

Mercury

Mercury is a unique metallic element: it is liquid at ambient temperatures and does not solidify until the temperature drops to -39°C . It was known to the ancient Chinese, Hindu and Egyptian civilisations, and is thought to have been in use for over 3,000 years. Its early applications seem to have been limited to pigments, ointments and amalgams, but its single greatest use in modern times has been as a mercury cathode for the electrolytic production of chlorine and caustic soda by the chlor-alkali process.

The other large consuming industries are battery production, mining, dentistry and electrical and electronic switches. Temperature- and pressure-measuring devices, fluorescent lights, latex paint and a number of other products consume small quantities. But, due to the health risks posed by mercury's toxicity – high doses can be fatal and even small doses can seriously damage the nervous system – the market for "liquid silver" is shrinking fast.

Substitutes have been found to replicate mercury's many useful properties – fluidity, electrical conductivity, a uniform volume expansion over the entire liquid temperature range, high surface tension and an ability to alloy with base metals and some precious metals.

Diaphragm and membrane cells are replacing the mercury cells used in the electrolytic chlor-alkali process; lithium, nickel-hydride and zinc-air batteries are replacing mercury-zinc batteries; indium compounds are being used instead of mercury in alkaline batteries; ceramic composites have been developed to replace dental amalgams, and digital instruments are replacing many of the devices that use mercury, including the best-known – the thermometer.

While the developing world accounts for most mercury consumption today, certain applications continue everywhere: mining operations throughout the world use mercury to extract gold from ores through amalgamation. It is consumed during mining and either lost to the atmosphere as vapour or discarded.

The US Toxic Release Inventory for 2003 cites gold mining as the country's largest source of mercury emissions to air, according to the Washington-based campaign group, Earthworks. In Indonesia, Newmont Mining disposes of mercury from its gold operations in submarine tailings. However, burning coal is said to be the world's largest source of mercury pollution.

SUPPLY-DEMAND

Mercury is a naturally-occurring element found in some 25 different minerals, but is most commonly recovered from the red sulphide mineral, cinnabar (HgS). Native mercury exists in nature, but is rare. Mercury comes from mercury mines, as a by-product from mining other metals, and from recycling secondary material.

Mercury is measured in flasks (one flask is equal to 34.5 kg or 76 lb). World-wide consumption has fallen from about 400,000 to 100,000 flasks in the last twenty years, according to Howard Masters, md of UK-based minor metals trader, Lambert Metals.

"World primary mercury supply has been dominated in recent years by Spain, Algeria and Kyrgyzstan, which mined and produced mercury, mostly for export," Masters says. "These mines are all state-owned, although there have been unsuccessful attempts to privatise both the Spanish and Kyrgyzstan operations," he adds. China is close behind as a major producer. According to Natural Resources Canada, these four countries accounted for 93% of world supply in 2002, and in 2004, primary sources accounted for 60% of world use.

As evidence of the threat to health has grown, western states have increased their control over the production and use of mercury. But availability is now more restricted than demand – which continues unabated in non-western countries – driving up the price from around US\$200/fl at the start of 2004 to over \$1,000/fl at its peak in the early part of 2005.

Spain's Minas de Almaden used to be the largest single producer, but as EU restrictions on mining have taken hold, it no longer mines primary mercury. The company continues to process existing stocks of ore and to recycle rising volumes of secondary material. Of the other major mines, the life of the Sonarem mine in Algeria came to an end in mid-2003 when continual flooding made it too expensive to maintain, leaving the Khaydarkan mine in



M. Kampr

Mercury's main ore is an attractive red mineral called cinnabar

Kyrgyzstan as the only one remaining of the world's three large mercury mines.

However, the boom in Chinese consumption of raw materials has reopened many of that country's small mercury mines, which were closed when prices were low. Masters says that China has the resources to match Spain as a major producer, and until the late 1980s was an important exporter. As well as its own production, China consumes most of the production from Kyrgyzstan.

Primary mercury is also extracted as a by-product from gold, zinc and silver mining operations. Newmont Mining's Yanacocha gold mines in Peru are thought to be the largest single source of by-product mercury with 2,000-3,000 flasks/year, which is refined in the USA. Small amounts come from Boliden's zinc mining in Finland and Nomura Kohshan's lead-zinc operation in Japan, according to Masters.

Methods of extracting metal from mercury ores are inexpensive. Due to the low boiling point (356.6°C) of elemental mercury, mercury metal is recovered by heating the ore and condensing the vapour. This method yields mercury that is 99.9% pure. Refining on a small scale uses simple firing and condensing equipment, while larger operations use continuous rotary kilns or mechanically feeding and discharging multiple-hearth furnaces.

Strategic stockpiles are no longer a source of primary mercury. The USA's Defense National Stockpile suspended sales in 1994, and stocks in the former Soviet Union were exhausted by the end of the 1990s, although further stocks may still exist.

Volumes of secondary mercury are likely to grow as western environmental regulations take effect. The decommissioning of chlor-alkali plants in the western world yields large amounts of mercury waste, and small amounts from scrapped mercury-containing mechanical and electrical products contribute to a substantial secondary resource.

MANAGEMENT OF MERCURY

In certain conditions, mercury can be converted in the environment into a more complex compound called methylmercury, which inhibits mental development in unborn children. Because it is a primary element, mercury is indestructible. The global pool of mercury is therefore permanent and will never diminish. But because it is hazardous to health, the management of the mercury pool is becoming an important subject for international organisations.

In 2003, the United Nations called for greater supervision of the mercury trade as part of a wider effort to reduce mercury pollution. A report focused on emissions and the harm the metal causes as it enters and remains in the environment. One of its conclusions noted that "the most significant global movement of mercury that remains poorly understood is the flow of mercury through international commerce".

Primary and by-product mine output in tonnes

	2001	2002	2003	2004
Algeria	320	620	300 ^e	–
China	190	495	610	650 ^e
Finland	76	71	42	30
Italy	20	15	7	6
Japan	–	–	50	70 ^e
Kyrgyzstan	300	537	370	488
Kazakhstan	–	–	13	–
Mexico	15	20	n/a	n/a
Peru	–	–	–	100
Russia	20	–	n/a	n/a
Spain	524	726	745	350
Tajikistan	30	–	–	–
Total	1,490	2,455	2,125	1,685
Flasks	43,188	71,160	61,594	48,840

Source: USGS, January 2005 and Lambert Metals
e = estimate, n/a = not available

Although there are regulations in place around the world governing the use, storage and transportation of mercury, the report said that stockpiled metal, as well as material contained in tailings and landfills, still presents a future threat of release into the environment.

The EU is a significant exporter of mercury, but this year the European Commission announced its intention to phase out this trade by 2011. "There are continuing high levels of mercury demand, for which the EU is presently the main supplier," the Commission says.

However, Masters estimates that the chlor-alkali plants in Europe still to be decommissioned will yield another 350,000-450,000 flasks (12,000-15,000 tonnes) of mercury. Euro Chlor, representing the European caustic soda producers, is committed to phasing out the use of mercury cells by 2020 and has had an agreement with Almaden since 2001 to recycle all the mercury recovered from contaminated equipment and the decommissioning of chlor-alkali facilities. Since European consumption is falling, the issue of safe storage will be important if the EU ban on exports is enacted in 2011.

The EU is proposing an international treaty to control mercury trade, emissions and use, while the USA is promoting a voluntary partnership to track emissions and share information on emission control techniques. However, Masters points out that old technology is still in use in China, India, Mexico and Russia: "There's really no chance of an international binding agreement, as the EU is proposing," he says. And – as demand from developing countries is not going to disappear: "If recycled material from the closing EU plants is not made available to fulfil this demand, then world prices are likely to continue high, encouraging increased mine production," Masters observes.

So, while the USA, the EU and Japan have announced their intentions to at least limit the use of mercury, it appears that developing countries will continue to consume it. ■