# CADMIUM

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Compared with that of 2002, estimated cadmium metal production in the United States declined by about 4% in 2003. Apparent domestic consumption declined by about 5% compared with consumption in 2002. Sales from the National Defense Stockpile, operated by the Defense Logistics Agency of the U.S. Department of Defense, ceased at the beginning of 2003 owing to depletion of its inventory. Cadmium prices declined slightly in 2003 (table 1).

In the United States, only two companies produced cadmium in 2003—Pasminco Ltd. produced primary cadmium as a byproduct of the smelting and refining of zinc concentrates, and 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 2003 was calculated to be about $737,000. Although definitive consumption data do not exist, the International Cadmium Association (ICdA) made the following estimates of cadmium consumption for various end uses in 2003: batteries, 79%; pigments, 12%; coatings and plating, 7.5%; stabilizers for plastics and similar synthetic products, 1%; and nonferrous alloys and other uses, 0.5% (Hugh Morrow, President, International Cadmium Association, oral commun., February 2004).

Worldwide, cadmium market prices rose in 2003 owing to increased demand (mainly from the Chinese NiCd battery industry), decreased primary production (because most zinc producers are cutting cadmium output), and decreasing stocks. The decrease in primary production was partly offset by increased secondary production, mainly from recycled NiCd batteries.

## Legislation and Government Programs

During the past decade, regulatory pressure to reduce or even eliminate the use of cadmium, a metal which is toxic in certain forms and concentrations, has gained momentum—mainly in the European Union (EU) and other developed countries, such as the United States. In December 2003, a protocol that will restrict the emission of three harmful heavy metals—cadmium, lead, and mercury—became effective as part of a United Nations treaty to protect the quality of the air. The Protocol on Heavy Metals, ratified by 18 countries, including the United States, and the EU, requires all signatories to reduce emissions of cadmium, lead, and mercury to levels below those of 1990 (United Nations, 2003§[1]). In the United States, Federal and State agencies regulate the cadmium content of air, water (including bottled water), pesticides, color and food additives, waste, and other harmful substances. Cadmium, together with other nonferrous metals, also was included in the list of persistent, bioaccumulative, and toxic (PBT) pollutants prepared by the U.S. Environmental Protection Agency (EPA) in 1999.

In July, at the request of interested parties, the U.S. Occupational Safety and Health Administration (OSHA) held public hearings on phase 2 of their Standards Improvement Project. The testimony and documentary evidence submitted on phase 2 was intended to help in revising several standards in the proposed rule that was first issued in October 2002, and which OSHA considered outdated, duplicative, unnecessary, or inconsistent. For cadmium, the revised provisions would remove the requirement that the examining physician sign the medical opinion that determines whether the employee may continue to work in cadmium-exposed jobs and would allow employers who monitor the workplace environment to either post or individually inform employees of their monitoring results (ILZRO Environmental Update, 2003b).

The Joint Food and Agriculture Organization/World Health Organization (FAO/WHO) Expert Committee on Food Additives recommended that the permissible tolerable weekly intake for cadmium in food remain at the current level of 7 micrograms per kilogram of body weight. After considering an extensive amount of new information, the committee concluded that kidney dysfunction is the critical outcome with regard to cadmium toxicity (ILZRO Environmental Update, 2003a).

## Production

Worldwide production of cadmium in 2003 increased to about 16,900 metric tons (t) from 16,800 t in 2002. In some countries, the decline in the output of cadmium has been the result of the reduction or discontinuation of zinc mining and smelting (table 5).

In addition to stringent environmental restrictions, U.S. production was also impeded by low cadmium prices, because for producers to make a profit, the price of cadmium must be above $1 per pound. As a result, Pasminco is currently the only producer of primary cadmium in the United States. At its Clarksville, TN, zinc smelter, Pasminco is using an electrolytic process in which cadmium is recovered as a byproduct during the roasting and leaching of zinc concentrates. After removing various impurities, cadmium is processed to its final form by either refining or electrowinning. The whole process consists of heating the zinc concentrate in fluidized bed roasters to produce an impure zinc oxide (calcine) suitable for acid leaching. Between 60% and 85% of the calcine, which contains cadmium and other impurities, is volatilized with the sulfur dioxide gas generated during the roasting process. Calcine and fume are separated from the gas and collected in waste heat boilers, cyclones, and electrostatic precipitators. The collected calcine dust is combined

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

with the unvolatilized portion of the calcine and dissolved in sulfuric acid at a leaching plant. Generally, manganese dioxide is added to the leaching tank to remove iron and significant amounts of other impurities. These insoluble residues are sold to other smelters for further processing as iron cake. The leachate is sent to a series of cold and hot purification tanks, where cadmium and other remaining undesirable metals are removed from the solution. After the first stage of zinc sulfate purification, discharged impurities form a copper cake, which, like the previously captured leach residues, are sold for processing. The bulk of cadmium is precipitated in the second stage of purification, and the remainder is precipitated in a third stage. The cadmium precipitate is filtered and forms a cake containing about 12% cadmium, 25% zinc, and small amounts of other impurities. The cake is then redissolved in sulfuric acid. After two additional acid treatments, a cadmium sponge is produced and then is dissolved in another sulfuric acid bath; the solution, if sufficiently pure, is passed into electrolytic cells where the cadmium is deposited on cathodes. The resulting cadmium metal (more than 99.99% pure) is melted and cast into 50-millimeter (mm)-diameter ball anodes or 250-mm-long sticks or oxidized in a controlled atmosphere to produce cadmium oxide powder. Higher purity cadmium for special purposes, such as for semiconductors, can be produced by vacuum distillation (U.S. Environmental Protection Agency, 1987, p. 9).

Although primary cadmium production is declining, production of secondary cadmium has been increasing steadily over the past several years. There are three major industry collection and recycling programs in the world: the Rechargeable Battery Recycling Corp. (RBRC) in the United States and Canada, the Battery Association of Japan, and the CollectNiCad program in Europe. The amount of cadmium that is recycled, however, is difficult to estimate for a number of reasons. For example, cadmium from baghouse dust, which is generated at lead and copper smelters, enters the primary cadmium production circuit at zinc refining operations and may or may not be included in reported production statistics for primary cadmium metal. The reported amount of NiCd batteries collected is fairly accurate, but there are no firm data on the amounts of cadmium recovered from recycled batteries and other sources, such as electric arc furnace (EAF) dust, which contains about 0.05% cadmium, electroplating wastes, filter cakes, sludges, and other cadmium-containing materials.

In 1995, INMETCO (a subsidiary of the International Nickel Co.) began reclaiming cadmium from spent batteries at its Ellwood City plant, northwest of Pittsburgh, PA. The $5 million, high-temperature metal recovery addition to the Ellwood City plant was the first facility of its kind in the world. It is capable of processing more than 2,500 metric tons per year (t/yr) of spent NiCd batteries. Cadmium recycling at the facility thus far has been practical only for NiCd batteries, some alloys, and EAF dust.

The most difficult aspect of NiCd battery recycling has been the collection of spent batteries. Like all elements, cadmium is subject to physical and chemical laws that make its processing predictable and dependable. On the other hand, efforts to change the attitudes and habits of the public about recycling have proven to be much more complicated and difficult. 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 usually discarded by the public. Therefore, voluntary industry-sponsored collection programs and Government agency programs are being devised to improve the collection of these small consumer batteries, because, in addition to improving the environment, economies of scale are very important—larger recycling operations lower unit costs. Several different collection programs have been developed by INMETCO to meet the varied needs of battery manufacturers and the numerous consumers, firms, organizations, and agencies 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 begun 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 that are specified in EPA regulations (40 CFR part 273), Federal law (The Mercury-Containing and Rechargeable Battery Management Act of 1996), and various State laws. These elements include uniform battery labeling, removability from appliances, a national network of collection systems, regulatory relief to facilitate battery collection, and widespread publicity to encourage public participation. For that purpose, RBRC has undertaken an extensive public education campaign and has established several collection sites in the United States and Canada. Another successful collection program is INMETCO's prepaid container program in which companies that generate spent batteries purchase a 14-kilogram (kg) container for collection and shipment of spent batteries. The fee for the container includes shipping by United Parcel Service of America Inc. handling, sorting, and processing. Additional collection programs, initiated by INMETCO, include mail-back envelopes, a small package program, and so-called "milk runs." Because most of the industrial NiCd batteries are not allowed to be discarded in municipal waste dumps, they are recycled through collection programs in which producers of these batteries collect and send their spent batteries to INMETCO (Money, Tomaszewski, and Bleakney, undated).

The process of cadmium recovery from industrial and consumer sealed batteries differs only in the manner of battery preparation. Processing of industrial batteries that contain up to 7% cadmium consists of draining the sodium hydroxide electrolyte, cutting the tops off the batteries, and separating the nickel and cadmium plates. Small batteries that contain up to 16% cadmium must be handsorted because only newer batteries are color coded; very few of them carry bar codes, making optical scanning and other automated sorting very difficult.

In addition to the primary and secondary production, the availability of cadmium metal during the past decade was greatly affected by material available from stockpiles. The largest stocks during the past decade were held by the U.S. Defense Logistics Agency (DLA). About 693 t of cadmium was sold in 2002, and the remaining DLA stock was sold by the beginning of 2003. Less certain is the amount of stockpiled cadmium held by producers and traders. Because of low prices since 1996, many producers curtailed production of refined cadmium and may have stockpiled impure cadmium sponge against expectations of future improvements in price. For the same reason, many traders and investors stockpiled inexpensive cadmium, purchased mainly from DLA.

**Recycling**

On October 14, 2003, the cellular telephone industry in the United States, including AT&T Wireless, Sprint, Verizon Wireless, and a handful of others, joined the cadmium recycling movement. More than 80 million wireless phones are sold in North America each year. On average, consumers update their wireless devices every 18 months. As the stockpile of retired wireless devices continued to grow, the Cellular Telecommunications & Internet Association launched its initiative to promote the environmentally sound recycling of used wireless products that contain cadmium, lead, lithium, and other hazardous metals. The "Wireless: The New Recyclable" program will focus the public's attention on the importance and ease of recycling wireless devices (RecycleWirelessPhones, undated§).

The European Commission has prepared a revised version of the 1991 Directive on Batteries and Accumulators, which, in its original version, alarmed many cadmium and battery producers and consumers. According to the latest available data, about 45% of all portable batteries and accumulators sold in the EU in 2002, were disposed in landfills or incinerated. It is estimated that emissions into the air from waste incineration account for 16 t/yr of cadmium, and up to 66 kg of cadmium enters groundwater from landfills. Instead of banning most cadmium and mercury use, the new Directive 2002/96/EC on waste electrical and electronic equipment aimed to establish a closed-loop system for recycling. In addition, the new directive proposed minimum recycling efficiencies—the recycling process of NiCd batteries should recover all the cadmium and at least 75% of the average weight of those batteries (Commission of the European Communities, 2003, p. 9-10).

China is beginning to consider the environmental benefits of battery recycling as domestic battery consumption, which currently amounts to more than 8 billion annually, continues to grow. According to the preliminary proposal by the State Environmental Protection Administration of China, domestic battery manufacturers and importers will be required to set up collection networks for discarded batteries, based on their distribution chains. They also will be required to attach labels to their products that will describe what toxins their batteries contain and how they should be recycled or discarded. In time, the number of facilities to treat hazardous waste should increase to 31 from the current 5. However, no time frame was given for this expansion, or whether collection of discarded batteries will be made mandatory (Metal-Pages, 2003b§).

**Consumption**

According to the World Bureau of Metal Statistics, cadmium consumption in 2003 increased by about 1% compared with that of 2002. Growth of cadmium consumption in the 1990s was fueled by growth in the NiCd rechargeable battery market. The 1990s were also characterized by the relocation of several manufacturing facilities from developed countries in Europe and North America to countries with fewer environmental restrictions and lower labor cost. The main beneficiary of this transfer was China, which emerged as the leading cadmium consumer in the world, followed by Japan. Together, they consumed more than one-half of total world cadmium production. China alone consumed about 5,400 t of cadmium, more than twice as much as it produces.

The U. S. Geological Survey (USGS) does not collect consumption data on either cadmium metal or cadmium compounds. Apparent consumption of cadmium metal in the United States is calculated by the USGS from production, trade, and 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, because they are not expected to grow; in fact, some of the markets have already started to decline. Consumption of cadmium for these dispersible and dissipative applications probably will continue to decline because of increasingly stringent environmental regulations, concerns of manufacturers about long-term liability, and the development of less toxic substitutes.

Other uses of cadmium, in addition to its prominent use in NiCd batteries, are based on certain physical and chemical attributes of the metal. It has a low melting temperature, good electrical conductivity, excellent corrosion resistance in alkaline and saline environments, and the ability to improve the mechanical properties of other metals. Therefore, cadmium metal is commercially used as a corrosion-resistant coating on steel, aluminum, and other nonferrous metals, 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. All cadmium compounds are made from cadmium metal and are primarily used, in batteries, pigments, plastic stabilizers, and semiconductor applications.

**Prices**

With the exception of 1995, the 1990s were marked by a steady decline in cadmium prices, due to more strict regulatory controls that reduced consumption in some traditional cadmium markets, such as coatings, pigments, and stabilizers. The closure of Metaleurop SA's cadmium facility at its Noyelles-Godault smelter in France was the main reason for an increased supply deficit in the cadmium market and a consequent increase in the cadmium price to a high of $0.90 per pound for 4N material (99.99% purity cadmium) in 2002, from $0.25 per pound at the beginning of the year (Metal-Pages, 2003a§). A larger deficit that could have pushed the price above production cost, was partially offset by increased recycling of NiCd batteries. Although a cadmium price increase stalled at yearend 2002, it started to increase in 2003 and reached an average of $0.50 per pound for the year (table 1).

## Environmental Issues

The four main environmental and human health concerns involved with NiCd batteries are occupational exposure, manufacturing emissions and wastes, product use, and product disposal. Because most of the environmental and health problems involved in the production of NiCd batteries can easily be controlled, and it already is regulated by OSHA (Golden Artist Colors, undated§), recent regulations have focused on product disposal. Basically, only four disposal options are available—composting, incineration, landfilling, and recycling. The first two options are not practical; landfilling was the most frequently used alternative and recycling was the one most preferred by battery manufacturers and environmentalists. Because most cadmium is produced as a byproduct, mainly of zinc production, restrictions on the use of cadmium in batteries could increase the amount of unprocessed cadmium that is disposed in landfills by zinc producers, making restrictions counter productive. Therefore, an effective collection and recycling system for spent batteries in the United States is probably the best alternative.

## Current Research and Technology

According to a published report, cadmium can affect rats in ways that functionally mimic the female hormone estrogen and its impact on cell growth. In the study, even relatively low doses of cadmium affected the mammary glands and sexual development of the animals. Previous studies in male rats showed prostate changes after the administration of cadmium. However, it is too early to predict whether cadmium will affect humans in the same way it does rats (Washington Post, 2003).

The world's largest rechargeable battery, larger than a football field and weighting 1,300 t, was commissioned in Alaska to provide emergency power to Fairbanks, one of the most isolated cities in the United States. Stored in a warehouse near the city, the battery consists of 13,760 energy cells able to feed the power grid in an emergency with 40 megawatts (MW) of power for 6 to 7 minutes, or 27 MW of power for 15 minutes. This is enough time for the power company to start up diesel generators in case of power failure. The $30 million battery system, operated by the local cooperative Golden Valley Electric Association, provides an important safeguard for residents of the city where temperatures plunge to minus 50° C in winter. The battery was manufactured from recycled cadmium by the SAFT battery production company in Sweden (a subsidiary of ABB Group) and should last for 20 years (Metal-Pages, 2003c§).

## Outlook

Cadmium faces an unusual situation: On one hand, environmentalists eschew the proliferation of cadmium in any form because of the metal's toxicity, while consumers are demanding power tools, computers, and other electric gadgets that require the use of NiCd batteries. There is no easy solution to this situation, and the supply shortfall is likely to become greater if production cutbacks continue for zinc or an affordable substitute for NiCd batteries is not found. However, until significant technological advances are made in nickel hydride and lithium batteries, NiCd batteries will remain dominant in cordless power tools and telecommunication devices. Consumption of NiCd batteries in the foreseeable future will most likely be driven by Chinese and Indian markets, which are free of stringent environmental controls on the use of the metal in both batteries and pigments: China alone consumes more than twice as much as it produces, mainly to feed the burgeoning NiCd battery manufacturing industry.

The growing supply deficit will likely be somewhat offset by increased availability of recycled cadmium. For this to happen, more people will have to recycle their spent NiCd batteries. 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, also conducted by the RBRC, highlighted America's growing reliance on cordless electronic products. There is an average of five or more cordless products to a household, such as cordless and cellular phones, 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 they 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§). The survey demonstrated that a more user-friendly collection of spent rechargeable batteries would increase production of secondary cadmium, which in turn would allow decreased primary production, and make production and consumption of cadmium more environmentally friendly.

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TABLE 1
SALIENT CADMIUM STATISTICS[1]

(Metric tons, cadmium content, unless otherwise specified)

| | | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|
| United States: | | | | | | |
| Production of metal[2] | | 1,190 | 1,890 | 680 e | 700 e | 670 e |
| Shipments of metal by producers[3] | | 1,020 | 1,580 | 954 | 776 | 320 |
| Exports of metal, alloys, scrap | | 20 | 314 | 272 | 168 r | 558 |
| Imports for consumption, metal | | 294 | 425 | 107 | 25 | 18 |
| Stocks of metal, Government, yearend | | 1,130 | 807 | 773 | 80 | -- |
| Apparent consumption of metal | | 1,850 | 2,010 | 659 | 561 r | 530 |
| Price, average, New York dealer[4] | dollars per pound | $0.14 | $0.16 | $0.23 | $0.52 r | $0.50 |
| World, refinery production | | 20,000 r | 20,800 r | 18,800 r | 16,800 r | 16,900 |

[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)

| | 2002 | 2003 |
|---|---|---|
| Industry stocks, January 1 | 1,090 | 1,780 |
| Production[e] | 700 | 670 |
| Imports for consumption of metal, alloy, scrap | 25 | 18 |
| Shipments from Government stockpile excesses | 693 | 80 |
| Total supply | 2,510 | 2,550 |
| Exports of metal, alloys, scrap | 168 r | 558 |
| Industry stocks, December 31 | 1,780 r | 1,460 |
| Consumption, apparent[2] | 561 r | 530 |

[e]Estimated. [r]Revised.
[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]

| Country | 2002 Quantity (kilograms) | 2002 Value | 2003 Quantity (kilograms) | 2003 Value |
|---|---|---|---|---|
| Cadmium metal:[2] | | | | |
| Belguim | -- | -- | 79,900 | $80,000 |
| Canada | 32,500 | $501,000 | 10,700 | 227,000 |
| Chile | 1,150 | 11,700 | -- | -- |
| China | 60,500 | 74,600 | 145,000 | 189,000 |
| Costa Rica | 6,610 | 15,200 | -- | -- |
| Ecuador | 121 | 2,840 | -- | -- |
| France | 21,300 | 31,600 | 48,600 | 51,000 |
| Germany | 8,330 | 354,000 | 118 | 88,500 |
| India | 14,500 | 8,810 | 38,500 | 12,000 |
| Israel | -- | -- | 16,100 | 65,400 |
| Jordan | 21,900 | 19,200 | -- | -- |
| Korea, Republic of | -- | -- | 7 | 8,220 |
| Mexico | 297 | 47,900 | 125 | 23,300 |
| Netherlands | -- | -- | 168,000 | 219,000 |
| Singapore | -- | -- | 7,110 | 16,100 |
| South Africa | 1,000 | 101,000 | -- | -- |
| Sweden | 232 | 106,000 | -- | -- |
| Thailand | -- | -- | 3 | 2,610 |
| United Kingdom | -- | -- | 40,500 | 70,600 |
| Venezuela | -- | -- | 3,540 | 3,000 |
| Total | 168,000 r | 1,270,000 r | 558,000 | 1,060,000 |
| Cadmium sulfide, gross weight: | | | | |
| China | -- | -- | 70,600 | 36,700 |
| Germany | 12,100 | 6,300 | -- | -- |
| Japan | 13,300 | 6,900 | 43,900 | 22,800 |
| Mexico | -- | -- | 69,800 | 37,600 |
| Total | 25,400 | 13,200 | 184,000 | 97,100 |

[r]Revised. -- 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 | 2002 Quantity (kilograms) | 2002 Value | 2003 Quantity (kilograms) | 2003 Value |
|---|---|---|---|---|
| Cadmium metal: | | | | |
| Canada | 8,260 | $947,000 | 1,530 | $337,000 |
| China | 34 | 16,200 | 55 | 19,300 |
| Mexico | 16,400 | 8,820 | 16,400 | 26,300 |
| United Kingdom | 22 | 6,360 | -- | -- |
| Total | 24,700 | 978,000 | 18,000 | 383,000 |
| Cadmium sulfide, gross weight: | | | | |
| China | 20 | 9,280 | 3,840 | 10,600 |
| United Kingdom | 6,690 | 78,500 | 3,630 | 42,300 |
| Total | 6,710 | 87,700 | 7,470 | 52,900 |

-- 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 | 1999 | 2000 | 2001 | 2002 | 2003[e] |
|---|---|---|---|---|---|
| Algeria[e] | 10 | 10 | 10 | 10 | 10 |
| Argentina | -- | -- | 34 | -- | 30 [3] |
| Australia | 462 | 552 | 378 | 350 | 350 |
| Belgium | 1,235 | 1,148 | 1,236 | 117 | 120 |
| Brazil[e] | 300 | 300 | 300 | 300 | 300 |
| Bulgaria[e] | 150 | 150 | 150 | 150 | 150 |
| Canada | 1,911 | 1,941 [r] | 1,429 | 1,400 [r] | 1,400 |
| China[e] | 2,150 | 2,370 | 2,510 | 2,440 [r] | 2,500 |
| Finland[4] | 700 [e] | 683 | 604 | -- [e] | -- |
| France | 195 | 160 | 176 | 175 | 178 [3] |
| Germany | 1,145 | 1,130 | 540 | 422 | 450 |
| India | 269 | 314 | 436 | 466 [r] | 480 |
| Italy | 360 | 284 | 312 | 391 [r] | 100 |
| Japan | 2,567 | 2,472 | 2,460 [r] | 2,444 [r] | 2,497 [3] |
| Kazakhstan | 1,246 | 1,250 [r, e] | 1,250 [r, e] | 1,300 [r] | 1,351 [3] |
| Korea, North[e] | 100 | 100 | 100 | 100 | 100 |
| Korea, Republic of | 1,791 | 1,911 | 1,879 | 1,827 [r] | 1,850 |
| Macedonia[e] | (5) | (5) | (5) | (5) | (5) |
| Mexico[6] | 1,275 | 1,268 | 1,241 | 1,382 [r] | 1,400 |
| Netherlands | 731 | 628 | 455 | 485 | 500 |
| Norway | 211 | 298 | 372 | 209 | 320 |
| Peru | 466 | 483 | 456 | 422 | 450 |
| Poland, metal, primary refined | -- | 6 | 330 | 300 [r] | 300 |
| Russia[e] | 900 | 925 [3] | 950 | 950 | 950 |
| Thailand | -- [r] | -- [r] | -- [r] | -- [r] | -- |
| Turkey | 64 | -- | -- [e] | -- [e] | -- [e] |
| Ukraine[e] | 25 | 25 | 25 | 25 | 25 |
| United Kingdom[7] | 547 | 503 | 485 | 450 [e] | 450 |
| United States[7] | 1,190 | 1,890 | 680 [e] | 700 [e] | 670 |
| Total | 20,000 [r] | 20,800 [r] | 18,800 [r] | 16,800 [r] | 16,900 |

[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 of 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, 2004.

[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]Reported figure.

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

[5]Less than 1/2 unit.

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

[7]Includes secondary.