

#### 4. PRODUCTION, IMPORT, USE AND DISPOSAL

##### 4.1 PRODUCTION

Silver is a rare, but naturally occurring, element. It is often found deposited as a mineral ore in association with other elements. It is acquired primarily as a by-product during the retrieval of copper, lead, zinc, and gold ores (Grayson 1983). The primary silver mines of the United States are located in the Coeur d'Alene mining district in the northern Idaho panhandle (Smith and Carson 1977). This area accounts for approximately 71% of domestic mine production (Drake 1980). It is mined using either open pit or underground methods, and the ore is then upgraded through a series of processes including flotation and smelting. The silver is finally extracted electrolytically by the Moebius process, the Balbach-Thum process, or the Parkers process (Grayson 1983; Smith and Carson 1977).

World mine production in 1986 was 419.8 million troy ounces (for conversion: troy ounces x 31.1034768 = grams) (Reese 1986). Mine production in the United States declined from 1978 to 1986, reaching a low of 34.2 million troy ounces in 1986, due to a combination of falling silver prices and rising production costs (Reese 1986). This trend appeared to continue according to a survey conducted by The Silver Institute in 1988 and 1989. The United States production of silver from ores and concentrates was 3.4 and 4.2 million troy ounces in 1988 and 1989, respectively. However, when recovered silver is included in the production figures, total production was 8.8 and 9.3 million troy ounces for 1988 and 1989, respectively (The Silver Institute 1990). United States consumption in 1986 reached a high of 126.4 million troy ounces, -largely due to increased industrial consumption and use in special issue coinage (Reese 1986). In 1987, the estimated consumption was 63.7 million troy ounces for the United States and 172 million troy ounces worldwide (The Silver Institute 1988)

Since 1951, silver consumption has exceeded its extraction from ore. Secondary silver production involves the recovery of silver from new and old scrap, resulting from silver-containing wastes generated by industry and the consumer. Recycled silver accounted for 40% of U.S. refinery production in 1971 and had increased to 67% by 1974 (Smith and Carson 1977). It was estimated to be 61% and 56% in 1988 and 1989, respectively (The Silver Institute 1990). The estimated world-wide recovery of silver from the photographic industry is about 67% of the total used (The Silver Institute 1988). It has been estimated that 80%, 68%, and 75% of today's annual consumption by the electrical, industrial-alloy, and art industries, respectively, is recycled silver, but these estimates may be high.

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##### 4.2 IMPORT

The United States 1986 net import reliance approximated 60% of apparent domestic consumption. Despite this, the 1986 U.S. dependence on foreign imports decreased. Import levels fell from 152.6 million troy ounces in 1985 to 144.9 million troy ounces in 1986 (Reese 1986).

The largest decrease in imported silver was from the United Kingdom and Switzerland. For these two countries import levels fell by 18.1 million ounces, primarily in the form of refined bullion. A total of 125.4 million troy ounces of refined silver were imported in 1986 with only 9.5 million troy ounces accounted for in other forms.

U.S. exports of silver decreased slightly from 28.8 million troy ounces in 1985 to 25.1 million troy ounces in 1986 (Reese 1986).

##### 4.3 USE

Silver metal and silver compounds have been and still are used in a wide variety of ways. In the past, silver was used for surgical prostheses and/or splints, fungicides (both of which are now obsolete), and coinage (discontinued from general circulation within the United States in 1970). Although silver still serves some of the above functions, the current uses are even more varied. Photographic materials accounted for 45% of the U.S. consumption in 1986. Electrical and electronic products, such as electrical contacts, silver paints, and batteries, consumed approximately 25%. Silver has been an important component in the manufacture of bearings in the past, although today its use in this area is limited by cost and availability. Silver is also an important component in brazing alloys and solders, which represent approximately 5% of the 1986 silver consumption. More aesthetic uses of silver include electroplated ware, sterling ware, and jewelry; in 1986, they accounted for 11% of recorded uses.

Other uses account for the remaining 14%; these include use in mirrors, dental amalgam, and medical supplies for treatment of burns, use as a catalyst in the manufacture of formaldehyde and ethylene oxide, as an active agent for purification and disinfection of drinking water and water in swimming pools, in certain chemical analyses involving titration, and in cloud seeding (Grayson 1983; HSDB 1988; NRC 1977; Smith and Carson 1977). Silver ions are also used medically as an antibacterial agent (Becker 1987; Becker et al. 1978; Fox et al. 1969; Webster et al. 1981).

##### 4.4 DISPOSAL

Treatment of air emissions containing silver is not a concern as atmospheric emissions rarely approach the federal threshold limit value for occupational exposure of  $0.01 \text{ mg/m}^3$  (Smith and Carson 1977).

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Moreover, as consumption of silver-containing products outweighs supply, these products tend to be recycled whenever feasible. The largest source of nonrecycled silver in the waste stream is attributable to photographic material use by small-scale consumers (Smith and Carson 1977). This tends to be released in the form of silver thiosulfate, which is converted into insoluble silver forms by micro-organisms during wastewater treatment (Grayson 1983). Several methods have been suggested for recovering silver from various waste media, including waste water, solid waste, and gas effluents. These include electrolytic recovery, agglomeration, and metal concentration (CHMR 1989). At present the criteria for land disposal practices are undergoing significant revision, and consultation with environmental regulatory agencies is advised (HSDB 1988).

