CADMIUM

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Compared with that of 2003, estimated cadmium metal production in the United States declined by about 18% in 2004. Cadmium prices increased by about 42% in 2004 from those of 2003 (table 1). In the United States, only two companies produced cadmium in 2004. Zinifex Ltd. (formerly Pasminco Ltd.) produced primary cadmium as a byproduct of the smelting and refining of zinc concentrates, while the International Metals Reclamation Company, Inc. (INMETCO) produced secondary cadmium from scrap, almost entirely from spent nickel-cadmium (NiCd) batteries. The total value of cadmium produced in the United States in 2004 was calculated to be about $861,000. Although definitive consumption data do not exist, the International Cadmium Association (ICdA) made the following estimates of cadmium consumption for various end uses in 2004: batteries, 81%; pigments, 10%; coatings and plating, 7%; stabilizers for plastics and similar synthetic products, 1.5%; and nonferrous alloys and other uses, 0.5% (Hugh Morrow, President, International Cadmium Association, oral commun., March 2005).

Worldwide, cadmium market prices rose in mid-2004 owing to increased demand (mainly from the Chinese NiCd battery industry), decreased primary production (because some zinc producers cut byproduct cadmium output), and decreasing stocks of refined metal. The decrease in primary production was partly offset by increased secondary production, mainly from recycled NiCd batteries. Some leading producers of primary cadmium in 2004 were: Akita Smelting Co. Ltd. (Japan), Budel Zink BV (Netherlands), Falconbridge Ltd. (Canada), Hindustan Zinc Ltd. (India), Huludao Zinc Smelting Co. (China), JSC Chelyabinsk Electrolytic Zinc Plant (Russia), Korea Zinc Co., Ltd. (Republic of Korea), Met-Mex Peñoles, S.A. de C.V. (Mexico), Noranda, Inc. (Canada), Glencore AG—Porto Vesme (Italy), Teck Cominco Ltd. (Canada), Toho Zinc Co. Ltd. (Japan), Zhuzhou Smelter Group Co., Ltd. (China), and Zinifex Ltd. (Australia). The smelter of Britannia Zinc Ltd. (United Kingdom) was idle the entire year.

Legislation and Government Programs

During the past decade, regulatory pressure to reduce or even eliminate the use of cadmium, a metal that is toxic in certain forms and concentrations, has gained momentum. The initiative to ban or at least drastically reduce the use of cadmium is more pronounced in developed countries with high population densities such as the United States and the European Union (EU). About 146,000 metric tons (t) of consumer batteries of all types was discarded in the United States in 1992 (latest available data). Spent batteries are of particular concern to landfill operators and regulators because they contribute a disproportionate percentage of certain toxic heavy metals—primarily cadmium and mercury—to the waste stream (Fishbein, 1996§[1]).

In December 2004, the U.S. Environmental Protection Agency (EPA) published a draft of its "Framework for Inorganic Metals Risk Assessment" for public comment. For more than a decade, the U.S. Government has worked to establish a scientific method for evaluating the effects of different metals on human health and the environment. In January 2002, the EPA's Science Policy Council tasked an EPA workgroup with devising a Metals Action Plan (MAP). The Plan would be used to establish a process for ensuring a consistent application of scientific principles to metals risk assessment. The need for a new study became apparent when some segments of industry complained about inclusion of metals and inorganic metal compounds in the EPA list of bioaccumulative, persistent, and toxic pollutants—a list designed mainly for organic compounds.

In September 2002, the EPA-nominated Science Advisory Board (SAB) reviewed the draft MAP and supported the Plan's recommendation that the EPA develop a framework for metals assessment. The SAB review panel agreed that metals should be assessed differently than organic pollutants because metals do not degrade like most organic compounds and can have complex environmental chemistries. The panel also pointed out that some metals are essential for living organisms. In response to public comments on the MAP, the EPA commissioned several issue papers in 2003. These issue papers were subsequently incorporated into the "Framework for Inorganic Metals Risk Assessment." The issue papers dealt with bioavailability and bioaccumulation of metals, as well as the ecological effects of metals, their environmental chemistries, exposure pathways, and human health effects. In February 2005, the SAB began a peer review of the draft framework (U.S. Environmental Protection Agency, 2005§).

In addition to Federal regulations, 13 States have passed legislation regulating battery labeling and removeability from consumer products. Eight States now have takeback requirements that apply to all NiCds batteries. The most stringent takeback regulations are in Minnesota, where 90% of NiCd and small sealed lead-acid batteries must be recovered, and in New Jersey, where manufacturers are required to take responsibility for used rechargeable batteries and either recycle or dispose of them in an environmentally sound manner (Fishbein, 1996§). Because nearly 40,000 cell phones are thrown away daily in California, the California State Assembly passed Bill 2901 (The Cell Phone Recycling Act of 2004) requiring retailers of cellular phones to recycle old telephones at no cost to consumers after July 1, 2006 (Recycling Today,

[1]References that include a section mark (§) are found in the Internet References Cited section.

2004§). The bill was subsequently passed by the California State Senate and signed into law by the Governor in late September (Ursery, 2004§).

In December 2004, the Environment Council of the European Union approved the draft of a new directive on batteries and accumulators. The Council formally adopted the directive proposal on January 19, 2005. The primary objective of the proposed directive was to halt unregulated dumping and incineration of waste batteries. The most controversial part of the directive was a partial ban on some portable cadmium batteries. NiCd batteries would only be permitted to be used in alarm and emergency systems, cordless power tools, and medical equipment, although the exemption for power tools was to be reviewed. These exempted batteries would also have to be collected and recycled. Collection targets for portable household batteries were 25% and 45% to be achieved in 4 and 8 years, respectively, after the transposition of the directive into the laws of the member country (European Commission, 2004§; United Kingdom Department for Environment, Food and Rural Affairs, 2005§).

In February 2003, the EU adopted a set of environmental regulations that are having a profound impact on electronics and semiconductor manufacturing. One directive in particular is affecting electronic-circuit design worldwide. This directive—"The Restriction of the Use of Hazardous Substances" (RoHS)—takes effect on July 1, 2006. The RoHS directive restricts the incorporation of cadmium, hexavalent chromium, lead, and mercury in most electrical and electronic equipment sold in the EU after the 2006 deadline. The directive covers computers, digital video disk players, electronic tools and toys, household appliances, radios, telephones, televisions, and many other products. Cadmium plating is exempt from RoHS. Under a related directive, "Waste from Electrical and Electronic Equipment" (WEEE), the EU now holds manufacturers financially responsible for the collection and recycling of used electronic products. The WEEE directive took effect on August 13, 2005 (Katz, 2005§).

Production

Worldwide production of cadmium in 2004 increased slightly to about 18,800 t from 18,500 t in 2003. Consumption declined by about 8%, narrowing the gap between world production and consumption. In a few countries, like Belgium and the United States, the decline in the output of cadmium was the result of the reduction or discontinuation of zinc mining and smelting (table 5).

Primary.—Much of the byproduct cadmium produced in Tennessee in 2004 was derived from imported zinc concentrates.

On April 5, 2004, Zinifex Ltd. went public and acquired a number of lead-zinc mining and smelting operations from Pasminco Ltd. These assets included the Clarksville zinc smelter and refinery, 80 kilometers (km) northwest of Nashville, TN. Clarksville is the smallest of Zinifex's smelting and refining complexes and has a capacity of 110,000 metric tons per year (t/yr) of zinc metal (Zinifex Limited, 2005, p. 7, 14). The complex, located in Montgomery County, also produces byproduct cadmium and approximately 145,000 t/yr of sulfuric acid.

Prior to 2004, the Clarksville smelter obtained the bulk of its cadmium-bearing zinc concentrates from the Clinch Valley (Grainger County) and Gordonsville Mines (Smith County). Gordonsville was closed in 2003; Clinch Valley, in 2004. In the first half of 2005, Clarksville was to obtain all of its concentrates from Australia, Central America, Ireland, and South America.

The zinc operations of ASARCO LLC in northeastern Tennessee were idle throughout all of 2004 and did not produce any cadmium. In November 2001, ASARCO suspended operations at its Coy, Immel, and Young underground mines in the Mascot-Jefferson City District. The Young mill at Strawberry Plains (Jefferson County) was placed on care-and-maintenance status at the same time.

Secondary.—Although primary cadmium production has declined somewhat since 2000, production of secondary cadmium has been increasing steadily. There are three major industry collection and recycling programs in the world: the Rechargeable Battery Recycling Corp. (RBRC) program in the United States and Canada, the Battery Association of Japan program, and the CollectNiCad program in Europe. The amount of cadmium being recycled, however, is difficult to estimate. The reported amount of NiCd batteries collected is fairly accurate, but there are no published data on the amounts of cadmium recovered from recycled batteries and other sources, such as electric arc furnace (EAF) dust, electroplating wastes, filter cakes, sludges, and other cadmium-containing materials. EAF dust typically contains about 0.05% cadmium.

The most difficult aspect of NiCd battery recycling has been the collection of spent batteries purchased for household use. Although large industrial batteries (containing about 20% of all cadmium used for batteries) are easy to collect and are recycled at a rate of about 80%, the small consumer NiCd batteries are frequently discarded by the public. Voluntary industry-sponsored collection programs and Government agency programs have been devised to improve the collection of these small consumer batteries and are continually being upgraded. Public participation is critical because, in addition to improving the environment, economies of scale are very important—larger recycling operations lower unit costs. INMETCO has developed several different collection programs to meet the varied needs of battery manufacturers and the numerous agencies, consumers, firms, and organizations that use the many diverse products containing NiCd batteries (cordless phones, personal computers, power tools, etc.). The most successful recycling program in the United States is operated by the RBRC. Established when INMETCO began cadmium recycling in 1995, RBRC has organized a multifaceted collection program financed with proceeds from licensing its seal of approval to individual companies involved in the manufacturing, importation, and distribution of rechargeable batteries or battery-operated products. The RBRC recycling program contains several key elements including uniform battery labeling, removeability from appliances, a national network of collection systems, regulatory relief to facilitate battery collection, and widespread publicity to encourage public participation. To increase participation, RBRC has undertaken an extensive public education campaign and has established numerous collection sites throughout the United States and Canada (Money, Tomaszewski, and Bleakney, undated). In 2004, the RBRC collected about 1,500 t of NiCd batteries.

Recycling of Cellular Telephone Batteries.—In 2003 (latest available data), 100 million cellular telephones were taken out of service in the United States. About 150 million cell phones are in use in the United States and are replaced on average every 12 to 18 months. Of the 100 million taken out of use, an estimated 60% to 70% was left by consumers in their home. Of the remaining 30% to 40%, only about 5 million were refurbished or recycled, while at least 25 million were discarded in municipal waste sites. Although cell phones make up only a small percentage of the overall municipal waste stream, they may contain several toxic elements such as cadmium, lead, and mercury (Wireless Recycling, 2004§).

In response to public concern about the environment, the cellular telephone industry in the United States joined the telephone recycling movement. As the stockpile of retired wireless devices continued to grow, the Cellular Telecommunications & Internet Association launched its initiative to promote environmentally sound recycling of used wireless products that contain cadmium, lead, lithium, and other hazardous metals. The association's "Wireless: The New Recyclable" program is designed to focus the public's attention on the importance and ease of recycling wireless devices (Recycle Wireless Phones, undated§).

The recycling of phones is typically carried out by contractors who turn consumer and industry discards into profit, reduce environmental waste, and at the same time help some nonprofit organizations. One of the latest companies to begin phone recycling is GRC Wireless Recycling, headquartered in Miramar, FL. The company has formed a national partnership with businesses affected by the California Cell Phone Recycling Act of 2004. GRC pays $1 per pound or more for used telephones collected through 1,200 organizations in 49 States. The company has paid out more than $1.2 million since the partnership's establishment in 2001. About 70% of collected phones is refurbished and sold to buyers, mainly in Latin America, or given to nonprofit organizations. The remaining 30% is shredded and sold to nonferrous metal smelters for feed (Sun-Sentinel, 2004§).

Consumption

According to the World Bureau of Metal Statistics, global cadmium consumption in 2004 decreased to about 18,300 t, about 8% less than the tonnage for 2003. Cadmium consumption in the 1990s was fueled by the growing NiCd rechargeable battery market. However, since 2002, consumption has weakened because of increasingly restrictive environmental regulations.

During the 1990s, several battery manufacturing facilities relocated from Europe and North America to countries with less stringent environmental restrictions and lower labor costs. The main beneficiary of this transfer was China, which emerged as the leading cadmium consumer in the world, followed by Japan. Together, the two countries consumed more than one-half of world cadmium production in 2004 (Wilson, 2005). China alone consumed an estimated 6,600 t of cadmium, more than twice as much as it produced. China was also the leading importer of cadmium metal in 2004, receiving 6,890 t, a 21% increase compared with that of 2003 and an eight-fold increase since 1999. Although Chinese imports of cadmium-bearing waste and scrap declined by 43% to an estimated 940 t, total cadmium imports rose by 6%. Nearly one-quarter of the imported cadmium was reported to be from Kazakhstan, followed by the Republic of Korea, the United States, and the Former Yugoslavia (China's Customs Statistics, 2005; Metal-Pages, 2005a§). NiCd battery production in China was estimated to have increased to about 800 million units in 2004, a 20% increase compared with that of 2003 (Wilson, 2005; Metal-Pages, 2004a§).

The U.S. Geological Survey (USGS) does not collect consumption data on cadmium metal or cadmium compounds. Apparent consumption of cadmium metal in the United States is calculated by the USGS using the production data of individual companies, U.S. foreign trade statistics, and reported stock changes (table 1).

Worldwide consumption of cadmium for production of rechargeable batteries, which is the dominant use of cadmium, has been growing steadily for more than 15 years. Other cadmium markets, such as alloys, coatings, pigments, and stabilizers, are regarded as mature and are not expected to grow. Cadmium metal is commercially used as a corrosion-resistant coating on aluminum, other nonferrous metals, and steel, especially where low friction or low electrical resistivity is needed. Cadmium metal is also added to some nonferrous alloys to improve properties such as strength, hardness, wear resistance, castability, and electrochemical behavior. Cadmium compounds are used in batteries, pigments, plastic stabilizers, and semiconductor applications.

Prices

In 2004, the cadmium price increased to $0.71 per pound owing to continued supply shortages (table 1). China was the main factor behind the 2004 price increase owing to the country's increased consumption and lower than anticipated production. Production growth in China slowed because of power shortages and a scarcity of zinc concentrates (Metal-Pages, 2005a§, b§).

Environmental Issues

Emissions From Lead and/or Zinc Smelters.—In March 2004, a team of environmental health specialists from the Centers for Disease Control and Prevention (CDC) visited the La Oroya copper and lead smelter in Peru (The Doe Run Company, 2005§). Prolonged cadmium and lead emissions have been a concern at the Andean smelter for several decades. The Doe Run Company of St. Louis, MO, acquired Metaloroya (now Doe Run Peru) in 1997 from Centromin, a Peruvian parastatal, with the understanding that the U.S.-based company would improve operational efficiencies, reduce hazardous metal emissions, and dramatically increase industrial safety. Since then, Doe Run has spent $140 million on facility improvements designed to reduce plant emission and improve community life. The CDC team was to provide technical assistance to the project and recommend ways of further reducing exposure to lead, cadmium, and other contaminants. In May 2005, the team submitted its recommendations in a report to the Government of Peru and the U.S. Agency for International Development (Centers for Disease Control and Prevention, 2005, p. 13, 23, 33-35). The long-term environmental remediation project currently underway at the La Oroya smelter illustrates how similar pollution problems can be alleviated at other nonferrous smelters worldwide (The Doe Run Company, 2005§).

Because of these improvements, lead levels in the blood of the workers have fallen more than 30% on the average. Air lead emissions of the main stack are down by more than 35% since 1998 (The Doe Run Company, 2005). Doe Run is planning to spend an additional $150 million on sulfur emissions abatement (Moore, 2005§). Remediation efforts to address historical soil contamination by arsenic, cadmium, and lead cannot be completely addressed until air emissions from the smelter are fully controlled.

Life-cycle Studies of Batteries.—Rydh and Karlström have studied the environmental impact of recycling portable NiCd batteries in Sweden. Their results showed that in Sweden in 2001, 25% of NiCd batteries was recycled, 45% incinerated, and 30% landfilled. Their model indicated that batteries manufactured from recycled cadmium and nickel would have 16% lower primary energy requirements than if only virgin metals were used (Rydh and Karlström, 2002, p. 296-302, 307).

Plated Automotive Parts.—The European Commission has proposed stricter regulations on the disposal and end-of-life recycling of automobiles. Two major Japanese automakers recently revealed plans to produce cars with no cadmium, hexavalent chromium, lead, or mercury, except for the lead in lead-acid batteries (an end use where lead recycling exceeds 90%). Toyota Motor Corporation already has developed a mercury-free lamp and has ceased using lead in such parts as fuel tanks (Metal-Pages, 2004b§). Honda Motor Co. Ltd. intends to abolish all applications of the four metals in its vehicles by yearend 2005, 2 years earlier than required by the Japan Manufacturers Association (Metal-Pages, 2005c§).

Current Research and Technology

Thin film photovoltaic solar panels may provide a more cost-effective alternative to traditional solar systems that rely on crystalline silicon wafers. Substantial progress has been made in improving cadmium telluride (CdTe)-based thin-film solar cells. For more than 30 years, designers have relied on tin oxide (SnO_2)/cadmium sulfide (CdS)/CdTe device structures. Scientists at the National Renewable Energy Laboratory in Golden, CO, have improved the performance of these devices by incorporating cadmium stannate (Cd_2SnO_4) and zinc stannate (Zn_2SnO_4) into device structures. One such modified device had a total-area efficiency of 16.5%—the highest efficiency ever reported for CdTe solar cells (Wu and others, 2001). This efficiency compares favorably with the efficiencies attained with thin-film copper indium aluminum diselenide devices (U.S. Department of Energy, 2005§).

In June 2004, TeraRecon, Inc. of San Mateo, CA, teamed up with Acrorad Co. Ltd. of Okinawa, Japan, to develop advanced CdTe semiconductor devices for direct conversion x-ray and gamma-ray detectors. CdTe is one of a few semiconductor materials that can convert x rays and gamma rays directly into electrical signals while attaining high conversion efficiency. Acrorad reportedly has overcome many of the difficulties that prevented competitors from manufacturing large monolithic CdTe crystals. Acrorad's facility on Okinawa is reportedly the largest CdTe production operation in the world in terms of volume. The two companies will focus their efforts initially on flat panel area-detectors and gamma-ray cameras. Both products would be sold to original equipment manufacturers and have numerous applications in the fields of industrial and medical imaging (TeraRecon, Inc., 2004).

Outlook

Cadmium producers and consumers face an unusual situation. Environmentalists oppose the proliferation of cadmium in any form because of the metal's toxicity. Consumers, meanwhile, are demanding computers, power tools, and other electric products that require the use of relatively inexpensive NiCd batteries. To date, nickel-metal hydride (NiMH) and lithium-ion batteries have been more expensive to manufacture than NiCds and are not being used in many low-end products. The commercialization of novel nickel-zinc (Ni-Zn) batteries may change the current situation. San Diego-based PowerGenix has developed and patented the next generation Ni-Zn battery that is up to 10 times more powerful than traditional NiCd, NiMH, or lead-acid batteries, while up to 75% lighter and about 30% smaller. Venture capitalists have invested $13 million in Ni-Zn battery research hoping that the new battery will become an economically viable and environmentally friendly alternative to NiCds (Metal-Pages, 2004c§).

Chinese and Indian markets will continue to drive NiCd battery demand in the foreseeable future. China currently consumes more than twice as much cadmium as it produces, mainly to feed the country's burgeoning NiCd battery manufacturing industry.

If cadmium prices continue to strengthen, the growing supply deficit will be partially offset by improved recycling rates and the increased availability of recycled cadmium. According to a 1999 survey conducted by the RBRC, 95% of Americans own cordless electronic products, but only about 16% recycle their power sources (American Metal Market, 1999). Another survey conducted by the RBRC has highlighted America's growing reliance on cordless electronic products. The average U.S. household has five or more of these products, which include cordless and cellular telephones, cordless power tools, laptop computers, electric toothbrushes, camcorders, handheld minivacuums, and remote-controlled toys. The survey found that more than one-half of respondents would recycle their rechargeable batteries if the batteries were collected together with other recyclables through curbside collection programs at home, at businesses, or at retail stores that sell replacement batteries (Rechargeable Battery Recycling Corp., 2002§).

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TABLE 1
SALIENT CADMIUM STATISTICS[1]

		2000	2001	2002	2003	2004
United States:						
Production of metal, Cd content[2]	metric tons	1,890	680 e	700 e	670 e	550 e
Shipments of metal by producers[3]	do.	1,580	954	776	320	44
Exports of metal, alloys, scrap	do.	314	272	168	558	132
Imports for consumption, metal	do.	425	107	25	18	38
Stocks of metal, Government, yearend	do.	807	773	80	--	--
Apparent consumption of metal	do.	2,010	659	561	530	500
Price, average, New York dealer[4]	dollars per pound	0.16	0.23	0.52	0.50	0.71
World, refinery production, Cd content	metric tons	20,300 r	19,000 r	17,500 r	18,500 r	18,800

[e]Estimated. [r]Revised. -- Zero.

[1]Data are rounded to no more than three significant digits, except prices.

[2]Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.

[3]Includes metal consumed at producer plants.

[4]Price for 1- to 5-short-ton lots of metal having a minimum purity of 99.95% (Platts Metals Week).

TABLE 2
SUPPLY AND APPARENT CONSUMPTION OF CADMIUM METAL[1]

(Metric tons)

	2003	2004
Industry stocks, January 1	1,780	1,460
Production[e]	670	550
Imports for consumption of metal, alloy, scrap	18	38
Shipments from Government stockpile excesses	80	--
Total supply	2,550	2,050
Exports of metal, alloys, scrap	558	132
Industry stocks, December 31	1,460	1,420
Consumption, apparent[2]	530	500

[e]Estimated. -- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Total supply minus exports and yearend stocks.

TABLE 3
U.S. EXPORTS OF CADMIUM PRODUCTS, BY COUNTRY[1]

	2003		2004	
Country	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Cadmium metal:[2]				
Belguim	79,900	$80,000	--	--
Canada	10,700	227,000	19,600	$429,000
China	145,000	189,000	--	--
France	48,600	51,000	16,400	19,500
Germany	118	88,500	37,500	209,000
India	38,500	12,000	--	--
Israel	16,100	65,400	24,300	99,000
Korea, Republic of	7	8,220	--	--
Mexico	125	23,300	2,640	19,800

See footnotes at end of table.

TABLE 3—Continued

U.S. EXPORTS OF CADMIUM PRODUCTS, BY COUNTRY[1]

Country	2003 Quantity (kilograms)	2003 Value	2004 Quantity (kilograms)	2004 Value
Cadmium metal—Continued:[2]				
Netherlands	168,000	219,000	--	--
Pakistan	--	--	21,100	24,500
Singapore	7,110	16,100	10,300	60,400
Thailand	3	2,610	--	--
United Kingdom	40,500	70,600	--	--
Venezuela	3,540	3,000	--	--
Total	558,000	1,060,000	132,000	861,000
Cadmium sulfide, gross weight:				
Belgium	--	--	25,600	13,800
China	70,600	36,700	--	--
Colombia	--	--	6,350	3,300
Germany	--	--	--	--
Israel	--	--	6,720	3,500
Japan	43,900	22,800	--	--
Korea, Republic of	--	--	38,500	12,300
Mexico	69,800	37,600	83,200	43,300
Total	184,000	97,100	160,000	76,200

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes exports of cadmium in alloys and scrap.

Source: U.S. Census Bureau.

TABLE 4

U.S. IMPORTS FOR CONSUMPTION OF CADMIUM PRODUCTS, BY COUNTRY[1]

Country	2003 Quantity (kilograms)	2003 Value	2004 Quantity (kilograms)	2004 Value
Cadmium metal:				
Canada	1,530	$337,000	74	$27,800
China	55	19,300	--	--
France	--	--	14	30,300
Mexico	16,400	26,300	37,900	51,500
Netherlands	--	--	2	8,540
United Kingdom	--	--	7	9,040
Total	18,000	383,000	38,000	127,000
Cadmium sulfide, gross weight:				
China	3,840	10,600	--	--
United Kingdom	3,630	42,300	1,810	22,600
Total	7,470	52,900	1,810	22,600

-- Zero.

[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5

CADMIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2000	2001	2002	2003	2004[e]
Algeria[e]	10	10	8 [r]	5 [r]	--
Argentina	--	34	--	25 [r]	25
Australia	552	378	350	350 [e]	350
Belgium	1,148	1,236	117	120 [e]	120
Brazil[e]	300	300	300	300	300
Bulgaria	331 [r]	333 [r]	345 [r]	307 [r]	300
Canada[3]	1,941	1,493 [r]	1,706 [r]	1,759 [r]	1,888 [4]
China[e]	2,370	2,510	2,440	2,710 [r]	2,800
Finland[5]	683	604	4 [r]	-- [e]	--
France	160	176	175	178	175
Germany	458 [r]	539 [r]	422	640 [r, e]	640
India	314	436	466	477 [r]	489 [4]
Italy	284	312	391	100 [e]	100
Japan	2,472	2,460	2,444	2,497	2,233 [4]
Kazakhstan	1,250 [e]	1,250 [e]	1,300	1,351	1,900
Korea, North[e]	100	100	100	100	100
Korea, Republic of	1,911	1,879	1,827	2,180 [r]	2,100
Macedonia[e]	(6)	(6)	(6)	(6)	(6)
Mexico[7]	1,268	1,241	1,382	1,590 [r]	1,600
Netherlands	628	455	485	500 [e]	500
Norway	298	372	209	331 [r]	260 [4]
Peru	483	456	422	529 [r]	532
Poland, metal, primary refined	6	330	440 [r]	400 [r, e]	400
Russia[e]	925 [4]	950	950	950	950
Ukraine[e]	25	25	25	25	25
United Kingdom[3]	503	485	450 [e]	450 [e]	450
United States[e, 3]	1,890 [4]	680	700	670	550
Total	20,300 [r]	19,000 [r]	17,500 [r]	18,500 [r]	18,800

[e]Estimated. [r]Revised. -- Zero.

[1]This table gives unwrought production from ores, concentrates, flue dusts, and other materials of both domestic and imported origin. Sources generally do not indicate if secondary metal (recovered from scrap) is included or not; where known, this has been indicated by a footnote. Data derived in part from World Metal Statistics (published by World Bureau of Metal Statistics, Ware, United Kingdom) and from Metal Statistics (published jointly by Metallgesellschaft AG, Frankfurt am Main, Germany, and World Bureau of Metal Statistics). Cadmium is found in ores, concentrates, and/or flue dusts in several other countries, but these materials are exported for treatment elsewhere to recover cadmium metal; therefore, such output is not reported in this table to avoid double counting. This table includes data available through May 13, 2005.

[2]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[3]Includes secondary.

[4]Reported figure.

[5]Excludes secondary production from recycled nickel-cadmium batteries.

[6]Less than ½ unit.

[7]Excludes significant production of both cadmium oxide and cadmium contained in exported concentrates.