestic copper scraps in a certain year. So, an estimation of copper scraps generated in a certain year can be obtained by way of such reckoning and is generally based on the following account: by calculating the quantity of copper scraps generated from the processing and the manufacturing industry at the rate of 10 percent of refined copper consumption of the current year (at times of planned economy, the relevant authorities would calculate the recovery rate of copper scraps by a rate of 15 to 20 percent. With the advancement of technologies and the application of the scrapless cutting technology, the portion of scraps in copper processing has been brought down. So the recovery rate of the processing industry may be calculated at a rate of 8 percent); for discarded machines and equipment, the scrap copper recovery rate is calculated by the amount of refined copper consumption 15 years before (generally, an equipment will be discarded after 15 years of usage), and finally, considering such factors as extended service and etc., a coefficient of 0.6 is multiplied to the calculated figure. Based on the calculations described above, we get the generation of domestic copper scraps for the year of 2002 as follows: with the consumption of refined copper in 2002 being 2.6 million tons, we get 21 tons of copper scraps from copper processing; as the copper products and equipment produced in 1987 had entered their elimination period in 2002, and based on the apparent consumption of approximately 580,000 tons of refined copper for the year of 1987, which is then multiplied by the coefficient of 0.6, we get an estimation of 350,000 tons of copper equipment to be scrapped in the year of 2002. So our reckoning of the generation of domestic copper scraps for the year 2002 is an approximate amount of 560,000 tons.

An analysis of the quantity of imported copper scraps

According to the statistics of the customs, China had imported 21,700 tons of copper scraps in 1990, and had imported over 3 million tons of copper scraps in 2002. What is worth noting is that apart from pure copper scraps (the sixth category waste materials), great quantities of used electric motors, cables and wires and discarded metals and electric appliances that contain nonferrous metals (the seventh category waste materials) have also been imported from overseas countries starting from 1993. So the statistics of the customs are the quantity of imported materials altogether, which include both the sixth category waste materials and the seventh category of waste materials rather than pure copper scraps. Based on the information we have gathered, the actual amount of copper scraps that China had imported in 2002 was about 750,000 tons. See Table 5 for the quantities of copper scraps imported by China in the period from 1993 to 2002.

Table 5 China's Import of Copper Scraps (1993-2002)

Unit: 10,000 tons

Year	All Materials	Copper Content	Year	All Materials	Copper Content
1993	56.8	--	1998	95.7	24
1994	77	--	1999	170	42
1995	118	--	2000	250.1	62.5
1996	31.8	--	2001	270	67.5
1997	79.68	20	2002	300	75

Please note that the copper contents in Table 5 are only estimations, which might not be the same as the actual amounts.

Recovery Rate of Copper Scraps and Productions of Secondary Copper

At times of the planned economy, the statistics on China's copper scrap recovery were comparatively more accurate, because the local authorities concerned could accurately report the recovered and reused amount of copper of the year, likewise, the government authority responsible for the nonferrous metals industry could also report an accurate production of secondary copper of the year. However, as China transforms itself from a planned economy to a market economy, the administrative system for the collection and reuse of copper scraps as well as secondary copper production has experienced great changes, therefore, we have quite different calculations on the recovery rate of copper scraps and the production of secondary copper. At present, the calculations of secondary copper by China Nonferrous Metals Industry Association (CNIA) are based on the amounts of electrolytic copper productions produced by copper makers of the old metallurgic industry, i.e., the state-owned enterprises, whereas the electrolytic copper outputs of the private copper makers, which have grown up and developed after China adopted the reform and opening to the outside world policy, are not included in the calculations, and thus such statistics do not always reflect the actual production of secondary copper in China. Take year 2002 for example, the output of secondary copper produced by copper makers of the old metallurgic industry totaled to 360,000 tons, however, the actual quantity of secondary copper were greater than this amount, which was at least more than 460,000 tons. In 2002, the actual amount of copper scraps recycled in China was about 1.3 million tons.

The Resources and Market Prospect of China's Secondary Copper Industry

Generation of domestic copper scraps is likely to increase

With the increase of our national strength as well as the accruement of copper usage in China, the generation of copper scraps will likely to increase. If we calculate the annual growth of copper consumption by 7.26 percent, which is the average growth rate in the last five years, then we get the generation of copper scraps in the next decade as shown in Table 6. These projections are based on the calculation method described in part III of this article.

Table 6 Projections of Generation of Domestic Copper Scraps in the Next Decade

Unit: 10,000 tons

Year	Outputs	Year	Outputs
2003	56	2008	76.7
2004	58.3	2009	79.3
2005	60.1	2010	105
2006	62.2	2011	117
2007	70.1	2012	119.1

Growing reliance on imported copper scraps

Development of the secondary copper industry relies on the supply of copper scraps, as well as the boom of China's industry and the accelerated rate of equipment update, i.e., sufficient copper scraps resources are required to guarantee the growth of the industry. However, in view of the current situation of China, domestic supply of copper scraps cannot meet the needs of the industry by far. 2002 saw an import of over 3 million tons of waste materials containing copper, which is converted to 750,000 tons of copper scraps. From January to May of this year, China has already imported a substantial amount of 1.31 million tons of waste materials containing copper, which is converted to 327,500 tons of copper scraps, a rapid increase from the preceding year.

China's copper smelting industry will witness rapid growth in the next decade. As primary copper involves a series of issues such as resources, energy and environment, a good number of primary copper smelters are beginning to consider the advantages and disadvantages of importing copper concentrates and, the use of copper scraps to make secondary copper. In fact, over the last few years some copper smelters have already begun to make use of copper scraps as raw materials. The wide use of copper scrap as raw materials by primary copper smelters will make the raw material supply issue even worse. So, China will rely more on overseas resources of copper scraps in the future.

• *A good prospect for imported copper scraps*

In the current *"Catalogue of Waste Materials as Industrial Raw Materials Subject to Import Restrictions of the State"*, imported copper scraps are classified into two major categories, of which the waste materials of the sixth category mean pure copper scraps and the waste materials of the seventh category mean discarded motors, cables and wires, hardware and electric appliances, etc. Prospect of the import of copper scraps (including the sixth category and the seventh category waste materials) will largely depend on the development of the government policy on the import of waste materials. My personal view is that the central government will further standardize and regulate the import of copper scraps with the implementation of the reform and opening to the outside world policy, so that it will be more compatible to the WTO environment. The import control policy on pure copper scraps (government control on the import of the sixth category copper scraps) will be lifted further and the State government will finally remove all the restrictions on such import. At present, an automatic registration system is implemented and import procedures have become more simplified, bringing hopes to those copper smelters that rely on imported copper scraps.

Since the waste materials that contain copper of the seventh category waste materials have taken a large share in China's import of copper scraps, which have been vital to the production of secondary copper in China, the State policy on controlling the import of such materials should be more regulated and, the central government should develop the relevant regulations and standards to make them more consistent, so that the import of the seventh category waste materials will be brought onto the right track.

In respect of the development trend of the import of the seventh waste materials, I believe the prospect will be good, too, because China has been a country impoverished in copper resources and China's copper industry has relied heavily on imported copper scraps of the seventh category waste materials. In addition, China has a rich and cheap resource of labor which has been a great advantage in importing and disassembling the seventh category waste materials. For the issue of the import types of the seventh category waste materials, I believe the import of discarded motors, as well as some sorts of used cables and wires, which render a solid amount of copper contents and which compositions are relatively simple, will see a steady growth; whereas the import of used hardware and electric appliances, which have a low content of copper and complicated compositions, will be further restricted. Nevertheless, what we feel certain about is that as China has joined the WTO, the domestic market is more interlinked with the international market, and so, the import of copper scraps will definitely present a firm growth trend.

Production of secondary copper will increase significantly

In the coming three years, China's production of secondary copper (electrolytic copper) is expected to increase by 200,000 to 300,000 tons. Only the year 2003 alone will see a construction of 100,000 tons secondary copper production capacity. In particular, the large-scale, state-owned primary copper smelters will further extend their production capacities to cover secondary coppers for lack of raw materials and a narrowing profit margin by importing copper concentrates from overseas. Using copper scraps will be a realistic solution and, these companies do have the capability and conditions to process copper scraps, especially they can directly put the anode furnaces and the electrolyzing equipment into use in the production of secondary copper.

Domestic secondary copper industry enters the international market

China's primary copper industry made a breakthrough over the last ten-odd years by opening up the mineral resources of overseas countries. They have constructed mines and smelters in overseas regions aiming at combining the resources and energy of overseas markets with China's own technologies and human resources, and tried to bring the products directly to the international market. Through years of efforts, some Chinese companies have already gained mature experiences in such operations.

While China is importing a great deal of nonferrous metals scraps, some experts have put forth a new idea, which is to guide the domestic secondary copper industry to enter into the international market. Although none of these domestic copper recyclers have entered the international market right now, this idea has given us new light. Under the current situations of economic globalization, to realize the globalization of resources is a development trend. One shortcut for the development of China's secondary copper industry is to enter the world market and open up the secondary copper resources in overseas markets by constructing copper smelters in overseas regions or third countries, where we can find access to the resources. By using the resources in overseas countries, these smelters constructed in overseas markets can be used to disassemble, process and further process the copper resources, so that we can take full advantage of the copper resources and energy in overseas markets, as well as a part of the human resources and technologies at home. Meanwhile, it saves a lot of transportation, so that the production cost will be greatly reduced. In sum, to utilize the overseas resources of copper scraps is a way worthy of exploring for China's secondary copper industry.

Since copper is a nonferrous metal that is used in big quantities and has a wide range of applications, under the situation of insufficient copper resources and stringent balance of supply and demand, the development of the secondary copper industry requires our focused attention. The relevant government authorities should develop an industrial policy that suits the needs of this industrial sector so as to make copper recycling a long-term strategy of China's nonferrous industry and realize the goal of sustainable growth of the industry.

NON - FERROUS

China to boost copper scrap purchases

12 November 2003 17:49

China's copper industry will increasingly rely on scrap rather than concentrates as its raw material feed, MB's 10th China Metals Conference in Shanghai was told.

As domestic copper demand races ahead, China's copper mining sector will be unable to keep up. For Chinese smelters to benefit they must either increase their imports of copper concentrates or look to the cheaper option of increasing their reliance on scrap.

Zhang Xizhong, md of the China Regeneration Institute told delegates that increasing Chinese secondary smelting output is the best option.

"It provides us with a shortcut in the development of our copper industry," he said. "It requires time to increase domestic production of copper concentrates and, even if domestic production of copper concentrates has increased in the next few years, it will not be ready to serve the instant demand of the domestic market."

Chinese refined copper production last year totalled 1.63 million tonnes, said Zhang, of which 34 percent was attributable to domestic concentrates, while 36.8 percent came from imported concentrates.

In the meantime Chinese consumption of refined copper is surging. Total domestic consumption is estimated to have totalled 2.68 million tonnes in 2002, up from 2.32 million in 2001 and 1.89 million tonnes in 2000.

In 2002 gross Chinese imports of copper scrap totalled around 3 million tonnes, containing between 600,000 and 750,000 tonnes of copper, according to estimates presented by both Zhang and Gu Liangming, deputy general manager of Minmetals Copper Dept.

Lianming said that China imports the vast majority -- over 75 percent -- of its copper scrap from the USA, which is a preferred supplier owing to good levels of clarification and quality.

He outlined plans put in place by the Chinese government to more efficiently manage the domestic collection of copper scrap, while Chinese secondary smelters are working on technical improvements regarding the direct feed of scrap.

The need to focus on secondary production was reinforced by Wang Jingbin, president of the Beijing Institute of Geology for Mineral Resources. He said that if domestic mined copper production continues at its current rate of about 600,000 tpy, China's current known extractable reserves will only be sustainable for 17 years.

"China starves for copper resources, particularly rich copper resources," he noted.

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US Exports of Copper Scrap
(in short tons)

	Sept.	Aug.	July	Year to date 2003	Year to date 2002	Percent change
Belgium	375	511	997	5,735	6,539	−12.3
Canada	4,075	3,671	4,395	34,659	35,200	−1.5
China	43,195	48,786	43,193	362,753	213,448	+69.9
Germany	604	1,858	791	13,556	27,279	−50.3
Hong Kong	1,274	1,454	1,067	9,415	12,900	−27.0
India	3,979	4,364	4,735	44,086	40,126	+9.9
Japan	1,423	1,470	1,806	14,599	17,114	−14.7
Mexico	449	283	460	2,971	2,259	+31.5
S. Korea	3,507	3,230	3,928	35,925	27,758	+29.4
Taiwan	1,323	1,728	993	14,280	16,496	−13.4
Others	872	1,021	1,843	15,557	13,303	+16.9
Totals	**61,076**	**68,376**	**64,208**	**553,536**	**412,422**	**+34.2**

Source: Compiled by *AMM* from data released by the U.S. Commerce Department.

Tight copper supplies reduce exports

PHILADELPHIA — Copper and brass scrap exports slipped slightly as the third quarter came to a close.

U.S. exports of copper scrap might have declined from the 12-year high posted during August, but international sales remained strong in September as China and its rapidly expanding economy continued to drive the overall export market.

According to the U.S. Commerce Department, 61,076 short tons of copper and brass scrap were sold overseas in September: 50,856 tons of refined copper scrap and non-brass copper scrap and 10,220 tons of brass scrap. Nearly 71 percent of the material was shipped to China.

Some domestic buyers said the escalating price of copper scrap in September contributed to the modest drop in exports, but one Midwest scrap executive said recently that Chinese buyers hadn't dialed back consumption yet and continued to pay premium prices for metal. The executive speculated that the problem had been in locating a large enough supply of copper and brass scrap to buy, and said domestic shortages were the only thing holding back international purchases during September.

China took 43,195 tons of mostly refined copper and non-brass copper scrap in September, helping to push its year-to-date total nearly 70 percent ahead of last year's pace.

Behind the Chinese, South Korea was the fastest-growing consumer of copper scrap, taking 3,507 tons in September to increase its intake during the first nine months of the year by more than 29 percent.

The year-to-date copper and brass scrap export total passed the 500,000-ton mark in September, up 34.2 percent from the tonnage shipped overseas in the first nine months of 2002.

According to the Commerce Department, copper scrap prices jumped to one of the highest levels this year as the average price hit 46 cents a pound in September.

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US Exports of Copper Scrap
(in short tons)

				Year to date		Percent
	Oct.	Sept.	Aug.	2003	2002	change
Belgium	711	375	511	6,446	7,803	–17.4
Canada	3,246	4,075	3,671	37,905	38,306	–1.0
China	52,824	43,195	48,786	415,577	236,573	+75.7
Germany	1,906	604	1,858	15,462	29,529	–47.6
Hong Kong	1,372	1,274	1,454	10,787	13,437	–19.7
India	4,408	3,979	4,364	48,494	44,681	+8.5
Japan	1,227	1,423	1,470	15,826	18,439	–14.2
Mexico	534	449	283	3,505	2,486	+41.0
S. Korea	2,834	3,507	3,230	38,759	30,386	+27.6
Taiwan	965	1,323	1,728	15,245	17,850	–14.6
Others	1,231	872	1,021	16,788	15,691	+7.0
Totals	**71,258**	**61,076**	**68,376**	**624,794**	**455,181**	**+37.3**

Source: Compiled by *AMM* from data released by the U.S. Commerce Department

US copper scrap exports hit 12-year high

PHILADELPHIA — U.S. exports of copper and brass scrap exploded in October as year-end considerations pushed the monthly total to the highest level in 12 years.

Reports of rampant consumption throughout the industry back in October were confirmed by the U.S. Commerce Department's latest statistics, which showed that exports of copper and brass scrap went through the roof in October to 71,258 short tons, topping the 70,000-ton mark for the first time in the past decade.

Furthermore, exports for the first 10 months of the year reached a new high. The 10-month total of 624,794 tons, up a whopping 37.3 percent from the same period last year, was higher than any full-year total in the past decade.

Chinese scrap consumers led the feverish charge in October, buying 52,824 tons of brass and copper scrap, a gain of close to 10,000 tons from September. The Chinese market has grown by 75.7 percent from the first 10 months of last year to 415,577 tons, putting it on pace to top 500,000 tons by the end of the year.

Chinese consumers in October anticipated escalating metal prices and started to stockpile large amounts of copper scrap and other nonferrous metals, U.S. industry sources said.

Other sources noted that October was the last month for guaranteed deliveries into China before the end of the year, when the Chinese government is scheduled to revise the country's value-added tax on most metal commodities sold into the country.

Almost 33,000 tons of refined copper scrap were exported in October, according to the Commerce figures, edging out 24,472 tons of non-brass scrap as the most coveted red-metal scrap in October. The metals sold for an average price of 43 cents a pound.

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Copper

China is calling all the shots

By Joseph McCann

PHILADELPHIA — The copper scrap market has endured one of the most tumultuous years in recent history, and the hearty consumption of secondary red metals in 2003 could very well spill over into 2004.

December might be copper scrap's quietest month in 2003 after domestic prices broke long-standing records and supplies sank to new lows.

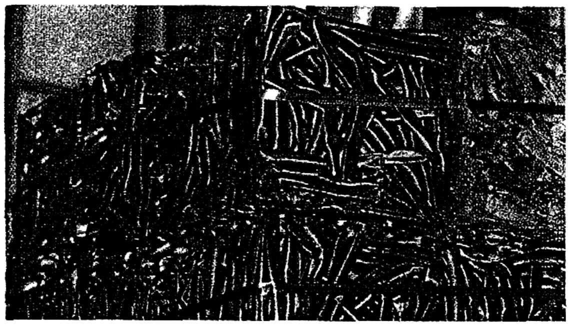
According to market data compiled by *AMM*, copper scrap prices have climbed more than 25 cents since the beginning of 2003 and Bare Bright copper scrap was poised to finish the year near the elusive $1-a-pound mark.

Price spreads between primary and secondary copper remained thin throughout the year because of tight supplies and international competition. Consequently, profits margins were razor thin for much of the year.

With domestic manufacturing staging a comeback in the latter half of 2003, however, many dealers said they look for spreads to widen slightly in the first quarter of 2004.

Coupled with the Chinese New Year and increased manufacturing in the United States, sources speculated that nonferrous scrap inventories should increase early in 2004.

It was Chinese demand that captivated the market in 2003 as Asian buyers scoured the globe for copper scrap supplies and pushed prices to a six-year high. A vast majority of copper scrap sources said they see Chinese buyers dominating the market again next year, although the extent of Chinese involvement has come into question recently. With a new tax structure taking effect Jan. 1, copper scrap experts wonder if Chinese buyers will find other red metal bargains internationally.



VORACIOUS: Chinese demand stokes prices to a six-year high.

But other segments of the industry said that Chinese buyers wouldn't stray very far from the U.S. market in 2004. With scrap supplies depleted in Europe and more profitable mixed loads still available throughout the United States, some believe Chinese involvement in the U.S. scrap market could outpace this year's record-breaking rate. AMM

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Metals Week

December 22, 2003

Elkem to idle Norway ferrosilicon furnace: source

STEEL & FERROALLOYS

New York–Elkem plans to idle a ferrosilicon furnace at one of its two plants in Norway for as long as four months because of high hydroelectric power costs and low ferrosilicon prices, a source close to production told *Platts* Dec 18. If down for the entire period, it would take 12,000mt to 14,000mt out of Elkem's Norwegian ferrosilicon output.

It is difficult to estimate Elkem's total ferrosilicon production capacity in Norway because "it's combined with foundry products and we swing production based on demand," the source said.

The shutdown is likely to occur in early January 2004, the source said. Elkem plans to decide this week at which location—Thamshavn or Salten—a furnace will be taken down. It's unclear how the shutdown would affect Elkem's distribution of ferrosilicon to various customers around the world in the first quarter of 2004, the source said.

"It's more important for Europe for obvious reasons," said a US-based supplier, who sells throughout the world, pointing to large steel producers in Europe as obvious first-choice customers. But a different supplier pointed out that "there is very little ferrosilicon production in the US," with Tennessee Alloys the only producer still operating after plant closures in recent years. "A lot of ferrosilicon from Norway usually comes here," this supplier said.

Another US supplier said he thought the US market would be mildly affected by the shutdown—assuming it lasts

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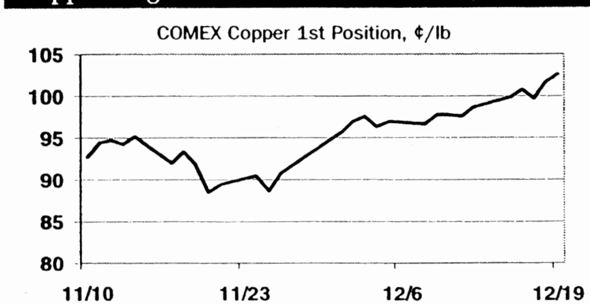
Copper prices soar on news of another Grasberg slippage

COPPER

London, Washington—Copper prices soared to new six-year highs last week after Freeport-McMoRan declared *force majeure* on copper concentrate supply following a landslide at its mammoth Grasberg mine in Indonesia, the second such incident in three months. The slippage, which occurred Dec 12, involved about 150,000mt of material in the same section of the pit as the slippage on Oct 9. No injuries occurred, and the slippage caused only minor property damage.

Copper surges over $1/lb on FCX news, outlook



COMEX March copper surged over $1/lb last week for the first time in six years as the bull market showed no signs of stalling. March gained .90¢ Dec 19 to settle at 102.40¢/lb, a high for the week and up from 98.80¢ at the start of trade Dec 15. The gains were partly driven by news from Freeport-McMoRan that another slippage had occurred at its Grasberg mine in Indonesia, one trader said.

But the event has temporarily interrupted access to the higher-grade ore areas of the mine, Freeport said. The Oct 9 landslide killed eight workers and prompted the company to reduce its copper production forecast in the fourth quarter by 70-mil lb.

Word of the slippage, when announced Dec 18, caused copper prices to reach new highs last week on both the COMEX and London Metal Exchange. Copper closed Dec 18 at $2,225/mt on the LME, basis three-months, up from $2,185 the previous day, while the COMEX active March contract settled at 101.50cts/lb, up from 99.65cts on Dec 17. The gains held as the week drew to a end, with copper closing Dec 19 at $2,238 on the LME and at 102.40cts on the COMEX after piercing another six-year high.

"Certainly, the announcement about Grasberg definitely" affected the market, one US-based trader told *Platts*.

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This Week in Metals...

ALUMINUM

US premiums steady amid producer buys, stock balance

Washington—The US prompt primary aluminum market remained relatively steady and firm last week as the year was coming to a close amid some producer buying and balanced inventories. And nearly all market players were bullish on demand and prices for early next year due to the expected strengthening of the economy and more producer purchases. The *Platts* Transaction premium was assessed at 3.9¢/lb over LME cash, delivered Midwest, on Dec 19.

A dealer said there was a lot of business on the books for January, but "people are nervous of the market." He said his January looked fine, with a reasonable amount of business, but he said, "A lot of customers are just not booking with the [LME] price rise. We had people raise their [end price] targets by 4¢/lb and they are still 2¢ away from where they need to be. It's really going to hurt the small extruders, etc."

A consumer who bought for December delivery at 3.9¢/lb said he did not see a lot of metal around. A trader said a customer recently needed more material after previously expecting orders to be weak for the rest of the year.

Market players said premiums had remained surprisingly strong for a December, as producers were out buying metal and inventories were kept balanced, so there was little dumping. One producer paid 3.85-4¢/lb for January delivery Midwest, and market players said this buying was an indication of improved downstream business. "Sentiment is up," said a trader. "None of the producers have metal to sell."

A trader said he was active for December and would not sell at below 4-4.25¢, while another sold at 4.5¢. A trader sold at 3.5¢ for January Midwest and was offered metal at 4¢ FOT East Coast port for December/January. He also sold at 3.85¢, delivered railhead for December/January. An extruder saw the market at 3.75¢, while others said it was 3.8-4¢.

A consumer said the market was quiet but expected January demand to be healthy. "I won't have a problem getting metal [in January]," he said. A trader agreed that there should not be a squeeze in the first quarter.

For 2004, a producer said premiums were 4-4.25¢ in the first quarter, rising to 4.5-4.75¢ second-half. A consumer said there was no real rush to buy. A trader offered at 4.4¢ for the first half but was turned down, and was bid at 4.25¢ for January but declined to sell. Another trader did a financial swap at 4.65¢ for October 2004 but also lost business with an offer at 4.55¢ on a swap for April through December 2004. He said that deal was transacted at 4.1¢.

On scrap, a consumer said spreads were widening slightly as the LME has risen and as buying has abated

Metals week price index

	Dec 18	Week Ago	Month Ago	Year ago
MW Base Metals	176.4	172.0	162.3	130.3
MW Precious Metals	136.8	134.2	130.1	125.5
MW Nonferrous Composite	160.5	156.9	149.4	128.4

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somewhat at year-end. But he said he expected the spreads to narrow again next month. "The Chinese appetite for scrap is insatiable right now," he said. A mill said spreads were unchanged but agreed the flow would slow down in the first quarter.

A scrap dealer said dealers were bullish because the LME had risen. He said over the past month or so he bought "a tremendous amount of scrap as the market went up." He said the mills also bought ahead, "so they are in a better position going into the beginning of the year than they were last year." He said the spreads have not tightened right now, "but there's no question they will tighten going into January."

The dealer saw painted siding prices at 10.5¢ under LME, mill-grade MLCCs at 62-63¢, dealer 10/10 at 9-10¢ under P1020, press scrap at 3¢ under. Market players said UBCs jumped to 58-60¢, delivered Midwest, late last week from 56-57¢ the previous week. The dealer said big buyers would come back in January, and a trader said he thought scrap could get "very tight" next year.

An extruder said he planned to use more scrap than prime next year and planned to change his mix to allow for more scrap.

US secondary alloy prices rise on NASAAC, scrap strength

Washington—US secondary aluminum alloy prices received a healthy boost at the end of last week, supported by tight scrap supplies and higher LME NASAAC (North American Special Aluminum Alloy Contract) prices.

Deals completed last week on A380 were at 75-76¢/lb, delivered Midwest, up from 72.5-74¢ on Nov 17. This move up was surprising given that December A380 prices for the past several years have been flat to just slightly above November's levels. But producers said the rise was justified given the presence of the Chinese in the market buying scrap, which had been pushing up prices. Market players said this was more than offsetting the slightly quieter conditions with the approaching holidays.

Producers indicated they expected further price increases throughout January, and Wabash Alloys moved its A380 list price up a penny to 77¢/lb on Dec 18, according to its website. "The market still has more room to go up," added another producer.

Further out, producers reported A380 prices at 76-77¢ for January and 77-78¢ for the first quarter. Some had just set their offer levels for January but had not yet completed any business. One producer said he sold at 75.75¢ for January earlier last week but had since moved his quote up to 76¢ as "scrap is still tight and expensive."

For January, while some smelters continued to cite strong orders, one noted it varied considerably customer by customer. He had also seen a new cheap-selling competitor. A producer said he was shipping ahead of his plan and expected December to be better than expected.

On scrap, though some scrap grades are more plentiful, scrap prices have been supported by rising London Metal Exchange prices and reports of transportation problems. A scrap dealer and several smelter sources said they thought the Chinese scrap buyers have been less aggressive at the moment but that there was a lot of speculation about whether they will come back into the market buying heavily in January.

"The Chinese are not in the market as much as they were—the dealers are using the Chinese as kind of a ghost" to scare buyers, said one smelter scrap buyer. A scrap dealer agreed that the Chinese might not be in the market all the time but said scrap "is going to get tight—the Chinese are selectively coming in and buying." Another dealer said he continued to see the Chinese buyers as active, despite their New Year's holiday, but said he saw most interest in copper scrap.

A buyer said he thought the market had moderated, but most other buyers and scrap dealers reported higher numbers late last week. "Scrap is still tight, but I have a feeling it is now trying to plateau," said a buyer. A buyer said he thought dealers were holding out for a higher price in January. "A lot of scrap people are just sitting on material," despite the much higher LME price, he said.

At the same time, the flow of auto shreds has improved as steel prices have risen. "Steel prices are the best they've ever been. Guys have been selling frags [steel pieces of auto shreds] at $175/ton their door," noted the dealer. But a buyer pointed out that rising steel prices from an aluminum scrap perspective only help auto shreds, not the other grades of scrap the secondaries buy. He said he was finding most other grades tight, and "December is the month where if someone offered to move a lot at a higher price I'd probably take it, but it's just not there."

Another smelter source said he'd seen a shortage of trucks being "quite an issue" with scrap deliveries, and even though there was a good flow of scrap, he found deliveries hard to book. He said it was affecting supply in, not shipments out.

The *Platts* old cast price was up to 53-55¢/lb as of Dec 18, delivered Midwest, from 52-54¢ on Nov 17, while old sheet edged up to 53-54¢ from 51-53¢. The *Platts* auto shreds price rose to 57-59¢ Dec 18 from 55-56¢ on Nov 17. Also seeing a large gain was mill-grade mixed low copper clips to 61-63¢/lb from 59-60¢, and smelter-grade MLCCs, up to 58-59¢ from 56-57¢ Nov 17.

Elsewhere in aluminum...

Kaiser inks deal to sell Valco: Kaiser Aluminum has executed a memorandum of understanding to sell its 90% interest in Volta Aluminium Co Ltd to the Republic of Ghana for consideration of $35-mil to $100-mil, plus the assumption of all of Kaiser's related liabilities and obligations. The MOU provides that the transaction will close by Apr 30, 2004. Valco operates a primary aluminum smelter in Ghana with a capacity of 200,000mt/year but has had all of its potlines idled since April due to hydroelectric power limitations. Just this May, Kaiser and the government of Ghana signed an MOU committing to return Valco to "full operational level within the shortest possible time." Under terms of the MOU sales agreement with Ghana, Kaiser is to pay the $35-mil to $100-mil consideration in 2004 and beyond. A Kaiser statement said the purchase by the Republic of Ghana is "subject to Alcoa's right of first refusal pursuant to Valco's corporate governance requirements."

LME NASAAC OKs Russian alloy: The London Metal Exchange has approved the "RUSAL B" brand of aluminum alloy ingot produced at Russian Aluminium's Bratsk smelter as good delivery against its North American Special Aluminum Alloy Contract, effective Dec 19, the LME said in a notice to members.

Kaiser, Pechiney increase rolled prices: Kaiser Aluminium has upped its prices for its flat rolled sheet and plate products. The price for all 6000-series products will increase by 10¢/lb, while Kaiser said that the price for all 2000- series and 7000-series products are to increase by 5%. The increases are effective with new orders from Dec 19, 2003, and all shipments after Feb 14 next year. Pechiney Rolled Products also announced a 10¢/lb increase to its 6061 flat-rolled aluminum product prices, effective with orders on or after Dec 19 and with all orders scheduled to ship on Mar 1. This is in addition to previously announced price increases of 5% for 2000 and 7000 series plate, 5¢/lb on 6061 plate from short-lead-time stocks and 3% on high-magnesium alloys (5083, 5086, 5383, 5454). With the two increases, 6061 short-lead-time plate will be increased a total of 10¢.

PBGC assumes Kaiser retirement plan: In other Kaiser news, the company said it has been notified by the Pension Benefit Guaranty Corporation (PBGC) that the PBGC intends to assume responsibility for the Kaiser Aluminum Salaried Employees Retirement Plan as of Dec 17. After consulting its advisors, the Unsecured Creditors' Committee, the Asbestos Claimants' Committee, and other constituents, the company has agreed to the termination of the plan for its 5,000 of its salaried workers and retirees. The company has stated since the inception of its Chapter 11 reorganization proceedings that pension obligations were one of the significant legacy factors that would have to be addressed during the reorganization process. The company had previously stated that termination of the pension plans was a possibility. The PBGC action does not address seven other defined benefit plans sponsored by the company and thus does not resolve all the issues surrounding the company's pension obligations. As previously disclosed, the company is discussing modification or termination of hourly retiree benefits pursuant to collective bargaining with the appropriate union representatives. Kaiser Aluminum is a leading producer of fabricated aluminum products, alumina and primary aluminum.

Chalco ups alumina prices: Aluminum Corporation of China Limited (Chalco) is to raise its alumina price to Yuan 3,700/mt ($447/mt), effective Dec 18, 2003, up 12.1% from its previous price of Yuan 3,300/mt, said a Chalco official. This is the seventh alumina price adjustment made by Chalco this year. The price change was mainly attributed to a continual rise in international alumina prices, and a further decrease in alumina inventories at Chinese domestic aluminum smelters, resulting in the widening of the alumina supply shortfall and the imbalance in the demand and supply equilibrium. Based on Chalco's information, the current selling price of imported alumina at Chinese ports has reached Yuan 4,200-4,500/mt. This has placed pressure on domestic alumina prices with the shortage in the supply of alumina. Chalco had planned to produce 5.7-mil mt alumina in 2003, up from 5.4-mil mt one year ago, "but as operations this year have been very smooth, final output is expected to be 100,000mt more at 5.8-mil mt," the source said.

Alumina tightness may hamper Al output: Chinese smelters' inability to obtain sufficient alumina in 2004 may reduce aluminum output and lift second-quarter 2004 Japan Good Western aluminum spot premiums, said Japanese sources. "Contacts say that Chalco (Aluminum Corporation of China) was unable to supply the usual number of smelters with sufficient alumina recently," said one end user. As a result, higher volumes of alumina will be sought to make up any shortfall, which may cause prices to rise. Alumina demand will also rise as China's ingot output continues to expand. Higher alumina prices may increase ingot prices in general and affect Japan Q2 Good Western ingot premiums. Industry sources said Chalco has been allocating alumina to smelters with a capacity over 50,000mt/year. Traders and end users said there would be a clearer direction for premiums after the Chinese New Year holidays in January, but were unable to put a figure on their price rise projections for CIF Japan premiums.

Boeing details scrap awards: The high bidders for Q1 scrap generated by Boeing's Washington state facilities were as follows and include the estimated quantity of scrap to be generated: South Sound Steel Recycling bid $0.58510/lb for mixed aluminum solids (600,00lb) at Kent, Washington; Joseph Simon and Sons bid $0.52790/lb for mixed aluminum solids "parts" requiring destruction (60,000lb) at Kent; and $0.58690/lb for 2000-series aluminum solids (210,000lb) at Kent; and $0.62290/lb for

6000-series aluminum solids (80,000lb) at Kent; as well as $0.60290/lb for 7000-series aluminum solids, (280,000lb) at Kent; Tacoma Metals bid $0.40920/lb for contaminated aluminum borings (25,000lb) at Kent. Other high bidders were: Allied Metal Co bid $0.54610 for briquetted aluminum borings (mix of 2000- and 7000-series alloys, 800,000lb) at Auburn; Wabash Alloys bid $0.53850/lb for briquetted aluminum borings (mix of 2000- and 7000-series alloys, 800,000lb) at Auburn, and Bermco bid $0.54130/lb and $0.55060/lb for briquetted aluminum borings (mix of 2000- and 7000-series alloys) in two 900,000lb lots at Puyallup.

Ural completes anode potline: Russia's Ural Aluminium Smelter, part of the SUAL Group, has completed its new pre-baked anode potline, following an investment of some $40-mil. The new potline is expected to boost average primary aluminum output by 35,000mt/year. "Completion of this new potline demonstrates SUAL's commitment to upgrading its production assets, and our ability to complete projects on time and within budget. The investment program at Ural Aluminium also further strengthens the industrial base of the Sverdlovsk Region," Chris Norval, president of SUAL Holding, said. The plant, situated near Kamensk-Uralsky, was originally opened in 1939 and has been extensively modernized and expanded since then. Its potline contains 162 'pots' or 'cells.' In addition, the potline is also fitted with a new gas scrubbing system, which uses alumina powder to de-fluorinate the gas formed in the production process, so that it conforms to international environmental standards. SUAL is Russia's largest bauxite and alumina producer and second-largest primary aluminum producer, producing in excess of 860,000mt/year of primary aluminum. SUAL has secured a $400-mil loan through a syndicate of international lenders which will be used to refinance existing debt.

Huomei to complete Mongolia line in '04: Huomei Hongjun Aluminium—a new Chinese aluminum/power joint venture formed among Inner Mongolia-based Huolinhe Coal Corp (41%), Hubei-based Hongjun Investment Co (51%) and Shandong-based Haichuan International Co (8%)—expects to complete a 100,000mt/year aluminum line in Inner Mongolia's Tongliao City by October 2004, a Huolinhe Coal official said last week. The new line, which is under construction, is part of the company's phase one plan for its 400,000mt/year aluminum project. "Phase one is to build a 200,000mt/year plant. The remaining 100,000mt/year will be finished by 2005," the official added. The entire 400,000mt/year project is expected to be ready around 2007-2008. With the initial 100,000mt/year line to start production by next October, the new venture expects output for 2004 to reach just around 10,000mt, "of which 50-70% will be exported," an official with Haichuan International said.

MINOR METALS

US DLA sells 110kg of germanium: The US Defense Logistics Agency sold 110kg of germanium from its November offering at $450-465/kg to Canberra Industries for a total market value of $50,250. DLA awarded 50kg at $465/kg and 60kg at $450/kg. Germanium is usually offered for sale on the fourth Monday of each month, but December's sale was canceled due to the holidays. The next germanium bid opening will be Jan 26.

Peru's cadmium production dips: Refined cadmium output at Doe Run's La Oroya and Cominco's Cajamarquilla refineries in Peru fell 11.8% in October 2003 to 37mt, according to figures from the Energy and Mines Industry. Cadmium production through the first 10 months of 2003 totaled 292mt, down 12.1% from 333mt in 2002.

Chinese antimony output to fall in 2004: China's antimony output in 2004 is expected to decline further to around 80,000mt, down from an estimated 90,000mt this year due to reduced antimony resources in the country, said Antaike, the state-run metals research group. "Judging from China's cumulative antimony output of 84,000mt from January to October this year, total output in 2003 should reach 90,000mt," an Antaike source said. Antaike said that due to the shutdown of mines in Guangxi's Nandan county, China's key antimony mining area, China's antimony-in-concentrate output was expected to dip to 40,000-45,000mt in 2003 from 50,000mt last year. "Due to reduced resources, China's antimony-in-concentrate output is expected to fall further to just 30,000-40,000mt in 2004," the source added. Based on antimony producer Liuzhou Huaxi's estimates, antimony reserves at Dachang's No 100 Mine in Nandan had dipped to 200,000mt in 2002 from 10.6-mil mt in 1995 due to illegal mining over the years.

Japan sees improving Sb trioxide demand: Japanese traders and end users expect demand for antimony trioxide to rise in 2004 on an improved Japanese economy. One end user said demand had started to slowly improve over the last few months, following a 3-5% decline this year up to July. "We are not seeing a flood of orders now, though I believe we can expect a gradual increase as the economy continues to show improvement," he said. Meanwhile, the reduction in the export tax rebate scheme in China from Jan 1, 2004, is expected to see producers of antimony metal raise prices, and the supply/demand balance may push the price of antimony trioxide higher in 2004, a trader said. Antimony was quoted last week at $2,100-2,200/mt CIF Japan, up from $2,100-2,150/mt CIF Japan in late October. Market sentiment is that antimony is near the bottom of the range and will not drift any lower, the trader said. Antimony is used in flame retardants.

COPPER

Price soars on Grasberg news

... from page 1

"Generally speaking, most of the market was short this [Dec 18] morning before that news came out, and [the news] took it right back up," he said.

Freeport said the effort to shore up the pit wall at Grasberg would disrupt sales of metal in 2004 and 2005. "In the near term, PT-FI will be mining waste and low-grade material in its Grasberg open pit. These operations will result in the deferral of certain metal sales from 2004 to 2005, the extent of which will be determined by the progress of the pit wall stabilization activities," the company said.

Freeport's CEO Richard Adkerson said the company would have a clearer idea early next year regarding how much copper it had available to sell. "Our ore sites included in our previous 2004 plan are immediately available for mining once safe access is assured," he said. "As we evaluate our stabilization activities during the first quarter of 2004, we will be able to provide additional information on estimated sales volumes for 2004 and future periods," he said.

After the previous incident, the US-based producer had revised its metals sales forecast for the fourth quarter of this year to around 165-mil lb, about 35-mil lb (16,000mt) below previous estimates.

Analysts said Asian copper refiners, some of whom have reduced production of copper cathode following the Oct 9 event, are likely to feel the effects of the supply disruption very quickly. In November, Japanese refiner Sumitomo cut back production by 3,000mt/month until the end of the first quarter of 2004. Pan Pacific and LG Nikko, which are also Japanese producers of refined copper, lowered production targets for the first half of 2004.

Barclays Capital analyst Ingrid Sternby noted comments from China's Yunnan Copper that it may bring forward planned output cuts to the first quarter from second quarter following the latest supply disruptions. Yunnan, which currently produces 180,000mt/year, told *Platts* just hours before Freeport declared *force majeure* that plans to increase cathode production were being hampered by tight concentrate supply. A company official said its own mines only provided one-third of its concentrate needs, and it was forced to buy the rest on the tight open market.

Sternby also noted plans by China's six largest copper smelters to reduce output by about 10-15% next year in response to the tightness in concentrate.

With treatment and refining charges at record lows around the $40/mt mark, smelters may prove unwilling to operate at full production, particularly as the latest incident at Grasberg will make it even more difficult for refiners to demand higher charges.

Supplies of copper scrap also have grown tight due to Asian demand, particularly from China. "They've been buying it way over the market price, and it's sucked the United States dry...that's putting a lot of pressure on the market," one merchant told *Platts*. The low amount of copper scrap being produced by manufacturers in the US was adding to the problem, another merchant said.

The latest Grasberg slippage comes on the heels of investor concerns about diminishing world stockpiles of copper. Inventories of copper in LME-registered warehouses fell to 447,175mt by the end of the week, down from 460,425mt the week before.

Despite the concerns about supply, US copper producer Phelps Dodge indicated it had no plans to increase curtailed production. "We would announce that if we were considering that kind of action," a company spokesman said. Phelps Dodge CEO J Steven Whisler in October said any decision to restart part or all of PD's 250,000-300,000mt/year of curtailed capacity would depend on several factors, including spot and future copper prices, total stocks, world supply and demand figures and other considerations. Since then, the spot copper price is up about 9¢/lb.

Asarco, a division of Grupo Mexico, did not return a call seeking comment on potential restarts.

But Chile's Codelco, the world's largest copper producer, said it might sell up to half its stockpile of 200,000mt of cathode if world inventories dropped below 800,000mt. Chile's mining minister Alfonso Dulanto said last week before the Grasberg news broke that he expected world exchange inventories to reach that level in about a month's time. State-owned Codelco produced around 1.59-mil mt in 2002 from its five operations in Chile.

Bloomsbury Minerals Economics, which published its monthly outlook ahead of the Freeport announcement, said world demand would exceed world refined copper production next year, with demand for refined copper projected to rise 6.8% to 16.894-mil mt, while production should increase 6.9% to 16.318-mil mt, compared with 2003. The UK-based research company noted that output in China was expected to grow by 13.6% to 1.92-mil mt next year, while consumption in China would increase a further 15% next year to 3.480-mil mt.

Cochilco, SONAMI raise copper price forecasts

Santiago—Chile's state copper agency, Cochilco, joined other local market watchers last week and bumped up its copper price outlook for 2004. Cochilco, which monitors the copper market on behalf of the Chilean government, now expects copper to average 92-96¢/lb, up from a previous forecast of 84-88¢/lb made in October.

The new forecast is the third in six months and came just days after Chile's national mining association SONAMI lifted its prediction to a similar 95¢/lb due to continued strong demand from major copper-consuming countries. SONAMI president Hernan Hochschild said prices would continue to hover around 94-95¢/lb in 2005 before returning to around 80¢/lb in 2006.

The higher prices would result if forecasted deficits in the world copper market—500,000mt in 2003 and 400,000mt in 2004—occur, he said. Balance is forecasted for 2005.

Cochilco said its new forecast was based on increased demand from copper-consuming countries, like the US and Japan, and an expected world market deficit. The global copper shortfall likely will total 70,000mt in 2004, down from 557,000mt in 2003. But rising demand would see the deficit jump to 209,000mt in 2005, Cochilco predicted.

Chilean copper production is expected to total 5.494-mil mt in 2004, up 10.8% on-year, followed by a slight increase in 2005 to 5.525-mil mt, the agency said. SONAMI's Hochschild said he expected Chile to produce 5.5-mil mt of copper in 2004, up 10% from 2003. The production increase reflects a rise in output at the Escondida mine and the expansion of Codelco's El Teniente division, he said.

Global copper production is expected to rise to 16.4-mil mt in 2004 and 17.5-mil mt in 2005, with consumption rising to 16.8-mil mt in 2004 and 17.5-mil mt in 2005, SONAMI said.

Elsewhere in copper...

Codelco may expand Andina: Codelco is analyzing alternative plans to expand its Andina copper mine in central Chile, which could result in a larger investment than originally planned, mining minister Alfonso Dulanto said Dec 16. Chile's national copper company had put on hold plans to expand processing capacity at Andina's concentrator plant to 150,000mt/day from 72,000mt/day. But now the state-owned miner is looking at plans which could lift capacity up to 180,000mt/day, said the minister. Another plan would limit capacity at around 120,000mt/year. But the mine's location, at the head of a steep valley high in the Andes mountains, complicates the planning process. "It's an extremely difficult problem how to carry out this expansion, where to locate the plants and the tailings pool," the minister said. Despite such problems, the expansion remains in Codelco's investment plans. Completion of the alternative studies have deferred a decision on the investment, originally scheduled for late 2003. "The issue's not on the agenda at coming board meetings," Dulanto said. Meanwhile, 665 miners at Andina returned to work Dec 15 after an 11-day strike. The miners approved a 2.57% wage increase plus improved bonuses and a payout for ending the strike. A spokesman for Codelco said the strike would have a negligible impact on Andina's annual production, while a contingency plan of bringing forward an annual maintenance cutback had prevented any financial losses. The Andina mine, one of five operated by state-owned Codelco, is due to produce about 240,000mt of copper-in-concentrate in 2004.

EC fines copper tube producers: The European Commission last week fined three of the main copper tube producers in Europe a total of Eur79-mil ($97.4-mil). The companies, Outokumpu, Wieland Werke and KM Europa Metal, "have operated a cartel in the market for tubes used mainly in the air-conditioning and refrigeration industry to the detriment of their customers and ultimately, European businesses and households," the EC said, adding that the companies operated the cartel between 1998 and 2001 in a market worth around Eur290-mil/year in the European Economic Area. The three companies accounted for 75-85% of the total output, the EC added. The Competition Commission, which investigates allegations of price fixing in the 15-nation EU, said the cartel was organized within the framework of Cuproclima Quality Assn for ACR Tubes, which had been formed in 1985 with the primary purpose of promoting a quality standard for ACR industrial tubes. "The companies held regular price-fixing and market-sharing talks under the cover of official trade meetings organized by the Swiss-based association," the EC said. The EC added that none of the companies seriously disputed the facts gathered during the investigation and all had cooperated. The German-owned KME Group was fined Eur39.81-mil; compatriot Wieland Werke was fined Eur20.79-mil, and Finland's Outokumpu will have to pay Eur18.13-mil. US-based Mueller Industries, which is another player in the European copper tube market through its ownership of a plant in the UK, wasn't named in the EC decision. In September the company said it had taken the lead in bringing price-fixing issues to the attention of the EC and had fully cooperated in the resulting investigation from the beginning.

Cathode premiums reflect market: Kennecott: The rise in premiums for copper cathode reflect current US market conditions, which are different from those in South America and Europe, a senior sales official with Kennecott Utah Copper Corp told *Platts* last week. "South America and Europe have bumped up premiums by almost 100 points. We don't think that exactly translates to the US market," Jim Cowley, Kennecott vice-president of sales, said. "Our view is that the 0.35¢ [increase] keeps us competitive with most of our destinations, which are primarily in the Midwest," he said. "Most consumers in the Northeast could get their supply from Canada or offshore sources. Our freight costs have gotten so high that it's hard to be competitive" in those areas, Cowley said. "The market in the Midwest is in need of all the copper we can produce." Kennecott last week raised its premiums for the first quarter of 2004 for 25 locations in the US. Premiums are 0.35¢/lb higher than fourth-quarter 2003 premiums, and range from 2.65¢/lb over COMEX for delivery to the COMEX warehouse at Salt Lake City, Utah, to 4.10¢/lb for delivery to Carrollton, Georgia.

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US Exports of Copper Scrap
(in short tons)

	Nov.	Oct.	Sept.	Year to date 2003	2002	Percent change
Belgium	1,264	711	375	7,710	8,833	−12.7
Canada	2,334	3,246	4,075	40,239	41,223	−2.4
China	56,295	52,824	43,195	471,872	272,026	+73.5
Germany	1,315	1,906	604	16,777	31,994	−47.6
Hong Kong	1,384	1,372	1,274	12,171	14,218	−14.4
India	4,223	4,408	3,979	52,717	48,875	+7.9
Japan	770	1,227	1,423	16,596	20,559	−19.3
Mexico	471	534	449	3,976	2,632	+51.1
S. Korea	2,103	2,834	3,507	40,862	33,238	+22.9
Taiwan	683	965	1,323	15,928	19,270	−17.3
Others	1,010	1,231	872	17,798	17,657	+0.8
Totals	71,852	71,258	61,076	696,646	510,525	+36.5

Source: Compiled by *AMM* from data released by the U.S. Commerce Department.

US red metal scrap exports set record

PHILADELPHIA — Just when you thought it couldn't go any higher, copper and brass scrap exports in November edged out the previous month's record-breaking total.

U.S. exporters shipped 71,852 short tons of copper and brass scrap overseas in November, according to the latest U.S. Commerce Department statistics, up almost 1 percent from 71,258 tons in October. November's shipments pushed the 11-month total to 696,646 tons, 36.5 percent ahead of 510,525 tons exported in the comparable 2002 period.

China (including Hong Kong) stood at the top of the heap at the end of November, taking nearly 70 percent of all copper and brass scrap shipped out of the United States in the first 11 months of last year. Busy Chinese buyers took more than 80 percent of November's shipments.

The Chinese gain more than offset a 17.3-percent fall in the tonnage of copper and brass scrap exported to Taiwan, a 19.3-percent decline to Japan and a 47.6-percent decrease in exports to Germany during the first 11 months of 2003.

"They (the Chinese) are buying metal just to own metal right now," a Midwest dealer said. "They're anticipating a real run-up in the price of scrap metal over the next few months."

Even though China's dominance of the market hasn't been a surprise for months now, November's data indicated a fundamental shift in Chinese consumption. November was only the second month in 2003 when China's non-brass import totals surpassed its purchases of refined copper scrap, China's preferred scrap material over the past two years.

The increase in non-brass consumption coincided with copper scrap's supply drought and illustrated China's eagerness to scour the globe for copper scrap stockpiles, sources said.

Despite the overall increase of copper scrap demand worldwide, the majority of countries listed on the Commerce Department's monthly report showed significant decreases in overall copper scrap consumption in 2003.

Joseph McCann
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A strike here, a landslide there . . . behind the pinch in copper

NEW YORK — The past several months have been rocky for the red metal market. A series of blows to supply, coupled with persistent demand from China and a rebound in U.S. economic growth, have created a backdrop against which prices have soared to record highs.

With global demand expected to increase as the economic recovery takes hold, and with a new supply crisis seemingly hitting the market each week, copper could become even tighter in the months ahead.

"If consumers decide to restock before the market becomes chronically tight, the resulting boost to demand could result in a significantly greater effective deficit," Macquarie Research, a division of Macquarie Group, London, said in a report.

The International Copper Study Group (ICSG), Lisbon, Portugal, agreed with that assessment. "Because of the restocking effect on demand—stocks are low—everyone's going to scramble to refill his pipeline and that will happen in the calendar year," said ICSG statistician Thomas Baack.

The recent supply-side setbacks have served to exacerbate tightness in a market that already was headed toward a second consecutive year of heavy deficit. In October, before the second landslide at New Orleans-based Freeport-McMoRan Copper & Gold Inc.'s Grasberg Mine in Indonesia forced the world's biggest copper mine to turn away from its most fruitful vein, Natexis Metals Ltd., London, predicted deficits in 2004 and 2005. And in November, the ICSG forecast a supply-demand deficit of 390,000 tonnes for 2004 following a 350,000-tonne deficit in 2003.

Since then, the news of supply-side problems has flooded in, ranging from Freeport's subsequent *force majeure* at the Grasberg Mine to several strikes or threatened strikes, to mechanical failures and technical problems. Even when some positive supply news—such as Phelps Dodge Corp., Phoenix, restarting idled capacity (*AMM*, Jan. 30)—does arrive, it is rarely of sufficient magnitude to compensate for the other problems.

Plus and Minus: A Rough Accounting
(in tonnes)

Producer	Output adjustment
Freeport-McMoRan Copper & Gold	
Grasberg, Indonesia	-220,000
OK Tedi Mining	
Papua, New Guinea	-15,000
BHP Billiton	
Escondida, Chile	-75,000
Phelps Dodge	
Various restarts	98,000
Total	**-212,000**

Source: Macquarie Bank, London

Refined Copper Supply-Demand Balance
(Estimates in thousands of tonnes)

	Production	Consumption	Difference
1998	13,865	13,409	456
1999	14,332	14,168	164
2000	14,650	15,079	-429
2001	15,438	14,512	926
2002	15,190	15,037	153
2003	15,168	15,448	-280
2004	15,700	16,300	-600
2005	16,700	16,850	-150

Source: CRU International, London

"Every couple of days we seem to be getting news of some sort of disruption," one trader lamented.

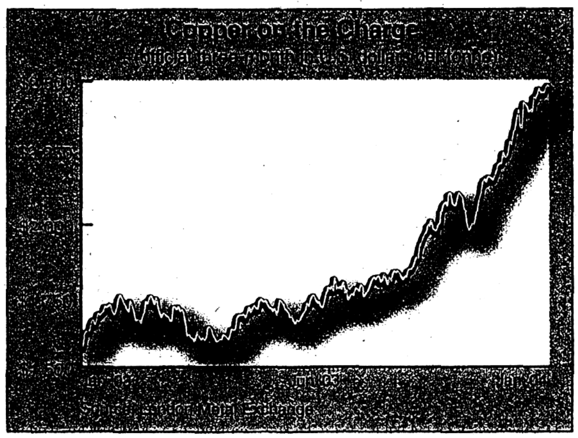
Despite the supply problems, however, research group Brook Hunt of Surrey, England, predicted that global copper production would actually increase by 5.5 percent this year to 16.2 million tonnes. But demand, boosted by the global economic recovery, is expected to grow by 6.4 percent, according to Brook Hunt's estimates.

As a result, most analysts are forecasting a 2004 deficit of up to 500,000 tonnes. The impact of this shortfall—hot on the heels of last year's deficit—has been to deplete global stocks, including those held by the major exchanges, producers, consumers and merchants. Brook Hunt's figures put current global stocks at around 2.8 million tonnes, or 8.8 weeks' consumption.

While the rise in demand and constrictions on supply have hit the refined copper market hard, an even greater impact has been seen in the copper concentrates market as many of the supply disruptions have been to mines rather than to smelters or refineries.

"The cathode shortage is being met from stocks, but the shortage of concentrate is not," Kamal Naqvi, an analyst at Barclays Capital, London, said.

Treatment charges have plummeted, with 2004 contracts between major miners and Japanese smelters settled in the region of $42 a tonne for treatment charges and 4.2 cents a pound for refining charges. Japanese smelters, in particular, have been feeling the pain, according to sources.



In addition, the major customers of the Grasberg Mine are faced with a chronic shortage. As far back as November, Sumitomo Metal Mining Co. Ltd., Nippon Mining & Metals Co. Ltd. and Mitsui Mining & Smelting Co. Ltd., all based in Tokyo, warned of cuts in their copper output through March following disruptions to concentrate shipments from Grasberg.

The impact of the tightness in both the concentrates and refined metal markets has been reflected in soaring copper prices on the London Metal Exchange and the Comex division of the New York Mercantile Exchange. Last week, copper futures on the LME were up 47 percent from a year earlier. One trader suggested that LME prices could go as high as $3,000. Macquarie Research suggested 2004 prices would average $2,645 a tonne ($1.20 a pound) and peak at more than $3,086 a tonne ($1.40 a pound). Another analyst said the price would continue to rise over the next three years.

As prices rise and the market continues to tighten, industry participants watch warily for news of the next new development. Here is a scorecard to help keep track of the ongoing drama:

Freefall at Freeport — The revised mining sequence at Freeport-McMoRan's Grasberg Mine in Indonesia put the biggest dent in projected copper supplies. The initial landslide at Grasberg, which killed eight workers, prompted Freeport to reduce projected 2003 totals to 1.3 billion pounds from 1.4 billion pounds. In an effort to avoid having to declare *force majeure*, the company reworked its delivery schedule only to endure another landslide in December. The second incident forced Grasberg's hand, and Freeport declared *force majeure* on its copper concentrates delivery contracts and redirected its mining activity to low-grade ore and waste. Freeport announced Jan. 20 a revised 2004 projection of 1 billion pounds of copper—453,592 tonnes—or 400 million pounds less than originally planned. The market is now watching developments closely at Grasberg as any further downward revision in projected output could have a serious impact on an already tight market.

Things not OK at Ok Tedi — Mechanical failure at one of Ok Tedi Mining Ltd.'s grinding mills prompted a 15,000- to 17,000-tonne reduction in its concentrates output (*AMM*, Jan. 29). The Papua New Guinea mine, part owned by Inmet Mining Corp., Toronto, originally was slated to produce 200,000 tonnes of copper contained in concentrate. A 7- to 8-percent reduction in output from Ok Tedi normally wouldn't be a big issue for the market, but given the already super-tight supply conditions, the news from Papua New Guinea served as yet another potential headache for concentrate-hungry smelters in Asia.

Catching-up at Escondida — On Jan. 28, having just touted the completion of Phase 4 of an expansion project at the Escondida copper mine in Chile, BHP Billiton ran short of necessary water recovery rates and was forced to amend its originally scheduled date for reaching full capacity production of 1.3 million tonnes, up from 800,000 tonnes. Reports from BHP Billiton indicate that the mine will operate at 5 to 10 percent below full capacity for at least a full quarter. The massive Chilean mine is already months behind on deliveries, having operated at reduced capacity until late last year.

Restarts at Phelps Dodge — As January wound down, the market awaited news of restarts from Phelps Dodge, which idled a significant amount of capacity during the bear market of 2001. Most analysts said the market already had taken the liberty of factoring in that idled capacity, but when the long-awaited announcement arrived Jan. 29 many were disappointed with the scale of the restart. Having already activated production at its Sierrita and Bagdad mines in Arizona and factoring in successful restarts in Chile and Mexico, Phelps Dodge plans to add 108,000 tonnes to its 2004 output and a further 168,000 tonnes in 2005. Thus, the largest U.S. copper producer raised its projected totals to 2.35 billion pounds in 2004 and 2.5 billion pounds in 2005. Many market observers had hoped that Phelps would go a step further and restart all its idled capacity. However, the company said it had no plans to restart its remaining 300 million pounds (136,078 tonnes) of capacity.

Meanwhile . . . Against the backdrop of tension spurred by the severity of Grasberg's production delays, insatiable demand from China and other events impacting the supply-demand balance, other news that normally might have a negligible impact resonated throughout the copper market:

• For several months the market watched closely the events at the Highland Valley Copper mine in Logan Lake, British Columbia. The labor contract there had expired in September and Highland Valley and United Steelworkers union Local 7619 were deadlocked over a new agreement for several months. In mid-November, union members voted in favor of a strike mandate, which they enacted in early January only to accept an 11th-hour offer from the company (*AMM*, 30).

• If the market had a lucky escape at Highland Valley, it was less fortunate at Falconbridge Ltd.'s Sudbury mine. The Ontario operation of Toronto-based Falconbridge, which usually is discussed in terms of its nickel output, voted in favor of a strike mandate Jan. 8. Negotiations continued for just short of a month before 1,080 Canadian Auto Workers union members went on strike Feb. 1 (*AMM*, Feb. 3). Estimates put the loss of Sudbury's copper contributions to the market at approximately 2,400 tonnes a month.

• Around the same time as the strike at Sudbury, workers at the BHP Billiton-owned Cerro Colorado Mine in northern Chile rejected the company's 3.7-percent (and later 3.9-percent) pay increase and benefits package and walked out. The mine originally was expected to contribute about 130,000 tonnes of copper per year to the market, and while BHP Billiton hasn't revealed at what level it's able to operate, union officials claimed that Cerro Colorado had been operating at 25 percent of capacity.

• Besides restarts, existing stockpiles offer potential relief for the tight supply market. When combined inventories on the LME, Comex and Shanghai Futures Exchange fell below 800,000 tonnes, Corporacion Nacional del Cobre de Chile, Santiago, Chile—the world's largest copper producer—decided the time was ripe to release some of its stockpile into the market. It is understood the Chilean company has contracted to sell half of its stockpiled metal to European merchants at extremely healthy premiums. Meanwhile, LME warehouse inventories continue to fall, with metal leaving U.S. warehouses, in particular, at an accelerated rate.

Pacorini Copper Supply Dwindles as Codelco Sells More to China

2004-02-25 12:07 (New York)

By Claudia Carpenter

Feb. 25 (Bloomberg) -- The 5,500-pound bundles of copper plates in Mario Casiano's three New Orleans warehouses will be gone by the end of this week, and the 38-year-old metals manager for Pacorini USA said remaining inventories at other storage depots in the city will disappear by August.

Surging demand for wire, pipes and electronic parts already has emptied copper warehouses in Singapore, Barcelona and Hamburg. New Orleans is home to the largest copper pile monitored by the London Metal Exchange, which says global inventories fell 65 percent in the past year to the lowest since 1998.

``The whole world knows exactly how hot the market is," said Casiano, who came to New Orleans from Switzerland in 2000 to expand a $200 million-a-year warehousing and distribution business owned by Trieste, Italy-based Pacorini Group. ``Consumption is much higher than production."

Copper prices are at an eight-year high, fueled by demand from China, where manufacturers are expanding plants to make home appliances, televisions and cars. China's appetite for raw materials, as its economy expands, is draining inventories elsewhere in the world.

Chile's Codelco, the world's largest copper producer, hasn't shipped any copper to New Orleans in almost a year, instead sending more metal to Asia, Casiano said. Pacorini's warehouses on the Mississippi River held about 90,000 metric tons of copper in January 2002. Now they have 5,000.

Global inventories of refined copper, including metal held by consumers and at exchanges, totaled 1.779 million metric tons at the end of November, worth about $5.11 billion, figures from the Lisbon-based International Copper Study Group show. That's down 16 percent from a year earlier.

Surging Prices

Dwindling supplies have sent copper futures on the Comex division of the New York Mercantile Exchange up 72 percent in the past year, reaching a high of $1.36 a pound today. In London, home of the world's largest metal exchange, copper fetched as much as $2,980 a ton ($1.352 a pound).

Shares of Phoenix-based Phelps Dodge Corp., the world's second-largest copper producer, and New Orleans-based Freeport McMoRan Copper & Gold Inc., have more than doubled in the past year.

China has accounted for much of the increase in demand.

Copper consumption in the country will jump as much as 12 percent this year after a 20 percent gain in 2003, said Andrew Keen,
manager of base metals at CRU International, a private research company in London.

China last year consumed a fifth of the copper produced in the world as its economy surged. The nation's industrial production rose 19 percent in January from a year earlier, the fastest pace on record. Disposable incomes in China's towns and cities last year topped $1,000 per person for the first time.

Housing Growth

Also helping to fuel demand are the lowest U.S. interest rates in 45 years, which have kept new-home construction at a near-record pace. A typical single-family home contains 400
pounds of copper, while a car has about 50 pounds, said the Copper Development Association, a New York industry group.

``Inventories are dropping now at really a rapid pace,'' said Thomas Baack, a 20-year veteran of the copper business who is the chief statistician at the International Copper Study Group in Lisbon. ``The problem is if suddenly prices go up and people realize they might go up for a while, they might all scramble to cover their needs and suddenly all the available metal is gone.''
Inventories in warehouses that back the copper contracts traded on the London Metal Exchange, the world's biggest metals exchange, stood at 291,800 tons today, down 65 percent in the past year and the lowest since August 1998.

`Going to Zero'

``I could see all of the stockpiles in the LME going to zero by the end of this year,'' said Peter Sellars, the 52-year-old chief executive of Liverpool, England-based Henry Bath & Son
Ltd., the metals warehouse division of San Diego-based Sempra Energy.

``So far the real demand has been taken to the Far East, particularly China,'' Sellars said in a telephone interview. ``As the U.S. economy continues to pick up, then I think the supply
will get even tighter.''

Stockpiles in warehouses in Long Beach, California, have dropped 56 percent this year alone. Inventories have declined in warehouses along the West Coast, including Los Angeles, which
supplies copper to Asia.

``All the metal in the Long Beach warehouse has gone to China,'' said Tim Strelitz, chief executive of Los Angeles-based California Metal-X Inc., which produces about 3 million pounds of copper-based ingots a month used in the manufacturer of faucets and valves.

``We've had to change the way we do our business, so we can be ahead of the rising market and historically, that's something nobody ever did," Strelitz said.

Seek New Supply

California Metal-X has had to seek new supplies because some scrap dealers the company used to buy from are selling scrap at a premium of 7 cents a pound over the price of copper on the Comex in New York, he said. ``I can't do that. It's too expensive."

Some manufacturers are stocking up on copper in anticipation that supply won't be enough to meet growing demand.

``I bought some material for April delivery which I normally wouldn't do until March," said Janet Sander, vice president of purchasing at Encore Wire Corp., a copper wire manufacturer in McKinney, Texas.

This year, Encore's cost for delivery of copper sheets, called cathode, has gone up 25 percent this year on top of an almost 30 percent rise in the price of the metal. Encore buys direct from mining companies, including Phelps Dodge, Rio Tinto Plc's Kennecott Utah Copper and BHP Billiton Ltd., rather than from exchange-monitored warehouses.

Changed Process

Deerfield, Illinois-based American Chemet Corp., which makes copper products used in paints and coatings, has changed the kind of metal it uses because of the higher prices.

``The tightness it the U.S. market, which has been caused by offshore buying, has required us to make modifications in our raw material input mix and to make some changes in our facilities as to the way we process them," Chemet President William Shropshire said in an interview.
``It's been a considerable inconvenience for us, but we have been able to meet demand from our customers," Shropshire said.

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February 26, 2004
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Copper speculators flirting with $3,000/T

NEW YORK — Copper continued to tease the $3,000-a-tonne mark Wednesday as spot prices on the London Metal Exchange hit $3,001 during early trading driven mostly by speculative buying and some short covering, analysts said.

"There's no consumer buying, really," said Tony Warwick-Ching, an analyst at CRU International Ltd., London. "The price shouldn't be here, really, but it is."

Three-month copper continued to lag, with Wednesday's official settlement at $2,965 a tonne. In New York, the Comex March contract closed at $1.3085 a pound.

"There's no consumer buying, really. The price shouldn't be here, really, but it is."
— *Tony Warwick-Ching, CRU International*

Copper prices have followed a dramatic pattern this week, sticking close to currency markets, according to sources. "You could track the whole day today on strength or weakness of the dollar," one trader said.

Dollar weakness has been held partly responsible for increases in all base metal prices. Earlier this week, the dollar fell on news of lower-than-expected consumer confidence index numbers, but climbed Wednesday on reports that German Chancellor Gerhard Schroeder had asked the European Central Bank to stem the strength of the euro.

"A serious correction could come from the dollar," Warwick-Ching said.

Other factors affecting copper prices include tightening supply, most vividly illustrated by the steady decline of LME warehouse stocks, as well as speculative trading. And among the speculators, talk of a correction persists (*AMM*, Feb. 19).

"Experience might suggest that it's overbought, but the price is where it is," Warwick-Ching said. "I sort of agree that it's overbought, but nevertheless the price is still there. Mostly it's because of the fundamentals, which are getting tighter."

LME warehouse stocks fell another 2,925 tonnes Tuesday, leaving open tonnage in the United States at 171,025 tonnes, most of it in New Orleans. Stocks have been falling an average of 3,000 tonnes a day recently, reflecting the severity of the shortage, sources said. Combined with persistent demand from China, there was little to indicate a near-term change in fundamentals.

"Domestic demand is really strong," the trader said.

Copper also approached the $3,000 mark last week before fund profit-taking forced it down.

Julie Bresnick *jbresnick@amm.com*

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March 1, 2004
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Scrap

Hot copper market growing still hotter

By Joseph McCain

PHILADELPHIA — Copper scrap pricing is setting records and experts throughout the industry say the secondary market is still heating up rather than cooling down as the winter season ends.

A weak U.S. dollar and domestic supply shortages have fueled rising scrap prices recently, but several sources believe overseas demand will drive the current feeding frenzy for material well into the summer.

"The terminal markets are still drawing down and primary copper cathode production is still way behind," said Mark Weintraub, purchasing director at Federal Metal Co., a Bedford, Ohio,-based brass ingot maker. "So this could go on for quite awhile."

With tensions mounting in the copper scrap industry and competition for domestic supplies escalating, prices have soared to record levels throughout the winter, a time of year usually noted for inactivity and seasonal shutdowns.

Copper scrap prices were mired in a narrow range a year ago. *AMM* pricing during February 2003 saw Bare Bright copper scrap bought and sold at between 73.5 and 76.5 cents a pound; one year later, the Bare Bright buying price was quoted at $1.32 a pound as of Thursday, a six-year high.

"We've seen copper scrap at $1.50 before, but you could very well see these prices next year," a Chicago-based buyer said. "All of the evidence points to a sustained run up. Unless the Chinese stop buying material, these prices aren't going away anytime soon."

Copper scrap spreads have remained virtually unchanged since February last year, with one notable exception: During the past month, dealers and brokers reported that Bare Bright was being sold for 1 cent more than the March Comex price.

"There are two types of supply right now: tight and tighter. And the competition for material has forced guys to pay premiums," a Midwest scrap broker said. "These guys have to get scrap into their furnaces right away so they can get their products out to market."

Even though orders for No. 2 refiners material have slipped in recent weeks, domination from Chinese buyers throughout the Midwest for mixed loads has sustained pricing for lower grades of copper scrap.

"The Chinese would buy copper scrap right now regardless of the price," Weintraub said. "They're not buying like they did last October, but they're still not generating enough scrap right now to drive their own machine."

> The terminal markets are still drawing down and primary copper cathode production is still way behind.
> — Mark Weintraub, Federal Metal Co.

The weak U.S. dollar also has attracted new buyers to the market since the beginning of the year, and brokers reported renewed interest from European buyers recently.

"Europe has really stepped up in the last month and we're finding more and more metal headed to Europe," Weintraub said. "It's really making it hard on the brass business."

One scrap dealer noted that warmer weather on the U.S. East Coast should draw out more scrap material in the coming weeks. But several other industry sources said that, aside from new demolition work, the material just wasn't there.

The New York Times
Saturday, March 13, 2004
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Lee Celano for The New York Times

American scrap dealers, like Ekco Metals in California, are sharing in boom times. The industry has about 1,200 small operations.

China's Need for Metal Keeps U.S. Scrap Dealers Scrounging

By ANDREW POLLACK and KEITH BRADSHER

LOS ANGELES, March 12 — At a time when toys, televisions and other products made in China are flooding into the United States, helping push the trade deficit to record levels, there is at least one American product for which China has a nearly insatiable demand — industrial junk.

Sales of scrap metal to China have surged, with effects that are ricocheting across the American economy. Prices are soaring not just for scrap, but for metals in general. After years of surpluses that forced many steel makers into bankruptcy, supplies are so tight that contractors told a Congressional hearing in Washington this week that they sometimes cannot obtain supplies at any price.

China last year became the first country ever to import more than $1 billion of American scrap, according to the newspaper American Metal Market. Indeed, it would not be an exaggeration to say that China's transformation into an industrial powerhouse is being fueled by America's waste, and that of other countries, as well. Much of the material being used to build China's skyscrapers, factories and telecommunications systems — along with many of the products it exports — is derived from scrap, which is usually cheaper than new metal made from ore.

"China is very hungry," said David Pan, a Chinese-born scrap metal buyer, as a truck carrying steel reinforcing bars from a dismantled

Continued on Page B3

China Keeps U.S. Scrap Dealers Busy

Continued From Page A1

building in San Diego prepared to dump its cargo with a deafening clatter on the floor of his warehouse in Maywood, an industrial town just south of here. "They need a lot of material."

A decade ago, Mr. Pan was working in a Los Angeles restaurant when relatives back in China asked him to start buying scrap. Now, as China booms, so does Mr. Pan's business, called Universal Scrap Metals. He ships about 500 containers a month to China filled with battered pipes, fine metal shavings, doorknobs, jumbles of wire, crumpled cars and all other manner of flotsam. He is even negotiating to buy the remains of a steel factory in Utah; he would ship it, as scrap, to his native country.

American scrap dealers, an industry of 1,200 or so mainly mom-and-pop operations, are sharing in the boom times.

"They're scrounging every yard in the country, like a vacuum cleaner," Ely Keenberg, president of Ekco Metals, a Los Angeles scrap dealer, said of purchasers from China. At one point during an interview, Mr. Keenberg's receptionist interrupted to show him the business card of a man from Hong Kong who had just made a cold call looking for scrap. "If we allowed it, we'd have one in here every five minutes," said Mr. Keenberg, who sells 90 percent of his scrap to Chinese buyers.

American companies that depend on scrap are, in the meantime, scrounging.

"We're having greater and greater difficulty in securing scrap," said M. Brian O'Shaughnessy, chief executive and principal owner of Revere Copper Products in Rome, N.Y., a company founded by Paul Revere that turns copper scrap into sheets and strips. "It's causing the price of scrap to go through the ceiling."

Both copper and steel industry trade groups are drawing up petitions that would ask the government to temporarily limit scrap exports — an authority that Washington has used only once, in the mid-1970s.

The price of scrap steel has soared to more than $300 a ton, compared with about $156 a ton at the end of 2003 and $77 at the beginning of 2001, according to the Emergency Steel Scrap Coalition, a group backed by steel users and minimills, which use scrap to make about half of the nation's steel. Many minimills have imposed surcharges to pass the higher costs onto customers like automobile and construction companies, with some of them resisting.

"Scrap is the overwhelming factor determining steel prices at this point," said Christopher Plummer, managing director of Metal Strategies, a consulting firm in West Chester, Pa.

Rising exports are clearly one factor behind the high prices, but the extent to which they can be blamed is debated. Over all, exports of steel scrap have almost doubled since 2000 to 11.9 million tons last year, close to a record. China was the largest importer, accounting for 3.5 million tons, or about 30 percent, of the exports.

Domestic users, saying exports drive up metals prices, weigh a plea to Washington.

But scrap dealers argue that exports are still small compared with domestic consumption of about 70 million tons a year, and so could not account for the huge price increases. Moreover, they note, there have been several occasions in the last two decades when total scrap exports reached or even exceeded last year's levels.

"What is happening now is not unique," said Robin Wiener, president of the Institute of Scrap Recycling Industries, the dealers' trade group. Attempts to restrict scrap exports, she said, are "just clearly a smoke screen attempt to control the price of scrap" and would be a "distortion of free trade."

Some experts add that in any event, China's building boom has the look of a bubble and cannot last indefinitely. Indeed, China's State Development and Reform Commission just announced that after fixed investment in steel mills rose 90 percent last year, it would stop approving virtually all applications to build mills. Still, with many mills approaching completion, one Chinese trade group forecasts that imports of scrap will nearly double by 2005 over last year's levels.

David L. Edelstein, copper commodities specialist at the United States Geological Survey, noted that while copper prices — about $1.30 a pound — are high, they have been as high before. One reason for price increases, he said, was that some copper producers were holding back output, after an oversupply a couple of years ago.

But copper scrap exports to China, including Hong Kong, have quintupled since 1998, and China now accounts for 70 percent of the total. China's purchases of American copper scrap last year were equal to about 40 percent of American consumption.

Scrap dealers argue that in some cases, the scrap going to China would be of no use to Americans because it would cost too much to sort into its various parts. But with China's cheap labor, that effort is affordable.

"We send everything to China," said Danny C. Yiu, vice president of Ekco Metals, the company owned by Mr. Keenberg. "They will use chisels, hammers, hand tools to break this apart and sort it out."

He pointed around Ekco's yards at various heaps of old automobile radiators, pots and pans, air-conditioner condensers, even parts of jet engines. There were also old soda cans squashed into giant cubes weighing 1,000 pounds each, stacked six or seven high.

At a loading dock, small Bobcat construction vehicles were loading two of the 25 or so 20-ton shipping containers that leave here each day for the ports of Los Angeles and Long Beach. After a Bobcat shoved a load deep into the container, the driver backed up, then accelerated forward, crashing into the pile with a loud bang to compress it.

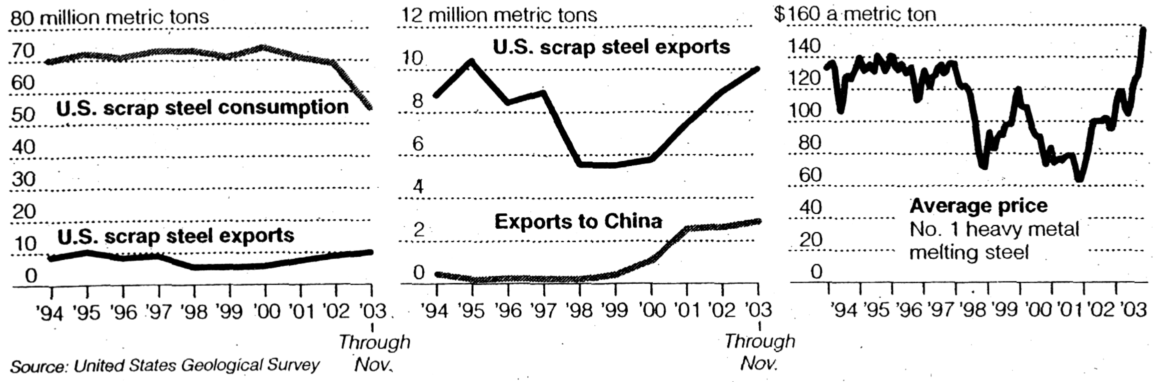
The scrap world has its own vernacular to facilitate trading. Copper wire is known as "barley," yellow brass is "honey" and No. 1 copper tubing is "candy." And there is a food chain, where one company's scrap turns into another company's raw material.

The people above Ekco Metals in the food chain say they are not getting enough to eat. A few miles from

Andrew Pollack reported from Los Angeles for this article and Keith Bradsher from Hong Kong.

More Demand, Not Enough Supply

Exports of scrap steel are a fraction of overall domestic consumption, but they have been rising steadily, with China accounting for most of the new foreign demand. The higher demand, and lower domestic supply, have pushed prices to their highest level in a decade.



Source: United States Geological Survey

The New York Times

Ekco is California Metal-X, which buys copper scrap and melts it in huge furnaces to make bronze and brass ingots. It then sells those ingots to foundries that make everything from bronze statues to brass valves.

"Last year was a year from hell," said Tim Strelitz, who founded and runs the company with his wife, Karen. The company last year cut its work force from 70 to 38 people, the first layoffs since its founding in 1979.

One problem, Mr. Strelitz said, was that it was difficult to compete with Chinese buyers, who have grown in sophistication since the days when Mr. Pan and others first came shopping. "They are not owners of restaurants trying to buy for a cousin anymore," he said. "They are buying for a dollar what I can only offer 80 cents for."

Yet another reason for Mr. Strelitz's problems is that his customers are ailing — and in some cases going out of business — in part because they face stiff competition from Chinese manufacturers of valves, faucets and other brass products.

"I've lost millions of dollars per year to China already," said Leigh Omer, foundry manager at Fresno Valves and Castings in Selma, Calif., a customer of Mr. Strelitz.

To Mr. Strelitz, Mr. Omer and others dependent on copper scrap, this seems like the ultimate indignity — that Chinese companies drive up scrap prices, yet are able to sell products made from that scrap for less than American manufacturers can. Indeed, American copper companies contend that China is subsidizing importers of copper scrap and exporters of finished products, in part through tax rebates.

Yang Xi/Imaginechina

Workers use reprocessed steel at a construction site in Nanjing, China. Much of the material used in building China's skyscrapers and factories is derived from scrap, which is usually cheaper than new metal.

Joe Mayer, president and general counsel of the Copper and Brass Fabricators Council, said the group might file a trade complaint about this. "The faucets from China are coming into the United States at less than the metal value that we would have to pay," Mr. Mayer said.

Meng Jianbin, director of international cooperation at the Metallurgical Council of China for the Promotion of International Trade, a Chinese trade group, denied that his government subsidizes the scrap industry. While some incentives are provided for scrapyards to set up operations in particular industrial zones, they are not especially generous, he said.

Mr. Pan, the Chinese scrap merchant, said that Americans should be a little more appreciative of the benefits of China's scrap purchases. After all, he argued, they keep some junk that could never be used in the United States from ending up in American landfills.

"We do something good for America," he said. "We do something good for China."

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The ACC's Copper College 2004

Why copper prices promise to stay at the head of the class

By Julie Bresnick

NEW YORK — The hottest topic at the American Copper Council's biennial Copper College event in Tucson, Ariz., was, well, golf—but then came supply shortages, China, metal premiums and market prices.

Michael Cook, London-based chief economist for Finland's Outokumpu Oyj, summed it all up in his senior seminar Friday, cutting through the fog and frenzy to size up the current situation in the copper market and make a few projections for the future.

According to Cook's assessment, the majority of market conditions favor continued high prices. Tightness in copper supplies, fostered by improving demand and a lack of new production, at least until 2005, led Cook to make an early March prediction for London Metal Exchange cash prices to range between $1.20 and $1.50 a pound in 2004 and $1 to $1.25 a pound in 2005.

One factor lending weight to Cook's bullish assessment is that, in historical terms, current copper prices aren't all that exceptional. Cook said that in the context of its pattern since 1988, the current copper price of around $1.30 wasn't particularly high—in December 1988, for example, the LME cash price averaged $1.59 a pound, and then spent most of the subsequent decade over $1; the 1995 average was $1.33.

What Cook found most noteworthy about the price was not its level, but the speed at which it climbed.

The original cause of the rise was fund interest. Besides the fact that the amount of money under fund management surged in 2003, funds recognized commodities as more inviting during recession circumstances, and metals in general as a way to "play the China card," Cook said. They saw low prices and—with metals already forecast to fall into deficit—increasingly strong fundamentals.

The fund activity lit a fuse. In the wake of "blast-off" fundamentals prompted by unexpected disruptions in supply, physical tightness became the driving force behind the strong prices.

Mine output took about a 300,000-tonne hit last year due to disruptions at Cia. Minera Antamina in northern Peru; two mines run by Corporacion Nacional del Cobre de Chile, Andina and El Teniente, both in central Chile; Freeport-McMoRan Copper & Gold Inc.'s Grasberg Mine in Indonesia; and Minera Escondida Ltda., Santiago, Chile. Along with a massive pick-up in copper scrap demand from China, the concentrates shortage became the headliner.

Cook said he expected refined copper production to increase by 3 to 4 percent in 2004 and even more in 2005.

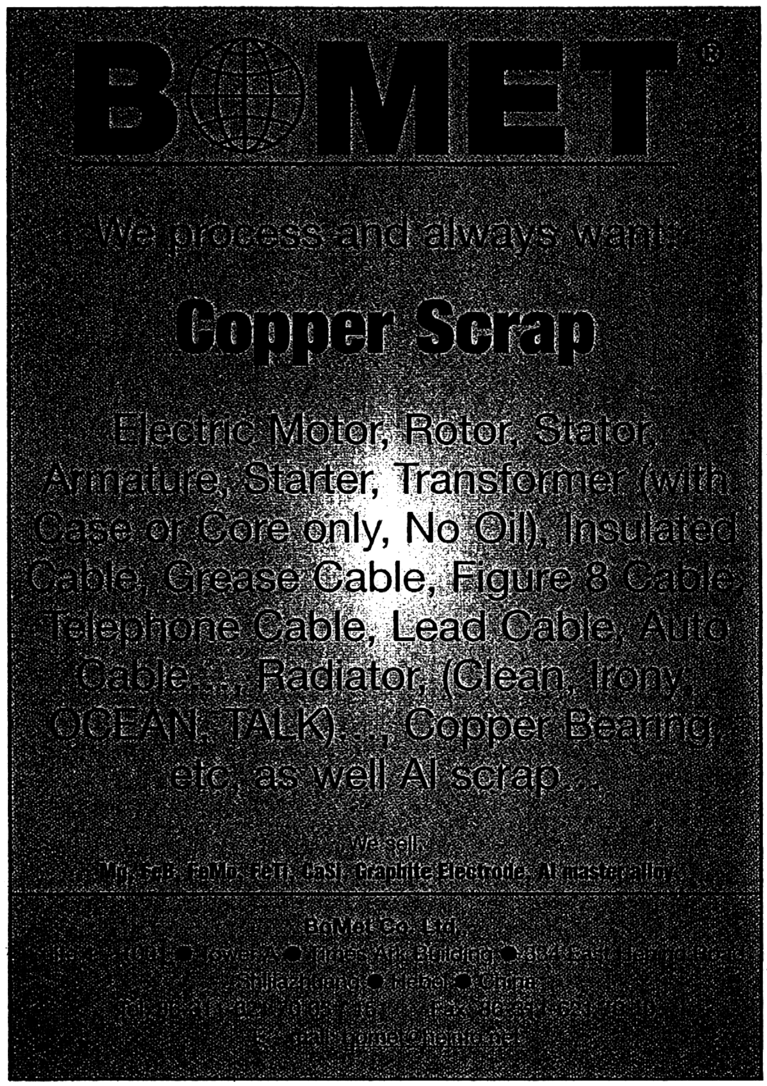
COPPER FUNDAMENTALS 101: Outokumpu Oyj economist Michael Cook sees continued high prices in the copper market until at least 2005 due to tight supplies, improving demand and a lack of new production.

But for now, with tonnage flying out of warehouses and the stock-to-consumption ratio at a mere six-and-a-half weeks, there was cause for concern, according to Cook. "Could demand growth be constrained by metal availability?" he asked.

The next three or four months could be the tightest because, against a backdrop of various production problems, all economic factors point to a continued increase in demand. U.S. industrial production was expected to continue to grow, and the same applied to most Asian countries, led by China, which Cook noted was responsible for 80 percent of the 2.7-percent increase in global copper consumption in 2003. And China, he added, was set for a construction and auto explosion—both copper-hungry industries.

Potential credit restraints in China could abate demand somewhat, as could continually disappointing consumer confidence data, which Cook said he believed was another liability to a bull market. But the impact of restocking could counter those bearish forces, and despite a potential slowing Cook said he ultimately felt that Asian demand would continue to be a force to contend with.

What it all boils down to, Cook said, are high prices and high volatility.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Chinese ready stricter rules on imports of scrap metals

SINGAPORE — China is imposing stricter regulations on imports of scrap metals in an effort to clamp down on contaminated material entering the country.

The new measures, which were introduced in December and will take effect July 1, will require all Chinese companies importing scrap metals to register with the Chinese government's State Administration of Quality Supervision, Inspection and Quarantine.

"The time lag for the formal imposition of the law will give the Chinese companies ample time to register with the government," said an official of the Metallurgical Council of China for the Promotion of International Trade, which recently organized a scrap metals conference in China.

"Through these new measures, the Chinese government hopes to have a better control over the scrap metal industry," the official said. The majority of scrap processors in China still used old-fashioned methods of scrapping metal that were causing massive environmental problems, he added. "Also, the government can minimize the probability of any introduction of radioactive materials in scrap metal as well as track down the origin of the scrap metal should high levels of radioactive material be found in the shipment."

The agency official said the registration system would not disrupt the flow of scrap imports into China or create a potential shortage of raw materials. "The move is targeted to reduce environmental pollution and force Chinese companies to clean up their act at their scrap recycling plants," he said.

One Hong Kong source said that the new rules were unlikely to have a big impact on the market as the Chinese government already was cracking down on local scrap processors that had been causing environmental damage. Most of the nonferrous scrap metal imports entering China are offloaded at the Guangzhou city port or at the port in Ningbo in Zhejiang province.

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MB's 17th International Copper Conference

Bulls and bears butt heads over China and copper's future

PARIS — Copper testing $3,000 a tonne, a cash-to-three-month backwardation of $70 a tonne and London Metal Exchange stocks falling to multiyear lows of 247,825 tonnes provided much stimulus for discussion at *Metal Bulletin*'s 17th International Copper Conference in Paris.

By [illegible]

Delegates expressed opposing bullish and bearish views on copper's immediate and future price prospects.

Some analysts, like Simon Hunt, director of Simon Hunt Strategic Services (U.K.) Ltd., expect a price correction shortly and cast serious doubt on the sustainability of copper's recent bull run, which has taken the LME price from $1,703 a tonne on March 18 last year to around $2,978 a tonne currently.

"The bull run in copper has nearly ended. Prices will peak in the next two months, followed by a sharp fall in the summer and lower prices this autumn, and prices continuing in a falling pattern until the first half of 2007," he said.

Hunt believes the twin drivers of global economic growth—the United States and China—are starting to appear fragile and that copper demand is beginning to slow and weaken. Larger macroeconomic funds had already begun to liquidate their positions in copper that they started building in early 2003, he said.

"We anticipate a major currency crisis midyear. A debt-ridden country (the U.S.) with few savings is not a sustainable growth forum. In my view, the U.S. will start a recession that will last until 2007," Hunt added.

China, meanwhile, wants to slow its economic growth and move its focus from manufacturing to services and the rural economy. This will lead to surplus copper inventory in China, some of which is already customs cleared, being sold back to the market, which would have a downward effect on prices.

Oscar L. Groeneveld, chief executive officer of Rio Tinto's copper division, said that new production capacity coming onstream and the expansion of brownfield facilities would boost copper supplies, causing prices to cool. "I don't see prices continuing upwards beyond this year," he said. "As miners, we have to respond to the supply and demand situation."

Mining companies must respond to the growing consumption of copper and meet the "clear need for additional resources in the market place," Groeneveld said. "With the size of the copper consumption and the influence of China, which has taken us all by surprise, the mining industry must be flexible enough to respond."

Other commentators said they expected copper to reach new highs as the market's tightness continues and demand is underpinned by continuing economic growth in China and the United States.

One British trader said he feared copper stocks would run dry by May as Chinese demand showed no sign of slowing. "The market has to wake up to the fact that stocks are running down to dangerously low levels, and at the current rate of demand LME warehouses will be completely bare in the next two months," he said.

With new production and expansion plans slow to come online, demand would continue to outstrip supply, he added.

The danger of dwindling stock levels was underlined following a decision by the LME in November to issue a regulation and compliance note to all members stating that the large-position reporting level for copper would be reduced to one lot as of Dec. 1 last year. "There are no long positions but there are a number of short-term warrant holders, none of which are above 30 percent of market stocks," an LME spokesman said.

A number of delegates said they believed China's hunger for copper would continue next year as the country continues to plow cash into upgrading its infrastructure.

A trader from Japan said copper stocks also were starting to come under demand pressure from emerging markets like India.

Patrick Hurens, secretary general of the Lisbon, Portugal,-based International Copper Study Group, echoed that view and said he believed India had the capacity for an additional 1 million tonnes of copper consumption as the economy was set to become the fastest growing in the world by 2020.

"The figure for the potential additional usage of copper could surpass this number if you consider the economic growth predicted in India," Hurens said. "India has been a sleeping giant for a while, but it is awakening and the question now is how fast will it stand up?"

Hunt said that China's copper fabricating industry was set to have an increasing impact on the global market through a combination of rising domestic production and exports, but this trend was likely to slow in future years as it moves production offshore.

"The next phase of China's growth in copper consumption will be driven by fabricators improving their quality and increasing their capacity to reduce the need for imported semi-(fabricated) products," Hunt said. "Thus, the relocation of capacity from West to East will slow but the speed of import substitution will increase."

China's imports of refined copper and copper alloy semi-fabricated products totaled 725,000 tonnes in 2003 vs. 93,000 tonnes in 1990, while China's exports of semi-fabricated copper products increased to 155,000 tonnes in 2003 from 10,000 tonnes in 1990.

Hunt calculated that if this rate of growth in semi-fabricated product exports were to continue at around 20 percent per year, China's exports of the products would reach 550,000 tonnes by 2010.

"China is rapidly building a complete chain of suppliers (for copper fabrication) in most sectors," Hunt said. He cited as an example China's domestic air-conditioning sector, where production is forecast to rise to 70 million units in 2010 from 29 million units last year. On the demand side, China's domestic need for air conditioners is expected to grow to 49 million units in 2010 from 20 million units in 2003.

"Unless current plans are changed, by 2010 China will be satisfying one-half of the rest of the world's demand (for air-conditioning units)," Hunt said.

China's surplus air-conditioning industry capacity and export activity had had "severe repercussions" for the global industry, depressing prices for tube by 55 percent to $1,080 a tonne c.i.f. since 1999.

Hunt said he detected a growing trend for multinational companies, including some Chinese, to move away from globalization to regionalized production that served local markets, encouraged by rising freight and insurance costs allied with the increasing threat of terrorism.

"Their (Chinese companies') strategy is to introduce innovative products for the niche consumer in the West and then to expand into larger markets," Hunt said. "The move is driven partly by the tougher competitive environment in their own market and the higher margins seen in the West."

However, Hunt said that by investing in manufacturing capacity offshore, China itself would be reducing the market for some of its exports and providing a market for local suppliers.

The Wall Street Journal
March 25, 2004
Page A15

China's Huge Hunger for Scrap

Metal Prices Surge as Nation Extends Lead as Biggest Importer

By Adam Minter

Tianjin, China

AT A SCRAPYARD just outside the northeast port of Tianjin, piles of U.S. scrap wire and electrical cable sprawl over most of the 80,000-square-yard site. Scattered among them, hundreds of workers strip insulation from copper wire by hand, steadily reducing the piles but never eliminating them.

In 2001, the yard's owners, Lane Tone Peace Material, imported 1,500 shipping containers of American scrap metal. In 2003, they imported 2,500. In 2004, they are bringing in even more—largely to provide raw materials for Tianjin's thriving electronics industry. "There isn't enough domestic ore and scrap to fulfill the need," says Lane Tone's president, Lester Huang. "So imports fill the gap."

Scrap is hotter than ever in China. World metal prices have set records the past two years as the country sucks in huge amounts of ore and scrap for processing to build its infrastructure, factories, apartment blocks and cars, as well as for other industrial uses. In less than a decade, China has become the world's largest scrap-metal importer. And still demand grows in a shining, if often ugly, example of how China roils global markets and how its plentiful and low-cost labor remains vital to its success.

Li Shouyin is one of hundreds of thousands of migrants working in China's scrap industry. She takes apart appliances, generators, wires and cables and sorts the metal. A mother of two from Hunan province, she and her husband—a supervisor of a wire-stripping crew—have worked for nearly a decade at a Shenzhen yard operated by Tung Tai International, a California-based scrap exporter. Each is paid $100 a month plus housing and meals, a fairly standard wage. "It's hard work, but it's a better life than the village," Ms. Li says in front of a manager.

In 2001, China overtook South Korea and Turkey to become the world's largest scrap-steel importer. It has held the top position since and has even extended its lead. So the U.S., as the world's largest scrap producer, is a natural partner for China, the largest importer of U.S. scrap in almost every category.

In 2003, China took more U.S. scrap than ever—for instance, nearly 2.8 million tons of U.S. ferrous scrap including steel but excluding stainless and alloy scrap, according to the U.S. International Trade Commission. That amounted to 30% of total U.S. ferrous-scrap exports. China took even larger proportions of other classes last year—79% of U.S. copper exports, 72% of U.S. zinc-scrap exports and 49% of U.S. aluminium exports.

But China's scrap hunt extends near as well as far. In Hong Kong, gangs are stealing metal manhole covers to send as scrap to the mainland. In South Korea, officials warned this month that the high price of raw materials caused by China's demand could knock the fragile economy off track, so limits were clamped on exports of steel scrap and bars beginning March 8. Seoul said the move was temporary, though China's appetite for many metals is long-term.

The China Iron and Steel Association, representing most Chinese steel producers, forecasts a scrap-steel shortfall of 15 million to 20 million tons in 2005, compared with domestic steel production of 250 million tons. The Beijing Nonferrous Metal and Regenerated Metal Research Institute foresees Chinese production from scrap copper doubling in the next three years.

"In the U.S. right now, the Chinese buyers are literally stuffing containers with as much scrap steel as they can find," says Joseph Chen, president of Tung Tai. "Price doesn't matter because the price just keeps moving up." Prices are usually discounted, depending on purity, from benchmark prices on the London Metal Exchange. But as supplies have run short with demand from China and other markets buoyed by the world economic recovery, discounts have narrowed until some top-grade scrap sells at the equivalent of the LME price.

And as the cost of scrap rises, so do metal prices. In January, the LME recorded 15-year highs for nickel, used to make stainless steel. Benchmark three-month copper hit an 8½-year high March 2. In the past year, the price of scrap steel has risen to $300 to $350 per ton from $100 to $150 per ton. Also, as internationally traded metals are usually priced in U.S. dollars, the dollar's weakening against most currencies has added to the rise in metals prices.

Imports to China of low-grade scrap material, such as wire and electric motors, are growing proportionally as fast as steel, with an added competitive spur that ensures China's dominance. "We can process [low-grade scrap] more cheaply than the Americans," says Mr. Huang of Lane Tone.

The result is that, for some smaller U.S. scrap processors, competing with China is a grim prospect. The Washington-based Institute of Scrap Recycling Industries Inc. says the number of member scrap dealers in the U.S. has dropped more than 30%, to 1,204 in 2002 from 1,768 in 1991. But some larger U.S. scrap companies actually are benefiting from higher prices and greater demand in China. With operations in 13 states, Chicago-based Metal Management Inc. is one of the largest recyclers of U.S. metal and is experiencing record stock prices and record shipments in recent months.

"The material has all gone to China," says Larry Snyder, Metal Management's executive vice president for metal trading in Chicago. While U.S. wire-chopping plants send plastic to landfills after separating it from the wire, the "Chinese can sort it out by hand and then recycle it," he says.

Metal Management exports 500 containers of scrap monthly—most to China. "Three years ago that all stayed in the U.S.," Mr. Snyder says. "And that's why there isn't a single copper refinery left in the United States."

Small manufacturers and trade associations in the U.S. that are affected by rising scrap prices have organized into a group called the Emergency Steel Scrap Coalition. They are lobbying Congress for relief on rising scrap prices and are preparing a petition to the Commerce Department that would seek a limit on exports of domestic scrap steel. The group's Washington attorney, Alan Price, says it will decide in coming weeks whether to file the petition for export restrictions.

Yesterday, Commerce Secretary Don Evans told the House Energy and Commerce Committee that the "spike in scrap steel prices around the world" was having an impact on all sizes of U.S. manufacturers and the U.S. needs to take a "hard look" at what it can do to address the sharp runup in scrap prices.

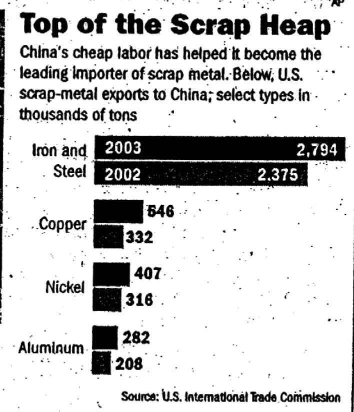
The U.S. exported about 12 million tons of scrap steel last year, a 21% increase from the 9.9 million tons exported in 2002. Scrap buyers say demand also is tightening the supply of domestic scrap, driving up domestic prices of finished steel. The Steel Manufacturers Association, which consists of about half the domestic U.S. steelmakers, is supporting the coalition.

By contrast, the mood was mostly upbeat at the China International Metal Recycling Forum in the southern city of Guangzhou in November. Presentations focused on how China's scrap-metal trade supplies China's steel and nonferrous-metal producers. But government officials expressed concern about China's decreasing ability to meet its own needs. From 1993 to 2002, self-sufficiency in copper and aluminium fell to 35% and 62% from 47% and 72%, respectively. With fast-rising scrap prices, this is a real cause for concern, so both Beijing and trade groups are trying to promote domestic recycling programs. But most analysts don't foresee any decline in scrap imports before 2010.

—Paul Glader in Pittsburgh contributed to this article.

AP

Women disassemble *junk computer boards in Guiyu (top); a worker at the Lane Tone scrap yard outside Tianjin (above)*



AMM.com - Scrap News - March 26, 2004

Copper exports blamed for rod output decline

By Philip Burgert

SAN ANTONIO, Texas, March 26 -- U.S. exports of copper scrap have led to as much as 200 million pounds per year of brass rod production being diverted from the U.S. market in the past three years to goods made elsewhere and then imported to the United States.

George M. Dykhuizen, president of Extruded Metals Inc., Belding, Mich., cited the diversions in a review of statistics that showed the North American brass rod market of 793 million pounds in 2003 was only slightly more than half of the 1.3 billion to 1.4 billion pounds of what he described as "modern, efficient," in-place production capacity.

The diversions resulted in supplies by U.S. mills falling from 1 billion pounds in 2000 despite rising demand for fabricated copper products in construction and consumer durable goods, the rod industry executive said in a presentation at the Copper & Brass Servicenter Association's annual meeting last week.

"Housing starts and consumer purchases remained strong, but domestic U.S. brass rod shipments dropped sharply," Dykhuizen said. "It cannot be that the plumbing fixtures, refrigerators, washers, dryers, etc. that are being installed in the new homes are suddenly no longer using brass parts. What happened is that the end-products parts are increasingly not being made in the U.S."

Dykhuizen blamed this trend mainly on the rising export of copper scrap, which made rod-based products manufactured in Asia more competitive when entering the United States.

U.S. exports of copper-based scrap rose to 1.1 billion pounds in 2002 and 1.5 billion pounds in 2003 from 866 million pounds in 1999, with China's share reaching 79 percent of last year's exports, or 1.2 billion pounds, compared with 10 percent of the total in 1999, Dykhuizen said.

About 80 percent of total rod prices was the cost of metal, most of it copper scrap, he said. "In past recessions, the scrap supply was generally strong and increasingly available. These purchases and exports accomplish two objectives: they provide raw material to China that China does not have, and at the same time the resulting scrap shortage drastically drives up the cost of goods made in the U.S."

EXHIBIT 1

Exhibit 1

COPPER & BRASS FABRICATORS COUNCIL
MEMBER COMPANIES

Ansonia Copper & Brass, Inc.

Brush Engineered Materials, Inc.

Cambridge-Lee Industries, Inc.

Cerro Flow Products, Inc.

Cerro Metal Products Co.

Chase Brass & Copper Company, Inc.

Chicago Extruded Metals Company

Drawn Metal Tube Company

Extruded Metals

Heyco Metals, Inc.

Hussey Copper Ltd.

KobeWieland Copper Products, LLC

metalsAmerica

The Miller Company

Mueller Industries, Inc.

Olin Corporation-Brass Group

Outokumpu American Brass

PMX Industries, Inc.

Revere Copper Products, Inc.

Wieland Metals, Inc.

NON-FERROUS FOUNDERS' SOCIETY

A & B Foundry, Inc.
A. Y. McDonald Mfg. Co.
Acme Brass & Aluminum Foundry
Active Brass Foundry
Advance Bronze, Inc.
Albco Foundry & Machine, Inc.
Algonac Cast Products
All Star Enterprises, Inc.
Alu-Bra Foundry, Inc.
Aluminum Foundry & Pattern Works Ltd.
American Bronze Corp.
Atlas Founders, Inc.
Aurora Metal Division L.L.C.
Avalon Precision Casting Company
Bergen Point Brass Foundry, Inc.
Berntsen Brass & Aluminum, Inc.
Bridesburg Foundry
Bronze Craft Corporation
Brost Foundry Company
Buck Company, Inc.
California Casting Inc.
California Metal-X
Cast Technologies, Inc.
Century Brass Works, Inc.
Chester Foundry Company
Colonial Metals
Concast Metal Products
Denton Castings Company, Inc.
Excal, Inc.
Federal Bronze Casting Industries, Inc.
Florida Aluminum Casting Co., Inc.
Flury Foundry Company
Fox Hills Industries, Inc.
Franklin Bronze & Alloy
Franklin Non-Ferrous Foundry
Gemini Incorporated
G-M Brass & Aluminum Foundries, Inc.
H. Kramer & Company
Hamilton Brass & Aluminum Castings Co.
Hebert Manufacturing Company
Hiler Industries
H-J Enterprises, Inc.
I. Schumann & Company

Illini Foundry Co.
Ingot Metal Company, Ltd.
J. Kuhl Metals Co. Inc.
Jef-Scot Metal Industries, Inc.
K P Bronze Company Ltd.
Keystone Foundry Div.
Lasalle Foundry & Machine Company
Magnolia Metal Corporation
Magnus, LLC
Martin Brass Foundry
Martin Foundry Co. Inc.
Matthews International
McHenry Brass Foundry
Meloon Foundries, Inc.
Meskan Foundry
Metal Dynamics Corporation
Midland Manufacturing Company
Milwaukee Valve Co. Inc.
Morrison Brothers Company
Mueller Company
Multi-Cast Corporation
National Metals, Inc.
Neptune Technology Group Inc.
New England Union Co., Inc.
New Jersey Shell Casting
Nibco Inc.
Non-Ferrous Cast Alloys, Inc.
Non-Ferrous Casting Co.
Oakes Foundry, Inc.
Perko, Inc.
Piad Precision Casting Corporation
R & D Pattern and Foundry Co., Inc.
River Recycling Industries Inc.
Rockford Foundries, Inc.
Rolls-Royce Naval Marine, Inc.
Ryder-Heil Bronze, Inc.
Sandwich Casting & Machine
Sipi Metals Corp.
Sloan Valve Company
Southern Centrifugal
Superior Brass & Aluminum Casting Co.
Techni-Cast Corporation
The G. A. Avril Company
Tri-State Cast Technologies
U.S. Bronze Foundry & Machine
Waukesha Kramer Inc.

West Phila. Bronze & Aluminum Corp.
Wisconsin Centrifugal/Metaltek Intl
Wolverine Bronze Co.
Yankee Casting Co.

EXHIBIT 2

Exhibit 2

7 COPPER

Edited by Derek E. Tyler, Olin Corp.

Review Committee: Eugene Shapiro, Olin Corp.; Ned W. Polan, Olin Corp.; Raymond Cribb, Brush Wellman Inc.; J. C. Harkness, Brush Wellman Inc.; William Black, Copper Development Association Inc.

This section was condensed from Metals Handbook, Ninth Edition, Volume 2, Properties and Selection: Nonferrous Alloys and Pure Metals, pages 237 to 490. Additional articles on copper and copper alloys can be found in the following sections: 23, Casting; 24, Forging; 26, Forming; 27, Machining; 28, Heat Treating; 29, Surface Technology; 30, Joining; and 35, Metallography.

Copper and Copper Alloys

COPPER and its alloys constitute one of the major groups of commercial metals. They are widely used because of their excellent electrical and thermal conductivities, outstanding resistance to corrosion, and ease of fabrication, together with good strength and fatigue resistance. They are generally nonmagnetic. They can be readily soldered and brazed, and many coppers and copper alloys can be welded by various gas, arc and resistance methods. For decorative parts, standard alloys having specific colors are readily available. Copper alloys can be polished and buffed to almost any desired texture and luster. They can be plated, coated with organic substances or chemically colored to further extend the variety of available finishes.

Pure copper is used extensively for cables and wires, electrical contacts, and a wide variety of other parts that are required to pass electrical current. Coppers and certain brasses, bronzes and cupronickels are used extensively for automobile radiators, heat exchangers, home heating systems, panels for absorbing solar energy, and various other applications requiring rapid conduction of heat across or along a metal section. Because of their outstanding ability to resist corrosion, coppers, brasses, some bronzes, and cupronickels are used for pipes, valves and fittings in systems carrying potable water, process water or other aqueous fluids.

In all classes of copper alloys, certain alloy compositions for wrought products have counterparts among the cast alloys, which enables the designer to make an initial alloy selection before deciding on the manufacturing process. Most wrought alloys are available in various cold worked conditions, which have room-temperature strengths and fatigue resistances that depend on the amount of cold work as well as the alloy content. Typical applications of cold worked conditions (cold worked tempers) include springs, fasteners, hardware, small gears, cams, electrical contacts, and components.

Certain types of parts—most notably plumbing fittings and valves—are produced by hot forging simply because no other fabrication process can produce the required shapes and properties as economically.

Copper alloys containing 1 to 6% Pb are free-machining grades, and are used widely for machined parts—especially those produced in screw machines.

Although fewer alloys are produced now than in the 1930's, new alloys continue to be developed and introduced, in particular to meet the challenging requirements of the electronics industry.

Properties and applications of wrought copper alloys are presented in Tables A and A-1. Similar data for cast copper alloys are given in Table B.

PROPERTIES OF IMPORTANCE

Good resistance to corrosion, good electrical conductivity, good thermal conductivity, color and ease of fabrication coupled with strength, resistance to fatigue and ability to take a good finish are criteria by which copper or one of its alloys is selected.

Corrosion Resistance. Copper is a noble metal but, unlike gold and other precious metals, can be attacked by common reagents and environments.

Pure copper resists attack quite well under most corrosive conditions. Some copper alloys, however, sometimes have limited usefulness in certain environments because of hydrogen embrittlement or stress-corrosion cracking.

Hydrogen embrittlement is observed when tough pitch coppers, which are alloys containing cuprous oxide, are exposed to a reducing atmosphere. Most of the copper alloys are deoxidized, and thus are not subject to hydrogen embrittlement.

Stress-corrosion cracking (season cracking) most commonly occurs in brass that is exposed to ammonia or amines. Brasses containing more than 15% zinc are the most susceptible. Copper and most copper alloys that either do not contain zinc or are low in zinc content are generally not susceptible to stress-corrosion cracking. Because stress-corrosion cracking requires both tensile stress and a specific chemical species to be present at the same time, removal of either the stress or the chemical species can prevent cracking. Annealing or stress relieving after forming alleviates stress-corrosion cracking by relieving residual stresses. Stress relieving is effective only if the parts are not subsequently bent or strained in service; such operations reintroduce stresses and resensitize the parts to stress-corrosion cracking.

Electrical and Thermal Conductivity. Copper and its alloys are relatively good conductors of electricity and heat. In fact, copper is used for these purposes more often than any other metal. Alloying invariably decreases electrical conductivity and, to a lesser extent, thermal conductivity. The amount of reduction due to alloying does not depend on the conductivity or any other bulk property of the alloying element, but only on the effect that the particular solute atoms have on the copper lattice. For this reason, coppers and high-copper alloys are preferred over copper alloys containing more than a few percent total alloy content when high electrical or thermal conductivity is required for the application.

Color. Copper and certain copper alloys are used for decorative purposes alone, or when a particular color and finish is combined with a desirable mechanical or physical property of the alloy. Table 1 lists the range of colors that can be obtained with standard copper alloys.

Ease of Fabrication. Copper and its alloys are generally capable of being shaped to the required form and dimensions by any of the common fabricating processes. They are routinely rolled, stamped, drawn and headed cold; they are rolled, extruded, forged and formed at elevated temperature; there are casting alloys for all of the generic families of coppers and copper alloys.

Copper metals can be polished, textured, plated or coated to provide a wide variety of functional or decorative surfaces.

(Text is continued on page 7•14.)

Table A. Properties of wrought coppers and copper alloys

Alloy number (and name)	Nominal composition, %	Commercial forms(a)	Mechanical properties(b): Tensile strength, MPa	Tensile strength, ksi	Yield strength, MPa	Yield strength, ksi	Elongation in 2 in., %	Corrosion resistance (c)	Machinability rating (d)
C10100 (oxygen-free electronic)	99.99 Cu	F, R, W, T, P, S	221-455	32-66	69-365	10-53	55-4	G-E	20
C10200 (oxygen-free copper)	99.95 Cu	F, R, W, T, P, S	221-455	32-66	69-365	10-53	55-4	G-E	20
C10300 (oxygen-free, extra-low phosphorus)	99.95 Cu, 0.003 P	F, R, T, P, S	221-379	32-55	69-345	10-50	50-6	G-E	20
C10400, C10500, C10700 (oxygen-free, silver-bearing)	99.95 Cu(e)	F, R, W, S	221-455	32-66	69-365	10-53	55-4	G-E	20
C10800 (oxygen-free, low-phosphorus)	99.95 Cu, 0.009 P	F, R, T, P	221-379	32-55	69-345	10-50	50-4	G-E	20
C11000 (electrolytic tough pitch copper)	99.90 Cu, 0.04 O	F, R, W, T, P, S	221-455	32-66	69-365	10-53	55-4	G-E	20
C11100 (electrolytic tough pitch, anneal resistant)	99.90 Cu, 0.04 O, 0.01 Cd	W	455	66	...	...	1.5 in 60 in.	G-E	20
C11300, C11400, C11500, C11600 (silver-bearing tough pitch copper)	99.90 Cu, 0.04 O, Ag(f)	F, R, W, T, S	221-455	32-66	69-365	10-53	55-4	G-E	20
C12000, C12100	99.9 Cu(g)	F, T, P	221-393	32-57	69-365	10-53	55-4	G-E	20
C12200 (phosphorus-deoxidized copper, high residual phosphorus)	99.90 Cu, 0.02 P	F, R, T, P	221-379	32-55	69-345	10-50	45-8	G-E	20
C12500, C12700, C12800, C12900, C13000 (fire-refined tough pitch with silver)	99.88 Cu(h)	F, R, W, S	221-462	32-67	69-365	10-53	55-4	G-E	20
C14200 (phosphorus-deoxidized, arsenical)	99.68 Cu, 0.3 As, 0.02 P	F, R, T	221-379	32-55	69-345	10-50	45-8	G-E	20
C19200	98.97 Cu, 1.0 Fe, 0.03 P	F, T	255-531	37-77	76-510	11-74	40-2	G-E	20
C14300	99.9 Cu, 0.1 Cd	F	221-400	32-58	76-386	11-56	42-1	G-E	20
C14310	99.8 Cu, 0.2 Cd	F	221-400	32-58	76-386	11-56	42-1	G-E	20
C14500 (phosphorus-deoxidized, tellurium-bearing)	99.5 Cu, 0.50 Te, 0.008 P	F, R, W, T	221-386	32-56	69-352	10-51	50-3	G-E	85
C14700 (sulfur-bearing)	99.6 Cu, 0.40 S	R, W	221-393	32-57	69-379	10-55	52-8	G-E	85
C15000 (zirconium copper)	99.8 Cu, 0.15 Zr	R, W	200-524	29-76	41-496	6-72	54-1.5	G-E	20
C15500	99.75 Cu, 0.06 P, 0.11 Mg, Ag(i)	F	276-552	40-80	124-496	18-72	40-3	G-E	20
C15710	99.8 Cu, 0.2 Al_2O_3	R, W	324-724	47-105	268-689	39-100	20-10	...	...
C15720	99.6 Cu, 0.4 Al_2O_3	F, R	462-614	67-89	365-586	53-85	20-3.5	...	...
C15735	99.3 Cu, 0.7 Al_2O_3	R	483-586	70-85	414-565	60-82	16-10	...	...
C15760	98.9 Cu, 1.1 Al_2O_3	F, R	483-648	70-94	386-552	56-80	20-8	...	...
C16200 (cadmium copper)	99.0 Cu, 1.0 Cd	F, R, W	241-689	35-100	48-476	7-69	57-1	G-E	20
C16500	98.6 Cu, 0.8 Cd, 0.6 Sn	F, R, W	276-655	40-95	97-490	14-71	53-1.5	G-E	20
C17000 (beryllium copper)	99.5 Cu, 1.7 Be, 0.20 Co	F, R	483-1310	70-190	221-1172	32-170	45-3	G-E	20
C17200 (beryllium copper)	99.5 Cu, 1.9 Be, 0.20 Co	F, R, W, T, P, S	469-1462	68-212	172-1344	25-195	48-1	G-E	20
C17300 (beryllium copper)	99.5 Cu, 1.9 Be, 0.40 Pb	R	469-1479	68-200	172-1255	25-182	48-3	G-E	50
C17500 (copper-cobalt-beryllium alloy)	99.5 Cu, 2.5 Co, 0.6 Be	F, R	310-793	45-115	172-758	25-110	28-5	G-E	...
C18200, C18400, C18500 (chromium copper)	99.5 Cu(j)	F, W, R, S, T	234-593	34-86	97-531	14-77	40-5	G-E	20
C18700 (leaded copper)	99.0 Cu, 1.0 Pb	R	221-379	32-55	69-345	10-50	45-8	G-E	85
C18900	98.75 Cu, 0.75 Sn, 0.3 Si, 0.20 Mn	R, W	262-655	38-95	62-359	9-52	48-14	G-E	20
C19000 (copper-nickel-phosphorus alloy)	98.7 Cu, 1.1 Ni, 0.25 P	F, R, W	262-793	38-115	138-552	20-80	50-2	G-E	30
C19100 (copper-nickel-phosphorus-tellurium alloy)	98.15 Cu, 1.1 Ni, 0.50 Te, 0.25 P	R, F	248-717	36-104	69-634	10-92	27-6	G-E	75
C19400	97.5 Cu, 2.4 Fe, 0.13 Zn, 0.03 P	F	310-524	45-76	165-503	24-73	32-2	G-E	20
C19500	97.0 Cu, 1.5 Fe, 0.6 Sn, 0.10 P, 0.80 Co	F	552-669	80-97	448-655	65-95	15-2	G-E	20
C21000 (gilding, 95%)	95.0 Cu, 5.0 Zn	F, W	234-441	34-64	69-400	10-58	45-4	G-E	20
C22000 (commercial bronze, 90%)	90.0 Cu, 10.0 Zn	F, R, W, T	255-496	37-72	69-427	10-62	50-3	G-E	20

(continued)

(a) F, flat products; R, rod; W, wire; T, tube; P, pipe; S, shapes. (b) Softest to hardest commercial forms. The strength of the standard copper alloys depends on the temper (annealed grain size or degree of cold work) and the section thickness of the mill product. Ranges cover standard tempers for each alloy. (c) E, excellent; G, good; F, fair. (d) Based on 100% for C36000. (e) C10400, 8 oz/ton Ag; C10500, 10 oz/ton; C10700, 25 oz/ton. (f) C11300, 8 oz/ton Ag; C11400, 10 oz/ton; C11500, 16 oz/ton; C11600, 25 oz/ton. (g) C12000, 0.008 P; C12100, 0.008 P and 4 oz/ton Ag. (h) C12700, 8 oz/ton Ag; C12800, 10 oz/ton; C12900, 16 oz/ton; C13000, 25 oz/ton. (i) 8.30 oz/ton Ag. (j) C18200, 0.9 Cr; C18400, 0.8 Cr; C18500, 0.7 Cr. (k) Rod, 61.0 Cu min. Compiled by Copper Development Assn. Inc., New York.

Table A. (continued)

Alloy number (and name)	Nominal composition, %	Commercial forms(a)	Mechanical properties(b) Tensile strength MPa	Tensile strength ksi	Yield strength MPa	Yield strength ksi	Elongation in 2 in., %	Corrosion resistance (c)	Machinability rating (d)
C22600 (jewelry bronze, 87.5%)	87.5 Cu, 12.5 Zn	F, W	269-669	39-97	76-427	11-62	46-3	G-E	30
C23000 (red brass, 85%)	85.0 Cu, 15.0 Zn	F, W, T, P	269-724	39-105	69-434	10-63	55-3	G-E	30
C24000 (low brass, 80%)	80.0 Cu, 20.0 Zn	F, W	290-862	42-125	83-448	12-65	55-3	F-E	30
C26000 (cartridge brass, 70%)	70.0 Cu, 30.0 Zn	F, R, W, T	303-896	44-130	76-448	11-65	66-3	F-E	30
C26800, C27000 (yellow brass)	65.0 Cu, 35.0 Zn	F, R, W	317-883	46-128	97-427	14-62	65-3	F-E	30
C28000 (Muntz metal)	60.0 Cu, 40.0 Zn	F, R, T	372-510	54-74	145-379	21-55	52-10	F-E	40
C31400 (leaded commercial bronze)	89.0 Cu, 1.75 Pb, 9.25 Zn	F, R	255-414	37-60	83-379	12-55	45-10	G-E	80
C31600 (leaded commercial bronze, nickel-bearing)	89.0 Cu, 1.9 Pb, 1.0 Ni, 8.1 Zn	F, R	255-462	37-67	83-407	12-59	45-12	G-E	80
C33000 (low-leaded brass tube)	66.0 Cu, 0.5 Pb, 33.5 Zn	T	324-517	47-75	103-414	15-60	60-7	F-E	60
C33200 (high-leaded brass tube)	66.0 Cu, 1.6 Pb, 32.4 Zn	T	359-517	52-75	138-414	20-60	50-7	F-E	80
C33500 (low-leaded brass)	65.0 Cu, 0.5 Pb, 34.5 Zn	F	317-510	46-74	97-414	14-60	65-8	F-E	60
C34000 (medium-leaded brass)	65.0 Cu, 1.0 Pb, 34.0 Zn	F, R, W, S	324-607	47-88	103-414	15-60	60-7	F-E	70
C34200 (high-leaded brass)	64.5 Cu, 2.0 Pb, 33.5 Zn	F, R	338-586	49-85	117-427	17-62	52-5	F-E	90
C34900	62.2 Cu, 0.35 Pb, 37.45 Zn	R, W	365-469	53-68	110-379	16-55	72-18	F-E	50
C35000 (medium-leaded brass)	62.5 Cu, 1.1 Pb, 36.4 Zn	F, R	310-655	45-95	90-483	13-70	66-1	F-E	70
C35300 (high-leaded brass)	62.0 Cu, 1.8 Pb, 36.2 Zn	F, R	338-586	49-85	117-427	17-62	52-5	F-E	90
C35600 (extra-high-leaded brass)	63.0 Cu, 2.5 Pb, 34.5 Zn	F	338-510	49-74	117-414	17-60	50-7	F-E	100
C36000 (free-cutting brass)	61.5 Cu, 3.0 Pb, 35.5 Zn	F, R, S	338-469	49-68	124-310	18-45	53-18	F-E	100
C36500 to C36800 (leaded Muntz metal)	60.0 Cu(k), 0.6 Pb, 39.4 Zn	F	372	54 (As hot rolled)	138	20	45	F-E	60
C37000 (free-cutting Muntz metal)	60.0 Cu, 1.0 Pb, 39.0 Zn	T	372-552	54-80	138-414	20-60	40-6	F-E	70
C37700 (forging brass)	59.0 Cu, 2.0 Pb, 39.0 Zn	R, S	359	52 (As extruded)	138	20	45	F-E	80
C38500 (architectural bronze)	57.0 Cu, 3.0 Pb, 40.0 Zn	R, S	414	60 (As extruded)	138	20	30	F-E	90
C40500	95 Cu, 1 Sn, 4 Zn	F	269-538	39-78	83-483	12-70	49-3	G-E	20
C40800	95 Cu, 2 Sn, 3 Zn	F	290-545	42-79	90-517	13-75	43-3	G-E	20
C41100	91 Cu, 0.5 Sn, 8.5 Zn	F, W	269-731	39-106	76-496	11-72	13-2	G-E	20
C41300	90.0 Cu, 1.0 Sn, 9.0 Zn	F, R, W	283-724	41-105	83-565	12-82	45-2	G-E	20
C41500	91 Cu, 1.8 Sn, 7.2 Zn	F	317-558	46-81	117-517	17-75	44-2	G-E	30
C42200	87.5 Cu, 1.1 Sn, 11.4 Zn	F	296-607	43-88	103-517	15-75	46-2	G-E	30
C42500	88.5 Cu, 2.0 Sn, 9.5 Zn	F	310-634	45-92	124-524	18-76	49-2	G-E	30
C43000	87.0 Cu, 2.2 Sn, 10.8 Zn	F	317-648	46-94	124-503	18-73	55-3	G-E	30
C43400	85.0 Cu, 0.7 Sn, 14.3 Zn	F	310-607	45-88	103-517	15-75	49-3	G-E	30
C43500	81.0 Cu, 0.9 Sn, 18.1 Zn	F, T	317-552	46-80	110-469	16-68	46-7	G-E	30
C44300, C44400, C44500 (inhibited admiralty)	71.0 Cu, 28.0 Zn, 1.0 Sn	F, W, T	331-379	48-55	124-152	18-22	65-60	G-E	30
C46400 to C46700 (naval brass)	60.0 Cu, 39.25 Zn, 0.75 Sn	F, R, T, S	379-607	55-88	172-455	25-66	50-17	F-E	30
C48200 (naval brass, medium-leaded)	60.5 Cu, 0.7 Pb, 0.8 Sn, 38.0 Zn	F, R, S	386-517	56-75	172-365	25-53	43-15	F-E	50
C48500 (leaded naval brass)	60.0 Cu, 1.75 Pb, 37.5 Zn, 0.75 Sn	F, R, S	379-531	55-77	172-365	25-53	40-15	F-E	70
C50500 (phosphor bronze, 1.25% E)	98.75 Cu, 1.25 Sn, trace P	F, W	276-545	40-79	97-345	14-50	48-4	G-E	20
C51000 (phosphor bronze, 5% A)	95.0 Cu, 5.0 Sn, trace P	F, R, W, T	324-965	47-140	131-552	19-80	64-2	G-E	20
C51100	95.6 Cu, 4.2 Sn, 0.2 P	F	317-710	46-103	345-552	50-80	48-2	G-E	20
C52100 (phosphor bronze, 8% C)	92.0 Cu, 8.0 Sn, trace P	F, R, W	379-965	55-140	165-552	24-80	70-2	G-E	20
C52400 (phosphor bronze, 10% D)	90.0 Cu, 10.0 Sn, trace P	F, R, W	455-1014	66-147	193 (Annealed)	28	70-3	G-E	20
C54400 (free-cutting phosphor bronze)	88.0 Cu, 4.0 Pb, 4.0 Zn, 4.0 Sn	F, R	303-517	44-75	131-434	19-63	50-16	G-E	80
C60800 (aluminum bronze, 5%)	95.0 Cu, 5.0 Al	T	414	60	186	27	55	G-E	20
C61000	92.0 Cu, 8.0 Al	R, W	483-552	70-80	207-379	30-55	65-25	G-E	20

(continued)

(a) F, flat products; R, rod; W, wire; T, tube; P, pipe; S, shapes. (b) Softest to hardest commercial forms. The strength of the standard copper alloys depends on the temper (annealed grain size or degree of cold work) and the section thickness of the mill product. Ranges cover standard tempers for each alloy. (c) E, excellent; G, good; F, fair. (d) Based on 100% for C36000. (e) C10400, 8 oz/ton Ag; C10500, 10 oz/ton; C10700, 25 oz/ton. (f) C11300, 8 oz/ton Ag; C11400, 10 oz/ton; C11500, 16 oz/ton; C11600, 25 oz/ton. (g) C12000, 0.008 P; C12100, 0.008 P and 4 oz/ton Ag. (h) C12700, 8 oz/ton Ag; C12800, 10 oz/ton; C12900, 16 oz/ton; C13000, 25 oz/ton. (i) 8.30 oz/ton Ag. (j) C18200, 0.9 Cr; C18400, 0.8 Cr; C18500, 0.7 Cr. (k) Rod, 61.0 Cu min. Compiled by Copper Development Assn. Inc., New York.

Table A. (continued)

Alloy number (and name)	Nominal composition, %	Commercial forms(a)	Mechanical properties(b) Tensile strength MPa	Tensile strength ksi	Yield strength MPa	Yield strength ksi	Elongation in 2 in., %	Corrosion resistance (c)	Machinability rating (d)
C61300	92.65 Cu, 0.35 Sn, 7.0 Al	F, R, T, P, S	483-586	70-85	207-400	30-58	42-35	G-E	30
C61400 (aluminum bronze, D)	91.0 Cu, 7.0 Al, 2.0 Fe	F, R, W, T, P, S	524-614	76-89	228-414	33-60	45-32	G-E	20
C61500	90.0 Cu, 8.0 Al, 2.0 Ni	F	483-1000	70-145	152-965	22-140	55-1	G-E	30
C61800	89.0 Cu, 1.0 Fe, 10.0 Al	R	552-586	80-85	269-293	39-42.5	28-23	G-E	40
C61900	86.5 Cu, 4.0 Fe, 9.5 Al	F	634-1048	92-152	338-1000	49-145	30-1	G-E	...
C62300	87.0 Cu, 3.0 Fe, 10.0 Al	F, R	517-676	75-98	241-359	35-52	35-22	G-E	50
C62400	86.0 Cu, 3.0 Fe, 11.0 Al	F, R	621-724	90-105	276-359	40-52	18-14	G-E	50
C62500	82.7 Cu, 4.3 Fe, 13.0 Al	F, R	689	100 (As extruded)	379	55	1	G-E	20
C63000	82.0 Cu, 3.0 Fe, 10.0 Al, 5.0 Ni	F, R	621-814	90-118	345-517	50-75	20-15	G-E	30
C63200	82.0 Cu, 4.0 Fe, 9.0 Al, 5.0 Ni	F, R	621-724	90-105	310-365	45-53	25-20	G-E	30
C63600	95.5 Cu, 3.5 Al, 1.0 Si	R, W	414-579	60-84	...	...	64-29	G-E	40
C63800	95.0 Cu, 2.8 Al, 1.8 Si, 0.40 Co	F	565-896	82-130	372-786	54-114	36-4	G-E	...
C64200	91.2 Cu, 7.0 Al	F, R	517-703	75-102	241-469	35-68	32-22	G-E	60
C65100 (low-silicon bronze, B)	98.5 Cu, 1.5 Si	R, W, T	276-655	40-95	103-476	15-69	55-11	G-E	30
C65500 (high-silicon bronze, A)	97.0 Cu, 3.0 Si	F, R, W, T	386-1000	56-145	145-483	21-70	63-3	G-E	30
C66700 (manganese brass)	70.0 Cu, 28.8 Zn, 1.2 Mn	F, W	315-689	45.8-100	83-638	12-92.5	60-2	G-E	30
C67400	58.5 Cu, 36.5 Zn, 1.2 Al, 2.8 Mn, 1.0 Sn	F, R	483-634	70-92	234-379	34-55	28-20	F-E	25
C67500 (manganese bronze, A)	58.5 Cu, 1.4 Fe, 39.0 Zn, 1.0 Sn, 0.1 Mn	R, S	448-579	65-84	207-414	30-60	33-19	F-E	30
C68700 (aluminum brass, arsenical)	77.5 Cu, 20.5 Zn, 2.0 Al, 0.1 As	T	414	60	186	27	55	G-E	30
C68800	73.5 Cu, 22.7 Zn, 3.4 Al, 0.40 Co	F	565-889	82-129	379-786	55-114	36-2	G-E	...
C69000	73.3 Cu, 3.4 Al, 0.6 Ni, 22.7 Zn	F	496-896	72-130	345-807	50-117	40-2	G-E	...
C69400 (silicon red brass)	81.5 Cu, 14.5 Zn, 4.0 Si	R	552-689	80-100	276-393	40-57	25-20	G-E	30
C70400	92.4 Cu, 1.5 Fe, 5.5 Ni, 0.6 Mn	F, T	262-531	38-77	276-524	40-76	46-2	G-E	20
C70600 (copper nickel, 10%)	88.7 Cu, 1.3 Fe, 10.0 Ni	F, T	303-414	44-60	110-393	16-57	42-10	E	20
C71000 (copper nickel, 20%)	79.0 Cu, 21.0 Ni	F, W, T	338-655	49-95	90-586	13-85	40-3	E	20
C71500 (copper nickel, 30%)	70.0 Cu, 30.0 Ni	F, R, T	372-517	54-75	138-483	20-70	45-15	E	20
C71700	67.8 Cu, 0.7 Fe, 31.0 Ni, 0.5 Be	F, R, W	483-1379	70-200	207-1241	30-180	40-4	G-E	20
C72500	88.2 Cu, 9.5 Ni, 2.3 Sn	F, R, W, T	379-827	55-120	152-745	22-108	35-1	E	20
C73500	72.0 Cu, 10.0 Zn, 18.0 Ni	F, R, W, T	345-758	50-110	103-579	15-84	37-1	E	20
C74500 (nickel silver, 65-10)	65.0 Cu, 25.0 Zn, 10.0 Ni	F, W	338-896	49-130	124-524	18-76	50-1	E	20
C75200 (nickel silver, 65-18)	65.0 Cu, 17.0 Zn, 18.0 Ni	F, R, W	386-710	56-103	172-621	25-90	45-3	E	20
C75400 (nickel silver, 65-15)	65.0 Cu, 20.0 Zn, 15.0 Ni	F	365-634	53-92	124-545	18-79	43-2	E	20
C75700 (nickel silver, 65-12)	65.0 Cu, 23.0 Zn, 12.0 Ni	F, W	359-641	52-93	124-545	18-79	48-2	E	20
C76200	59.0 Cu, 29.0 Zn, 12.0 Ni	F, T	393-841	57-122	145-758	21-110	50-1	G-E	...
C77000 (nickel silver, 55-18)	55.0 Cu, 27.0 Zn, 18.0 Ni	F, R, W	414-1000	60-145	186-621	27-90	40-2	E	30
C72200	82.0 Cu, 16.0 Ni, 0.5 Cr, 0.8 Fe, 0.5 Mn	F, T	317-483	46-70	124-455	18-66	46-6	G-E	...
C78200 (leaded nickel silver, 65-8-2)	65.0 Cu, 2.0 Pb, 25.0 Zn, 8.0 Ni	F	365-627	53-91	159-524	23-76	40-3	E	60

(a) F, flat products; R, rod; W, wire; T, tube; P, pipe; S, shapes. (b) Softest to hardest commercial forms. The strength of the standard copper alloys depends on the temper (annealed grain size or degree of cold work) and the section thickness of the mill product. Ranges cover standard tempers for each alloy. (c) E, excellent; G, good; F, fair. (d) Based on 100% for C36000. (e) C10400, 8 oz/ton Ag; C10500, 10 oz/ton; C10700, 25 oz/ton. (f) C11300, 8 oz/ton Ag; C11400, 10 oz/ton; C11500, 16 oz/ton; C11600, 25 oz/ton. (g) C12000, 0.008 P; C12100, 0.008 P and 4 oz/ton Ag. (h) C12700, 8 oz/ton Ag; C12800, 10 oz/ton; C12900, 16 oz/ton; C13000, 25 oz/ton. (i) 8.30 oz/ton Ag. (j) C18200, 0.9 Cr; C18400, 0.8 Cr; C18500, 0.7 Cr. (k) Rod, 61.0 Cu min. Compiled by Copper Development Assn. Inc., New York.

Table A-1. Fabricating characteristics and typical applications of wrought coppers and copper alloys

Alloy number (and name)	Fabricating characteristics and typical applications
C10100 (oxygen-free electronic)	Excellent hot and cold workability; good forgeability. Fabricated by coining, coppersmithing, drawing and upsetting, hot forging and pressing, spinning, swaging, stamping. Uses: busbars, bus conductors, waveguides, hollow conductors, lead-in wires and anodes for vacuum tubes, vacuum seals, transistor components, glass to metal seals, coaxial cables and tubes, klystrons, microwave tubes, rectifiers.
C10200 (oxygen-free copper)	Fabricating characteristics same as C10100. Uses: busbars, waveguides.
C10300 (oxygen-free, extra-low phosphorus)	Fabricating characteristics same as C10100. Uses: busbars, electrical conductors, tubular bus and applications requiring good conductivity and welding or brazing properties.
C10400, C10500, C10700 (oxygen-free, silver-bearing)	Fabricating characteristics same as C10100. Uses: auto gaskets, radiators, busbars, conductivity wire, contacts, radio parts, winding, switches, terminals, commutator segments; chemical process equipment, printing rolls, clad metals, printed circuit foil.
C10800 (oxygen-free, low-phosphorus)	Fabricating characteristics same as C10100. Uses: refrigerators, air conditioners, gas and heater lines, oil burner tubes, plumbing pipe and tube, brewery tubes, condenser and heat exchanger tubes, dairy and distiller tubes, pulp and paper lines, tanks, air, gasoline, hydraulic and oil lines.
C11000 (electrolytic tough pitch copper)	Fabricating characteristics same as C10100. Uses: downspouts, gutters, roofing, gaskets, auto radiators, busbars, nails, printing rolls, rivets, radio parts.
C11100 (electrolytic tough pitch, anneal resistant)	Fabricating characteristics same as C10100. Uses: electrical power transmission where resistance to softening under overloads is desired.
C11300, C11400, C11500, C11600 (silver-bearing tough pitch copper)	Fabricating characteristics same as C10100. Uses: gaskets, radiators, busbars, windings, switches, chemical process equipment, clad metals, printed circuit foil.
C12000, C12100	Fabricating characteristics same as C10100. Uses: busbars, electrical conductors, tubular bus, and applications requiring welding or brazing.
C12200 (phosphorus-deoxidized copper, high residual phosphorus)	Fabricating characteristics same as C10100. Uses: gas and heater lines; oil burner tubing; plumbing pipe and tubing; condenser, evaporator, heat exchanger, dairy, and distiller tubing; steam and water lines; air, gasoline, and hydraulic lines.
C12500, C12700, C12800, C12900, C13000 (fire-refined tough pitch with silver)	Fabricating characteristics same as C10100. Uses: same as C11000.
C14200 (phosphorus-deoxidized, arsenical)	Fabricating characteristics same as C10100. Uses: plates for locomotive fireboxes, staybolts, heat exchanger and condenser tubes.
C19200	Excellent hot and cold workability. Uses: automotive hydraulic brake lines, flexible hose, electrical terminals, fuse clips, gaskets, gift hollow ware, applications requiring resistance to softening and stress corrosion, air conditioning and heat exchanger tubing.
C14300	Fabricating characteristics same as C10100. Uses: anneal resistant electrical applications requiring thermal softening and embrittlement, resistance, lead frames, contacts, terminals, solder-coated and solder-fabricated parts, furnace-brazed assemblies and welded components, cable wrap.
C14310	Same as C14300.
C14500 (phosphorus-deoxidized, tellurium-bearing)	Fabricating characteristics same as C10100. Uses: forgings and screw machine products, and parts requiring high conductivity, extensive machining, corrosion resistance, copper color, or a combination of these; electrical connectors, motor and switch parts, plumbing fittings, soldering coppers, welding torch tips, transistor bases and furnace-brazed articles.
C14700 (sulfur-bearing)	Fabricating characteristics same as C10100. Uses: screw machine products and parts requiring high conductivity, extensive machining, corrosion resistance, copper color, or a combination of these; electrical connectors, motor and switch components, plumbing fittings, cold headed and machined parts, cold forgings, furnace brazed articles, screws, soldering coppers, rivets and welding torch tips.
C15000 (zirconium copper)	Fabricating characteristics same as C10100. Uses: switches, high-temperature circuit breakers; commutators, stud bases for power transmitters, rectifiers, soldering welding tips.
C15500	Fabricating characteristics same as C10100. Uses: high-conductivity light-duty springs, electrical contacts, fittings, clamps, connectors, diaphragms, electronic components, resistance welding electrodes.
C15710	Excellent cold workability. Fabricated by extrusion, drawing, rolling, impacting, heading, swaging, bending, machining, blanking, roll threading. Uses: electrical connectors, light-duty current-carrying springs, inorganic insulated wire, thermocouple wire, lead wire, resistance welding electrodes for aluminum, heat sinks.
C15720	Excellent cold workability. Fabricated by extrusion, drawing, rolling, impacting, heading, swaging, machining, blanking. Uses: relay and switch springs, lead frames, contact supports, heat sinks, circuit breaker parts, rotor bars, resistance welding electrodes and wheels, connectors, high-strength high-temperature parts.
C15735	Excellent cold workability. Fabricated by extrusion, drawing, heading, impacting, machining. Uses: resistance welding electrodes, circuit breakers, feed-through conductors, heat sinks, motor parts, high-strength high-temperature parts.
C15760	Excellent cold workability. Fabricated by extrusion and drawing. Uses: resistance welding electrodes, circuit breakers, electrical connectors, wire feed contact tips, plasma spray nozzles, high-strength high-temperature parts.
C16200 (cadmium copper)	Excellent cold workability; good hot formability. Uses: trolley wire, heating pad, electric-blanket elements, spring contacts, railbands, high-strength transmission lines, connectors, cable wrap, switch gear components and waveguide cavities.
C16500	Fabricating characteristics same as C16200. Uses: electrical springs and contacts, trolley wire, clips, flat cable, resistance welding electrodes.
C17000 (beryllium copper)	Fabricating characteristics same as C16200. Commonly fabricated by blanking, forming and bending, turning, drilling, tapping. Uses: bellows, bourdon tubing, diaphragms, fuse clips, fasteners, lock-washers, springs, switch parts, roll pins, valves, welding equipment.
C17200 (beryllium copper)	Similar to C17000, particularly for its nonsparking characteristics.
C17300 (beryllium copper)	Combines superior machinability with good fabricating characteristics of C17200.

(continued)

Table A-1. (continued)

Alloy number (and name)	Fabricating characteristics and typical applications
C17500 (copper-cobalt-beryllium alloy)	Fabricating characteristics same as C16200. Uses: fuse clips, fasteners, springs, switch and relay parts, electrical conductors, welding equipment.
C18200, C18400, C18500 (chromium copper)	Excellent cold workability, good hot workability. Uses: resistance welding electrodes, seam welding wheels, switch gear, electrode holder jaws, cable connectors, current carrying arms and shafts, circuit breaker parts, molds, spot welding tips, flash welding electrodes, electrical and thermal conductors requiring strength, switch contacts.
C18700 (leaded copper)	Good cold workability; poor hot formability. Uses: connectors, motor and switch parts, screw machine parts requiring high conductivity.
C18900	Fabricating characteristics same as C10100. Uses: welding rod and wire for inert gas tungsten arc and metal arc welding and oxyacetylene welding of copper.
C19000 (copper-nickel-phosphorus alloy)	Fabricating characteristics same as C10100. Uses: springs, clips, electrical connectors, power tube and electron tube components, high-strength electrical conductors, bolts, nails, screws, cotter pins, and parts requiring some combination of high-strength, high-electrical or thermal conductivity, high resistance to fatigue and creep, and good workability.
C19100 (copper-nickel-phosphorus-tellurium alloy)	Good hot and cold workability. Uses: forgings and screw machine parts requiring high strength, hardenability, extensive machining, corrosion resistance, copper color, good conductivity, or a combination of these; bolts, bushings, electrical connectors, gears, marine hardware, nuts, pinions, tie rods, turnbuckle barrels, welding torch tips.
C19400	Excellent hot and cold workability. Uses: circuit breaker components, contact springs, electrical clamps, electrical springs, electrical terminals, flexible hose, fuse clips, gaskets, gift hollow ware, plug contacts, rivets, and welded condenser tubes.
C19500	Excellent hot and cold workability. Uses: electrical springs, sockets, terminals, connectors, clips and other current carrying parts having strength.
C21000 (gilding, 95%)	Excellent cold workability, good hot workability for blanking, coining, drawing, piercing and punching, shearing, spinning, squeezing and swaging, stamping. Uses: coins, medals, bullet jackets, fuse caps, primers, plaques, jewelry base for gold plate.
C22000 (commercial bronze, 90%)	Fabricating characteristics same as C21000, plus heading and upsetting, roll threading and knurling, hot forging and pressing. Uses: etching bronze, grillwork, screen cloth, weatherstripping, lipstick cases, compacts, marine hardware, screws, rivets.
C22600 (jewelry bronze, 87.5%)	Fabricating characteristics same as C21000, plus heading and upsetting, roll threading and knurling. Uses: angles, channels, chain, fasteners, costume jewelry, lipstick cases, compacts, base for gold plate.
C23000 (red brass, 85%)	Excellent cold workability, good hot formability. Uses: weatherstripping, conduit, sockets, fasteners, fire extinguishers, condenser and heat exchanger tubing, plumbing pipe, radiator cores.
C24000 (low brass, 80%)	Excellent cold workability. Fabricating characteristics same as C23000. Uses: battery caps, bellows, musical instruments, clock dials, pump lines, flexible hose.
C26000 (cartridge brass, 70%)	Excellent cold workability. Fabricating characteristics same as C23000, except for coining, roll threading, and knurling. Uses: radiator cores and tanks, flashlight shells, lamp fixtures, fasteners, locks, hinges, ammunition components, plumbing accessories, pins, rivets.
C26800, C27000 (yellow brass)	Excellent cold workability. Fabricating characteristics same as C23000. Uses: same as C26000 except not used for ammunition.
C28000 (Muntz metal)	Excellent hot formability and forgeability for blanking, forming and bending, hot forging and pressing, hot heading and upsetting, shearing. Uses: architectural, large nuts and bolts, brazing rod, condenser plates, heat exchanger and condenser tubing, hot forgings.
C31400 (leaded commercial bronze)	Excellent machinability. Uses: screws, machine parts, pickling crates.
C31600 (leaded commercial bronze, nickel-bearing)	Good cold workability; poor hot formability. Uses: electrical connectors, fasteners, hardware, nuts, screws, screw machine parts.
C33000 (low-leaded brass tube)	Combines good machinability and excellent cold workability. Fabricated by forming and bending, machining, piercing and punching. Uses: pump and power cylinders and liners, ammunition primers, plumbing accessories.
C33200 (high-leaded brass tube)	Excellent machinability. Fabricated by piercing, punching, and machining. Uses: general-purpose screw machine parts.
C33500 (low-leaded brass)	Similar to C33200. Commonly fabricated by blanking, drawing, machining, piercing and punching, stamping. Uses: butts, hinges, watch backs.
C34000 (medium-leaded brass)	Similar to C33200. Fabricated by blanking, heading and upsetting, machining, piercing and punching, roll threading and knurling, stamping. Uses: butts, gears, nuts, rivets, screws, dials, engravings, instrument plates.
C34200 (high-leaded brass)	Combines excellent machinability with moderate cold workability. Uses: clock plates and nuts, clock and watch backs, gears, wheels and channel plate.
C34900	Good cold workability, fair hot workability for bending and forming, heading and upsetting, machining, roll threading and knurling. Uses: building hardware, rivets and nuts, plumbing goods, and parts requiring moderate cold working combined with some machining.
C35000 (medium-leaded brass)	Fair cold workability; poor hot formability. Uses: bearing cages, book dies, clock plates, engraving plates, gears, hinges, hose couplings, keys, lock parts, lock tumblers, meter parts, nuts, sink strainers, strike plates, templates, type characters, washers, wear plates.
C35300 (high-leaded brass)	Similar to C34200.
C35600 (extra-high-leaded brass)	Excellent machinability. Fabricated by blanking, machining, piercing and punching, stamping. Uses: same as C34200 and C35300.
C36000 (free-cutting brass)	Excellent machinability. Fabricated by machining, roll threading and knurling. Uses: gears, pinions, automatic high-speed screw machine parts.
C36500 to C36800 (leaded Muntz metal)	Combines good machinability with excellent hot formability. Uses: condenser tube plates.
C37000 (free-cutting Muntz metal)	Fabricating characteristics similar to C36500 to C36800. Uses: automatic screw machine parts.

(continued)

Table A-1. (continued)

Alloy number (and name)	Fabricating characteristics and typical applications
C37700 Forging brass	Excellent hot workability. Fabricated by heading and upsetting, hot forging and pressing, hot heading and upsetting, machining. Uses: forgings and pressings of all kinds.
C38500 (architectural bronze)	Excellent machinability and hot workability. Fabricated by hot forging and pressing, forming, bending and machining. Uses: architectural extrusions, store fronts, thresholds, trim, butts, hinges, lock bodies and forgings.
C40500	Excellent cold workability. Fabricated by blanking, forming and drawing. Uses: meter clips, terminals, fuse clips, contact and relay springs, washers.
C40800	Excellent cold workability. Fabricated by blanking, stamping and shearing. Uses: electrical connectors.
C41100	Excellent cold workability, good hot formability. Fabricated by blanking, forming and drawing. Uses: bushings, bearing sleeves, thrust washers, terminals, connectors, flexible metal hose, electrical conductors.
C41300	Excellent cold workability; good hot formability. Uses: plater bar for jewelry products, flat springs for electrical switchgear.
C41500	Excellent cold workability. Fabricated by blanking, drawing, bending, forming, shearing and stamping. Uses: spring applications for electrical switches.
C42200	Excellent cold workability; good hot formability. Fabricated by blanking, piercing, forming and drawing. Uses: sash chains, fuse clips, terminals, spring washers, contact springs, electrical connectors.
C42500	Excellent cold workability. Fabricated by blanking, piercing, forming and drawing. Uses: electrical switches, springs, terminals, connectors, fuse clips, pen clips, weather stripping.
C43000	Excellent cold workability; good hot formability. Fabricated by blanking, coining, drawing, forming, bending, heading, and upsetting. Uses: same as C42500.
C43400	Excellent cold workability. Fabricated by blanking, drawing, bonding, forming, stamping and shearing. Uses: electrical switch parts, blades, relay springs, contacts.
C43500	Excellent cold workability for fabrication by forming and bending. Uses: bourdon tubing and musical instruments.
C44300, C44400, C44500 (inhibited admiralty)	Excellent cold workability for forming and bending. Uses: condenser, evaporator and heat exchanger tubing, condenser tubing plates, distiller tubing, ferrules.
C46400 to C46700 (naval brass)	Excellent hot workability and hot forgeability. Fabricated by blanking, drawing, bending, heading and upsetting, hot forging, pressing. Uses: aircraft turnbuckle barrels, balls, bolts, marine hardware, nuts, propeller shafts, rivets, valve stems, condenser plates, welding rod.
C48200 (naval brass, medium-leaded)	Good hot workability for hot forging, pressing, and machining operations. Uses: marine hardware, screw machine products, valve stems.
C48500 (leaded naval brass)	Combines excellent hot forgeability and machinability. Fabricated by hot forging and pressing, machining. Uses: marine hardware, screw machine parts, valve stems.
C50500 (phosphor bronze, 1.25% E)	Excellent cold workability; good hot formability. Fabricated by blanking, bending, heading and upsetting, shearing and swaging. Uses: electrical contacts, flexible hose, pole-line hardware.
C51000 (phosphor bronze, 5% A)	Excellent cold workability. Fabricated by blanking, drawing, bending, heading and upsetting, roll threading and knurling, shearing, stamping. Uses: bellows, bourdon tubing, clutch discs, cotter pins, diaphragms, fasteners, lock washers, wire brushes, chemical hardware, textile machinery, welding rod.
C51100	Excellent cold workability. Uses: bridge bearing plates, locator bars, fuse clips, sleeve bushings, springs, switch parts, truss wire, wire brushes, chemical hardware, perforated sheets, textile machinery, welding rod.
C52100 (phosphor bronze, 8% C)	Good cold workability for blanking, drawing, forming and bending, shearing, stamping. Uses: generally for more severe service conditions than C51000.
C52400 (phosphor bronze, 10% D)	Good cold workability for blanking, forming and bending, shearing. Uses: heavy bars and plates for severe compression, bridge and expansion plates and fittings, articles requiring good spring qualities, resiliency, fatigue resistance, good wear and corrosion resistance.
C54400 (free-cutting phosphor bronze)	Excellent machinability; good cold workability. Fabricated by blanking, drawing, bending, machining, shearing, stamping. Uses: bearings, bushings, gears, pinions, shafts, thrust washers, valve parts.
C60800 (aluminum bronze, 5%)	Good cold workability; fair hot formability. Uses: condenser, evaporator and heat exchanger tubes, distiller tubes, ferrules.
C61000	Good hot and cold workability. Uses: bolts, pump parts, shafts, tie rods, overlay on steel for wearing surfaces.
C61300	Good hot and cold formability. Uses: nuts, bolts, stringers and threaded members, corrosion-resistant vessels and tanks, structural components, machine parts, condenser tube and piping systems, marine protective sheathing and fastening, munitions mixing troughs and blending chambers.
C61400 (aluminum bronze, D)	Similar to C61300.
C61500	Good hot and cold workability. Fabricating characteristics similar to C52100. Uses: hardware, decorative metal trim, interior furnishings and other articles requiring high tarnish resistance.
C61800	Fabricated by hot forging and hot pressing. Uses: bushings, bearings, corrosion-resistant applications, welding rods.
C61900	Excellent hot formability for fabricating by blanking, forming, bending, shearing, and stamping. Uses: springs, contacts, and switch components.
C62300	Good hot and cold formability. Fabricated by bending, hot forging, hot pressing, forming, and welding. Uses: bearings, bushings, valve guides, gears, valve seats, nuts, bolts, pump rods, worm gears, and cams.
C62400	Excellent hot formability for fabrication by hot forging and hot bending. Uses: bushings, gears, cams, wear strips, nuts, drift pins, tie rods.
C62500	Excellent hot formability for fabrication by hot forging and machining. Uses: guide bushings, wear strips, cams, dies, forming rolls.
C63000	Good hot formability. Fabricated by hot forming and forging. Uses: nuts, bolts, valve seats, plunger tips, marine shafts, valve guides, aircraft parts, pump shafts, structural members.
C63200	Good hot formability. Fabricated by hot forming and welding. Uses: nuts, bolts, structural pump parts, shafting requiring corrosion resistance.

(continued)

Table A-1. (continued)

Alloy number (and name)	Fabricating characteristics and typical applications
C63600	Excellent cold workability; fair hot formability. Fabricated by cold heading. Uses: components for pole line hardware, cold-headed nuts for wire and cable connectors, bolts and screw products.
C63800	Excellent cold workability and hot formability. Uses: springs, switch parts, contacts, relay springs, glass sealing and porcelain enameling.
C64200	Excellent hot formability. Fabricated by hot forming, forging, machining. Uses: valve stems, gears, marine hardware, pole-line hardware, bolts, nuts, valve bodies and components.
C65100 (low-silicon bronze, B)	Excellent hot and cold workability. Fabricated by forming and bending, heading and upsetting, hot forging and pressing, roll threading and knurling, squeezing and swaging. Uses: hydraulic pressure lines, anchor screws, bolts, cable clamps, cap screws, machine screws, marine hardware, nuts, pole-line hardware, rivets, U-bolts, electrical conduits, heat exchanger tubing, welding rod.
C65500 (high-silicon bronze, A)	Excellent hot and cold workability. Fabricated by blanking, drawing, forming and bending, heading and upsetting, hot forging and pressing, roll threading and knurling, shearing, squeezing and swaging. Uses: similar to C65100 including propeller shafts.
C66700 (manganese brass)	Excellent cold formability. Fabricated by blanking, bending, forming, stamping, welding. Uses: brass products resistance welded by spot, seam, and butt welding.
C67400	Excellent hot formability. Fabricated by hot forging and pressing, machining. Uses: bushings, gears, connecting rods, shafts, wear plates.
C67500 (manganese bronze, A)	Excellent hot workability. Fabricated by hot forging and pressing, hot heading and upsetting. Uses: clutch discs, pump rods, shafting, balls, valve stems and bodies.
C68700 (aluminum brass, arsenical)	Excellent cold workability for forming and bending. Uses: condenser, evaporator and heat exchanger tubing, condenser tubing plates, distiller tubing, ferrules.
C68800	Excellent hot and cold formability. Fabricated by blanking, drawing, forming and bending, shearing and stamping. Uses: springs, switches, contacts, relays, drawn parts.
C69000	Fabricating characteristics same as C68800. Uses: wiring devices, relays, switches, springs, high-strength shells.
C69400 (silicon red brass)	Excellent hot formability for fabrication by forging, screw machine operations. Uses: valve stems where corrosion resistance and high strength are critical.
C70400	Excellent cold workability; good hot formability. Fabricated by forming, bending and welding. Uses: condensers, evaporators, heat exchangers, ferrules, salt water piping, lithium bromide absorption tubing, shipboard condenser intake systems.
C70600 (copper nickel, 10%)	Good hot and cold workability. Fabricated by forming and bending, welding. Uses: condensers, condenser plates, distiller tubing, evaporator and heat exchanger tubing, ferrules, salt water piping.
C71000 (copper nickel, 20%)	Good hot and cold formability. Fabricated by blanking, forming and bending, welding. Uses: communication relays, condensers, condenser plates, electrical springs, evaporator and heat exchanger tubes, ferrules, resistors.
C71500 (copper nickel, 30%)	Similar to C70600.
C71700	Good hot and cold formability. Uses: high-strength constructional parts for sea water corrosion resistance, hydrophone cases, mooring cable wire, springs, retainer rings, bolts, screws, pins for ocean telephone cable applications.
C72500	Excellent cold and hot formability. Fabricated by blanking, brazing, coining, drawing, etching, forming and bending, heading and upsetting, roll threading and knurling, shearing, spinning, squeezing, stamping and swaging. Uses: relay and switch springs, connectors, brazing alloy, lead frames, control and sensing bellows.
C73500	Fabricating characteristics same as C74500. Uses: holloware, medallions, jewelry, base for silver plate, cosmetic cases, musical instruments, name plates, contacts.
C74500 (nickel silver, 65-10)	Excellent cold workability. Fabricated by blanking, drawing, etching, forming and bending, heading and upsetting, roll threading and knurling, shearing, spinning, squeezing and swaging. Uses: rivets, screws, slide fasteners, optical parts, etching stock, hollow ware, nameplates, platers' bars.
C75200 (nickel silver, 65-18)	Fabricating characteristics similar to C74500. Uses: rivets, screws, table flatware, truss wire, zippers, bows, camera parts, core bars, temples, base for silver plate, costume jewelry, etching stock, hollow ware, nameplates, radio dials.
C75400 (nickel silver, 65-15)	Fabricating characteristics similar to C74500. Uses: camera parts, optical equipment, etching stock, jewelry.
C75700 (nickel silver, 65-12)	Fabricating characteristics similar to C74500. Uses: slide fasteners, camera parts, optical parts, etching stock, nameplates.
C76200	Fabricating characteristics same as C77000. Uses: electrical terminals, contact springs, release brackets, ornamental bits and spurs, optical parts, surgical instruments, electrical contacts.
C77000 (nickel silver, 55-18)	Good cold workability. Fabricated by blanking, forming and bending, and shearing. Uses: optical goods, springs and resistance wire.
C72200	Good hot and cold workability. Fabricated by forming, bending and welding. Uses: condenser and heat exchanger tubing, salt water piping.
C78200 (leaded nickel silver, 65-8-2)	Good cold formability. Fabricated by blanking, milling and drilling. Uses: key blanks, watch plates, watch parts.

Table B. Properties and applications of cast coppers and copper alloys

UNS designation(a)	Nominal composition, %(a)	Typical mechanical properties, as cast (heat treated)(b): Tensile strength MPa	Tensile strength ksi	Yield strength MPa	Yield strength ksi	Elongation in 2 in., %	Hardness: Rockwell	Hardness: Brinell 500 kg	Hardness: Brinell 3 000 kg	Machinability rating(c)	Casting types(d)	Typical applications
C80100	99.95 Cu + Ag min, 0.05 others max	172	25	62	9	40	...	44	...	10	C, T, I M, P, S	Electrical and thermal conductors; corrosion and oxidation resistant applications.
C80300	99.95 Cu + Ag min, 0.034 Ag min, 0.05 others max	172	25	62	9	40	...	44	...	10	C, T, I M, P, S	Electrical and thermal conductors; corrosion and oxidation resistant applications.
C80500	99.75 Cu + Ag min, 0.034 Ag min, 0.02 B max, 0.23 others max	172	25	62	9	40	...	44	...	10	C, T, I M, P, S	Electrical and thermal conductors; corrosion and oxidation resistant applications.
C80700	99.75 Cu + Ag min, 0.02 B max, 0.23 others max	172	25	62	9	40	...	44	...	10	C, T, I M, P, S	Electrical and thermal conductors; corrosion and oxidation resistant applications.
C80900	99.70 Cu + Ag min, 0.034 Ag min, 0.30 others max	172	25	62	9	40	...	44	...	10	C, T, I M, P, S	Electrical and thermal conductors; corrosion and oxidation resistant applications.
C81100	99.70 Cu + Ag min, 0.30 others max	172	25	62	9	40	...	44	...	10	C, T, I M, P, S	Electrical and thermal conductors; corrosion and oxidation resistant applications.
High-copper alloys												
C81300	98.5 Cu min, 0.06 Be, 0.80 Co, 0.40 others max	(365)	(53)	(248)	(36)	(11)	...	(39)	...	20	C, T, I, M, P, S	Higher hardness electrical and thermal conductors.
C81400	98.5 Cu min, 0.06 Be, 0.80 Cr, 0.40 others max	(365)	(53)	(248)	(36)	(11)	(B 69)	...	...	20	C, T, I, M, P, S	Higher hardness electrical and thermal conductors.
C81500	98.0 Cu min, 1.0 Cr, 0.50 others max	(352)	(51)	(276)	(40)	(17)	...	(105)	...	20	C, T, I, M, P, S	Electrical and/or thermal conductors used as structural members where strength and hardness greater than that of C80100-81100 are required.
C81700	94.25 Cu min, 1.0 Ag, 0.4 Be, 0.9 Co, 0.9 Ni	(634)	(92)	(469)	(68)	(8)	...	...	(217)	30	C, T, I, M, P, S	Electrical and/or thermal conductors used as structural members where strength and hardness greater than that of C80100-81100 are required. Also used in place of C81500 where electrical and/or thermal conductivities can be sacrificed for hardness and strength.
C81800	95.6 Cu min, 1.0 Ag, 0.4 Be, 1.6 Co	345 (703)	50 (102)	172 (517)	25 (75)	20 (8)	B 55 (B 96)	...	...	20	C, T, I, M, P, S	Resistance welding electrodes, dies.
C82000	96.8 Cu, 0.6 Be, 2.6 Co	345 (689)	50 (100)	138 (517)	20 (75)	20 (8)	B 55 (B 95)	...	(195)	20	C, T, I, M, P, S	Current carrying parts, contact and switch blades, bushings and bearings, soldering iron and resistance welding tips.
C82100	97.7 Cu, 0.5 Be, 0.9 Co, 0.9 Ni	(634)	(92)	(469)	(68)	(8)	...	...	(217)	30	C, T, I, M, P, S	Electrical and/or thermal conductors used as structural members where strength and hardness greater than that of C80100-81100 are required. Also used in place of C81500 where electrical and/or thermal conductivities can be sacrificed for hardness and strength.

(*continued*)

(a) Nominal composition, unless otherwise noted. For seldom-used alloys, only compositions are available. (b) Values for C82700, 84200, 96200, 96300 are minimum, not typical. As-cast values are for sand casting except C93900, continuous cast; and C85800, 87800, 87900, die cast. Heat treated values, in parentheses, indicate that the alloy responds to heat treatment. If heat treated values are not shown, the copper or copper alloy does not respond. (c) Free cutting brass = 100. (d) C, centrifugal; T, continuous; D, die; I, investment; M, permanent mold; P, plaster; S, sand. (e) As-heat treated value for C94700, 20; for C94800, 40. (Note: C82000, 82400, 82500, 82600, 82800 are also pressure cast.) **Source**: Copper Development Assn. Inc., New York. (Revised March 1980)

Table B. (continued)

UNS designation(a)	Nominal composition, %(a)	Typical mechanical properties, as cast (heat treated)(b): Tensile strength, MPa	Tensile strength, ksi	Yield strength, MPa	Yield strength, ksi	Elongation in 2 in., %	Hardness: Rockwell	Hardness: Brinell 500 kg	Hardness: Brinell 3 000 kg	Machinability rating(c)	Casting types(d)	Typical applications
High-copper alloys (continued)												
C82200	96.5 Cu min, 0.6 Be, 1.5 Ni	393 (655)	57 (95)	207 (517)	30 (75)	20 (8)	B 60 (B 96)	...	...	20	C, T, I, M, P, S	Clutch rings, brake drums, seam welder electrodes, projection welding dies, spot welding tips, beam welder shapes, bushings, water-cooled holders.
C82400	96.4 Cu min, 1.70 Be, 0.25 Co	496 (1034)	72 (150)	255 (965)	37 (140)	20 (1)	B 78 (C 38)	...	...	20	C, I, M, P, S	Safety tools, molds for plastic parts, cams, bushings, bearings, valves, pump parts, gears.
C82500	97.2 Cu, 2.0 Be, 0.5 Co, 0.25 Si	552 (1103)	80 (160)	310	45	20 (1)	B 82 (C 40)	...	...	20	C, I, M, P, S	Safety tools, molds for plastic parts, cams, bushings, bearings, valves, pump parts.
C82600	95.2 Cu min, 2.3 Be, 0.5 Co, 0.25 Si	565 (1138)	82 (165)	324 (1069)	47 (155)	20 (1)	B 83 (C 43)	...	...	20	C, I, M, P, S	Bearings and molds for plastic parts.
C82700	96.3 Cu, 2.45 Be, 1.25 Ni	(1069)	(155)	(896)	(130)	(0)	(C 39)	...	...	20	C, I, M, P, S	Bearings and molds for plastic parts.
C82800	96.6 Cu, 2.6 Be, 0.5 Co, 0.25 Si	669 (1138)	97 (165)	379 (1000)	55 (145)	20 (1)	B 85 (C 45)	...	...	10	C, I, M, P, S	Molds for plastic parts, cams, bushings, bearings, valves, pump parts, sleeves.
Red brasses and leaded red brasses												
C83300	93 Cu, 1.5 Sn, 1.5 Pb, 4 Zn	221	32	69	10	35	...	35	...	35	S	Terminal ends for electrical cables.
C83400	90 Cu, 10 Zn	241	35	69	10	30	F 50	...	...	60	C, S	Moderate strength, moderate conductivity castings; rotating bands.
C83600	85 Cu, 5 Sn, 5 Pb, 5 Zn	255	37	117	17	30	...	60	...	84	C, T, I, S	Valves, flanges, pipe fittings, plumbing goods, pump castings, water pump impellers and housings, ornamental fixtures, small gears.
C83800	83 Cu, 4 Sn, 6 Pb, 7 Zn	241	35	110	16	25	...	60	...	90	C, T, S	Low-pressure valves and fittings, plumbing supplies and fittings, general hardware, air-gas-water fittings, pump components, railroad catenary fittings.
Semi-red brasses and leaded semi-red brasses												
C84200	80 Cu, 5 Sn, 2.5 Pb, 12.5 Zn	193	28	103	15	27	...	60	...	80	C, T, S	Pipe fittings, elbows, T's, couplings, bushings, locknuts, plugs, unions.
C84400	81 Cu, 3 Sn, 7 Pb, 9 Zn	234	34	103	15	26	...	55	...	90	C, T, S	General hardware, ornamental castings, plumbing supplies and fixtures, low-pressure valves and fittings.
C84500	78 Cu, 3 Sn, 7 Pb, 12 Zn	241	35	97	14	28	...	55	...	90	C, T, S	Plumbing fixtures, cocks, faucets, stops, waste, air and gas fittings, low-pressure valve fittings.
C84800	76 Cu, 3 Sn, 6 Pb, 15 Zn	248	36	97	14	30	...	55	...	90	C, S	Plumbing fixtures, cocks, faucets, stops, waste, air and gas fittings, general hardware, and low-pressure valve fittings.
Yellow brasses and leaded yellow brasses												
C85200	72 Cu, 1 Sn, 3 Pb, 24 Zn	262	38	90	13	35	...	45	...	80	C, T	Plumbing fittings and fixtures, ferrules, valves, hardware, ornamental brass, chandeliers, and irons.
C85400	67 Cu, 1 Sn, 3 Pb, 29 Zn	234	34	83	12	35	...	50	...	80	C, T, M, P, S	General purpose yellow casting alloy not subject to high internal pressure. Furniture hardware, ornamental castings, radiator fittings, ship trimmings, cocks, battery clamps, valves and fittings.

(continued)

Table 8. (continued)

UNS designation(a)	Nominal composition, %(a)	Typical mechanical properties, as cast (heat treated)(b): Tensile strength, MPa	Tensile strength, ksi	Yield strength, MPa	Yield strength, ksi	Elongation in 2 in., %	Hardness: Rockwell	Hardness: Brinell, 500 kg	Hardness: Brinell, 3 000 kg	Machinability rating(c)	Casting types(d)	Typical applications
Yellow brasses and leaded yellow brasses (continued)												
C85500	61 Cu, 0.8 Al, bal Zn	414	60	159	23	40	B 55	85	...	80	C, S	Ornamental castings.
C85700	63 Cu, 1 Sn, 1 Pb, 34.7 Zn, 0.3 Al	345	50	124	18	40	...	75	...	80	C, M, P, S	Bushings, hardware fittings, ornamental castings.
C85800	58 Cu, 1 Sn, 1 Pb, 40 Zn	379	55	207	30	15	B 55	...	...	80	D	General purpose die casting alloy having moderate strength.
Manganese and leaded manganese bronze alloys												
C86100	67 Cu, 21 Zn, 3 Fe, 5 Al, 4 Mn	655	95	345	50	20	...	...	180	30	C, I, P, S	Marine castings, gears, gun mounts, bushings and bearings, marine racing propellers.
C86200	64 Cu, 26 Zn, 3 Fe, 4 Al, 3 Mn	655	95	331	48	20	...	...	180	30	C, T, D, I, P, S	Marine castings, gears, gun mounts, bushings and bearings.
C86300	63 Cu, 25 Zn, 3 Fe, 6 Al, 3 Mn	793	115	572	83	15	...	...	225	8	C, I, P, S	Extra-heavy duty, high-strength alloy. Large valve stems, gears, cams, slow-speed heavy-load bearings, screwdown nuts, hydraulic cylinder parts.
C86400	59 Cu, 1 Pb, 40 Zn	448	65	172	25	20	...	90	105	65	C, D, M, P, S	Free-machining manganese bronze. Valve stems, marine fittings, lever arms, brackets, light-duty gears.
C86500	58 Cu, 0.5 Sn, 39.5 Zn, 1 Fe, 1 Al	490	71	193	28	30	...	100	130	26	C, I, P, S	Machinery parts requiring strength and toughness, lever arms, valve stems, gears.
C86700	58 Cu, 1 Pb, 41 Zn	586	85	290	42	20	B 80	...	155	55	C, S	High strength, free-machining manganese bronze. Valve stems.
C86800	55 Cu, 37 Zn, 3 Ni, 2 Fe, 3 Mn	565	82	262	38	22	...	...	80	30	S	Marine fittings, marine propellers.
Silicon bronzes and silicon brasses												
C87200	89 Cu min, 4 Si	379	55	172	25	30	...	85	...	40	C, I, M, P, S	Bearings, bells, impellers, pump and valve components, marine fittings, corrosion-resistant castings.
C87400	83 Cu, 14 Zn, 3 Si	379	55	165	24	30	...	70	100	50	C, D, I, M, P, S	Bearings, gears, impellers, rocker arms, valve stems, clamps.
C87500	82 Cu, 14 Zn, 4 Si	462	67	207	30	21	...	115	134	50	C, D, I, M, P, S	Bearings, gears, impellers, rocker arms, valve stems, small boat propellers.
C87600	90 Cu, 5.5 Zn, 4.5 Si	455	66	221	32	20	B 76	110	135	40	S	Valve stems.
C87800	82 Cu, 14 Zn, 4 Si	586	85	345	50	25	B 85	...	...	40	D	High-strength, thin-wall die castings; brush holders, lever arms, brackets, clamps, hexagonal nuts.
C87900	65 Cu, 34 Zn, 1 Si	483	70	241	35	25	B 70	...	...	80	D	General purpose die casting alloy having moderate strength.
Tin bronzes												
C90200	93 Cu, 7 Sn	262	38	110	16	30	...	70	...	20	C, S	Bearings and bushings.
C90300	88 Cu, 8 Sn, 4 Zn	310	45	145	21	30	...	70	...	30	C, T, I, P, S	Bearings, bushings, pump impellers, piston rings, valve components, seal rings, steam fittings, gears.
C90500	88 Cu, 10 Sn, 2 Zn	310	45	152	22	25	...	75	...	30	C, T, I, S	Bearings, bushings, pump impellers, piston rings, valve components, steam fittings, gears.
C90700	89 Cu, 11 Sn	303 (379)	44 (55)	152 (207)	22 (30)	20 (16)	...	80 (102)	...	20	C, T, I M, S	Gears, bearings, bushings.
C90800	87 Cu, 12 Sn											
C90900	87 Cu, 13 Sn	276	40	138	20	15	...	90	...	20	C, S	Bearings and bushings.

(continued)

(a) Nominal composition, unless otherwise noted. For seldom-used alloys, only compositions are available. (b) Values for C82700, 84200, 96200, 96300 are minimum, not typical. As-cast values are for sand casting except C93900, continuous cast; and C85800, 87800, 87900, die cast. *Heat treated values, in parentheses, indicate that the alloy responds to heat treatment.* If heat treated values are not shown, the copper or copper alloy does not respond. (c) Free cutting brass = 100. (d) C, centrifugal; T, continuous; D, die; I, investment; M, permanent mold; P, plaster; S, sand. (e) As-heat treated value for C94700, 20; for C94800, 40. (Note: C82000, 82400, 82500, 82600, 82800 are also pressure cast.) **Source**: Copper Development Assn. Inc., New York. (Revised March 1980)

. (continued)

	Nominal composition, %(a)	Tensile strength MPa	Tensile strength ksi	Yield strength MPa	Yield strength ksi	Elongation in 2 in., %	Hardness Rockwell	Hardness Brinell 500 kg	Hardness Brinell 3 000 kg	Machinability rating(c)	Casting types(d)	Typical applications
...zes (continued)												
	85 Cu, 14 Sn, 1 Zn	221	32	172	25	2	...	105	...	20	C, T, I, S	Piston rings and bearings.
	84 Cu, 16 Sn	241	35	172	25	2	...	...	135	10	S	Piston rings, bearings, bushings, bridge plates.
	81 Cu, 19 Sn	241	35	207	30	0.5	...	...	170	10	C, T, M, S	Piston rings, bearings, bushings, bridge plates, bells.
	88 Cu, 10.5 Sn, 1.5 Ni	303 (414)	44 (60)	152 (221)	22 (32)	16 (16)	...	85 (106)	...	20	C, T, M, S	Gears.
	86.5 Cu, 12 Sn, 1.5 Ni	303 (414)	44 (60)	152 (221)	22 (32)	16 (16)	...	85 (106)	...	20	C, T, I, M, S	Gears.
...tin bronzes												
	88 Cu, 6 Sn, 1.5 Pb, 4.5 Zn	276	40	138	20	30	...	65	...	42	C, T, I, M, P, S	Valves, fittings, and pressure-containing parts for use up to 550 °F.
	87 Cu, 8 Sn, 4 Zn	276	40	138	20	25	...	70	...	42	C, T, S	Valves, pipe fittings, and high-pressure steam castings. Superior machinability to C90300.
	88 Cu, 10 Sn, 2 Pb, 2 Zn											
	87 Cu, 11 Sn, 1 Pb, 1 Ni	303	44	138	20	20	...	80	...	30	C, T, M, S	Gears, automotive synchronizer rings.
	87 Cu, 10 Sn, 1 Pb, 2 Zn	303	44	138	20	30	F 78	70	...	40	C, T, S	Bearings, bushings, pump impellers, piston rings, valve components, steam fittings, and gears. Superior machinability to C90500.
I	88 Cu, 10 Sn, 2 Pb	290	42	145	21	20	...	77	...	45	C, T, S	Bearings, bushings, pump impellers, piston rings, valve components, steam fittings, and gears. Superior machinability to C90500.
I	79 Cu, 16 Sn, 5 Pb	276	40	207	30	1	B 80	...	...	70	C, S	Piston rings.
I	84 Cu, 10 Sn, 2.5 Pb, 3.5 Ni	324 (324)	47 (47)	179 (179)	26 (26)	20 (20)	...	80 (80)	...	40	C, T, M, S	Gears, wear plates, guides, cams, parts requiring machinability superior to that of C91600 or 91700.
...aded tin bronzes												
)	83 Cu, 7 Sn, 7 Pb, 3 Zn	241	35	124	18	20	...	65	...	70	C, T, M, S	General-utility bearings and bushings.
)	84 Cu, 8 Sn, 8 Pb	221	32	110	16	20	...	60	...	70	C, T, S	Bearings and bushings.
)	85 Cu, 5 Sn, 9 Pb	221	32	110	16	20	...	60	...	70	C, T, S	Small bearings and bushings, bronze backing for babbitt-lined automotive bearings.
)	80 Cu, 10 Sn, 10 Pb	241	35	124	18	20	...	60	...	80	C, T, M, S	Bearings for high speed and heavy pressures, pumps, impellers, corrosion-resistant applications, pressure tight castings.
)	78 Cu, 7 Sn, 15 Pb	207	30	110	16	18	...	55	...	80	C, T, M, S	Bearings for general service and moderate pressures, pump impellers and bodies for use in acid mine water.
)	79 Cu, 6 Sn, 15 Pb	221	32	152	22	7	...	63	...	80	T	Continuous castings only. Bearings for general service, pump bodies and impellers for mine waters.
0	70.5 Cu, 13.0 Sn, 15.0 Pb, 0.50 Zn, 0.75 Ni, 0.25 Fe, 0.05 P, 0.35 Sb(h)											
0	70.0 Cu, 5.5 Sn, 18.5 Pb, 3.0 Zn, 1.0 others max											
0	70 Cu, 5 Sn, 25 Pb	186	27	90	13	15	...	48	...	80	C, S	High-speed bearings for light loads.
0	81 Cu, 8 Sn, 11 Pb	221	32	110	16	18	...	55	...	80	C, T, S	General-utility alloy for bushings and bearings.

(continued)

Table B. (co

UNS designa-tion(a)

High-leaded
C94500 7:
Nickel-tin b
C94700 8
C94800 8
C94900 8
Aluminum
C95200
C95300
C95400
C95410
C95500
C95600
C95700
C95800
Copper-
C96200
Copper-
C96300
C96400
C96600
C96700
Nickel
C97300
C97400

(a) No
casting e
or coppe
40. (Not

Table B. (continued)

UNS designation(a)	Nominal composition, %(a)	Typical mechanical properties, as cast (heat treated)(b): Tensile strength MPa	Tensile strength ksi	Yield strength MPa	Yield strength ksi	Elongation in 2 in., %	Hardness: Rockwell	Hardness: Brinell 500 kg	Hardness: Brinell 3 000 kg	Machinability rating(c)	Casting types(d)	Typical applications
High-leaded tin bronzes (continued)												
C94500	73 Cu, 7 Sn, 20 Pb	172	25	83	12	12	...	50	...	80	C, S	Locomotive wearing parts, high-speed low-load bearings.
Nickel-tin bronzes												
C94700	88 Cu, 5 Sn, 2 Zn, 5 Ni	345 (586)	50 (85)	159 (414)	23 (60)	35 (10)	...	85	(180)	30 (d)	C, T, I, M, S	Valve stems and bodies, bearings, wear guides, shift forks, feeding mechanisms, circuit breaker parts, gears, piston cylinders, nozzles.
C94800	87 Cu, 5 Sn, 5 Ni	310 (414)	45 (60)	159 (207)	23 (30)	35 (8)	...	80 (120)	...	50 (d)	M, S	Structural castings, gear components, motion translation devices, machinery parts, bearings.
C94900	80 Cu, 5 Sn, 5 Pb, 5 Zn, 5 Ni											
Aluminum bronzes												
C95200	88 Cu, 3 Fe, 9 Al	552	80	186	27	35	...	...	125	50	C, T, M, P, S	Acid-resisting pumps, bearings, gears, valve seats, guides, plungers, pump rods, bushings.
C95300	89 Cu, 1 Fe, 10 Al	517 (586)	75 (85)	186 (290)	27 (42)	25 (15)	...	...	140 (174)	55	C, T, M, P, S	Pickling baskets, nuts, gears, steel mill slippers, marine equipment, welding jaws.
C95400	85 Cu, 4 Fe, 11 Al	586 (724)	85 (105)	241 (372)	35 (54)	18 (8)	...	...	170 (195)	60	C, T, M, P, S	Bearings, gears, worms, bushings, valve seats and guides, pickling hooks.
C95410	85 Cu, 4 Fe, 11 Al, 2 Ni											
C95500	81 Cu, 4 Ni, 4 Fe, 11 Al	689 (827)	100 (120)	303 (469)	44 (68)	12 (10)	...	...	192 (230)	50	C, T, M, P, S	Valve guides and seats in aircraft engines, corrosion-resistant parts, bushings, gears, worms, pickling hooks and baskets, agitators.
C95600	91 Cu, 7 Al, 2 Si	517	75	234	34	18	...	...	140	60	C, T, M, P, S	Cable connectors, terminals, valve stems, marine hardware, gears, worms, pole-line hardware.
C95700	75 Cu, 2 Ni, 3 Fe, 8 Al, 12 Mn	655	95	310	45	26	...	...	180	50	C, T, M, P, S	Propellers, impellers, stator clamp segments, safety tools, welding rods, valves, pump casings.
C95800	81 Cu, 5 Ni, 4 Fe, 9 Al, 1 Mn	655	95	262	38	25	...	...	159	50	C, T, M, P, S	Propeller hubs, blades, and other parts in contact with salt water.
Copper-nickels												
C96200	88.6 Cu, 10 Ni, 1.4 Fe	310	45	172	25	20	...	...	...	10	C, S	Components of items being used for sea water corrosion resistance.
Copper-nickels (continued)												
C96300	79.3 Cu, 20 Ni, 0.7 Fe	517	75	379	55	10	...	150	...	15	C, S	Centrifugally cast tailshaft sleeves.
C96400	69.1 Cu, 30 Ni, 0.9 Fe	469	68	255	37	28	...	...	140	20	C, T, S	Valves, pump bodies, flanges, elbows used for sea-water corrosion resistance.
C96600	68.5 Cu, 30 Ni, 1 Fe, 0.5 Be	(758)	(110)	(482)	(70)	(7)	...	...	(230)	20	C, T, I, M, S	High-strength constructional parts for sea-water corrosion resistance.
C96700	67.6 Cu, 30 Ni, 0.9 Fe, 1.15 Be, 0.15 Zr, 0.15 Ti	(1207)	(175)	(552)	(80)	(10)	C26	...	...	40	I, M, S	Corrosion-resistant molds for plastics, high-strength constructional parts for sea-water use.
Nickel silvers												
C97300	56 Cu, 2 Sn, 10 Pb, 12 Ni, 20 Zn	241	35	117	17	20	...	55	...	70	I, M, S	Hardware fittings, valves and valve trim, statuary, ornamental castings.
C97400	59 Cu, 3 Sn, 5 Pb, 17 Ni, 16 Zn	262	38	117	17	20	...	70	...	60	C, I, S	Valves, hardware, fittings, ornamental castings.

(continued)

(a) Nominal composition, unless otherwise noted. For seldom-used alloys, only compositions are available. (b) Values for C82700, 84200, 96200, 96300 are minimum, not typical. As-cast values are for sand casting except C93900, continuous cast; and C85800, 87800, 87900, die cast. Heat treated values, in parentheses, indicate that the alloy responds to heat treatment. If heat treated values are not shown, the copper or copper alloy does not respond. (c) Free cutting brass = 100. (d) C, centrifugal; T, continuous; D, die; I, investment; M, permanent mold; P, plaster; S, sand. (e) As-heat treated value for C94700, 20; for C94800, 40. (Note: C82000, 82400, 82500, 82600, 82800 are also pressure cast.) **Source:** Copper Development Assn. Inc., New York. (Revised March 1980)

Table 8. (continued)

UNS designation(a)	Nominal composition, %(a)	Typical mechanical properties, as cast (heat treated)(b): Tensile strength, MPa	Tensile strength, ksi	Yield strength, MPa	Yield strength, ksi	Elongation in 2 in., %	Hardness: Rockwell	Hardness: Brinell 500 kg	Hardness: Brinell 3 000 kg	Machinability rating(c)	Casting types(d)	Typical applications
Nickel silvers (continued)												
C97600	64 Cu, 4 Sn, 4 Pb, 20 Ni, 8 Zn	310	45	165	24	20	...	80	...	70	C, I, S	Marine castings, sanitary fittings, ornamental hardware, valves, pumps.
C97800	66 Cu, 5 Sn, 2 Pb, 25 Ni, 2 Zn	379	55	207	30	15	...	...	130	60	I, M, S	Ornamental and sanitary castings, valves and valve seats, musical instrument components.
Leaded coppers												
C98200	76.0 Cu, 24.0 Pb											
C98400	70.5 Cu, 28.5 Pb, 1.5 Ag											
C98600	65.0 Cu, 35.0 Pb, 1.5 Ag											
C98800	59.5 Cu, 40.0 Pb, 5.5 Ag											
Special alloys												
C99300	71.8 Cu, 15 Ni, 0.7 Fe, 11 Al, 1.5 Co	655	95	379	55	2	...	200	20	20	T, S	Glass making molds, plate glass rolls, marine hardware.
C99400	90.4 Cu, 2.2 Ni, 2.0 Fe, 1.2 Al, 1.2 Si, 3.0 Zn	455 (545)	66 (79)	234 (372)	34 (54)	25	...	...	125 (170)	50	C, T, I, S	Valve stems, marine and other uses requiring resistance to dezincification and dealuminification, propeller wheels, electrical parts, mining equipment gears.
C99500	87.9 Cu, 4.5 Ni, 4.0 Fe, 1.2 Al, 1.2 Si, 1.2 Zn	483	70	276	40	12	...	145	50	50	C, T, S	Same as C99400, but where higher yield strength is required.
C99600	58 Cu, 2 Al, 40 Mn	558 (558)	81 (81)	248 (303)	36 (44)	34 (27)	B 72	...	130	...	C, T, M, S	Damping alloys to reduce noise and vibration.
C99700	56.5 Cu, 1 Al, 1.5 Pb, 12 Mn, 5 Ni, 24 Zn	379	55	172	25	25	...	...	110	80	C, D, I, M, P, S	
C99750	58 Cu, 1 Al, 1 Pb, 20 Mn, 20 Zn	448 (517)	65 (75)	221 (276)	32 (40)	30 (20)	B 77 (B 82)	110 (119)	...	...	D, I, M, P, S	

(a) Nominal composition, unless otherwise noted. For seldom-used alloys, only compositions are available. (b) Values for C82700, 84200, 96200, 96300 are minimum, not typical. As-cast values are for sand casting except C93900, continuous cast; and C85800, 87800, 87900, die cast. Heat treated values, in parentheses, indicate that the alloy responds to heat treatment. If heat treated values are not shown, the copper or copper alloy does not respond. (c) Free cutting brass = 100. (d) C, centrifugal; T, continuous; D, die; I, investment; M, permanent mold; P, plaster; S, sand. (e) As-heat treated value for C94700, 20; for C94800, 40. (Note: C82000, 82400, 82500, 82600, 82800 are also pressure cast.) **Source:** Copper Development Assn. Inc., New York. (Revised March 1980)

Table 1. Standard color-controlled wrought copper alloys

UNS number	Common name	Color description
C11000	Electrolytic tough pitch copper	Soft pink
C21000	Gilding, 95%	Red brown
C22000	Commercial bronze, 90%	Bronze gold
C23000	Red brass, 85%	Tan gold
C26000	Cartridge brass, 70%	Green gold
C28000	Muntz metal, 60%	Light brown gold
C63800	Aluminum bronze	Gold
C65500	High-silicon bronze, A	Lavender-brown
C70600	Copper-nickel, 10%	Soft lavender
C74500	Nickel silver, 65-10	Gray white
C75200	Nickel silver, 65-18	Silver

Copper and copper alloys are readily assembled by any of the various mechanical or bonding processes commonly used to join metal components. Crimping, staking, riveting and bolting are mechanical means of maintaining joint integrity. Soldering, brazing and welding are the most widely used processes for bonding copper metals. Selection of the best joining process is governed by service requirements, joint configuration, thickness of the components, and alloy composition(s). These factors are reviewed in Section 30 ("Joining") of this Handbook, and discussed in detail in Metals Handbook, 9th Edition, Volume 6.

MECHANICAL WORKING

High-purity copper is a very soft metal. It is softest in its undeformed, single-crystal form, requiring a shear stress of only 3.9 MPa (570 psi) on {111} crystal planes for slip. Annealed tough pitch copper is almost as soft as high-purity copper, but many of the copper alloys are much harder and stiffer, even in annealed tempers.

Copper is easily deformed cold. Once flow has been started it takes little energy to continue, and thus extremely large changes in shape or reductions in section are possible in a single pass. The only limitation appears to be the ability to design and build the necessary tools. Very heavy reductions are possible, especially with continuous flow. Rolling reductions of more than 90% in one pass are used for rolling strip.

Copper and many of its alloys also respond well to sequential cold working. Tandem rolling and gang-die drawing are common. Some copper alloys work harden rapidly, so there is a limit to the number of operations that can be performed before annealing to resoften the metal.

Copper can be cold reduced almost limitlessly without annealing but heavy deformation (more than about 80 to 90%) may induce preferred crystal orientation, or texturing. Textured metal has different properties in different directions, which is undesirable for some applications.

Cold working increases both tensile strength and yield strength, but the effect is more pronounced on the latter. For most coppers and copper alloys, the tensile strength of the hardest cold worked temper is approximately twice the tensile strength of the annealed temper. For the same alloys, the yield strength of the hardest cold worked temper may be as much as five to six times that of the annealed temper.

Hardness as a measure of temper is inaccurate—the relation between hardness and strength is different for different alloys. Usually, hardness and strength for a given alloy can be correlated only over a rather narrow range of conditions. Also, the range of correlation is often different for different methods of hardness determination.

Hot Working. Not all shaping is confined to cold deformation. Hot working is commonly used for alloys that remain ductile above the recrystallization temperature. Hot working permits more extensive changes in shape than cold working, so that a single operation can replace a sequence of forming and annealing operations. To avoid preferred orientation and textures, as well as to achieve processing economy, copper and many of its alloys are hot worked to nearly finished size. Hot working reduces as-cast grain size from about 1 to 10 mm to about 0.1 mm or less, and yields a soft, texture-free structure suitable for cold finishing.

Some hot working operations may produce strengths that exceed that of the annealed temper. However, property control by hot working is very difficult, and is rarely attempted.

HEAT TREATING

Work hardened metal can be returned to a soft state by heating, or annealing. During the annealing of simple, single-phase alloys, deformed and highly stressed crystals are transformed into unstressed crystals by recovery, recrystallization and grain growth. In severely deformed metal, recrystallization occurs at lower temperatures than in lightly deformed metal. Also, the grains are smaller and more uniform in size when severely deformed metal is recrystallized.

Grain size can be controlled by proper selection of cold working and annealing practices. Large amounts of prior cold work, fast heating to annealing temperature and short annealing times favor fine grain sizes. Larger grain sizes are normally produced by a combination of limited deformation and long annealing times. In normal commercial practice, annealed grain sizes are controlled about a median value in the range 0.01 to 0.10 mm.

Variations in annealed grain size produce variations in hardness and other mechanical properties that are smaller than the variations that occur in cold worked material, but by no means negligible. Fine grain sizes often are required to enhance end-product characteristics such as load-carrying capacity, fatigue resistance, resistance to stress-corrosion cracking, and surface quality for polishing or buffing of either annealed or cold formed parts.

Heat treating processes may also be applied to copper and copper alloys to achieve homogenization, stress relieving, solutionizing, precipitation hardening, and quench hardening and tempering. These aspects are referred to throughout this section, and are reviewed in more detail in Section 28 ("Heat Treating") in this Handbook.

TEMPER DESIGNATIONS

The temper designations for wrought copper and copper alloys were traditionally specified on the basis of cold reduction imparted by rolling or drawing. This scheme related the nominal temper designations to the amount of reduction stated in Browne & Sharpe (B & S) gage numbers for rolled sheet and drawn wire. Heat-treatable alloys and product forms such as rod, tube, extrusions and castings, were not readily described by this system. For simple, single-phase alloys the annealed temper is generally specified by the recrystallized grain size. Grain-stabilized alloys which resist recrystallization at high annealing temperatures are, however, frequently supplied in terms "light annealed," "soft annealed," or "annealed to temper." The Standard Recommended Practice ASTM B60, "Temper Designations for Copper and Copper Alloys—Wrought and Cast," was recently developed to unambiguously cover all alloy types and product forms currently in widespread use.

ELECTRICAL COPPERS

Commercially pure copper is represented by UNS numbers C10100 to C13000. The various coppers within this group have different degrees of purity, and therefore different characteristics. Fire-refined tough pitch copper C12500 is made by deoxidizing anode copper until the oxygen content has been lowered to a value of 0.02 to 0.04%. Both the traditional method of "poling" (or "pitching") a bath of molten anode copper and the more modern method of deoxidizing with hydrocarbons produce metal with essentially the same high ductility and excellent electrical conductivity. Fire-refined tough pitch copper contains a small amount of residual sulfur, normally 10 to 30 ppm, and a somewhat larger amount of cuprous oxide, normally 500 to 3000 ppm.

Electrolytic tough pitch copper C11000 is made from cathode copper—that is, copper that has been refined electrolytically. C11000 is the most common of all the electrical coppers. It has high electrical conductivity, in excess of 100% IACS. It has the same oxygen content as C12500, but contains less than 50 ppm total metallic impurities (including sulfur).

Oxygen-free coppers C10100 and C10200 are made by induction melting prime-quality cathode copper under nonoxidizing conditions produced by a granulated graphite bath covering and a protective reducing atmosphere that is low in hydrogen. Oxygen-free coppers are particularly suitable for applications requiring high conductivity coupled with exceptional ductility, low gas permeability, freedom from hydrogen embrittlement or low out-gassing tendency.

If resistance to softening at slightly elevated temperature is required, C11100 is often specified. This copper contains a small amount of cadmium, which raises the temperature at which recovery and recrystallization occur. Oxygen-free copper, electrolytic tough pitch copper and fire-refined tough pitch copper are available as silver-bearing coppers having specific minimum silver contents. The silver, which may be present as an impurity in anode copper or may be intentionally alloyed to molten cathode copper, also imparts resistance to softening to cold worked metal. Silver-bearing coppers and cadmium-bearing coppers are used for applications such as automotive radiators and electrical conductors that must operate at temperatures above about 200 °C (400 °F).

If good machinability is required, C14500 (tellurium-bearing copper) or C14700 (sulfur-bearing copper) can be selected. As might be expected, machinability is gained at a modest sacrifice in electrical conductivity.

Addition of small amounts of elements such as silver, cadmium, iron, cobalt and zirconium to deoxidized copper imparts resistance to softening at times and temperatures encountered in soldering operations, such as those used to join components of automobile and truck radiators, and in semiconductor packaging operations.

The thermal and electrical conductivities and the room-temperature mechanical properties are unaffected by small additions of these elements. However, the cadmium coppers and zirconium coppers work harden at higher rates than either silver-bearing copper or electrolytic tough pitch copper, as shown in Fig. 1.

Cold rolled silver-bearing copper is used extensively for automobile-radiator fins. Usually such strip is only moderately cold rolled, because heavy cold rolling makes silver-bearing copper more likely to soften during soldering or baking operations. Some manufacturers prefer cadmium copper C14300, because it can be severely cold rolled without making it susceptible to softening during soldering. Figure 2 illustrates the softening characteristics of C14300 and C11400 as measured for several temperatures and two tempers. As illustrated in Fig. 2(b), C14300 cold rolled to a tensile strength of 440 MPa (64 ksi) retains 91% of its strength after a typical core bake of 3 min at 345 °C (650 °F). Silver-bearing copper C11400 given the same cold reduction retains only 60% of its tensile strength after the same baking schedule.

Another application in which softening resistance is of paramount importance is leadframes for electronic devices, such as plastic dual in-line packages. During packaging and assembly, leadframes may be subjected to temperatures up to 350 °C for several minutes and up to 500 °C for several seconds. It is most desirable that the leads maintain good strength, because they are pressed into socket connectors, often by automated assembly machines, and softened leads collapse, causing spoilage.

Alloy C15100 (copper-zirconium), alloy C15500 (copper-silver-magnesium-phosphorus), alloy C19400 (copper-iron-phosphorus-zinc), and alloy C19500 (copper-iron-cobalt-tin-phosphorus) are popular alloys for these applications because they have good conductivity, good strength and good softening resistance. Figures 3 and 4 compare the softening resistance of these alloys with electrolytic copper C11000.

COPPER ALLOYS

The most common way to catalog copper and its alloys is to divide them into six families: coppers, dilute copper alloys, brasses, bronzes, copper nickels and nickel silvers. The first family, the coppers, is essentially commercially pure copper, which ordinarily is soft and ductile and contains less than about 0.7% total impurities. The dilute copper alloys contain small amounts of various alloying elements that modify one or more of the basic properties of copper. Each of the remaining families contains one of five major alloying elements as its primary alloying ingredient (see Table 2). All five of the major alloying elements have room-temperature solid solubility in copper of at least 8 at. %.

Solid-Solution Alloys. The most compatible alloying elements with copper are those that form solid-solution fields. These include all elements forming useful alloy families (see Table 2) plus manganese. Hardening in these systems is great enough to make useful objects without encountering brittleness associated with second phases or compounds.

Cartridge brass is typical of this group, consisting of 30% Zn in copper and exhibiting no beta phase except an occasional small amount due

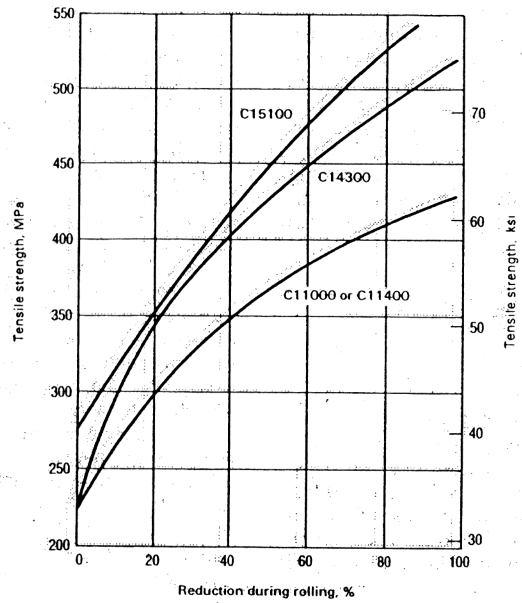


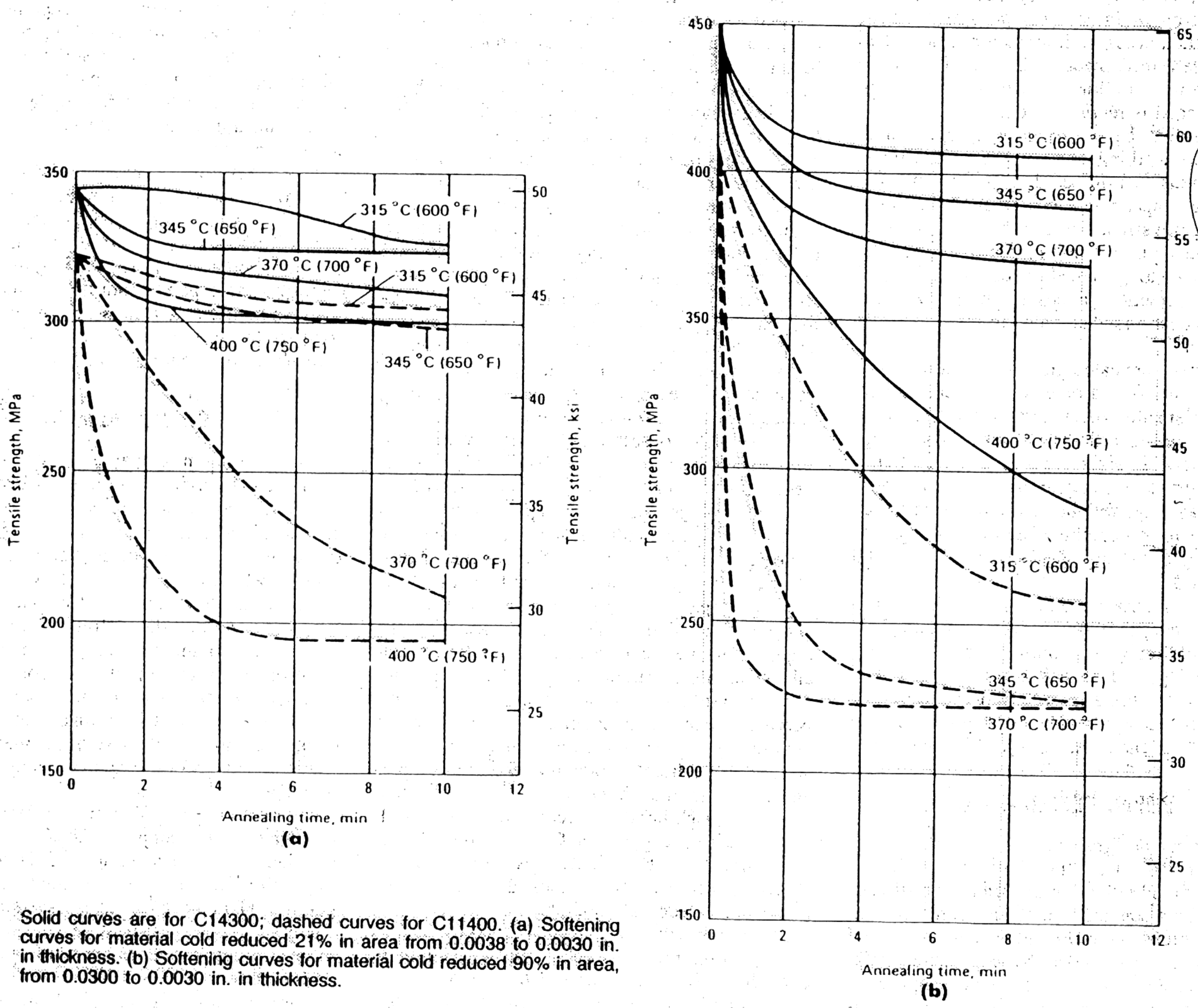
Fig. 1. Tensile strength versus reduction during rolling for cadmium copper (C14300), zirconium copper (C15100) and tough pitch copper (C11000)

to segregation, which normally disappears after the first anneal. Provided that there are no tramp elements, such as iron, cold working and grain growth relationships are easily reproduced in practice.

Modified Solid-Solution Alloys. The solid-solution-strengthened alloys of copper are noted for their strength and formability. Since they are single-phase and are not transformed by heating or cooling, their maximum strength is developed by cold working, such as cold rolling or cold drawing. Formability is reduced in proportion to the amount of cold work applied.

Modifications of some solid-solution alloys were developed, by adding elements which react to form dispersions of intermetallic particles. These dispersions have a grain refining and strengthening effect. As a result, higher strengths can be produced with less cold working, and consequently better formability at higher strength results. Since these modifications do not require large amounts of costly elements, the gains are reasonably economical.

Alloy C63800 (Cu 95, Al 2.8, Si 1.8, Co 0.4) is a high-strength alloy with an annealed tensile strength of 82 ksi (570 MPa) nominal, and nominal tensile strengths of 96 to 130 ksi (660 to 900 MPa) for the standard rolled tempers. Cobalt



Solid curves are for C14300; dashed curves for C11400. (a) Softening curves for material cold reduced 21% in area from 0.0038 to 0.0030 in. in thickness. (b) Softening curves for material cold reduced 90% in area, from 0.0300 to 0.0030 in. in thickness.

Fig. 2. Softening characteristics of cadmium-bearing copper and silver-bearing tough pitch copper

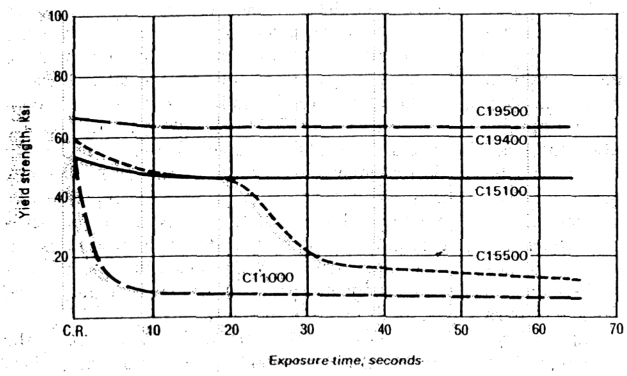


Fig. 3. Softening resistance of leadframe materials at the upper limit of temperature used (500 °C)

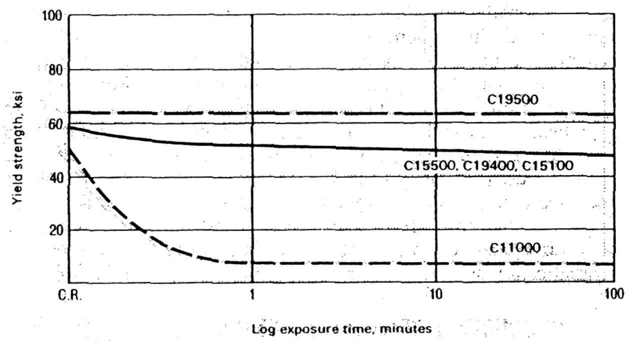


Fig. 4. Softening resistance of leadframe materials at an intermediate temperature level (350 °C)

Table 2. Classification of copper and copper alloys

Family	Principal alloying element	Solid solubility, at. %(a)	UNS numbers(b)
Coppers, high-copper alloys	(c)	...	C10000
Brasses	Zn	37	C20000, C30000, C40000, C66400 to C69800
Phosphor bronzes	Sn	9	C50000
Aluminum bronzes	Al	19	C60600 to C64200
Silicon bronzes	Si	8	C64700 to C66100
Copper nickels, nickel silvers	Ni	100	C70000

(a) At 20 °C (68 °F). (b) Wrought alloys. (c) Various elements having less than 8 at. % solid solubility at 20 °C (68 °F).

provides the dispersion of strengthening intermetallic particles.

Alloy C68800 (Cu 73.5, Zn 22.7, Al 3.4, Co 0.4) is a high-strength modified aluminum brass. Its bend formability parallel to the direction of rolling is outstanding relative to its strength. It also owes some of its unique properties to a dispersion of intermetallic particles occasioned by the presence of cobalt. Its strength range is essentially the same as that of alloy C63800.

Alloy C65400 (Cu 95.44, Si 3, Sn 1.5, Cr 0.06) is a very-high-strength alloy, which has excellent stress-relaxation resistance at temperatures up to 105 °C. Its nominal strength range in rolled tempers is 82 to 137 ksi (570 to 945 MPa). Electrical contact and connector springs are heat treated at 200 to 250 °C for one hour to stabilize internal stresses and maximize stress-relaxation resistance.

Alloy C66400 (Cu 86.5, Zn 11.5, Fe 1.5, Co 0.5) is a low-zinc brass modified by the addition of iron and cobalt. The dispersion of intermetallic particles resulting from these additions strengthens the alloy. At the same time, conductivity is only moderately reduced, and resistance to stress-corrosion cracking is very high. A high-zinc brass of the same strength and conductivity would be subject to stress-corrosion cracking unless plated for protection.

There are probably other modified solid-solution-strengthened alloys described in the literature of the brass-mill industries. The above should serve as examples of this additional class of copper alloys which is expanding through the development efforts of the producers of brass mill products throughout the world.

Age-Hardenable Alloys. Age hardening produces very high strengths, but is limited to those few copper alloys in which the solubility of the alloying element decreases sharply with decreasing temperature. The beryllium coppers can be considered typical of the age-hardenable copper alloys.

Wrought beryllium coppers can be precipitation hardened to the highest strength levels attainable in copper-base alloys. There are two commercially significant alloy families employing two ranges of beryllium with additions of cobalt or nickel. The so-called red alloys contain beryllium at levels ranging from approximately 0.2 to 0.7 wt % with additions of nickel or cobalt totaling 1.4 to 2.7 wt % depending on the alloy—e.g., C17500, C17510. These low-beryllium alloys achieve relatively high conductivity (e.g., 50% IACS) and retain the pink luster of other low-alloy coppers. The "red" alloys achieve yield strengths ranging from about 25 to 80 ksi (170 to 550 MPa), unheat treated, to greater than 130 ksi (895 MPa) after precipitation hardening, depending on degree of cold work.

The more highly beryllium-alloyed systems can contain from 1.6 to 2.0 wt % beryllium, and about 0.25 wt % cobalt—e.g., C17000 and C17200. These alloys are frequently termed the "gold" alloys due to the shiny luster imparted by the substantial amount of beryllium present, about 12 at. %. The "gold" alloys are the high-strength beryllium coppers and can attain yield strengths ranging from approximately 30 to 100 ksi (205 to 690 MPa) in the age-hardenable condition to above 200 ksi (1380 MPa) after aging. The conductivity of the "gold" alloys is lower than that of the "red" alloy family by virtue of the high beryllium content. However, conductivity ranging from about 20% to higher than 30% IACS is obtained in wrought products depending on cold work amount and heat treatment schedule. For enhanced machinability in rod and wire, lead is added (e.g., C17300).

Other age-hardenable alloys include C15000; C15100 (zirconium copper); C18200, C18400 and C18500 (chromium coppers); C19000 and C19100 (copper-nickel-phosphorus alloys); and C64700 (copper-nickel-silicon alloy).

Some age-hardening alloys have different desirable characteristics, such as high strength combined with better electrical conductivity than the beryllium coppers.

C71900 (copper-nickel-tin alloy) and other, similar alloys can be hardened by spinodal decomposition. By combining cold working with hot working these alloys can achieve high strengths, equivalent of the hardenable beryllium coppers. These alloys are unique in that their forming characteristics are isotropic, and thus do not reflect the directionality normally associated with wrought alloys.

Other Alloys. Certain aluminum bronzes, most notably those containing more than about 9% Al, can be hardened by quenching from above a critical temperature. The hardening process is a martensitic-type process, similar to the martensitic hardening that occurs when iron-carbon alloys are quenched. Mechanical properties of aluminum bronzes can be varied somewhat by temper annealing after quenching or by using an interrupted quench instead of a standard quench.

Aluminum bronzes alloyed with nickel or zinc utilize reversible martensitic transformations to provide "shape memory" effects.

Insoluble Alloying Elements. Lead, tellurium and selenium are added to copper and its alloys to improve machinability. They, along with bismuth, make hot rolling and hot forming nearly impossible and severely limit the useful range of cold working.

An exception here are the high-zinc brasses, which become fully beta phase at high temperature. The beta phase can dissolve lead—thus avoiding a liquid grain-boundary phase at hot forging or extrusion temperatures. Most free-cutting brass rod is made by beta extrusion. C37700, one of the leaded high-zinc brasses, is so readily hot forged that it is the standard alloy against which the forgeability of all copper alloys is judged.

DEOXIDIZERS

Li, Na, Be, Mg, B, Al, C, Si and P can be used to deoxidize copper. Ca, Mn and Zn can sometimes be considered deoxidizers, although they normally fulfill different roles.

The first requirement of a deoxidizer is that it have an affinity for oxygen in molten copper. Probably the second most important requirement is that it be relatively inexpensive compared to copper and any other additions. Thus, although zinc normally functions as a solid-solution strengthener, it is sometimes added in small amounts to function as a deoxidizer, because it has high affinity for oxygen and is relatively low in cost. In tin bronze, phosphorus has traditionally been the deoxidizer, hence the name "phosphor bronzes" for these alloys. Silicon instead of phosphorus is the deoxidizer for chromium coppers because phosphorus severely reduces electrical conductivity. Most deoxidizers contribute to hardness and other qualities, which often makes classification as a deoxidizer indistinct.

PRODUCTION OF COPPER METALS

The copper industry in the United States, broadly speaking, is composed of two segments: producers (mining, smelting and refining companies) and fabricators (wire mills, brass mills, foundries and powder plants). The end products of copper producers, the most important of which is refined cathode copper, are sold almost entirely to copper fabricators. The end products of copper fabricators may be generally described as mill products, and consist of wire and cable, sheet, strip, plate, rod, bar, mechanical wire, tubing, forgings, extrusions and castings. These products are sold to a wide variety of industrial users. Certain mill products—chiefly wire, cable and most tubular products—are used without further metalworking. On the other hand, most flat-rolled products, rod, bar, mechanical wire, forgings and castings go through multiple metalworking, machining, finishing and/or assembly operations before emerging as finished products.

Copper Producers. Figure 5 is a simplified flow diagram of the copper industry. The box at upper left represents mining companies which remove vast quantities of low-grade material, mostly from open-pit mines, in order to extract copper from the earth's crust. Approximately 2.5 t (tonnes) of overburden must be removed along with each tonne of copper ore. (The ratio of overburden to ore is sometimes as high as 3 to 1.) The ore itself averages only about 0.5% copper. The importance of efficient materials handling by copper producers is dramatized by the fact that, in the U.S., more tonnage must be moved in mining copper than in mining all other metals combined.

Copper ore normally is crushed, ground and concentrated (usually by flotation) to produce a beneficiated ore containing 20 to 25% copper. Most copper ores are sulfide ores, composed chiefly of copper sulfide but also containing a significant amount of iron sulfide as an impurity plus recoverable trace amounts of silver and gold. Ore concentrates most often are reduced to the metallic state by a pyrometallurgical process. Traditionally, the concentrated ore is smelted in a reverberatory furnace to produce a copper sulfide–iron sulfide matte, and the matte is oxidized in a converter to convert the FeS to iron oxides, which separate out in a slag, and to burn off the sulfur from the CuS, leaving blister copper, which contains at least 98.5% copper. Fire refining of blister copper removes most of the oxygen and other impurities, leaving a product at least 99.5% pure, which is cast into anodes. Finally, most anode copper is electrolytically refined, usually to a purity of at least 99.95%. Gold and silver slimes are a byproduct of electrorefining, which helps defray the cost of the electrical energy used to refine the anode copper. The resulting cathodes are the normal end product of the producer companies, and are a common item of commerce. In recent years many producers have installed continuous cast rod mills, which convert cathode copper to wire rod. Primary producers may also convert the cathode to cakes or billets for sale to brass mills. The consumption of refined copper (mostly cathodes) in the United States was about 1.8 million t (3.9 billion lb) in 1983, about 19% of the world total of 9.3 million t (20.6 billion lb).

Hydrometallurgical processing is an alternative to pyrometallurgical processing that has more recently become commercially important, particularly for nonsulfide ores (oxides, silicates or carbonates). Waste dump leaching followed by cementation is one common hydrometallurgical process, although others such as vat leaching or agitation leaching, both of which require richer ores, have also become important. In dump leaching, water is percolated through waste dumps formed from rejected materials from mining (overburden) too low in copper to justify pyrometallurgical processing. The process leaches out (dissolves) some of the remaining copper. The copper in the pregnant leach liquor may be recovered by a process called cementation; in this process, the liquor is passed over scrap steel, upon which the copper precipitates from solution. Impure copper precipitates then are sent to a converter or smelting furnace for pyrometallurgical refining.

The liquor from leaching operations can be concentrated and purified by solvent extraction to produce an electrolyte suitable for electrowinning. In electrowinning, copper is extracted electrolytically from the electrolyte much as anode copper is electrorefined. The chief difference is that the copper is present in an enriched electrolyte instead of as impure copper anodes. With modern techniques electrowon copper is essentially equal in quality to that produced by electrolytic refining.

The box at lower left in Fig. 5 represents the portion of copper supply provided by scrap. This portion is substantial: nearly half of the copper consumed in the United States each year is derived from recycled scrap. (Runaround scrap, which is scrap recycled within a particular plant, is not included in these statistics.) About 30 to 40% of the scrap is fed into the smelting or refining stream and thus quickly loses its identity. The remainder is consumed directly by brass mills, by ingot makers (whose main function is to melt scrap into alloy ingot for use by foundries), by foundries themselves, and by others, such as the chemical, aluminum and steel industries.

The box labeled "Copper consumed" in Fig. 5 represents the total tonnage of refined copper plus the copper content of scrap consumed directly by fabricator companies. To this sum are added the amounts of various alloying elements used in producing copper alloys, and the alloy content of the directly consumed scrap, to obtain "Metal consumed."

Copper Fabricators. The four classes of copper fabricators together consume about 97% of the total output of the copper producers. Other industries, such as the steel, aluminum and chemical industries, consume the remaining 3%. As shown in Fig. 5, wire rod mills and brass mills are roughly equal in output: on the average, each produces 40 to 50% of total mill products. Foundries account for roughly 8% of the fabricated mill products, and powder plants about 1%.

Wire mills make copper wire and cable. The starting material is refined copper cathodes. Tra-

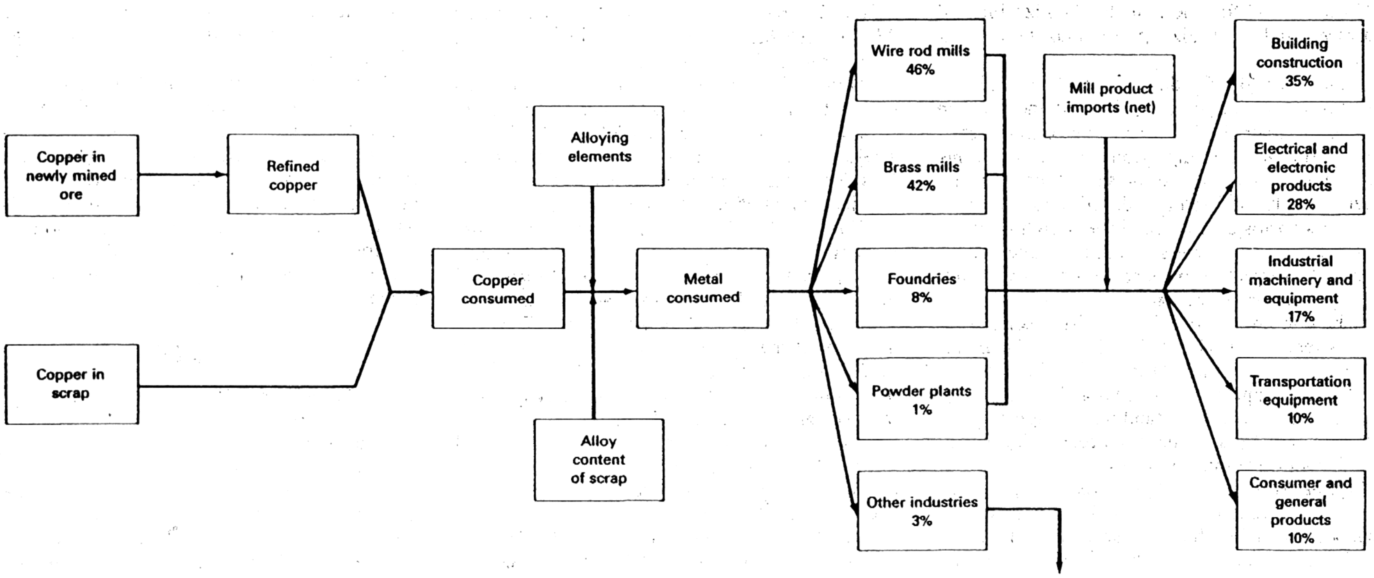


Fig. 5. Flow of copper from mine production and scrap collection through end use (percentages based on 1983 data)

Table 3. Major wrought copper and copper-base alloy systems

Copper or copper alloy group	UNS numbers	Approximate U.S. shipments in 1983, millions of pounds	Remarks
Wire Mill Shipments			
Coppers	C10000 to C15900	2390	C11000 is predominant material.
Brass Mill Shipments			
Coppers	C10000 to C15900, C16000 to C16900, C18000 to C18900	955	Includes modified coppers, cadmium copper, and chromium coppers.
Common brasses	C20000 to C29900	475	Of this, 89% is sheet, strip and plate.
Leaded brasses	C30000 to C39900	684	Of this, 95% is rod.
Tin bronzes	C50000 to C53900	36	Unleaded only; also known as phosphor bronzes.
Aluminum bronzes, silicon bronzes and manganese bronzes	C60000 to C68400	20	
Copper nickels	C70000 to C72900	81	
Nickel silvers	C73000 to C79900	11	
Others	C17000 to C17900, C19000 to C19900, C40000 to C49900, C54000 to C54900, C68500 to C69900	110	Includes beryllium coppers, copper-iron alloys, tin brasses, leaded tin bronzes, aluminum brasses, and silicon brasses.

ditionally, cathodes have been melted and then cast into wirebars, followed by hot rolling to wire rod. More recently, continuous casting has been chosen for new plants or for major renovation of older plants. Facilities for producing wire rod may be integrated into a refinery, be a separate operation or be integrated into a wiredrawing plant.

Wire rod is cold drawn to final dimensions through a series of dies. The cold drawn wire may or may not be annealed, depending on requirements. Wire may be used as a single conductor, but more often is fabricated into a stranded conductor; most copper wire is insulated. Various types of electrical cable are produced from individual conductors, each of which may be stranded and/or insulated separately before being incorporated into the finished cable.

Brass mills melt and alloy feedstock to make sheet, strip, plate, tubing, rod, bar, mechanical wire, forgings and extrusions. Of the feedstock used by brass mills, about half is scrap and about half is virgin metal. Fabricating processes such as hot rolling, cold rolling, extrusion and drawing are employed to convert the melted and cast feedstock into wrought mill products. Some brass mills are secondary mills that do not melt and cast the feedstock they fabricate into mill products, but merely reroll strip to thinner gages or redraw tubing or mechanical wire to smaller dimensions.

About 40% of the output of U.S. brass mills is unalloyed copper and high-copper alloys—chiefly in such forms as plumbing and air-conditioning tube, busbar and roofing sheet. Copper alloys comprise the remaining 60%, and are distributed approximately as indicated in Table 3. The several varieties of leaded brass rod (which exhibits outstanding machinability and good corrosion resistance) and unleaded brass strip (which has high strength, corrosion resistance, excellent formability and good electrical properties) constitute about three-fourths of the total tonnage of wrought copper alloys shipped from U.S. brass mills. Other alloy types of commercial significance include tin bronzes, which are noted for their excellent cold forming behavior; tin brasses, known for outstanding corrosion resistance; copper nickels, which are particularly resistant to seawater; nickel silvers, which combine a silvery appearance with good formability and corrosion resistance; beryllium coppers, whch can provide outstanding strength when hardened; and aluminum bronzes, which have high strength along with good resistance to both chemical attack and mechanical abrasion.

Foundries use prealloyed ingot, scrap and virgin metal as raw materials. Their chief products are shape castings for many different industrial and consumer goods, the most important of which are plumbing products, industrial valves and bearings.

Powder plants produce powder metallurgy parts, chiefly sintered bronze bushings.

APPLICATIONS OF COPPER AND ITS ALLOYS

The five major market categories at far right in Fig. 5 constitute the chief customer industries of the copper fabricators. Of the chief customer industries, the largest is building construction, which purchases large quantities of electrical wire, tube and parts for electrical, plumbing, heating and air-conditioning systems, and for builders' hardware and architectural uses. Next are electrical and electronic products, including those for telecommunications, nonconsumer electronics, wiring devices, electric motors and power utilities. The industrial machinery and equipment category includes various types of in-plant equipment (with a large usage of motors and bearings, industrial valves and fittings); industrial, chemical and marine heat exchangers; and various other types of heavy equipment and off-road vehicles. Transportation equipment includes on-road vehicles, railroad equipment and aircraft parts; automobile radiators and wiring harnesses are two of the most important products in this category. Finally, consumer and general products include electrical appliances, fasteners and closures, ordnance, consumer electronics, coinage, jewelry and various household products.

About 90% of the total tonnage of wrought copper alloys sold by U.S. fabricator plants is represented by the 15 application categories listed in Table 4. In the three categories that account for the greatest tonnages—telecommunications, automotive, and plumbing and heating—a continuing effort has been made to conserve materials and to manufacture products more efficiently. Most often this effort involves redesign of components, and is accomplished through reductions in material gage. In some instances, such as small motors for appliances and other devices, there is a trend toward using more copper for each unit to increase the energy efficiency of the end product. In the wiring of buildings, copper's usage intensity has also increased due to an ever-increasing use of electricity.

Table 4 also shows the mill products used in each application category, plus the property or properties that dictate the use of copper or its alloys. High electrical conductivity is a major reason for choosing copper in ten of the sixteen categories, corrosion resistance a major reason in eight, ease of fabrication (including good machinability and good formability) in eight (although ease of fabrication is a significant factor in all sixteen categories), and good heat-transfer properties in five.

Table 4. Major end-use applications for copper and copper alloys in the United States—1983

Application	% of total	Principal mill products	Principal reason(s) for using copper
Plumbing and heating	13.8	Copper tube, brass rod, castings	Corrosion resistance, machinability, heat transfer
Building wiring	12.8	Copper wire	Electrical properties
Telecommunications	10.5	Copper wire	Electrical properties
In-plant equipment	9.7	All	Corrosion resistance, wear resistance, electrical properties, heat transfer, machinability
Automotive: automobiles, trucks and buses	9.4	Brass and copper strip, copper wire	Heat transfer, electrical properties, corrosion resistance
Power utilities	7.2	Copper wire and bar	Electrical properties
Air conditioning and commercial refrigeration	6.5	Copper tube and wire	Heat transfer, formability, electrical properties
Electronics	5.9	Alloy strip, copper wire	Electrical properties, formability
Industrial valves and fittings	3.8	Brass rod, castings	Corrosion resistance, machinability
Lighting and wiring devices	2.8	Alloy strip, copper wire	Electrical properties
Appliances and extension cords	2.7	Copper wire and tube	Electrical properties, heat transfer
Military and commercial ordnance	2.0	Brass strip and tube	Ease of fabrication
Builders' hardware	1.6	Brass rod and strip	Corrosion resistance, formability, aesthetics
Fasteners and closures	1.2	Brass wire and strip	Corrosion resistance, formability, machinability
Coinage	1.1	Alloy and copper strip	Ease of fabrication, corrosion resistance, electrical properties, aesthetics
Other	9.0	All	Various

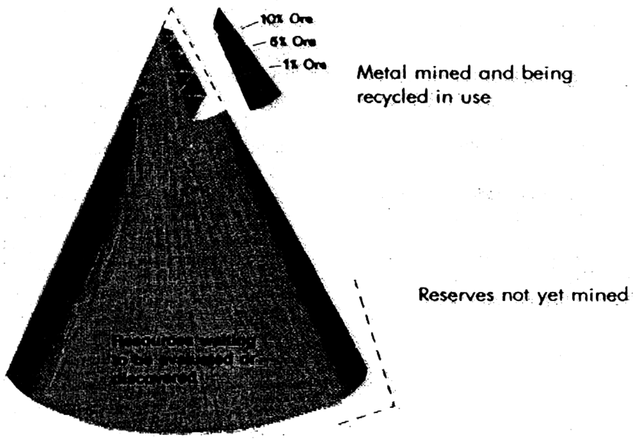
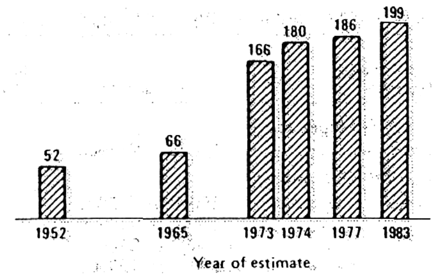


Fig. 6. United States copper reserves and resources



U.S. Bureau of Mines estimates in billions of pounds of copper content

Fig. 7. United States copper reserves

COPPER SUPPLY AND RESOURCES

All of the copper in the earth's crust is represented in Fig. 6 as a hypothetical "cone of resources." In this representation, the richest ores are at the tip of the cone. Up to now, man has discovered, extracted and used only a *slice* off the tip of the cone. Behind that slice are the known copper reserves that have been discovered but not yet mined. Below the known reserves are the rest of the earth's resources, only a fraction of which are known to be economically recoverable using current methods of extractive metallurgy. In 1983, the U.S. Bureau of Mines estimated that there were 199 billion lb of known copper reserves in the United States, plus another 634 billion lb of resources. By comparison, only about 2.3 billion lb of newly mined copper were consumed in 1978.

Not only are there substantial copper reserves in the United States (enough to ensure self-sufficiency for about the next half-century even if no new reserves are added), but there also are continual improvements in discovery and extractive metallurgy. As shown in Fig. 7, copper reserves in the United States increased from 52 billion lb to 199 billion lb from 1952 to 1983—a rate of increase in reserves which greatly outstripped the total consumption of newly mined copper over the same period of time.

The U.S. copper industry relies heavily on scrap copper as a raw material. For instance, in 1983 the copper industry used 2.7 billion lb of scrap, or about 54% of the total amount of copper used in that year. Such reliance is typical of a mature economy, and recycling of products such as building wire and plumbing, even after a 40- to 50-yr service life, is not uncommon. In fact, by percentage, copper is recycled more than any other engineering metal.

Substantial reserves and extensive use of scrap both contribute to the self-sufficiency of the United States, and therefore to the reliability of supply of copper to manufacturing industries. Over the period 1970 to 1983, the United States was more than 90% self-sufficient in copper.

Copper Tubular Products

TUBE AND PIPE made of copper or copper alloys are used extensively for carrying potable water in buildings and homes. These products also are used throughout the oil, chemical and process industries to carry diverse fluids, ranging from various natural and process waters to seawater to an extremely broad range of strong and dilute organic and inorganic chemicals. In the automotive and aerospace industries, copper tube is used for hydraulic lines, heat exchangers (such as automotive radiators), air conditioning systems and various formed or machined fittings. In marine service, copper tube and pipe are used to carry potable water, seawater and other fluids, but their chief application is in tube bundles for condensers, economizers and auxiliary heat exchangers. Copper tube and pipe are used in food and beverage industries to carry process fluids for beet and cane sugar refining, for brewing of beer and for many other food processing operations. In the building trades, copper tube is used widely for heating and air conditioning systems in homes, commercial buildings, and industrial plants and offices. Table 1 summarizes the copper alloys that are standard tube alloys, and gives ASTM specifications and typical uses for each of the alloys.

Frequently, resistance to corrosion is a critical factor in selecting a tube alloy for a specific application. Information that can help determine the alloy(s) most suitable for a given type of service is given in the article "Corrosion Characteristics of Copper and Copper Alloys," (page 7•35).

Joints in copper tube and pipe are made in various ways. Permanent joints can be made by brazing or welding. Semipermanent joints are made most often by soldering, usually in conjunction with standard socket-type solder fittings, but threaded joints also can be considered semipermanent joints for pipe. Detachable joints are almost always some form of mechanical joint—flared joints, flange-and-gasket joints, and joints made using any of a wide variety of specially designed compression fittings are all common.

Properties of Tube. As with most wrought products, the mechanical properties of copper tube depend on prior processing. With copper, it is not so much the methods used to produce tube, but rather the resulting metallurgical condition that has the greatest bearing on properties. Table 2 summarizes tensile properties for the standard tube alloys in their most widely used conditions.

PRODUCTION OF TUBE SHELLS

Copper tubular products are produced by two different processes:

- By extruding or piercing billets
- By forming strip into tubular shape and welding.

Extrusion of copper and copper alloy tube shells is done by heating a billet of material above the recrystallization temperature, and then forcing material through an orifice in a die and over a mandrel held in position within the die orifice. The clearance between mandrel and die determines the wall thickness of the extruded tube shell.

In extrusion, the die is located at one end of the container section of an extrusion press; the metal to be extruded is driven through the die by a ram, which enters the container from the end opposite the die. Tube shells are produced either by starting with a hollow billet or by a two-step operation in which a solid billet is first pierced and then extruded.

Extrusion pressure varies with alloy composition. Alloy C36000 (61.5Cu-3Pb-35.5Zn) requires a relatively low pressure, whereas C26000 (70Cu-30Zn) and C44300 (71.5Cu-1Sn-27.5Zn-0.06As) require the highest pressure of all the brasses. Most of the coppers require an extrusion pressure intermediate between those for C26000 and C36000. C71500 (70Cu-30Ni) requires a very high extrusion pressure.

Extrusion pressure also depends on billet temperature, extrusion ratio (the ratio of the cross-sectional area of the billet to that of the extruded section), speed of extrusion and degree of lubrication. The flow of metal during extrusion depends on many factors, including copper content of the alloy, amount of lubricant, and die design.

Rotary piercing on a Mannesmann mill is another method commonly used to produce seamless pipe and tube from copper and certain copper alloys. Piercing is the most severe forming operation

EXHIBIT 3

Exhibit 3

USGS

Copper
Statistics and Information

Copper is usually found in nature in association with sulfur. Pure copper metal is generally produced from a multistage process, beginning with the mining and concentrating of low-grade ores containing copper sulfide minerals, and followed by smelting and electrolytic refining to produce a pure copper cathode. An increasing share of copper is produced from acid leaching of oxidized ores. Copper is one of the oldest metals ever used and has been one of the important materials in the development of civilization. Because of its properties, singularly or in combination, of high ductility, malleability, and thermal and electrical conductivity, and its resistance to corrosion, copper has become a major industrial metal, ranking third after iron and aluminum in terms of quantities consumed. Electrical uses of copper, including power transmission and generation, building wiring, telecommunication, and electrical and electronic products, account for about three quarters of total copper use. Building construction is the single largest market, followed by electronics and electronic products, transportation, industrial machinery, and consumer and general products. Copper byproducts from manufacturing and obsolete copper products are readily recycled and contribute significantly to copper supply.

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Special Publications

- Historical Statistics for Mineral Commodities in the United States
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  - Copper
- Metal Prices in the United States through 1998
  - Copper (PDF)
- Physical Aspects of Waste Storage from a Hypothetical Open Pit Porphyry Copper Operation
  OF-03-143
- Statistical Compendium
  - Copper

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  Email: dedelste@usgs.gov

- USGS Resource Specialist

Links

- Copper Development Association
- International Copper Study Group

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MINERAL RESOURCES	Eastern	Central	Western	Crustal Imaging & Characterization	Minerals Information	Spatial Data

U.S. Department of the Interior
U.S. Geological Survey
Minerals Information
988 National Center
Reston, VA 20192 USA

URL: http://minerals.usgs.gov/minerals/pubs/commodity/copper/index.html
Maintained by: rcallaghan@usgs.gov
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Contact: Daniel L. Edelstein (dedelste@usgs.gov)

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Exhibit 4

COPPER.org

CDA A service of the Copper Development Association for the copper and brass industries in the USA

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Trends in U.S. Copper and Scrap and Effects of Product Shifts

Introduction

Copper alloy scrap provides about half of the copper consumed in the United States each year. Copper alloy cast products depend on this scrap stream for production of 100% of the ingot and other furnace charge metal. Automotive radiator and cast plumbing product scrap have been important components to the scrap used by the U.S. scrap smelting industry. Both are undergoing rapid change in the U.S. but for very different reasons. This paper describes the impact of the aluminum radiator on the copper/brass radiator market in the U.S., Europe and Japan and the reaction of the copper industry to this market loss. New lead-free plumbing alloys employing bismuth or bismuth and selenium are gaining market share and will be a factor in recycled material. Concerns about alloy contamination are discussed and the reasoning on this issue in the U.S. elaborated upon.

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Recycling Copper
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Copper and the Natural Environment

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EXHIBIT 5

Exhibit 5

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Copper Applications in General Interest

▸Scrap Terminology and Classifications

Anon.

June 1999

Scrap arises in many forms and from many sources. To facilitate sales, purchases, and pricing, dealers and merchants classify scrap in several ways:

- by copper content or composition (No. 1 or No. 2 copper scrap, red or leaded yellow brass scrap, copper-based or nickel-based scrap),
- by use (refinery scrap, smelter scrap, brass mill scrap),
- by appearance (bare bright or burnt wire, mixed heavy or light scrap)
- by source (turnings, borings, cartridge cases, old radiators, electronic scrap)

For purposes of analyzing scrap consumption, a broad but very useful classification is old scrap vs. new scrap. Old or post-consumer scrap is that which has been used by a consumer. New scrap is material that is generated during the manufacturing process. It includes both prompt-industrial and return scrap. For example, new scrap arises when molten copper is cast into shapes (cakes, billets, ingots, wirerod, etc.); it arises when shapes are converted into semi-fabricated products (strip and sheet, rod and bar, tube, wire, etc.); and it arises when these semis are used to manufacturer products for the electrical and electronic, building, transportation, industrial, and consumer markets.

Home or run-around scrap is usually generated and remelted in the same facility. For example, a fully integrated copper and copper alloy strip and sheet producer sends the scrap generated from milling and edge trimming operations back to the casting shop, where it is remelted and cast into cakes. The type of recycling is generally not recorded in the scrap statistics. However, for a mill that does not cast its own shapes, scrap arising from edge trimming, slitting, and off-spec production is sent to a primary mill for remelted and casting. Because this material is sold or toll processed, it generally is counted in the recycling statistics.

New scrap also includes prompt-industrial and return scrap. Prompt-industrial scrap arises in the form of the form of turnings, stampings, cuttings, etc., when semi-fabricated products are converted into parts. Examples include turnings generated when brass rod is machined to produce faucets and valves, and webbing that is left after leadframes or connectors are stamped from strip.

Usually this material is returned to the mill that supplied the semi-fabricated products, hence the term "return scrap". Most of this business is done on a toll basis. Essentially, the value of the return scrap is taken as a credit against a new order of rod or strip. However, if the parts are machined or stamped from imported material, the scrap may be sold to a mill or to a merchant. Return scrap makes up the bulk of the material in the new scrap category.

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Scrap that arises rises further downstream and is out of the manufacturing loop, for example, when the plumber installs the tube or the electrician installs the wiring, is usually classified as old scrap, even though it has not been used by the consumer. This scrap is usually sold to a merchant or dealer, who, in turn, sells it to a mill or other processor. ▲

EXHIBIT 6

Exhibit 6

U.S. Copper-Based Scrap Consumption, Year-End Stocks, Exports, and Imports as a Percentage of Total Supply and Consumption (in Metric Tons, Gross Weight)

	1999 Consumption	1999 Stocks	2000 Consumption	2000 Stocks	2001 Consumption	2001 Stocks	2002 Consumption	2002 Stocks	2003 Consumption *	2003 Stocks	% Change 1999-2003	Change in Stocks 1999-2002
Total Scrap												
Smelters/Refiners	501,000	29,600	440,000	19,600	371,000	13,600	240,000	14,000	230,182	-	-54.1%	
Brass/Wire Rod Mills	1,050,000	55,700	1,070,000	57,200	919,000	48,900	930,000	47,100	842,182	-	-19.8%	
Foundries/Misc. Manuf.	79,900	5,770	83,000	5,210	87,500	5,270	86,900	5,420	86,900	-	8.8%	
TOTAL	1,630,900	91,070	1,593,000	82,010	1,377,500	67,770	1,256,900	66,520	1,159,264	-	-28.9%	-27.0%
U.S. Scrap Exports	316,342		494,284		559,699		566,838		753,541		138.2%	
Total U.S. Scrap Supply	1,947,242		2,087,284		1,937,199		1,823,738		1,912,805		-1.8%	
Exports as % of Supply	16.2%		23.7%		28.9%		31.1%		39.4%		23.1%	
Exports as % of Consumption	19.4%		31.0%		40.6%		45.1%		65.0%		45.6%	
Exports as % of Brass/Wire Rod Mill Consumption	30.1%		46.2%		60.9%		61.0%		89.5%			
U.S. Scrap Imports	136,400		143,900		114,700		100,200		90,581		-33.6%	
Imports as % of Supply	7.0%		6.9%		5.9%		5.5%		4.7%		-2.3%	

Source: U.S. Geological Survey Minerals Yearbook: Copper, 2000-2002 Table 10 and November 2003 Mineral Industry Survey Table 10; 2003 consumption annualized based on January-November data; Foundries/Misc. Manuf. estimated as equal to 2002 figure. Exports from Exhibit 6. Imports from U.S. Department of Commerce.

EXHIBIT 7

Exhibit 7
U.S. Total Exports of Copper and Copper Alloy Waste and Scrap (HTS 7404.00), 1999-2003
Volume in Metric Tons, Value in $1000, Average Unit Value in $/kg.

	1999	2000	2001	2002	2003	% Change 1999-2003	% Change 2002-2003
Export Volume							
China	86,601	214,162	316,739	332,110	532,901	515.4%	60.5%
Korea	42,824	60,821	42,165	33,711	41,086	-4.1%	21.9%
Canada	67,678	86,792	71,886	40,341	39,136	-42.2%	-3.0%
India	28,757	28,275	36,218	47,424	50,986	77.3%	7.5%
Japan	20,174	32,322	27,013	20,164	15,960	-20.9%	-20.8%
All Others	70,308	71,912	65,678	93,088	73,472	4.5%	-21.1%
Total Export Volume	316,342	494,284	559,699	566,838	753,541	138.2%	32.9%
Export Value							
China	74,278	169,678	257,747	269,234	457,771	516.3%	70.0%
Korea	53,542	87,076	62,461	46,954	58,243	8.8%	24.0%
Canada	75,381	107,702	84,884	44,761	44,515	-40.9%	-0.5%
India	26,630	24,199	27,823	38,740	43,912	64.9%	13.4%
Japan	41,446	63,812	69,411	30,387	25,446	-38.6%	-16.3%
All Others	95,836	92,345	53,468	120,878	86,120	-10.1%	-28.8%
Total Export Volume	367,113	544,812	555,794	550,954	716,007	95.0%	30.0%
Average Unit Value							
China	$ 0.86	$ 0.79	$ 0.81	$ 0.81	$ 0.86	0.2%	6.0%
Korea	$ 1.25	$ 1.43	$ 1.48	$ 1.39	$ 1.42	13.4%	1.8%
Canada	$ 1.11	$ 1.24	$ 1.18	$ 1.11	$ 1.14	2.1%	2.5%
India	$ 0.93	$ 0.86	$ 0.77	$ 0.82	$ 0.86	-7.0%	5.4%
Japan	$ 2.05	$ 1.97	$ 2.57	$ 1.51	$ 1.59	-22.4%	5.8%
All Others	$ 1.36	$ 1.28	$ 0.81	$ 1.30	$ 1.17	-14.0%	-9.7%
Total Export Volume	$ 1.16	$ 1.10	$ 0.99	$ 0.97	$ 0.95	-18.1%	-2.2%

Source: U.S. Department of Commerce, U.S. Total Exports.

EXHIBIT 8

Exhibit 8
U.S. Exports of Copper Waste and Scrap by Month, Including Quarterly and Annual Averages, 2001-January 2004
in Metric Tons

	Jan	Feb	Mar	1Q Ave.	Apr	May	Jun	2Q Ave.	Jul	Aug	Sep	3Q Ave.	Oct	Nov	Dec	4Q Ave.	Annual Ave.
1999	20,742	24,690	29,369	24,934	26,698	26,270	24,045	25,671	25,534	24,993	25,688	25,405	26,881	28,661	32,772	29,438	26,362
2000	36,451	35,151	35,534	35,712	37,654	39,295	38,780	38,576	39,506	51,558	43,641	44,902	46,243	44,755	45,717	45,572	41,190
2001	42,604	47,402	52,316	47,441	46,379	48,012	49,718	48,036	49,635	44,041	41,988	45,221	52,025	41,122	44,455	45,867	46,641
2002	38,577	44,906	50,528	44,670	47,330	49,151	47,744	48,075	44,597	49,050	43,242	45,630	43,397	55,378	52,937	50,571	47,236
2003	48,931	55,603	62,268	55,601	60,214	63,799	63,572	62,528	63,436	67,889	61,703	64,343	71,116	72,782	62,229	68,709	62,795
2004	51,903																
% Change, 1999-03	135.9%	125.2%	112.0%	123.0%	125.5%	142.9%	164.4%	143.6%	148.4%	171.6%	140.2%	153.3%	164.6%	153.9%	89.9%	133.4%	138.2%
% Change, 2002-03	26.8%	23.8%	23.2%	24.5%	27.2%	29.8%	33.2%	30.1%	42.2%	38.4%	42.7%	41.0%	63.9%	31.4%	17.6%	35.9%	32.9%

Source: U.S. Department of Commerce, U.S. Total Exports.

EXHIBIT 9

Exhibit 9
Disaggregated Exports of Copper and Copper Alloy Waste and Scrap, 1999-2003
in Metric Tons

	1999	2000	2001	2002	2003	% Change 1999-2003	% Change 2002-2003
7404.00.0020	128,511	232,064	284,043	257,560	366,463	185.2%	42.3%
China	51,416	127,468	177,139	166,512	275,267	435.4%	65.3%
% of Total	40.0%	54.9%	62.4%	64.6%	75.1%		
7404.00.0045	38,608	68,469	68,138	55,529	78,437	103.2%	41.3%
China	12,445	31,936	30,948	17,066	37,301	199.7%	118.6%
% of Total	32.2%	46.6%	45.4%	30.7%	47.6%		
7404.00.0062	14,966	24,856	32,893	45,029	51,933	247.0%	15.3%
China	1,335	4,816	16,433	27,411	38,315	2770.0%	39.8%
% of Total	8.9%	19.4%	50.0%	60.9%	73.8%		
7404.00.0080	134,258	168,894	174,625	208,720	256,708	91.2%	23.0%
China	21,406	49,942	92,218	121,122	182,018	750.3%	50.3%
% of Total	15.9%	29.6%	52.8%	58.0%	70.9%		
Total Copper Alloy Waste and Scrap	187,832	262,219	275,656	309,278	387,078	106.1%	
China	35,186	86,694	139,599	165,599	257,634	632.2%	
% of Total	18.7%	33.1%	50.6%	53.5%	66.6%		
Total Copper-Based Waste and Scrap	316,343	494,283	559,699	566,838	753,541	138.2%	
China	86,602	214,162	316,738	332,111	532,901	515.3%	
% of Total	27.4%	43.3%	56.6%	58.6%	70.7%		

Source: U.S. Department of Commerce, U.S. Total Exports.

EXHIBIT 10

Exhibit 10

Copper Scrap and Comex Cathode Prices and Differentials, Annual Averages 1998-2003, Monthly Averages 2002-2003, and Weekly Samples December 2003 - March 2004 (in cents per pound)

	No. 1 Scrap	Comex Cathode	Differential	No. 2 Scrap	Comex Cathode	Differential
1998	73.55	75.08	1.53	60.19	75.08	14.89
1999	70.88	72.11	1.23	57.53	72.11	14.58
2000	80.67	83.97	3.30	64.99	83.97	18.98
2001	69.62	72.57	2.95	58.96	72.57	13.61
2002	70.23	71.67	1.44	59.45	71.67	12.22
2003 (Jan.-Nov.)	78.14	79.35	1.21	68.38	79.35	10.97
2002 Jan.	67.12	69.79	2.67	55.62	69.79	14.17
Feb.	69.45	72.23	2.78	57.29	72.23	14.94
Mar.	72.19	74.52	2.33	59.76	74.52	14.76
Apr.	71.82	73.11	1.29	54.00	73.11	19.11
May	71.98	73.22	1.24	60.39	73.22	12.83
Jun.	74.78	76.23	1.45	71.28	76.23	4.95
Jul.	71.91	72.33	0.42	61.04	72.33	11.29
Aug.	66.89	67.82	0.93	55.64	67.82	12.18
Sep.	66.80	67.71	0.91	55.68	67.71	12.03
Oct.	66.83	68.16	1.33	56.70	68.16	11.46
Nov.	71.38	72.57	1.19	60.50	72.57	12.07
Dec.	71.60	72.38	0.78	61.31	72.38	11.07
2003 Jan.	73.67	75.37	1.70	62.38	75.37	12.99
Feb.	75.55	76.96	1.41	63.95	76.96	13.01
Mar.	74.69	75.72	1.03	64.26	75.72	11.46
Apr.	70.82	72.18	1.36	61.80	72.18	10.38
May	73.95	75.05	1.10	64.53	75.05	10.52
Jun.	76.29	76.93	0.64	67.36	76.93	9.57
Jul.	73.86	78.06	4.20	65.00	78.06	13.06
Aug.	79.48	80.00	0.52	69.43	80.00	10.57
Sep.	81.96	81.84	(0.12)	72.75	81.84	9.09
Oct.	87.09	88.10	1.01	77.89	88.10	10.21
Nov.	92.22	92.68	0.46	82.81	92.68	9.87
Dec.						
Dec. 4	97.00	96.30	(0.70)	88.50	96.30	7.80
Dec. 11	97.00	97.60	0.60	88.00	97.60	9.60
Dec. 18	98.50	101.70	3.20	89.50	101.70	12.20
Dec. 24	101.50	102.65	1.15	92.00	102.65	10.65
Dec. 31	103.50	104.30	0.80	94.00	104.30	10.30
Monthly Ave.	99.50	100.51	1.01	90.40	100.51	10.11
2004 Jan. 8	107.50	110.45	2.95	97.00	110.45	13.45
Jan. 15	108.50	108.20	(0.30)	98.50	108.20	9.70
Jan. 22	111.50	111.65	0.15	100.50	111.65	11.15
Jan. 28	111.00	112.95	1.95	100.00	112.95	12.95
Monthly Ave.	109.63	110.81	1.19	99.00	110.81	11.81
Feb. 5	116.50	117.25	0.75	106.00	117.25	11.25
Feb. 12	123.00	124.25	1.25	111.00	124.25	13.25
Feb. 19	130.00	132.80	2.80	118.00	132.80	14.80
Feb. 26	132.50	134.80	2.30	121.00	134.80	13.80
Monthly Ave.	125.50	127.28	1.78	114.00	127.28	13.28
Mar. 4	129.00	131.75	2.75	118.00	131.75	13.75

Source: US Geological Survey Copper Annual Table 13 (scrap) and Table 12 (Comex high grade first position cathode price); USGS Monthly Mineral Industry Surveys Tables 12 and 13; and American Metal Market (daily Nonferrous Scrap Prices and Market Guide, Comex Spot Price). No. 1 copper scrap prices are estimated buying prices for carload lots for brass mill scrap. No. 2 scrap prices are estimated buying prices for carload lots for refiners' copper scrap.

EXHIBIT 11

Exhibit 11
U.S. Copper and Copper-Alloy Scrap Export Volumes (MT), 1996-2003

Country	1996	1997	1998	1999	2000	2001	2002	2003
China	37,659	41,137	49,396	86,601	214,162	316,739	332,110	532,901
Korea	16,322	13,898	14,344	42,824	60,821	42,165	33,711	41,086
Canada	149,347	162,881	107,776	67,678	86,792	71,886	40,341	39,136
India	34,163	28,614	29,313	28,757	28,275	36,218	47,424	50,986
Japan	37,930	31,598	20,658	20,174	32,322	27,013	20,164	15,960
Taiwan	6,311	4,746	8,343	11,627	11,597	15,693	19,366	15,529
Germany	12,522	16,483	13,755	3,231	7,681	16,092	30,664	15,586
Belgium	10,813	4,593	3,169	1,899	2,015	2,730	9,259	8,640
Mexico	6,539	8,797	11,421	22,295	17,486	7,156	2,549	4,008
Hong Kong	72,145	59,673	38,020	13,425	13,279	9,754	13,874	12,822
All Others	13,656	11,322	12,725	17,833	19,853	14,253	17,376	16,888
Total	397,407	383,742	308,920	316,344	494,283	559,699	566,838	753,542

1996-2000 Average	380,139	2001-2003 Average	626,693

Source: U.S. Total Exports, HTS 7404.00, U.S. Department of Commerce.

Prepared by Georgetown Economic Services