# Indian Minerals Yearbook 2016

## (Part- II : Metals & Alloys)

## 55th Edition

# CADMIUM

## (ADVANCE RELEASE)

**GOVERNMENT OF INDIA**
**MINISTRY OF MINES**
**INDIAN BUREAU OF MINES**

Indira Bhavan, Civil Lines,
NAGPUR – 440 001

PHONE/FAX NO. (0712) 2565471
PBX : (0712) 2562649, 2560544, 2560648
E-MAIL : cme@ibm.gov.in
Website: www.ibm.gov.in

**August, 2017**

# 3 Cadmium

Cadmium is a soft, bluish-white metal of low meltingpoint which is present generally in zinc ore deposits as greenockite (CdS). The principal source of cadmium is zinc ore, sphalerite. Other sulphides and sulphosalts may also carry small amounts of the metal.

In India, cadmium is recovered as a by-product during zinc smelting and refining. The concentration of cadmium in sphalerite, the principal ore of zinc, ranges from 0.03 to 9.0 wt%. In zinc concentrate at Rampura Agucha, the concentration of cadmium is 0.18% while in lead concentrate, it is 150 ppm. There are no separate resources of cadmium.

## INDUSTRY

The total installed capacity for recovering cadmium was 913 tonnes of which HZL accounted for 833 tpy capacity. Binani Zinc Ltd (Edayar Zinc Ltd) reported the remaining 80 tpy capacity (Table-1). HZL produces cadmium of high quality in its zinc smelters which is casted in the form of pencils weighing from 250 g to 500 g. The purity is 99.95% Cd (max.) at Debari; 99.97% Cd (max.) at Vizag and 99.99% Cd (min.) at Chanderiya plants. HZL has plans to conduct R&D for production of high purity cadmium. High purity cadmium is typically used for nuclear shielding applications.

**Table – 1 : Installed Capacity for Recovery of Cadmium**

| Unit | Location | Installed capacity (tpy) |
|---|---|---|
| **Total** | | **913** |
| 1. HZL, Debari Zinc Smelter | Debari, Distt. Udaipur, Rajasthan. | 250 |
| 2. HZL,* Vizag Zinc Smelter | Visakhapatnam, Andhra Pradesh. | 115 |
| 3. HZL, Chanderiya Lead-Zinc Smelter | Chanderiya, Distt. Chittorgarh, Rajasthan. | 468 |
| 4. Binani Zinc Ltd** (Edayar Zinc Ltd) | Binanipuram, Distt. Ernakulam, Kerala. | 80 |

** Operation suspended since 2002.*
*** Operation suspended since April-2014.*

## USES

Cadmium is used to control the fissionable elements in nuclear reactors. Along with nickel, it is used in electrical storage batteries. Cadmium-based bearing alloys are used in high-speed internal combustion engines. Copper-cadmium alloys possess high strength, high conductivity and high resistance to abrasion, and therefore, the alloys are used in electric transmission wires. The main use of cadmium is in electroplating where it can be applied as a very thin coating to protect iron, steel, copper alloys and other metals and alloys from corrosion. Cadmium sulphide forms brilliant golden yellow, orange-red, or reddish brown pigments used in paint, enamel, soap, rubber, glass and ceramic glazes. Some cadmium salts are also used in photographic films and in lithography. Cadmium coated products are preferred for a wide range of critical and safety-related applications in the aerospace, electrical, defence, mining, nuclear and offshore industries. Cadmium plating is used mainly in the aviation and aerospace industries to protect fastners exposed to hostile environments.

## PRODUCTION & PRICES

Cadmium is recovered as a by-product of zinc smelting. No production of cadmium was reported in 2015-16 as compared to 69 tonnes in the previous year. The entire production in 2014-15 was reported from Private Sector (Tables- 2 and 3). The foreign market prices of cadmium are furnished in the General Review on "Prices".

**Table – 2 : Production of Cadmium 2013-14 to 2015-16 (By States)**

(Quantity in tonnes; Value in ₹'000)

| State | 2013-14 | | 2014-15 | | 2015-16 (P) | |
|---|---|---|---|---|---|---|
| | Qty | Value | Qty | Value | Qty | Value |
| **India** | **228** | **36605** | **69** | **9610** | - | - |
| Kerala | 44 | 6400 | - | - | - | - |
| Rajasthan | 184 | 30205 | 69 | 9610 | - | - |

**Table – 3 : Production of Cadmium, 2014-15 and 2015-16**
**(By Sector/States/Districts)**

(Quantity in tonnes; Value in ₹'000)

| State/District | Smelter | 2014-15 | | 2015-16 (P) | |
|---|---|---|---|---|---|
| | | Quantity | Value | Quantity | Value |
| **India** | | **69** | **9610** | - | - |
| Private sector | | 69 | 9610 | - | - |
| **Rajasthan** | | **69** | **9610** | - | - |
| | HZL | 69 | 9610 | - | - |
| Chittorgarh | Chanderiya | | | | |
| Rajsamand | Dariba | | | | |
| Udaipur | Debari | | | | |

## RECYCLING

National Collection and Recycling Associations (NCRAs) have been created around the world to promote the collection and recycling of all batteries, both from the general public and industrial consumers. Nickel-cadmium batteries which account for about three-fourths of the cadmium consumed, are virtually 100 percent recyclable once they have been collected.

There are 9 major Ni-Cd battery recycling plants located in the United States of America, Europe and Japan. This includes copper-cadmium alloy scrap, some complex non-ferrous alloy scrap and cadmium containing dust from electric arc furnace. India imports cadmium & scraps. However, the details of the recycling units are not available.

## SUBSTITUTES

Suitable replacements of cadmium in all uses, especially in pigments and plating are being contemplated and enforced owing to the pollution hazards associated with the use of cadmium. Ni-Cd batteries, in some applications, are replaced with lead-acid, fuel cells lithium ion and nickel metal hydride batteries. However, higher costs of these substitutes restrict their uses. Cadmium in plating applications can be substituted by coatings of zinc or vapour-deposited aluminium. Cerium sulphide is used as a replacement for cadmium pigments mostly for plastics. Cadmium Telluride (CdTe) flexible thin film solar cells are an alternative to traditional crystalline silicon solar cells and are suitable for commercial roof top applications and large-scale ground mounted utility systems. CdTe photovoltaic cells are potentially safe, environment-friendly application for cadmium.

In India, cadmium is consumed in industries like paint, glass and chemical.

## HEALTH AND SAFETY

Cadmium in all its chemical forms is considered highly toxic to living species as it does not decompose and is ingested easily through food, water and air but cannot be excreted. It is both bioaccumulated and biomagnified. Ingested cadmium accumulates in liver, kidney, pancreas and thyroid. Excessive exposure to cadmium has been linked with respiratory insufficiency (via occupational exposure) and renal disturbance (via environmental and occupational exposure). Cadmium has also been implicated in the development of cancer of various types.

During the last decade, regulatory pressure to reduce or even eliminate the use of cadmium has gained momentum in many developed countries. The world recommended target guidelines for cadmium as a residual heavy metal below which no major risk is expected which could have significant or adverse impact on aquatic biota or human use, is 0.1 mg/l. In the USA, Federal and State agencies regulate cadmium content in the environment. Cadmium present in CRT screens, printer inks, toners, etc. is known to cause health hazards affecting the kidneys and causing flue like symptoms and muscular pain. In India, the Silver Jewellery Industry is an important cadmium consuming industry. Silver mixed with cadmium is used in the making of silver jewellery.

# WORLD REVIEW

Cadmium is extracted from zinc ores and concentrates and other materials like scrap. Zinc-to-cadmium ratios in typical zinc ores range from 200:1 to 400:1. Quantitative estimates of reserves are not available.

The world production of cadmium was estimated at 24,903 tonnes in 2015. Most of the world's primary cadmium is produced mainly in China, Republic of Korea, Japan, Kazakhstan, Mexico, Canada, Russia and Peru.

World's secondary cadmium production accounted for 20% of the total metal production. Most secondary metal is produced at Ni-Cd battery recycling facilities in Asia, Europe and the United States. China, Belgium and Japan are by far the world's largest consumers of cadmium. The world production of cadmium during 2013 to 2015 by principal countries is furnished in Table-4.

## Australia

Nyrstar produces cadmium as by-product from its Hobart zinc smelter in Tasmania and its Port Pirie integrated multi-metals recovery plant in South Australia. Following the completion of mining at MMG Ltd's Century zinc-lead mine in Australia in August, Nyrstar was reconfiguring its Hobart smelter to allow it to treat increased volumes of cadmium and zinc smelting residues generated from newly sourced, more complex feedstock. The project was expected to be commissioned in the second half of 2015. The Century Mine operated for 16 years and, at full production, was one of the leading global zinc-producing mines. Nyrstar had plans in place to step-up its cadmium cake production capacity at Port Pirie. The expansion project was expected to be completed in the third quarter of 2016.

## Belgium

Flaurea Chemicals [owned by Aurea SA (France), formerly Floridienne Chimie] consumed cadmium to produce cadmium compounds, including cadmium chloride, nitrate and oxide as well as cadmium powder at its manufacturing facility in Ath.

## Canada

Teck Resources Ltd's metallurgical complex in Trail, British Columbia, had the capacity to produce up to 1,400 tonnes per year of refined cadmium. Cadmium metal products included balls, billets and sticks for NiCd battery manufacturing and continuously cast cadmium sheet for radiation shielding. Teck also produced cadmium chemicals. HudBay Minerals Inc.'s copper smelting and zinc refining operations in Flin Flon, Manitoba, produced cadmium metal. Most of the cadmium metal produced in Canada is believed to be exported.

## Korea, Republic of

Korea Zinc Ltd's Onsan zinc-lead refinery do have the capacity to produce 3,000 tonnes per year of refined cadmium, and Young Poong Corp.'s Sukpo zinc refinery too has the capacity to produce 1,400 tonnes per year of cadmium. Most of the cadmium produced get exported mainly to China.

## Mexico

The Instituto Nacional de Estadística y Geografía (2016) reported that Mexico produced about 1,300 tonnes of cadmium in 2015, 8% less than that in 2014. According to data reported by the two known producers, the total cadmium production in 2015 was about 1,230 tonnes. Industrias Peñoles S.A.B. de C.V.'s Met-Mex metallurgical complex in Torreon produced 633 t of cadmium in 2015, 9% less than that in 2014, and Grupo Mexico S.A.B. de C.V.'s zinc smelter in San Luis Potosi produced about 600 tonnes of cadmium in 2015, unchanged from that in 2014.

**Table – 4 : World Production of Cadmium (By Principal Countries)**

(In tonnes)

| Country | 2013 | 2014 | 2015 |
|---|---|---|---|
| **World: Total** | **22795** | **25507** | **24903** |
| Australia**e** | 380 | 380 | 380 |
| Bulgaria | 411 | 382 | 380 |
| Canada | 1313 | 1187 | 1159 |
| China | 7496 | 8201 | 8200[e] |
| Germanye | 400 | 400 | 400 |
| India | 228 | 69 | - |
| Japan | 1821 | 1851 | 1959 |
| Kazakhstan | 1335 | 1633 | 1475 |
| Korea, Rep. of | 3904 | 5645 | 5600[e] |
| Mexico | 1451 | 1409 | 1301 |
| Netherlandse | 610 | 620 | 620 |
| Norwaye | 310 | 310 | 310 |
| Peru | 695 | 769 | 757 |
| Poland | 460 | 628 | 383 |
| Russia | 900 | 1000[e] | 1000[e] |
| USAe | 600 | 550 | 500 |
| Other countries | 481 | 473 | 479 |

***Source:*** *World Mineral Production, 2011-15.*

# FOREIGN TRADE

## Exports

In 2015-16, exports of cadmium (including waste & scrap) increased to 115 tonnes from that of 74 tonnes in the previous year. Exports were mainly to Bangladesh (97%) and Pakistan (2 %).

Exports of cadmium & alloys also increased to 99 tonnes during 2015-16 as against only 54 tonnes in the previous year. However, exports of cadmium & scrap decreased slightly at 15 tonnes as against 20 tonnes in the previous year. Exports also comprised nominal cadmium unwrought and powders (Tables-5 to 8).

## Imports

Imports of cadmium (including waste & scrap) increased to 5,053 tonnes in 2015-16 from 2,862 tonnes in the previous year. The imports comprised 3,658 tonnes unwrought, powders and 1,373 tonnes scrap besides nominal quantity of cadmium and alloys in 2015-16. Imports were mostly from Korea, Rep. of (41%), Japan (18%), Mexico (13%), Australia (7%), Peru (5%) and Belgium (4 %) (Tables-9 to 12).

**Table – 5 : Exports of Cadmium (Including Waste & Scrap) (By Countries)**

| Country | 2014-15 | | 2015-16 (P) | |
|---|---|---|---|---|
| | Qty (t) | Value (₹'000) | Qty (t) | Value (₹'000) |
| **All Countries** | **74** | **4545** | **115** | **9373** |
| Bangladesh | 70 | 2898 | 112 | 7119 |
| UK | ++ | 418 | ++ | 1280 |
| Pakistan | - | - | 2 | 428 |
| USA | - | - | ++ | 290 |
| Algeria | 3 | 743 | 1 | 219 |
| Indonesia | - | - | ++ | 35 |
| Ethiopia | - | - | ++ | 2 |
| Afghanistan | 1 | 196 | - | - |
| Hong Kong | ++ | 85 | - | - |
| Kenya | ++ | 85 | - | - |
| Other countries | ++ | 120 | - | - |

**Table – 6 : Exports of Cadmium & Alloys (By Countries)**

| Country | 2014-15 | | 2015-16 (P) | |
|---|---|---|---|---|
| | Qty (t) | Value (₹'000) | Qty (t) | Value (₹'000) |
| **All Countries** | **54** | **2216** | **99** | **7801** |
| Bangladesh | 53 | 2014 | 97 | 6056 |
| UK | - | - | ++ | 1280 |
| Pakistan | - | - | 2 | 428 |
| Indonesia | - | - | ++ | 35 |
| Ethiopia | - | - | ++ | 2 |
| Afghanistan | 1 | 196 | - | - |
| Sri Lanka | ++ | 4 | - | - |
| Morocco | ++ | 2 | - | - |

**Table – 7 : Exports of Cadmium & Scrap (By Countries)**

| Country | 2014-15 | | 2015-16 (P) | |
|---|---|---|---|---|
| | Qty (t) | Value (₹'000) | Qty (t) | Value (₹'000) |
| **All Countries** | **20** | **2079** | **15** | **1549** |
| Bangladesh | 17 | 884 | 14 | 1040 |
| USA | - | - | ++ | 290 |
| Algeria | 3 | 743 | 1 | 219 |
| UK | ++ | 418 | - | - |
| Saudi Arabia | ++ | 29 | - | - |
| UAE | ++ | 5 | - | - |

**Table – 8 : Exports of Cadmium Unwrought, Powders (By Countries)**

| Country | 2014-15 | | 2015-16 (P) | |
|---|---|---|---|---|
| | Qty (t) | Value (₹'000) | Qty (t) | Value (₹'000) |
| **All Countries** | **++** | **250** | **1** | **23** |
| Bangladesh | - | - | 1 | 23 |
| Hong Kong | ++ | 85 | - | - |
| Kenya | ++ | 85 | - | - |
| Saudi Arabia | ++ | 62 | - | - |
| Uganda | ++ | 18 | - | - |

## Table – 9 : Imports of Cadmium (Including Waste & Scrap) (By Countries)

| Country | 2014-15 | | 2015-16 (P) | |
|---|---|---|---|---|
| | Qty (t) | Value (₹'000) | Qty (t) | Value (₹'000) |
| **All Countries** | **2862** | **339575** | **5053** | **372981** |
| Korea, Rep. of | 1162 | 138431 | 2054 | 152726 |
| Japan | 559 | 67146 | 926 | 71232 |
| Mexico | 302 | 35239 | 666 | 47239 |
| Australia | 21 | 2637 | 370 | 24483 |
| Peru | 38 | 4739 | 246 | 17341 |
| Russia | 182 | 21588 | 119 | 12310 |
| Belgium | - | - | 198 | 12070 |
| Uzbekistan | - | - | 142 | 8575 |
| UAE | 10 | 1103 | 101 | 6794 |
| China | 60 | 9051 | 71 | 6567 |
| Other countries | 528 | 59641 | 160 | 13644 |

## Table – 10 : Imports of Cadmium & Alloys (By Countries)

| Country | 2014-15 | | 2015-16 (P) | |
|---|---|---|---|---|
| | Qty (t) | Value (₹'000) | Qty (t) | Value (₹'000) |
| **All Countries** | **40** | **7085** | **22** | **3463** |
| USA | ++ | 73 | 1 | 2035 |
| UAE | - | - | 20 | 1365 |
| Germany | ++ | 115 | 1 | 56 |
| UK | ++ | 155 | ++ | 7 |
| Korea, Rep. of | 40 | 5090 | - | - |
| China | ++ | 852 | - | - |
| Canada | ++ | 800 | - | - |

## Table – 11 : Imports of Cadmium: Unwrought, Powders (By Countries)

| Country | 2014-15 | | 2015-16 (P) | |
|---|---|---|---|---|
| | Qty (t) | Value (₹'000) | Qty (t) | Value (₹'000) |
| **All Countries** | **2116** | **251783** | **3658** | **269226** |
| Korea, Rep. of | 762 | 90941 | 1104 | 82297 |
| Japan | 539 | 64731 | 806 | 62330 |
| Mexico | 282 | 33079 | 585 | 41616 |
| Australia | 21 | 2637 | 370 | 24483 |
| Russia | 121 | 14234 | 119 | 12310 |
| Peru | 38 | 4739 | 166 | 12281 |
| Belgium | — | — | 198 | 12070 |
| Uzbekistan | — | — | 102 | 5887 |
| UAE | 10 | 1103 | 81 | 5429 |
| China | 1 | 1110 | 21 | 3009 |
| Other countries | 342 | 39209 | 106 | 7514 |

**Table – 12 : Imports of Cadmium & Scrap (By Countries)**

| Country | 2014-15 | | 2015-16 (P) | |
|---|---|---|---|---|
| | Qty (t) | Value (₹'000) | Qty (t) | Value (₹'000) |
| **All Countries** | **706** | **80707** | **1373** | **100292** |
| Korea, Rep. of | 360 | 42400 | 950 | 70429 |
| Japan | 20 | 2415 | 120 | 8902 |
| Mexico | 20 | 2160 | 81 | 5623 |
| Peru | - | - | 80 | 5060 |
| China | 59 | 7089 | 50 | 3558 |
| UK | - | - | 44 | 3037 |
| Uzbekistan | - | - | 40 | 2688 |
| Canada | 77 | 7298 | 8 | 975 |
| Germany | - | - | ++ | 20 |
| Bulgaria | 89 | 9801 | - | - |
| Other countries | 81 | 9544 | - | - |

# FUTURE OUTLOOK

The world cadmium market based on the world production of cadmium does indicate a fluctuate trend. While the primary cadmium supply is on decrease, there is a modest rise in production through recycling. Though, cadmium consumption in various applications is clamoured with concerns over its toxicity and hazardous effect on human health and environment, the production of cadmium as a by-product will however continue as long as lead and zinc are produced.

The demand for cadmium is increasing owing to several new market opportunities for Ni-Cd batteries, particularly in industrial applications. Ni-Cd battery is used in electrical vehicles albeit in limited number in hybrid electrical vehicles, and has been making important contribution to the development of the electric car market in Europe.

Cadmium pigments and stabilisers are important additives in certain specialised plastics, glasses, ceramics and enamels which enable achieve bright colours along with long service life, even in very demanding applications. It should also be emphasised that cadmium in these applications is in a chemically very stable, highly insoluble form and is embedded in the product matrix.