MERCURY

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Considering that the world market price for mercury has doubled since the beginning of 2002 after years of stability, a dramatic increase in demand, either from existing uses or new developments, could have been expected. However, mercury is an environmentally unfriendly metal whose use continues to be discouraged and increasingly legislated against. At best, demand was stable at the much reduced production levels of recent years, and mines that had ceased to operate due to poor demand and low prices remained shuttered. This left supplies of new material sourced mainly from just three mines, all of which experienced production difficulties. This was at a time of general world economic recovery, with most commodities, including many metals, experiencing substantial price increases. Share prices, particularly in the mining industry, boomed as new resources were sought. This did not include mercury, however, despite the fact that even the reduced demand could not be satisfied by primary production, and that the market was having to rely increasingly upon irregular supplies of secondary material.

Elemental mercury is a dense, naturally-occurring silver-coloured metallic element that is liquid at room temperature. Sometimes called ‘quicksilver’, liquid mercury has been used extensively in manufacturing processes because it conducts electricity, reacts to temperature changes, and alloys with many other metals. Examples of products that contain mercury include electrical switches, hospital equipment and supplies, fluorescent lights, switches for automobile lighting, and dental fillings. While mercury has many uses, it is designated a hazardous substance and must be stored and managed appropriately.

Mercury is usually packed in cast, wrought iron, or spun steel bottles known commonly as flasks, which each contain 34.50 kg nett.

Supplies of mercury come from both primary and secondary sources, each of which have two distinct categories. Primary mercury arises from mining operations carried out solely for the mercury and also as a by-product of the mining of other metals such as copper, gold and zinc, from which the mercury has to be recovered to provide the pure base metal.

Primary world mercury resources are estimated at nearly 600,000 t (approximately 17 million flasks) principally in China, Italy, Kyrgyzstan, Russia, Slovenia, Spain and Ukraine. Of the total resources, it is estimated that around 120,000 t (3.5 million flasks) could be mined economically (reserves) and 240,000 t (7.0 million flasks) recovered if costs were not considered (reserve base). These reserves at present production rates would be sufficient for some 50 and 100 years respectively (Table 1).

Primary supply

World primary mercury supply is dominated by three main countries: Spain, Kyrgyzstan and Algeria, which mine and produce mercury mostly for export. China, nowadays, produces mainly for its own fast-developing home market. These mines are all state-owned although there have been unsuccessful attempts in recent years to privatise both the Spanish and Kyrgyzstan operations.

The Spanish mines in the heart of La Mancha are operated by Minas de Almaden which has an annual capacity of some 100,000 fl (3,450 t) although production has been running at much lower levels in recent years (Table 2). The main reason for this was understood to be, and this idea was indeed encouraged by the producer, that Almaden was adjusting its production on an annual basis to prevent market over-supply and to prevent prices from falling even further. In its position as the world's largest mercury producer this was seen as a responsible strategy.

The reality appears, however, to be somewhat different in that the company was granted substantial EU subsidies in 1995 which were linked to a gradual phase-out of mercury mining. These subsidies allowed the company to purchase substantial quantities of mercury from the Former Soviet Union (FSU) stockpiles, along with supplies from decommissioned chlor-alkali plants. This enabled Almaden to maintain its customer base while reducing primary production from mining operations, thereby complying with EU guidelines. At the same time it reduced its staff at the mine to some 200 from around 1,400 in the mid-1980s. The FSU stockpiles are now mostly exhausted and receipts of mercury from chlor-alkali plants have diminished, requiring Almaden to significantly increase primary production again in the past two years (Table 3).

In April 2003, technical difficulties with a recently installed gas-cleaning process halted production for 5-6 weeks. Problems continued on and off until, by November, Almaden was forced to close down completely to carry out major work on the plant's emission system in order to reduce the amount of sulphur released during processing to meet new environmental requirements. This led to the company being unable to fulfil all its sales commitments from its stocks and production was not restarted until early 2004, although at a capacity of only 10,000 fl/y. It was hoped that production would be back up to 20,000-25,000 fl/y later in the year.

After Almaden, the most important primary mercury mine is the Khaidarkensky enterprise located in the town of Khaidarkan in the Kadamjay region of the Kyrgyz Republic. Annual capacity of the mine is 18,000 fl/y but since reopening in 1995, with the assistance of the World Bank, production has varied, only finally reaching a respectable level in 2002 of around 15,000 fl. Traditionally, any of this production not used in FSU countries is exported to China, with only occasional quantities (none in 2003) finding their way onto other world markets.

The mine has been beset by problems in recent years, not least flooding, which occurred again in the summer of 2003. As a result, production in 2003 was only 370 t (10,725 fl), a fall of 22.6% on the previous year. Most of the mercury was

produced in the first six months, prior to the incident in June, which saw all auxiliary shafts and mining horizons flooded. High electricity costs were another factor. Following an accident caused by an electricity shutdown, Khaidarkensky concentrated on previously-mined upper levels with much lower ore grades. Total damages were estimated at around US$2 million and, although most of the water was pumped out by early 2004, normal operations were not expected to resume until May. The Kyrgyzstan Government made several attempts to sell a 99.98% stake in the combine during the year but, not surprisingly, met with no success despite halving the amount that would be required as a commitment for new capital investment. The South Kyrgyz Geologic Expedition delineated two additional mercury deposits at Chauvay and Chonkoi, both within 70 km of Khaidarken, but currently there are no funds for their development.

The quantities of mercury produced in Algeria are uncertain but are believed to have been typically between 200 t (5,800 fl) and 500 t (14,500 fl) annually during the past decade. Supplies during 2003 were noticeably reduced, with the producer Sonarem believed to be having a problem with its flask manufacturer. This may be correct, but in March 2004 it was finally revealed that the mines were continually being flooded by an underground river. Pumping was proving unsuccessful and it was not known when or if the situation would be resolved.

China's National Bureau of Statistics shows that, as is the case with nearly all the country's non-ferrous metals, mercury production has been increasing in the past 2-3 years, and in 2003 production grew by 23.2% to 610 t (17,681 fl). Despite this, the reduced supplies from Kyrgyzstan meant that China continued as a major importer of mercury from other world sources to satisfy its insatiable demand for its ever-expanding economy.

Primary mercury is also produced as a by-product of certain base-metal operations to avoid releases of the metal into the environment when the ores being treated also contain mercury as well as other elements. Amounts of by-product mercury vary but are usually small. The most consistent producer is Outokumpu (now part of the New Boliden Group) in Finland, which recovers around 50-100 fl/mth from the refining of its zinc ores.

Also recovering mercury from zinc ore was the Portovesme lead and zinc refinery in Sardinia, Italy, but this plant was closed down in October after the company, unions and the Italian Government failed to resolve the country's high electricity costs, which are the highest in Europe. The high costs had bedevilled the plant for a long time, making it uneconomic and forcing it to run at only 80-90% capacity. The closure was intended to be for at least a year and, despite high lead and zinc prices, the plant remained closed into the second quarter of 2004.

In Japan, Nomura Kohsan produced about 50 t (1,450 fl) from its zinc operations, and further, small amounts of by-product mercury were recovered during the refining of copper ores in Slovakia and from gold and silver processing in the US, Peru and China. In China, APAC Minerals announced in October that it had signed an agreement with the Guizhou Bureau of Geology and Minerals Resources to explore five gold properties in the southwestern part

of Guizhou Province where samples taken from the Danguan property in Wangmo County showed high levels of mercury. Similar results were found in samples collected from prospects in the western part of Guizhou.

Although no longer a mercury producer, the US continues to have the possibility to supply the market from stocks held in the National Defence Stockpile (NDS). The government voluntarily halted sales in 1994 because of concerns about mercury's impact on the global environment, and remaining stocks total 4,436 t (128,580 fl) stored at New Haven in Indiana, Oak Ridge in Tennessee, Hillsborough in New Jersey and Warren in Ohio. In April 2003, the NDS published an extensive report evaluating consolidation of the stockpile and the options for a systematic sale of part of it. Public hearings followed but no decisions were taken. It does seem unlikely though, that the material will be allowed back into the market, and it is probably simply a case of finally deciding on a suitable storage location to consolidate the remaining stockpile safely and securely. Similar stockpiles had been held in FSU countries but these have mostly been sold for re-use in recent years although, occasionally, further quantities arise. During 2003, a further 86 t (2,500 fl) from Russia and the remainder of the Slovakian stockpile, consisting of only 18 t (525 fl), were sold off.

Secondary supply

Secondary sources of mercury fall into two main categories: recycled waste mercury and mercury recovered from chlor-alkali facilities. There has been increasing recycling of mercury from waste products in recent years although exact statistics worldwide are not known. In the EU, however, quantities recovered are estimated to have increased from less than 50 t/y in the early 1990s to over 180 t in 2003. The major products that are most commonly recycled for their mercury content are thermometers, barometers, manometers, dental amalgams, electrical switches and relays, thermostats, fluorescent (including compact fluorescent) tubes and lamps, high intensity discharge lamps and batteries.

Of most significance, however, has been arisings of mercury from the manufacture of caustic soda using the chlor-alkali process. Apart from the mercury wastes from contaminated old equipment, solids from water and brine purification etc that are routinely recycled or disposed of during normal operations, large quantities of mercury are recovered during the decommissioning of chlor-alkali facilities.

Nearly 6,000 t (17,300 fl) of mercury were made available by Western European plant closures during the period 1980-2000, although a significant part of this went directly to other operating chlor-alkali plants. Global mercury inventories associated with chlor-alkali plants that remain in operation have been estimated at some 25,000 t (725,000 fl) of which about half are in Western Europe. This matches well with a recent figure provided by the European Association of Chlor-Alkali producers (Euro-Chlor) of 11,600 t (336,000 fl) of mercury remaining in operating mercury cells in the EU and accession countries.

Mercury supplies from chlor-alkali plants are irregular and during 2003 they were limited at a time when there were also production difficulties for some primary suppliers. The result was a substantial increase in the market price. The move towards mercury-free chlor-alkali facilities continues, with Norsk Hydro's subsidiary Hydro Polymers announcing in August that it is to replace the mercury cells at its Stenungsund plant with non-mercury membrane technology by 2010. Also, in December 2003, the Siberian chlorine and sodium hydroxide producer, Sayanskkhinplast, finally secured the financing to replace its ageing mercury-based production units with similar non-mercury membrane technology, and in early 2004 the Swiss Solvay Group announced it would discontinue production of chlorine and soda at its Zurzach facility by the end of the year.

Even in less environmentally-conscious India, the state-owned caustic soda producer Travancore Cochin Chemicals (TCC) has announced that it will phase out its old mercury plant in 2004 and expand the capacity of the existing membrane facility. The move will give TCC a single production plant as well as the twin benefits of energy conservation and clean processing.

Indian protests

There are 41 units manufacturing caustic soda in India, with a total installed annual capacity of 22.61 t. Of them, 67% make use of the membrane cell technology and 31% use the mercury cell process. Nevertheless, imports of mercury into India have more than doubled since 1996, from 254 t (7,362 fl) to 531 t (15,391 fl) in 2002.

In the same period, imports of organic mercury compounds (pesticides, biocides, etc) have risen from 0.7 t to 1,312 t, according to the Indian Directorate General of Commercial Intelligence, raising fears at a conference in New Delhi in November that India is rapidly becoming the toxic dumping ground of the world's mercury. Whilst other countries around the world are phasing out mercury because of concerns over its toxicity, imports into India are rising. However, India is increasingly being confronted by the health risks associated with recycling a wide range of materials from computer equipment to metals. These fears were first highlighted in April 2003, when, in a clear victory for Green Peace (India) and local campaigners, 1,416 drums filled with 290 t of hazardous mercury wastes from a thermometer factory in Kodaikanal in Tamil Nadu were sent back to the US.

The largest hazardous waste transfer from India marks the end of a long struggle by the local people and environmental activists led by Green Peace, India. The shipment, including glass cullet, finished and semi-finished products and sludge, was shipped to the hazardous waste recycling firm, Bethlehem Apparatus, Pennsylvania.

Campaigners alleged that mercury vapours released from the factory in India owned by Hindustan Lever Ltd (HLL) ruined the health of the workers and community and caused lasting damage to the environment during its 18 years of operation. The controversial thermometer factory was relocated to India in 1983 after it was shut down in Watertown, New York. The factory imported all

its mercury, primarily from the US, and finished thermometers were exported back to the US for distribution to markets abroad. HLL's decision to send the wastes back to the US followed two days of public hearings and site visits in September 2002 held by the Indian Peoples' Tribunal under the chairmanship of Justice S.N. Bhargav. The tribunal confirmed that mercury pollution by the factory posed a threat to health of workers and ecology of the forest.

EU policy

A comparison of consumption in the EU against global figures (Table 4) shows the effects of environmental concerns, which are taken more seriously in developed countries. Batteries, the chlor-alkali industry, along with gold and silver mining, are major global users of mercury but in the EU the chlor-alkali industry is the only major user, and this use is diminishing as mercury cells are phased out.

There is a general question over whether it is better to encourage or ban recycling of mercury-containing waste. Present EU policy encourages recycling generally, with specific provisions concerning batteries, electrical and electronic equipment and end-of-life vehicles. In contrast, Swedish policy is that mercury should not be recycled, but should be disposed of terminally in a safe and environmentally-sound way, and that mercury should be phased out of products and processes as far as possible. The Swedish policy is not compatible with the broader EU position concerning mercury supply and use: if the use of mercury in products is still seen as legitimate, it would appear better to encourage recycling as being environmentally preferable to the production of virgin mercury.

Future availability

A large 'reservoir' of mercury is contained in products still in use, in storage and 'on the users' shelves. If responsibly collected, recycled and managed as these products are replaced or no longer used, this reservoir could be a significant source of mercury in future years.

Estimates of the total quantity of mercury contained in goods and products (excluding mercury cells in chlor-alkali plant, are around 20,000-30,000 t (580,000-870,000 fl) globally, a similar quantity to that held by the chlor-alkali sector. Additional supplies are held in government stockpiles. Of the total inventory, much could eventually be made available for re-cycling and recovery, given the right incentives, thus making the continuance of primary mining unnecessary. However, if the Swedish and probable US approach is taken, this mercury would not become available for re-use. Hence, unless mercury consumption is phased out completely, the performance of the few remaining mines will be critical to the market.

In Japan, several leading electronics manufacturers announced during 2003 that they will phase out the use of hazardous substances such as lead, cadmium and mercury from their products in response to the EU Directive on hazardous substances that prohibits such substances in goods. This prohibition is scheduled to take effect from July 2006. The Japanese companies concerned include Toshiba, Fujitsu, Matsushita and Toyota.

Nevertheless, although demand for mercury in developed countries has decreased considerably, its consumption in other parts of the world appears to have stabilised, despite the industrialised nations banning its use in a range of products from batteries to pesticides. Some less-industrialised countries are even increasing their consumption of cheap, mercury-based products such as paints. Industrialised countries, moreover, continue to use mercury in low-level applications, such as dental amalgams, lighting and measuring equipment.

Markets

Market quotations, which cover prime virgin mercury only, began 2003 at US$155-175/fl (as published by *Metal Bulletin*) to which level they had slowly but steadily risen during the previous three years. Prices quickly rose to the US$165-185/fl range and rose again in May to US$175-200/fl, where they remained unchanged until mid-November. Unfortunately mercury is not a commodity closely monitored by the trade publications, probably due to its lack of interest to the speculative elements of the trading world. As a result, the quotation was left basically unchanged throughout most of the rest of the year despite the fact that mercury was trading in the market at considerably higher levels owing to the tightening of supplies linked to the production problems affecting all of the three main producers. The quotation started to catch up with the market as the year ended and in November it moved up to US$180-220/fl. By early 2004, it had reached US$290-320/fl, which was a more accurate reflection of the market situation.

From a ten-year peak in 1987 of 7,250 t (210,300 fl), world primary and by-product mine production of mercury has declined steadily, to an estimated level of only 1,350 t (39,130 fl) in 2000.

World mercury consumption is impossible to calculate, given the lack of information from so many countries, particularly China and the CIS where consumption is probably quite high. This is because their industries lag behind in technology, environmental restrictions are less rigidly applied and, particularly in China, illegal gold mining is common. However, it is generally considered that overall consumption is declining and is probably down from 2000 when it was running at 3,388 t/y (approx. 9,800 fl). Even if this figure has slipped below 3,000 t (87,000 fl), this still leaves a substantial shortfall, which in recent years has been made up from secondary or recycled mercury, as well as from substantial quantities from Russian/CIS stockpiles. These stockpiles are, however, now mostly exhausted and during 2003 the availability of secondary mercury was greatly reduced.

In the past, primary producers were able to increase their production sufficiently to compensate but this was not the case in 2003. The only country able to increase production was China but this did not make up for the reduced output from its traditional supplier in Kyrgyzstan. With China's economy continuing to boom, demand for additional imports seems set to continue. Almaden appear to have resolved its problems for the time being but future production levels from Algeria and Kyrgyzstan are most uncertain.

Mercury demand and production will continue to be adversely affected by international environmental and human health concerns. Technological advances and changes in the chlorine-caustic soda industry, the primary end-use for mercury, will result in a decline in mercury use as alternative production systems are used and mercury cell plants are gradually phased out in Europe, the US and India. This will release large amounts of mercury which, if allowed to be treated, should help keep the market in balance. In the short term though, prices could continue to rise.

Table 1 World reserves and reserve base: (t)

	Reserves	Reserve Base
Algeria	2,000	3,000
Italy	-	69,000
Kyrgyzstan	7,500	13,000
Spain	76,000	90,000
US	-	7,000
Other countries	38,000	61,000
World total (rounded)	120,000	240,000

Source: US Geological Survey Mineral Commodity Summaries. January 2004

Continued tables and figures next page.

Table 2 World primary and by-product mine production by country (t)

	1999	2000	2001	2002	2003e
Algeria	240	216 r	320	620	300e
China	200	200	190r	495	610
Finland	40	76	71	42	30
Italy	7	20	20	15	7
Japan	-	-	-	-	50
Kyrgystan	300	257 r	300 r	537	370
Kazakhstan	-	-	-	-	13
Mexico	15	15 r	15 r	20	N/A
Russia	50 r	50 r	20	-	N/A
Slovakia	N/A	N/A	N/A	N/A	-
Slovenia	N/A	N/A	N/A	-	-
Spain	433	476 r	524	726	745
Tajikistan	35	40	30	-	-
Ukraine	N/A	N/A	N/A	-	-
US	N/A	N/A	N/A	-	-
TOTALS	**1,310**	**1,350**	**1,490**	**2,455**	**2,125**
Flasks	37,971	39,130	43,188	71,160	61,594

r = Revised. e = Estimated N/A =not available

Sources: US Department of the Interior Geological Survey on Mercury Mining Annual Review and US Geological Survey Mineral Commodity Summaries much of which contains estimated figures. Accordingly adjustments have been made where more accurate information has been obtained.

Table 3

Year	New Almaden production (t/flasks)	Returned from chlor-alkali industry (t/flasks)	Total (t/flasks)
2001	524 - 15,188	506 – 14,666	1,030 - 29,854
2002	726 - 21,043	182 - 5,275	908 - 26,318
2003	745 - 21,594	227 - 6,580	972 - 28,174

Figure 1

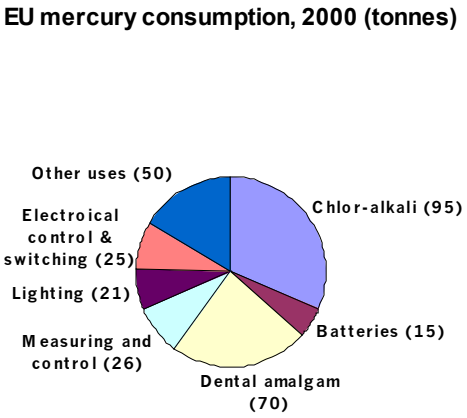
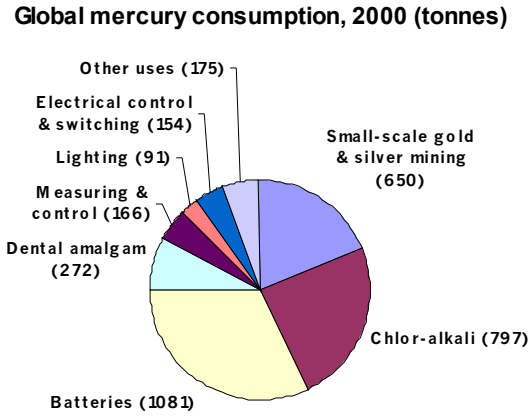


Figure 2



Source: Maxson P. (2004) Mercury Flows in Europe and the World