MERCURY

By Jozef Plachy

Mercury is the only common metal that is liquid at room temperature. It is a corrosion-resistant metal that melts at -38.87°C (-37.97°F) and boils at 356.58°C (673.84°F). Mercury has uniform volumetric thermal expansion, good electrical conductivity, and easily forms amalgams with almost all common metals except iron. It occurs either as native metal or in cinnabar, corderoite, livingstonite, and other minerals.

Since 1990, primary mercury production in the United States has been a byproduct of gold mining, mostly in California, Nevada, and Utah. Most domestic mercury production in 1996 was of secondary origin, derived from recycled mercury-containing devices. Although several companies were engaged in mercury-refining, the three largest were in the eastern and central United States. The value of mercury used in the United States was estimated at $2.8 million. Domestic consumption in 1996 continued to decrease, as mercury is gradually eliminated from products in favor of less toxic substances. About one-third of domestic consumption was used in the production of chlorine and caustic soda. Imports of mercury declined in 1996, following a large increase in 1995 that had been caused by a suspension of sales from the National Defense Stockpile in July 1994. Exports of mercury continued to decline for the fourth consecutive year. *(See table 1.)*

Legislation and Government Programs

On May 13, 1996, the President signed into law legislation affecting mercury-containing and other types of rechargeable batteries. The new law is entitled *The Mercury-Containing and Rechargeable Battery Management Act of 1996* (Public Law 104-142). Title I of the act prohibits the sale of regulated batteries after May 1997 without a label indicating recyclability or proper disposal of these batteries. Title I also empowers the Environmental Protection Agency to streamline the regulatory requirements so that the collection and recycling programs by industry or local governments can be efficient and cost-effective. Title II of the act phases out the use of alkaline-manganese and zinc-carbon batteries containing intentionally added mercury and button cell mercuric-oxide batteries. Other mercury-oxide batteries are allowed if the manufacturer identifies a collection site or telephone number to get information about recycling or disposal. Title II also authorizes EPA to exempt any new use of restricted batteries if safeguards exist against disposal in an incinerator or landfill.

On December 4, 1996, the U.S. Coast Guard signed an agreement with the Georgia Environmental Protection Division to remove from Georgia's waterways discarded zinc-air batteries containing mercury. These batteries were used in Coast Guard Aids to Navigation Stations or lighted navigation beacons. From 1960 through 1980, as these facilities were being serviced, the disposable batteries were sometimes dumped overboard by servicemen, jettisoned by vandals, or sunk during accidental collisions with vessels. The cleanup requires Coast Guard and Navy frogmen to sift through ocean and river sediments, collect all the discarded batteries, and transport them to a reclamation site. The final phase, sediment sampling, will determine if any site remediation is necessary (American Metal Market, 1997a).

Production

Domestic primary mercury was produced, solely as a byproduct, at six gold mines in California, Nevada, and Utah. *(See table 2.)* Reported mine production has been withheld in this report to avoid disclosing company proprietary data.

Whereas most of the world production of mercury is primary (newly mined), nearly all the mercury produced in the United States is derived from secondary sources. Recycling of mercury increased after the development of land disposal restrictions on mercury-containing waste. Because of these restrictions on the disposal of mercury-containing products of all kinds, including mine waste, secondary mercury has become a more cost-effective alternative to primary mercury. Common secondary sources include spent batteries, mercury vapor and fluorescent lamps, switches, dental amalgams, measuring devices, control instruments, and laboratory and electrolytic refining wastes. The secondary processors typically use high-temperature retorting to recover mercury from compounds and distillation to purify the contaminated liquid mercury metal. Refining of recycled mercury in 1996 was dominated by three companies: Bethlehem Apparatus Co., Hellertown, PA; D.F.G. Mercury Corp., Evanston, IL; and Mercury Refining Co., Albany, NY.

In Minnesota, State law prohibits the disposal of thermostats and other mercury-containing devices unless the mercury has been removed. The State also requires that manufacturers of mercury-containing devices provide incentives to induce purchasers to properly dispose of used devices. In response to this legislation, Honeywell Inc., a major manufacturer of thermostats, started a recycling program in which every replaced thermostat is returned to a wholesaler who sends it to Bethlehem Apparatus Co. In 1996, Honeywell began sending postage-paid envelopes with lined bubble packs to homeowners who requested them. Encouraged with 13,000 responses, the company will extend the program to five additional States in 1997 (American Metal Market, 1996b).

As recycling has become a profitable enterprise, an

increasing number of new companies are entering the mercury-recycling business and established companies are intensifying their recycling efforts. The National Electrical Manufacturers Association, together with three manufacturing companies, formed Thermostat Recycling Corp. to launch an expanded recycling program for mercury switches and thermostats. The goal of the company is eventually to run a national program to recycle all mercury-containing devices. It is estimated by industry specialists that by the year 2000, mercury contamination resulting from the disposal of fluorescent lamps to municipal solid waste will reach 37 tons. To tap into this secondary source, Greenlites Lamp Recycling Inc., of Utica, MI, was constructing a recycling facility for fluorescent, mercury vapor, metal halide, and sodium lamps. The plant was expected to be completed by January 1997. Envirolight Inc. of Riviera Beach, FL, saw its recycling business increase tenfold because of the enactment of tighter disposal restrictions in Florida (American Metal Market, 1996c).

Consumption

Domestic consumption of mercury has been trending downward since the early 1970's. The largest total use of mercury in 1996, the electrolytic production of chlorine and caustic soda in mercury cells, consuming about 0.4 kilogram of mercury per ton of chlorine production, accounted for 136 metric tons. After an increase in 1995, caused by increased use of mercury per unit of production, the overall use of mercury was being reduced by new technology and more efficient on-site mercury reclamation from recycled wastewater sludges. Three U.S. companies are planning to replace old mercury cells with new membrane cells in 1997. The second largest use of mercury was in the electrical industry, mainly for wiring devices and switches. Mercury switches are being replaced in most cases with electronic switches or special switches used in particular niche applications. In fluorescent lighting, where no economically viable alternative to mercury vapor exists, mercury content is being reduced. Light bulbs produced today contain 60% less mercury than those manufactured 10 years ago. However, reduced use of mercury per lamp has been largely negated by an increase in the number of lamps in use, a consequence of the high energy efficiency of fluorescent lighting. The use of mercury in electrical batteries has declined precipitously from more than 1,000 tons annually in the early 1980's to a small fraction of 1 ton in 1996. Alkaline button cell batteries, the only remaining consumer batteries that contain added mercury, are being replaced with zinc-air cells that use less than 1% by weight of mercury. The only mercury oxide batteries that are still produced are for military and medical equipment only, but even for these, research in the development of acceptable substitutes is continuing.

In dental practice, the overall mercury use has remained steady, because it is the most cost-effective and longest lasting dental cavity-filler.

Prices

The average domestic dealer price increased in 1996, the third consecutive annual increase, in response to the tighter market situation. Mercury is usually sold by the 34.5-kilogram (76-pound) flask. The Platt's Metals Week average price for 1996 was $262 per flask, a nearly 6% increase over the 1995 price.

World Review

Spain's Minas de Almadén y Arrayanes (MAA) remained the largest mercury producer in the world. The plant, which over the years has produced about 260,000 tons of mercury, has an annual capacity of about 3,500 tons. Because mercury's popularity has waned with concerns over environmental and health hazards, production in 1996 was only 1,380 tons. During the next 2 years, in addition to the already ongoing improvement of the plant, MAA plans to open a new underground mine, reopen the old underground mine, and extend its open pit El Entredicho Mine. The newly discovered Nuevo Entredicho deposit, which contains an average of 23% mercury, will replace the nearly depleted El Entredicho Mine and the underground Las Cuevas Mine. The mines, present and future, and plant are all located in the Province of Ciudad Real, about 300 kilometers southwest of Madrid. In addition, the state-owned MAA is considering a recycling plant, but it faces an uphill struggle to obtain the necessary permit (Metal Bulletin Monthly, 1996).

The Kyrgyzstan Government has decided to privatize the Government-owned 650-ton-capacity Khaydarkan mining complex by opening its ownership to foreign investors. The mining complex, in southern Kyrgyzstan, consists of underground and open pit mines, a concentration plant, and a metallurgical plant. Khaydarkan produced 380 tons of mercury in 1995 and 580 tons in 1996, plus antimony and fluorite. The increased production was based mainly on selective mining of high-grade ore. Since its opening, Khaydarkan has produced 29,820 tons of mercury, 200,200 tons of fluorite, and an undetermined amount of antimony. In the move to privatize, the State Committee for Reorganization and Liquidation of Enterprises reportedly had to overcome the reluctance of the local government to accept responsibility for social services that the Khaydarkan complex had provided, and liability for old debts owed to other state-owned enterprises. Privatization of the Khaydarkan complex was funded by the World Bank (Mining Journal, 1997a).

Current Research and Technology

The EPA standard for treatment of mercury-containing waste is based on the level of concentration of mercury. Roasting and retorting was determined as the best demonstrated available technologies for mercury-containing sludges having total mercury concentrations above 260 milligrams per kilogram of waste. Applicable technologies for the low-concentration mercury wastes were stabilization, amalgamation,

electrodialysis, electrowinning, ion exchange, or acid leaching followed by sulfide precipitation.

New technologies for removal of mercury contaminants, based on the classical thermal processes of roasting and retorting, were introduced in 1996. One variation is the medium-temperature thermal process that removes and recovers mercury from soils and industrial waste, invented and developed by Pittsburgh Mineral & Environmental Technology Inc. in Pennsylvania. The process was being tested at a copper smelter where it reportedly reduced residual mercury in the acid plant sludge to less than 1 part per million. This new patented process was marketed by Mercury Recovery Services, Inc., New Brighton, PA (Mining Journal, 1997b).

The DeHg^{SM} process, developed by Nuclear Fuel Services, Inc., begins with the sorting and shredding of waste materials containing mercury and other metals specified under the Resources Conservation and Recovery Act (RCRA). Shredded waste is slurried with water, then mixed with reagents to immobilize the mercury. The slurry is later dewatered and packed for shipment to a licensed landfill for disposal. Typical concentration of mercury is less than 0.05 milligram per liter of waste (mg/L), well below RCRA standard of 0.2 mg/L, or 0.2 part per million. The process was claimed by the company to be suitable for remediation of mixed waste containing both radioactive and hazardous metals (Nuclear Fuel Service, Inc., 1997).

Outlook

Ever stricter environmental policy and the advancement of new technology are increasingly affecting both primary and secondary mercury production and mercury's use. Because of the displacement of mercury from products and processes, secondary mercury will become an even more important component of domestic supply, especially if the ban on Government sales of mercury continues. The dismantling of mercury cells in three choralkali operations in the United States, now planned, would enhance the availability of secondary mercury.

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SOURCE OF INFORMATION

USGS Publication

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TABLE 1
SALIENT MERCURY STATISTICS 1/

(Metric tons, unless otherwise specified)

	1992	1993	1994	1995	1996
United States:					
Producing mines	9	9	7	8	6
Mine production, byproduct	64	W	W	W	W
Secondary production:					
Industrial	176	350	466	534	446
Government 2/	103	--	--	--	--
Shipments from the National Defense stockpile 3/	267	543	86	(4/)	--
Imports for consumption	92	40	129	377	340
Exports	977	389	316	179	45
Industry stocks, yearend 5/	436	384	469	321 r/	446
Industrial consumption	621	558	483	436	372
Price: New York, average per flask	$201.39	$187.00	$194.45	$247.39	$261.61
World: Mine production	1,960 r/	1,800 r/	1,980 r/	3,160 r/	2,890 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Data are rounded to three significant digits, except prices.

2/ Secondary mercury shipped from U.S. Department of Energy stocks.

3/ Primary mercury.

4/ Revised to zero.

5/ Stocks at consumers and dealers only. Mine stocks withheld to avoid disclosing company proprietary data.

TABLE 2
BYPRODUCT MERCURY-PRODUCING MINES IN THE UNITED STATES IN 1996

Mine	County and State	Operator
Alligator Ridge	White Pine, NV	Placer Dome U. S.
Carlin Mines Complex	Eureka, NV	Newmont Gold Co.
Getchell	Humboldt, NV	FMC Gold Co.
McLaughlin	Napa, CA	Homestake Mining Co.
Mercur	Tooele, UT	Barrick Mercur Gold Mines Inc.
Pinson Mine	Humboldt, NV	Pinson Mining Co.

TABLE 3
U.S. INDUSTRIAL CONSUMPTION OF REFINED MERCURY METAL, BY USE e/ 1/

(Metric tons)

SIC code	Use	1995	1996
28	Chemical and allied products:		
2812	Chlorine and caustic soda manufacture	154	136
36	Electrical and electronic uses:		
3641	Electric lighting	30	29
3643	Wiring devices and switches	84	49
38	Instruments and related products:		
382	Measuring and control instruments	43	41
3843	Dental equipment and supplies	32	31
--	Other uses 2/	93	86
	Total	436	372

e/ Estimated.

1/ The input of refined liquid mercury to domestic manufacturing establishments.

2/ Comprises unclassified uses and those uses from the three principal end-use categories for which the figures are withheld to protect company proprietary data, or for which the volume of use is small.

TABLE 4
U.S. TRADE IN MERCURY AND MERCURY-BEARING WASTE AND SCRAP, BY COUNTRY 1/

Country	1995 Quantity (metric tons)	1995 Value (thousands)	1996 Quantity (metric tons)	1996 Value (thousands)
Imports:				
Canada	107	$232	137	$791
Germany	3	51	(2/)	20
Japan	19	46	(2/)	3
Kyrgyzstan	45	128	33	266
Russia	179	636	79	302
Spain	14	57	68	327
Other	10	37	23	92
Total	377	1,190	340	1,800
Exports:				
Brazil	5	29	3	16
Canada	3	22	4	29
Germany	17	47	4	25
Hong Kong	52	188	--	--
India	33	93	--	--
Japan	1	18	13	15
Korea, Republic of	3	18	5	50
Mexico	3	60	3	26
Netherlands	5	33	--	--
Venezuela	15	67	--	--
Other	42	195	13	183
Total	179	770	45	344

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Less than ½ unit.

Source: Bureau of the Census.

TABLE 5
MERCURY: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1992	1993	1994	1995	1996 e/
Algeria	476	459	414	292	300
China e/	580	520	470	780 r/	240
Czechoslovakia 3/ 4/	60	XX	XX	XX	XX
Finland	75 r/	101 r/	90 r/	90 e/	90
Kyrgyzstan	350 r/ e/	350 r/ e/	379 r/	380 r/	580
Mexico	21	12	10 e/	15 e/	15
Morocco e/ 5/	20	20	20	20	20
Russia e/	70	60	50	50	50
Slovakia e/ 4/	XX	50	50	50	20
Slovenia e/	7	--	--	--	--
Spain	36	64 r/	393	1,497	1,500
Tajikistan e/	100	80	55	50	45
Turkey	5	--	--	--	--
Ukraine e/	100	80	50	40	30
United States 6/	64	W	W	W	W
Total	1,960 r/	1,800 r/	1,980 r/	3,160 r/	2,890

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total." XX Not applicable.
1/ Table includes data available through Apr. 29, 1997.
2/ World totals and estimated data are rounded to three significant digits; may not add to totals shown.
3/ Dissolved Dec. 31, 1992.
4/ All production in Czechoslovakia for 1992 came from Slovakia.
5/ Mercury was produced only as a byproduct of silver mining.
6/ Mercury was produced only as a byproduct of gold mining.