BERYLLIUM

By Deborah A. Kramer

Beryllium is a light weight material with a stiffness six times greater than that of steel, a high heat-absorbing capability, and dimensional stability over a wide range of temperatures. These properties allow it to be used as metal, alloy, or oxide in a wide range of consumer and defense applications, including automotive electronics, computers, and telecommunications systems.

The United States is one of few countries with an integrated beryllium industry. Bertrandite, mined and processed in Utah, is the primary source of ore for the end products—beryllium alloys, beryllium metal, and beryllium oxide—that are produced in Ohio and Pennsylvania. Imported beryl ore, mainly from Brazil, has supplemented domestic ore supply in the past, but insignificant quantities of beryl have been imported in recent years.

Reported U.S. consumption of beryllium ore declined in 1994, but the production of nearly all beryllium products, with the exception of metallic beryllium, increased. Computers and automotive electronics were the two principal uses of beryllium-containing materials. Consumption of beryllium is expected to remain stable or increase slowly over the next few years as new uses for beryllium alloys are developed. *(See table 1.)*

Legislation and Government Programs

Deliveries of beryllium metal to the National Defense Stockpile (NDS) were completed in the second quarter of 1994 under the terms of a contract initiated in 1990. The total quantity of metal delivered to the NDS under this contract was 73 metric tons, recovered from 2,940 tons of beryl in the NDS. *(See table 2.)*

In the fiscal year 1995 Annual Materials Plan, the Defense National Stockpile Center (DNSC) recommended that beryl sales for the fiscal year be limited to 1,800 tons. The quantities in the plan are the maximum quantities that can be sold.

Beginning in October, DNSC offered beryl ore for sale. On the third Tuesday of each subsequent month, DNSC solicited bids for 1,800 tons of beryl. There were no bids to purchase this material during 1994.

Production

Domestic production of beryllium ore declined in 1994. Conversely, production of beryllium-containing products—beryllium-aluminum alloys, beryllium-copper master alloy, beryllium-nickel alloys, and beryllium oxide—increased, with the exception of beryllium metal. Metallic beryllium production declined primarily as a result of the completion of the NDS contract.

The United States is the only country that can process beryllium ore and concentrates into beryllium products and supplies most of the rest of the world with these products. Brush Wellman Inc. mines bertrandite and converts this ore, along with beryl, to beryllium hydroxide at its facility in Delta, UT. Beryllium hydroxide is shipped to the company's plant in Elmore, OH, where it is converted into beryllium alloys, oxide, and metal.

One other company in the United States has the capability to produce beryllium alloys. NGK Metals Corp., a subsidiary of NGK Insulators of Japan, produces beryllium alloys at a plant near Reading, PA. Because NGK Metals does not have facilities to process the raw materials, the company purchases beryllium oxide from Brush Wellman.

Beryllium data are collected from two voluntary surveys of U.S. operations. In 1994, there were five responses to the "Beryllium Mineral Concentrate and Beryllium Ore" survey, representing 63% of the total canvassed. These respondents produced 100% of total domestic mine shipments, shown in tables 1 and 7. A small number of unidentified producers may have shipped insignificant quantities of byproduct beryl, which have not been included.

Beryllium dust and fumes have been recognized as the cause of beryllosis, a serious chronic lung disease. In the 1940's, the disease was diagnosed among industry employees and their relatives, who had handled dusty workclothes prior to the establishment of suitable hygienic procedures. Cases also were reported among residents of communities surrounding beryllium-processing plants. Although uncertainties related to the cause of the disease still exist, the problem appears to be controlled when established preventative measures are exercised. In beryllium-processing plants, harmful effects are prevented by maintaining clean workplaces; requiring the use of safety equipment such as personal respirators; collection of dust, fumes, and mists at the source of deposition in dust collectors; medical programs; and other procedures to provide safe working conditions. Control of potential health hazards adds significantly to the final cost of beryllium products.

Consumption

Reported beryllium ore consumption declined in 1994 even though Brush Wellman reported increases in sales in nearly all the company's product lines. Sales increases in beryllium alloys were attributed to a high level of demand for these materials in electronic applications and to development of new applications in automotive electronics, appliances, plastic molding, and telecommunications markets. Brush Wellman estimated that the demand pattern for the company's products, based on sales, was aerospace and defense, 14%; appliance and consumer applications, 11%; automotive electronics, 18%; computers, 36%; telecommunications, 12%; and other uses, 9%.

Beryllium-Copper Alloys.—Beryllium-copper alloys are used in a wide variety of applications and average about 75% of annual U.S. consumption on a beryllium metal equivalent basis. These alloys, most of which contain approximately 2% beryllium, are used because of their high electrical and thermal conductivity, high strength and hardness, good corrosion and fatigue resistance, and nonmagnetic properties. Beryllium-copper strip is manufactured into springs, connectors, and switches for use in applications in automobiles, aerospace, radar and telecommunications, factory automation, computers, home appliances, and instrumentation and control systems. The principal use of large-diameter beryllium-copper tubing is in oil and gas drilling equipment and in bushings and bearings in aircraft landing gear and heavy machinery. Connectors in fiber-optic telecommunications systems are the main application for beryllium-copper rod. Small, pluggable sockets for joining integrated circuits to printed circuit boards are the main application for beryllium-copper wire.

Beryllium-copper bar and plate are used in resistance-welding parts, components for machinery and materials-handling systems, and for molds to make metal, glass, and plastic components.

Beryllium also is used in small quantities in nickel- and aluminum-base alloys. Miniature electronic connector components that operate at high temperatures are the main use for beryllium-nickel alloys, and these alloys are used in automotive passive restraint systems (air bags). Beryllium-aluminum alloys are used as castings in the aerospace industry. Addition of small quantities of beryllium to magnesium alloys inhibits oxidation.

Beryllium Metal.—Beryllium metal, which averages about 10% of annual U.S. demand, is used principally in aerospace and defense applications. Its high stiffness, light weight, and dimensional stability over a wide temperature range make it useful in satellite and space vehicle structures, inertial guidance systems, military aircraft brakes, and space optical system components. Because beryllium is transparent to X-rays, it is used in X-ray windows. In nuclear reactors, beryllium also serves as a canning material, as a neutron moderator, in control rods, and as a reflector. In the past, the metal had been used as a triggering device in nuclear warheads. Other applications for metallic beryllium include high-speed computer components, audio components, and mirrors. In the U.S. space shuttles, several structural parts and brake components use beryllium.

Beryllium Oxide.—Beryllium oxide (beryllia) is an excellent heat conductor, with high hardness and strength. This material also acts as an electrical insulator in some applications. Beryllium oxide, averaging about 15% of domestic demand, serves mainly as a substrate for high-density electronic circuits for high-speed computers, automotive ignition systems, lasers, and radar electronic countermeasure systems. Because it is transparent to microwaves, microwave communications systems and microwave ovens may use beryllium oxide.

Because of its high cost compared to those of other materials, beryllium is used in applications in which its properties are crucial. Steel, titanium, or graphite composites substitute for beryllium metal in some applications, and phosphor bronze substitutes for beryllium-copper alloys, but these substitutions result in substantial loss in performance. In some cases, aluminum nitride may be substituted for beryllium oxide.

Prices

Yearend prices for beryllium products are shown in table 3. Prices for beryllium products at yearend 1994 were unchanged from those at yearend 1993. *(See table 3.)*

Foreign Trade

The Bureau of the Census does not separately identify all imports and exports of beryllium-copper alloys. The Journal of Commerce Port Import/Export Reporting Service (PIERS) provides some data on materials that are transported by ship. According to PIERS, 81 tons (gross weight) of beryllium-copper alloys in strip, bar, rod, and plate forms were exported in 1994. Principal destinations were Japan (48%) and Brazil (37%). In addition, 300 tons of beryllium-copper scrap was exported to Japan, and 8 tons of beryllium-aluminum alloys wasexported to Belgium (67%) and Brazil (33%). Imports of beryllium-copper alloys totaled 1,600 tons in the form of strip and billet, all from Japan. *(See tables 4 and 5.)*

World Review

In Japan, demand for beryllium-copper alloys in 1994 rebounded to about 1,300 tons from an estimated 1,250 tons in 1993. Increased production of personal computers and information and telecommunications instruments were responsible for part of the increase in demand for beryllium-copper rolled materials. In addition, exports of automotive components to the United States increased, contributing to the increase in demand for beryllium-copper rolled products. One of the Japanese beryllium-copper producers, Nippon Gaishi, introduced a lower cost beryllium alloy that contains less than 1% beryllium. The higher cost beryllium-copper alloy was used traditionally in industrial appliances, but because of its cost, it was not used in domestic appliances. With the introduction of the low-cost alloy, beryllium-copper could be used in domestic appliances, yielding smaller appliances with higher performance and special features that could not be achieved with phosphor bronze connectors and switches.[1] *(See tables 6 and 7.)*

Outlook

Consumption of beryllium materials in the United States is expected to grow slowly or remain at essentially the same level for the next few years. Metallic beryllium production likely will decline as the commitments to the NDS were completed in 1994, and defense applications have declined over the past several years. Companies that produce beryllium alloys are developing new applications for these materials, particularly in automotive electronics, so demand for the alloys will probably increase. If the increase in alloy demand offsets the decline in metal demand, overall beryllium demand will increase.

[1]Roskill's Letter From Japan. No. 226, Feb. 1995, pp. 7-9.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Beryllium. Ch. in Mineral Commodity Summaries, annual.

Other Sources

American Metal Market (daily newspaper).
Brush Wellman Inc., Annual Report.
Metals Week.
Roskill Information Services Ltd. Beryllium 1989, 5th ed.

TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons of beryllium metal equivalent unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Beryllium-containing ores:					
Mine shipments	182	174	193	198	173
Imports for consumption, beryl1/	14	12	2	2	--
Consumption, reported	232	196	196	196	174
Price, approximate, per short ton unit BeO, imported cobbed beryl at port of exportation	$101	$113	NA	NA	NA
Yearend stocks	119	112	111	114	113
World: Production1/	284	263	278	270 r/	245

e/Estimated. r/Revised. NA Not available.
1/Based on a beryllium metal equivalent of 4% in beryl.

TABLE 2
STOCKPILE STATUS, DECEMBER 31, 1994

(Metric tons, beryllium content)

Material	Goal	Uncommitted inventory	Authorized for disposal
Beryllium-copper master alloy	287	268	--
Beryllium metal	363	363	--
Beryllium ore	653	526	526

TABLE 3
YEAREND BERYLLIUM PRICES

(Dollars per pound unless otherwise specified)

Material		Price
Beryl ore	per short ton unit of contained BeO	$78- $85
Beryllium vacuum-cast ingot, 98.5% pure		308
Beryllium metal powder, in 1,000- to 4,999-pound lots and 98.5% pure		295
Beryllium-copper master alloy	per pound of contained Be	160
Beryllium-copper casting alloy		5.52- 6.30
Beryllium-copper in rod, bar, wire		10.24
Beryllium-copper in strip		9.25
Beryllium-aluminum alloy, in 100,000-pound lots		260

Sources: American Metal Market, Brush Wellman Inc., and Platt's Metals Week.

TABLE 4
U.S. EXPORTS OF BERYLLIUM ALLOYS, WROUGHT OR UNWROUGHT, AND WASTE AND SCRAP,1/ BY COUNTRY 2/

Country	1993		1994	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Canada	5,240	$263	7,180	$240
France	92	93	911	1,050
Hungary	6,880	224	18	3
Japan	3,140	560	7,380	535
Netherlands	1,310	101	578	135
Taiwan	--	--	8,070	124
United Kingdom	1,910	112	3,280	393
Other	1,150 r/	410 r/	1,060	223
Total	19,700	1,760	28,500	2,700

r/Revised.
1/Consisting of beryllium lumps, single crystals, powder; beryllium-base alloy powder; and beryllium rods, sheets, and wire.
2/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF BERYLLIUM METAL AND COMPOUNDS 1/

Material	1993		1994	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Beryllium-copper master alloy	107,000	$1,220	182,000	$2,270
Beryllium oxide and hydroxide	2,430	38	225	3
Beryllium, unwrought and waste and scrap	6,180	432	52,500	1,900

1/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

Source: Bureau of the Census.

TABLE 6
WORLD ANNUAL BERYL PRODUCTION CAPACITY,1/
DECEMBER 31, 1994

(Metric tons, contained beryllium)

	Capacity
North America: United States2/	360
Africa:	
Madagascar	5
Mozambique	3
Rwanda	3
South Africa, Republic of	3
Zimbabwe	5
Total	19
Asia: China	75
Europe:	
Kazakhstan	7
Portugal	3
Russia	70
Total	80
South America:	
Argentina	4
Brazil	65
Total	69
World total	603

1/Includes capacity at operating plants as well as at plants on standby basis.
2/Includes bertrandite ore.

TABLE 7
BERYL: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country 3/	1990	1991	1992	1993	1994 e/
Argentina	34	34	34 e/	-- r/ e/	--
Brazil e/	850	850	850	850	850
Kazakhstan e/	XX	XX	100	100	100
Madagascar e/ 4/	3 5/	3	3	3	3
Namibia	25	6	10 e/	15 r/	15
Nepal	1	-- r/	-- r/	-- r/	--
Portugal e/	4	4	4	4	4
Russia e/	XX	XX	1,100	800	800
South Africa, Republic of	1	(6/)	--	--	--
U.S.S.R. e/ 7/	1,600	1,300	XX	XX	XX
United States 8/ (mine shipments)	4,550	4,340	4,830	4,940	4,330 5/
Zambia	2	1	1	1	1
Zimbabwe (concentrate, gross weight)	28	29	23	32 r/	30
Total	7,100	6,570	6,950	6,740 r/	6,130

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through Apr. 6, 1995.

3/ In addition to the countries listed, China produced beryl and Bolivia may also have produced beryl, but available information is inadequate to formulate reliable estimates of production.

4/ Includes ornamental and industrial products.

5/ Reported figure.

6/ Less than 1/2 unit.

7/ Dissolved in Dec. 1991.

8/ Includes bertrandite ore, calculated as equivalent to beryl containing 11% BeO.