4. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

4.1 PRODUCTION

Mercury is a naturally occurring element that is usually found as mercuric sulfide (cinnabar), an insoluble, stable compound. It occurs in the earth's crust at levels averaging 0.5 ppm, but the actual concentration varies considerably depending on location (Merck 1989; Sidle 1993). Mercury is mined using both open pit (10% of production) and underground mining techniques (90%) (Drake 1981).

Mercury ores are processed inexpensively to produce metallic mercury. Due to the low boiling point of elemental mercury, mercury can be refined by heating the ore and condensing the vapor to form metallic mercury. This method is 95% efficient and yields mercury that is 99.9% pure. The methods used to refine mercury ores are uncomplicated. Smaller refineries use simple firing and condensing equipment, while larger operations use continuous rotary kilns or mechanically feeding and discharging multiple-hearth furnaces (Carrico 1985).

Table 4-1 lists the facilities in each state that manufacture or process mercury, the intended use, and the range of maximum amounts of mercury that are stored on site. There are currently 34 facilities that produce or process mercury in the United States. The data listed in Table 4-1 are derived from the Toxics Release Inventory (TRI96 1998). Since only certain types of facilities are required to report (EPA 1996d), this is not an exhaustive list.

With the closure of the McDermitt Mine in Nevada in 1990, mercury ceased to be a principal product of U.S. industry (USGS 1997). The figures for the total output of this mine have been withheld by the Bureau of Mines to avoid disclosure of company proprietary data (see Table 4-2). As of 1995, eight mines in California, Nevada, and Utah produced mercury as a by-product from gold mining operations. Metals in the gold ores are extracted with an aqueous cyanide solution, with typical mercury recoveries of between 10 and 20% (Jasinski 1993; USGS 1997). Approximately 58 metric tons of mercury were produced as a by-product from 8 mines in 1991 and 64 metric tons were produced as a by-product from 9 mines in 1992. Since then, production volumes have been withheld to avoid disclosing company proprietary data.

Although most of the world production of mercury is generated by mercury mines, most of the mercury produced in the United States comes from secondary production sources (recycling) (EPA 1997).

Table 4-1. Facilities That Manufacture or Process Mercury

FACILITY	LOCATION [a]	RANGE OF MAXIMUM AMOUNTS ON SITE IN POUNDS	ACTIVITIES AND USES
OCCIDENTAL CHEMICAL CORP.	MUSCLE SHOALS , AL	100,000 - 999,999	CHEMICAL PROCESSING AID
TUSCALOOSA STEEL CORP.	TUSCALOOSA , AL	0 - 99	ARTICLE COMPONENT
OCCIDENTAL CHEMICAL CORP.	NEW CASTLE , DE	100,000 - 999,999	CHEMICAL PROCESSING AID
OLIN CHLOR-ALKALI PRODS.	AUGUSTA , GA	100,000 - 999,999	CHEMICAL PROCESSING AID
ALEXANDER MFG. CO.	MASON CITY , IA	0 - 99	IMPORT , ON-SITE USE/PROCESSING , ARTICLE COMPONENT
MICRO SWITCH	FREEPORT , IL	10,000 - 99,999	ARTICLE COMPONENT
VALSPAR CORP.	ROCKFORD , IL	10,000 - 99,999	FORMULATION COMPONENT
DURAKOOL INC.	ELKHART , IN	10,000 - 99,999	ARTICLE COMPONENT
HERMASEAL CO.	ELKHART , IN	10,000 - 99,999	ARTICLE COMPONENT
U.S. STEEL	GARY , IN	10,000 - 99,999	PRODUCE , BYPRODUCT
UNITED TECHS. AUTOMOTIVE INC.	EDINBURGH , IN	10,000 - 99,999	ARTICLE COMPONENT
KOCH SULFUR PRODS. CO.	DE SOTO , KS	0 - 99	ANCILLARY/OTHER USE
BF GOODRICH CO.	CALVERT CITY , KY	100,000 - 999,999	CHEMICAL PROCESSING AID
DU PONT	LOUISVILLE , KY		
BORDEN CHEMICALS & PLASTICS	GEISMAR , LA	100,000 - 999,999	IMPORT , ON-SITE USE/PROCESSING , CHEMICAL PROCESSING AID
DOW CHEMICAL CO.	PLAQUEMINE , LA	1,000 - 9,999	PRODUCE , BYPRODUCT
PIONEER CHLOR ALKALI CO. INC.	SAINT GABRIEL , LA	100,000 - 999,999	CHEMICAL PROCESSING AID
PPG IND. INC.	LAKE CHARLES , LA	100,000 - 999,999	CHEMICAL PROCESSING AID
HOLTRACHEM MFG.	ORRINGTON , ME	100,000 - 999,999	CHEMICAL PROCESSING AID
ELM PLATING CO.	JACKSON , MI	0 - 99	ARTICLE COMPONENT
KERR CORP.	ROMULUS , MI	1,000 - 9,999	REPACKAGING
HOLTRACHEM MFG. CO. L.L.C.	RIEGELWOOD , NC	100,000 - 999,999	CHEMICAL PROCESSING AID
MERCURY REFINING CO. INC.	ALBANY , NY	10,000 - 99,999	PRODUCE , SALE/DISTRIBUTION , REPACKAGING , ANCILLARY/OTHER USE
ASHTA CHEMICALS INC.	ASHTABULA , OH	10,000 - 99,999	CHEMICAL PROCESSING AID
COMPONENT REPAIR TECHS.	MENTOR , OH		
SINCLAIR OIL CORP.	TULSA , OK	100 - 999	PRODUCE , BYPRODUCT
ADVANCED ENVIRONMENTAL	ALLENTOWN , PA	10,000 - 99,999	PRODUCE , SALE/DISTRIBUTION
BETHLEHEM APPARATUS CO. INC.	HELLERTOWN , PA	100,000 - 999,999	PRODUCE , IMPORT , ON-SITE USE/PROCESSING , SALE/DISTRIBUTION , REPACKAGING
ZINC CORP. OF AMERICA	MONACA , PA	10,000 - 99,999	PRODUCE , IMPURITY
OLIN CORP.	CHARLESTON , TN	100,000 - 999,999	CHEMICAL PROCESSING AID
OCCIDENTAL CHEMICAL CORP.	DEER PARK , TX	100,000 - 999,999	CHEMICAL PROCESSING AID
GEORGIA-PACIFIC WEST INC.	BELLINGHAM , WA	100,000 - 999,999	CHEMICAL PROCESSING AID
VULCAN MATERIALS CO.	PORT EDWARDS , WI	100,000 - 999,999	CHEMICAL PROCESSING AID
PPG IND. INC.	NEW MARTINSVILLE , WV	100,000 - 999,999	CHEMICAL PROCESSING AID

Source: TRI96 1998

[a] Post Office state abbreviations used

blank = not available

Table 4-2. U.S. Mercury Supply Demand, Imports, and Exports (metric tons)

Category	1987	1988	1989	1990	1991	1992	1993	1994	1995
Supply									
Mine production[a]		379	414	448	0	0	0		
By-product production[b]		W[c]	W	114	58	64	W		
Industrial recovery		278	137	108	165	176	350	466[e]	534[e]
DLA sales		52	170	52	103	267	543		
DOE sales		214	180	193	215	103	0		
Imports	636[e]	329	131	15	56	92	40		
Total supply	**NA[d]**	**1,252**	**1032**	**930**	**597**	**702**	**933**	**NA[d]**	**NA[d]**
Subtotal: federal sales	NA[d]	266	350	245	318	370	543	NA[d]	NA[d]
Federal sales as % of total supply	NA[d]	21.2%	33.9%	26.3%	53.3%	52.7%	58.1%	NA[d]	NA[d]
Demand	**NA[d]**	**1,503**	**1,212**	**720**	**554**	**621**	**558**	**NA[d]**	**NA[d]**
Federal sales as % of demand	NA[d]	17.6%	0.29%	34%	57.4%	59.6%	0.97%	NA[d]	NA[d]
Imports	**636[e]**	**329**	**131**	**15**	**56**	**92**	**40**	**129[e]**	**277[e]**
Exports	**NA[d]**	**N/A[d]**	**221**	**311**	**786**	**977**	**389**	**316[e]**	**179[e]**

[a] Mercury production from McDermitt mine; closed November 1990
[b] Mercury by-product from 9 gold mining firms
[c] Withheld for proprietary reasons
[d] Not available
[e] Information from USGS 1997

Source: EPA 1996b

Secondary production of mercury includes the processing of scrapped mercury-containing products, and industrial waste and scrap (EPA 1997). As a result of the increasingly stricter regulations that have been placed on the disposal of mercury-containing products, secondary production using recycled mercury has increased from 165 metric tons in 1991 to 176 metric tons in 1992, 350 metric tons in 1993, 466 metric tons in 1994, and 534 metric tons in 1995. Mercury was recovered from various waste materials, including mercury batteries, dental amalgams, switches (including thermostats), manometers, chloralkali wastewater sludges, chemical solutions, and fluorescent light tubes. Refining of the recycled mercury was dominated by three companies: Bethlehem Apparatus Co., Hellertown, Pennsylvania; D.F. Goldsmith Co., Evanston, Illinois; and Mercury Refining Co., Albany, New York (USGS 1997).

4.2 IMPORT/EXPORT

Until 1989, the United States was a net importer of mercury. After that, market values of mercury fluctuated and consumption diminished, leading to a decreased need for imported mercury (Carrico 1985; Drake 1981). U.S. imports of mercury fell sharply between 1987 and 1990 (Jasinski 1993; Reese 1990). The import volumes decreased drastically during the period from 1987 to 1990: 636 metric tons in 1987, 329 metric tons in 1988, 131 metric tons in 1989, and 15 metric tons in 1990 (see Table 4-2). However, import figures generally have increased substantially since 1990: 56 metric tons in 1991, 92 metric tons in 1992, 40 metric tons in 1993, 129 metric tons in 1994, and 277 metric tons in 1995 (USGS 1997). The major reason for the recent escalation in mercury imports is the suspension of mercury sales from the National Defense Stockpile (NDS) in 1994, which had been the major supplier of mercury to the domestic market in recent years. The suspension was imposed by Congress after the EPA raised questions about potential problems associated with the release of mercury. Also, there was concern about the export of NDS mercury for uses banned in the United States (USGS 1997).

From 1978 to 1988, figures were unavailable for the amount of mercury exported by the United States. The U.S. export figures for mercury from 1989 to 1992 are: 221 metric tons in 1989, 311 metric tons in 1990, 786 metric tons in 1991 (Jasinski 1993; Reese 1990), 977 metric tons in 1992, 389 metric tons in 1993, 316 metric tons in 1994, and 179 metric tons in 1995 (USGS 1997) (see Table 4-2). General trends in exportation of mercury are difficult to characterize because the data are unavailable for the 11 years prior to 1989. However, the decline of exports in 1995 is largely due to the suspension of sales from the NDS (USGS 1997).

Major mercury producing countries (primary production from mining operations) in the world currently include Algeria, China, Czechoslovakia, Finland, Kyrgyzstan, Mexico, Morocco, Russia, Slovakia, Slovenia, Spain, Turkey, and the Ukraine (USGS 1997). The world reserves of mercury are estimated to be sufficient to supply enough product for 100 years, given current production and consumption estimates (Jasinski 1993).

4.3 USE

Mercury has many applications in industry due to its unique properties, such as its fluidity, its uniform volume expansion over the entire liquid temperature range, its high surface tension, and its ability to alloy with other metals. However, domestic consumption of mercury has shown a downward trend since the early 1970s. In 1995, consumption was 463 metric tons, down 10% from 1994. The largest commercial use of mercury in the United States was for electrolytic production of chlorine and caustic soda in mercury cells, accounting for 35% of domestic consumption. Manufacture of wiring devices and switches accounted for 19%, measuring and control instruments for 9%, dental equipment and supplies used 7%, electric lighting used 7%, and other uses used 21% (EPA 1997; USGS 1997). Due to the high toxicity of mercury in most of its forms, many applications have been canceled as a result of attempts to limit the amount of exposure to mercury waste.

Electrical applications. Mercury is a critical element in alkaline batteries. In the past, excess amounts of mercury were used in batteries; however, alkaline battery manufacturers in Europe, Japan, and the United States are now reducing the mercury load from 0.1% to 0.025% of battery content. This reduction will ultimately limit the amount of mercury needed in the battery industry to below 4 metric tons per year (Cole et al. 1992; Reese 1990). Mercuric oxide has become increasingly important commercially in the production of galvanic cells with mercuric oxide anodes in combination with zinc or cadmium cathodes. The voltage for these small, button-shaped batteries remains constant during discharge. The batteries are used in hearing devices, digital watches, exposure meters, pocket calculators, and security installations (IARC 1993), but their use has been declining as non-mercury replacement battery production has increased. Some electrical lamps use mercury vapors in discharge tubes. These lamps are efficient, long-lasting, and produce more lumens per watt than most other industrial lamps (Drake 1981). Wiring and switching devices, such as thermostats and cathode tubes, use mercury because of its predictable contact resistance, thermal conductivity, and quiet operation (Carrico 1985; Drake 1981). In 1985, 64% of the mercury used in the United States was for electrical applications. This use declined to 29% in 1992 (IARC 1993).

Medical applications. Metallic mercury is used in dental restorations because of its ability to alloy with other metals. The World Health Organization (WHO 1991) estimated that, in industrialized countries, about 3% of the total mercury consumption is for dental amalgams. Based on 1992 dental manufacturer specifications, amalgam (at mixing) contains approximately 50% metallic mercury, 35% silver, 9% tin, 6% copper, and trace amounts of zinc. Estimates of annual mercury usage by United States dentists range from approximately 100,000 kg in the 1970s to 70,000 kg in 1995. More than 100 million fillings are replaced each year in the United States (Lorscheider et al. 1995). Until 30 years ago, mercury compounds were used extensively in pharmaceuticals. Mercury salts were components of antiseptics (e.g., merthiolate, mercurochrome), diuretics, skin lightening creams, and laxatives (calomel). Organic mercury compounds were employed in antisyphilitic drugs and some laxatives. Phenylmercury acetate was used in contraceptive gels and foams and as a disinfectant (IARC 1993). Since then, more effective and less toxic alternatives have replaced most pharmaceutical uses of mercury. Medical equipment, such as thermometers and manometers, use metallic mercury to measure temperature and pressure (Carrico 1985).

Chemical/mining applications. Mercury is a catalyst in reactions to form polymers, such as vinyl chloride and urethane foams. The preparation of chlorine and caustic soda (NaOH) from brines also uses mercury as a catalyst. In this process, mercury is used as a moving cathode to separate sodium and chlorine (Rieber and Harris 1994). This mercury can be recycled with 95% efficiency (Drake 1981). Consumption occurs as mercury is lost in wastewater treatment, is recaptured, reprocessed, and sent to landfills (Rieber and Harris 1994). Mercuric oxide and mercuric sulfide are used as pigments in paints (Winship 1985). Gold mining operations use mercury to extract gold from ores through amalgamation (Carrico 1985).

Other applications. Phenylmercuric acetate has been used in aqueous preparations such as inks, adhesives, and caulking compounds, as a catalyst for the manufacture of certain polyurethanes, and as a fungicide in seed dressings and interior and exterior paints (IARC 1993; Reese 1990). Dimethylmercury is used to prepare mercury nuclear magnetic resonance standards (Blayney et al. 1997) and mass spectrometer mercury calibration standards (Toribara et al. 1997).

Discontinued applications. The use of phenylmercuric acetate as a fungicide in interior latex paints was banned in 1990 (Reese 1990), and its use in exterior paint was banned in 1991 (Hefflin et al. 1993). Both of these bans were prompted because of releases of mercury vapors as the paint degraded. Alkyl mercurial compounds were used until the mid-1970s as a treatment to disinfect grain seeds. Most other agricultural applications of mercury compounds in bactericides and fungicides have been banned due to the toxicity of mercury. Mercuric nitrate was used in the production of felt hats to hydrolyze rabbit fur. The use of mercury as a wood preservative has ceased due to the use of polyurethane (Drake 1981).

4.4 DISPOSAL

Mercury is an element, and therefore its chemical structure cannot be further broken down. In its elemental form, mercury is highly toxic when inhaled. Therefore, incineration of mercury is not recommended as a disposal method. Mercury-containing waste products include waste effluents from chloralkali plants and discarded mercury-containing mechanical and electrical devices (Carrico 1985). Under current federal guidelines, mercury and its compounds are considered hazardous substances, and various regulations are in effect to control the emission of mercury into the environment (especially organic compounds) (Carrico 1985). Emissions from mercury ore processing facilities and mercury cell chloralkali plants are limited to 2.3 kg/day/facility. Emissions of mercury from the incineration or drying of wastewater sludges is limited to 3.2 kg/day/facility (EPA 1975a, 1975b). In addition, dumping wastes containing more than trace amounts of mercury is prohibited.

Recycling of mercury-containing compounds is an important method of disposal. Recycling (retorting) is a treatment for five categories of mercury wastes including: (D009) characteristic mercury; (K106) chlor-alkali waste; (P065) mercury fulminate; (P092) phenylmercuric acetate; and (U151) elemental mercury (see Table 7-1). From 1987 to 1991, annual production of mercury from old scrap averaged nearly 180 metric tons, equivalent to 16% of the average reported consumption during that period (Jasinski 1993). Virtually all mercury can be reclaimed from mercury cell chloralkali plants, electrical apparati, and control instruments when plants are dismantled or scrapped (Carrico 1985). Increased recycling would decrease the mercury load from waste sites and treatment plants. As environmental concerns increase with respect to the disposal of mercury, the recovery by recycling and industrial processes will become a more significant source of domestic supply (Carrico 1985).

Of the estimated 646,896 pounds of mercury reported in the Toxics Release Inventory (TRI) in 1991 to have been released to the environment, the largest percentage (96%, or 619,310 pounds) was transferred off-site from 51 industrial processing facilities, and another 314 pounds were transferred to publicly owned treatment works (POTWs) (TRI91 1993) (see Section 5-2 for additional information). By comparison, in 1994, only 83,064 pounds of mercury (less than 14% of the total reported in 1991) were released to the environment; and of this amount, 81% (67,480 pounds) was transferred off-site from 29 large processing facilities (TRI94 1996) and an estimated 15 pounds of mercury were released to POTWs (TRI94 1996). Again, by comparison, in 1996, only 84,772 pounds of mercury (less than 14% of the total reported in 1991) were released to the environment and of this amount, 78% (66,573 pounds) was transferred off-site from 34 large processing facilities and an estimated 15 pounds of mercury were released to POTWs (TRI96 1998). Releases of mercury to each of these compartments—the total environment, POTWs, and the volume transferred off-site—decreased dramatically (approximately 90%) in only 5 years. The data listed in the TRI should be used with caution, because only certain types of facilities are required to report (EPA 1996d). This is not an exhaustive list. A facility is required to report information to the Toxics Release Inventory only if the facility is a general manufacturing or processing facility with 10 or more full-time employees that produces, imports, or processes 75,000 or more pounds of any TRI chemical or that uses more than 10,000 pounds of a TRI chemical in a calendar year. No additional information on trends in disposal volume or on specific methods of disposal was located.

In addition, unknown quantities of metallic mercury used in religious or ethnic ceremonies, rituals, and practices (see Sections 5.4.4, 5.6, and 5.7) may reach municipal landfill sites by being improperly disposed of in domestic garbage, or may reach POTWs by being improperly discarded into domestic toilets or sink drains (Johnson [in press]). A survey was conducted to determine the use patterns of elemental mercury in the Latin American and Caribbean communities in New York City (Johnson [in press]). In a survey of 203 adults, about 54% used elemental mercury in various religious and ethnic practices. Of these users, 64% disposed of the mercury in household garbage, 27% flushed the mercury down the toilet, and 9% disposed of the mercury outdoors. It is commonly thought that the high mercury load found in sewage and garbage in New York City comes from dental clinics; however, improper disposal of mercury by religious practitioners in the Latin American and Caribbean communities may also contribute to this load (Johnson [in press]).