BERYLLIUM

By Deborah A. Kramer

Beryllium is a high-strength, lightweight metal with excellent anticorrosion characteristics. Beryllium, in the forms of alloys, metal, and oxide, is used in a wide variety of applications from aerospace and defense to leisure products, such as golf clubs and bicycles. The United States is one of only three countries to have an integrated beryllium industry and supplies most of the rest of the world with beryllium products.

Beryllium ore production and consumption increased in 1995. Much of the increase in demand was in the electronics sector, which is the largest consuming industry for beryllium products. *(See table 1.)*

Legislation and Government Programs

Because of high level of imports of beryllium metal from Kazakstan in 1994, classified under HTS number 8112.11.60, this material lost its Generalized System of Preferences (GSP) privileges beginning on July 1, 1995. The GSP program offers duty-free access to U.S. markets for eligible products that are imported from designated beneficiary developing countries. Total imports of beryllium in 1994 under this classification were 201 kilograms, all from Kazakstan.[1] Kazakstan first received GSP status in March 1994.

There were no sales of beryl ore from the National Defense Stockpile (NDS) in 1995; however, 1,800 metric tons of beryl were offered for sale each month. In the fiscal year 1996 Annual Materials Plan, which became effective on October 1, 1995, the Defense National Stockpile Center set the maximum quantity of beryl that can be sold from the NDS at 1,800 tons. *(See table 2.)*

Production

Domestic production of beryllium ore increased in 1995. Beryllium-nickel alloy production increased, and beryllium oxide production remained essentially the same. Production of beryllium-copper master alloy, beryllium-aluminum alloy, and beryllium metal declined slightly from the 1994 levels.

The United States is one of only three countries 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, into 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 1995, there were four responses to the "Beryllium Mineral Concentrate and Beryllium Ore" survey, representing 100% 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 increased significantly in 1995. Sales increases in beryllium alloys were attributed to a high level of demand for these materials in electronic applications, particularly automotive electronics, and to development of new applications. Brush Wellman estimated that the demand pattern for the company's products, based on sales, was commercial aerospace, 6%; appliance and consumer applications, 10%; automotive electronics, 18%; computers, 33%; defense, 8%; telecommunications, 12%; and other uses, 13%. International business accounted for about 34% of Brush Wellman's total sales in 1995. The largest foreign customers for beryllium products were Germany, Japan, Singapore, Switzerland, and the United Kingdom.

Brush Wellman announced plans to expand production capacity for alloy strip products, although no exact figures or timetables were disclosed. In addition to expanding capacity, the company is attempting to reduce production costs for these

materials, streamline processes, and reduce work-in-progress inventory requirements.

A castable beryllium-aluminum alloy was used to make parts for the Boeing-Sikorsky Comanche helicopter's electrooptical system. The beryllium-aluminum alloy has the strength and stiffness of beryllium, but is more resistant to cracking than beryllium metal. Nuclear Metals Inc., Concord, MA, has made more than 50 components of various sizes from the alloy. The beryllium-aluminum alloy has the potential to replace aluminum in housings for avionics or small structural components.[2]

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. Beryllium oxide prices declined by $2 per pound; but the remaining beryllium prices remained the same. The beryllium powder price was incorrectly reported at yearend 1994 to be $295 per pound; the correct price was $275 per pound. Beryllium-aluminum alloy prices also should have been quoted in 500-pound lots, not 100,000 pound lots at yearend 1994. *(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, 92 tons (gross weight) of beryllium-copper alloys in strip, rod, and plate forms was exported in 1995. Principal destinations were Japan (68%) and the United Kingdom (11%). In addition, 223 tons of beryllium-copper scrap was exported principally to Japan, and 6 tons of beryllium-aluminum alloys was exported to four countries. A total of 85 tons of beryllium-copper master alloy was exported, mainly to Japan. Imports of beryllium-copper alloys totaled 1,720 tons in the form of strip and billet, all from Japan. *(See tables 4 and 5.)*

World Review

Beryllium-copper rolled product demand in Japan in 1995 was estimated to have increased from the record demand in 1994 of 1,650 tons. In the first half of 1995, beryllium-copper shipments were 10% higher than those in the corresponding period of 1994, but the growth rate slowed in the second half of the year because of lower output of electrical appliances and components. Although demand for consumer electronics has decreased since 1992, increased demand for beryllium-copper components in electronic micromotors, air bags, and navigation systems in automobiles was responsible for overall increase in demand.

Increased acceptance of alloys with reduced beryllium

content (0.1% to 0.3%) has expanded the market for beryllium-copper materials in Japan. Some mobile telephone manufacturers have switched from phosphor bronze to beryllium-copper components. Personal computers and connectors for peripheral equipment are potential new uses for the lower beryllium content alloys. In the United States, a reduced beryllium content alloy has been used for relays and switches in automobiles, and as standardization of automotive materials in Europe, Japan, and the United States advances, there may be more opportunities for use of beryllium-copper in this application.[3] *(See tables 6 and 7.)*

Outlook

In the United States, beryllium consumption is expected to increase slightly as additional uses for beryllium alloys are developed. The automotive electronics market has shown rapid growth in the past 5 years, and this market is expected to continue to expand. Other electronic applications, such as those in personal computers, also have demonstrated significant growth rates in the same time period. Growth is expected to continue in these areas, but at a slower pace.

Increased beryllium demand in foreign markets should increase the demand for domestically produced beryllium ore. The United States has had little, if any, foreign-produced ore to supplement domestic supply since 1991. This trend also is expected to continue in the near future.

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[1]Federal Register. Generalized System of Preferences (GSP); Announcement of the Competitive Need Limits and Per Capita GNP Limits for 1994; Announcement of the Countries/Products Tha t Exceeded the Competitive Need Limits in 1994. Off. Trade Rep. V. 60, No. 103, May 30, 1995, pp. 28184-28187.

[2]Aviation Week & Space Technology. V. 142, No. 18, May 1, 1995, p. 65.

[3]Roskill's Letter From Japan. No. 238, Feb. 1996, pp. 7-9.

OTHER SOURCES OF INFORMATION

U.S. Geological Survey Publication

Beryllium. Ch. in Mineral Commodity Summaries, annual.

Other Sources

American Metal Market (daily newspaper).
Brush Wellman Inc., Annual Report.
Platt's 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)

	1991	1992	1993	1994	1995
United States:					
Beryllium-containing ores:					
Mine shipments	174	193	198	173	202
Imports for consumption, beryl 1/	12	2	2	--	--
Consumption, reported	196	196	196	174	227
Price, approximate, per short ton unit BeO, imported cobbed beryl at port of exportation	$113	NA	NA	NA	NA
Yearend stocks	112	111	114	113	162
World: Production 1/	263	278	270	244 r/	272 e/

e/ Estimated. r/ Revised. NA Not available.

1/ Based on a beryllium metal equivalent of 4% in beryl.

TABLE 2
STOCKPILE STATUS, DECEMBER 31, 1995

(Metric tons, beryllium content)

Material	Goal	Uncommitted inventory	Authorized for disposal
Beryllium-copper master alloy	287	268	--
Beryllium metal	363	363	--
Beryllium ore	653	545	545

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, in lots greater than 1,000 pounds		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 500-pound lots		260
Beryllium oxide powder in 10,000-pound lots		70.50

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	1994 Quantity (kilograms)	1994 Value (thousands)	1995 Quantity (kilograms)	1995 Value (thousands)
Canada	7,180	$240	6,640	$255
France	911	1,050	10,700	2,270
Germany	22	32	16,500	338
Japan	7,380	535	19,000	1,620
Netherlands	578	135	341	104
Taiwan	8,070	124	430	17
United Kingdom	3,280	393	7,070	696
Other	1,050 r/	194 r/	573	496
Total	28,500	2,700	61,300	5,800

r/ Revised.
1/ Consisting of beryllium lumps, single crystals, powder; beryllium-base alloy powder; and beryllium rods, sheets, and wire.
2/ Data are rounded 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	1994 Quantity (kilograms)	1994 Value (thousands)	1995 Quantity (kilograms)	1995 Value (thousands)
Beryllium-copper master alloy	182,000	$2,270	94,200	$880
Beryllium oxide and hydroxide	225	3	8,310	112
Beryllium, unwrought and waste and scrap	52,500	1,900	32,200	2,830

1/ Data are rounded to three significant digits.

Source: Bureau of the Census.

TABLE 6
WORLD ANNUAL BERYL PRODUCTION CAPACITY, 1/
DECEMBER 31, 1995

(Metric tons, contained beryllium)

	Capacity
North America: United States 2/	360
Africa:	
Madagascar	5
Mozambique	3
Rwanda	3
South Africa	3
Zimbabwe	5
Total	19
Asia: China	75
Europe:	
Kazakstan	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/	1991	1992	1993	1994	1995 e/
Argentina	34	34 e/	35 r/	-- e/	--
Brazil e/	850	850	850	850	850
Kazakstan e/	XX	100	100	100	100
Madagascar e/ 4/	3	3	3	3	3
Namibia	6	10 e/	15	15 e/	15
Portugal e/	4	4	4	4	4
Russia e/	XX	1,100	800	800	800
South Africa	(5/)	--	--	-- e/	--
U.S.S.R. e/ 6/	1,300	XX	XX	XX	XX
United States 7/ (mine shipments)	4,340	4,830	4,940	4,330	5,040 8/
Zambia	1	1	1	1 e/	1
Zimbabwe (concentrate, gross weight)	29	23	(5/) r/ e/	(5/) r/ e/	(5/)
Total	6,570	6,950	6,750 r/	6,100 r/	6,810

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

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through May 9, 1996.

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/ Less than 1/2 unit.

6/ Dissolved in Dec. 1991.

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

8/ Reported figure.