# BROMINE

By Phyllis A. Lyday

The quantity of bromine sold or used in the United States was 247 million kilograms valued at $198 million. The value of bromine sold or used was 80 cents per kilogram. Primary uses of bromine compounds were in flame retardants (38%), drilling fluids (22%), sodium bromide solutions (10%), brominated pesticides (mostly methyl bromide) (8%), water-treatment chemicals (7%), and other including photographic chemicals and rubber additives (15%) (Chemical Marketing Reporter, 1997d). International distribution of bromine production in 1997 was as follows: the United States, 53%; Israel, 29%; China, 7%; the United Kingdom, 6%; and other countries, 5%. The United States' portion of world production has decreased steadily since 1973, when the United States produced 71% of the world supply. The decrease in world share has been a result of environmental constraints and the emergence of Israel as the world's second largest producer. (*See table 1.*)

**Legislation and Government Programs**

The production of methyl bromide, which has both natural and man made sources, is being curtailed because it is thought to be responsible for a significant fraction of the ozone-destroying bromine that reaches the atmosphere. Researchers from the National Oceanic and Atmospheric Administration's Climate Monitoring and Diagnostic Laboratory in Boulder, CO, reported that previously unrecognized biological degradation contributes to efficient removal of methyl bromide by the oceans. A global model suggests that the atmospheric lifetime of methyl bromide is only about 0.7 year, which is significantly lower than earlier estimates (Chemical & Engineering News, 1997c).

Methyl bromide continues to be viewed as a significant ozone-depleting compound. Three potentially major anthropogenic sources of atmospheric methyl bromide have been identified (soil fumigation, biomass burning, and the exhaust of automobiles using leaded gasoline), in addition to vaporization from the ocean. Methyl bromide was listed as a Class I ozone depleting substance in the 1990 Clean Air Act, and the chemical is scheduled to be phased out in the United States by January 1, 2001. The Netherlands phased out the use of methyl bromide for soil fumigation in 1992 because of concerns over ground water contamination. Denmark will ban all agricultural uses of methyl bromide in 1998, and Sweden is expected to follow with a similar schedule (U.S. Environmental Protection Agency, Methyl bromide information, unpub. data accessed May 8, 1997, at URL http://www.epa.gov/doc/ozone/mbr/mb4rqa.html).

Members of Congress from States that are heavy users of methyl bromide, such as California and Florida, introduced legislation that would amend the Clean Air Act, that requires production to end in 2001 (Chemical Marketing Reporter, 1997e). The bill would make banning of methyl bromide dependent on the availability of a "viable, cost-effective substitute" (Chemical Marketing Reporter, 1997a).

Negotiators for the Montreal Protocol met in Montreal on September 13 for the 10th anniversary of the Protocol's signing to agree on an accelerated phaseout of methyl bromide. Developed countries will stop production and use by 2005 instead of 2010, and developing countries agreed to a phaseout by 2015. Developed countries also agreed on interim reduction of 25% by 1999, 50% by 2001, and 70% by 2003. Reductions are based on averages produced from 1995 through 1998 (Sisseli, 1997).

The U.S. Environmental Protection Agency (EPA) reported that 643 chemicals were included on Toxic Release Inventory (TRI). TRI was passed by Congress in 1986 after a chemical catastrophe in India. Called the Emergency Planning and Community Right-to-Know Act (Public Law 99-499), it was intended to give communities the information they need to plan for chemical emergencies. TRI is considered one of the nation's most significant environmental laws. EPA planned to present data for individual industry sectors, and it will make comparisons between similar facilities (Hess, 1997a). The reporting was extended to include seven industry sectors as follows: metal mining, coal mining, electric utilities, commercial hazardous waste treatment facilities, chemical and allied product wholesalers, bulk petroleum terminals, and solvent recovery services. Emissions have been reduced 43% since TRI was passed a decade ago. The guidance document for the seven industry sectors added during 1997 was expected by November 1997 and the first reports are due July 1999 (Johnson, 1997).

EPA announced in October 1996 its intent to expand the TRI to include chemical use data, also known as materials accounting, to give the public more information about toxic chemicals. EPA was reviewing comments on the "advanced notice of proposed rules making." The Chemical Manufacturers Association (CMA) and other trade groups are adverse to the expansion. At issue is the amount of information about manufacturing practices and thus industrial spying through the information in the TRI expansion. CMA thinks that more than 50 nations are engaged in economic espionage against the United States, including many traditional allies because the United States produces 70% of the world's intellectual property and is the leader in research and development (Hess, 1997a).

The National Institute of Standards and Technology (NIST) is providing a new compilation of chemical and physical data on the World Wide Web on thousands of chemicals contained in more than 50 NIST databases. Searches are currently free at http://webbook.nist.gov (Chemical & Engineering News, 1997b).

The Superfund taxes expired in December 1995 and have not been reinstated. Superfund is a trust set up from the taxes on petroleum and chemicals for cleaning up sites where no responsible party with sufficient funds can be found. Domestic bromine and chlorine, used to produce the bromine, are chemicals taxed to provide funds to the Superfund. Members of the bromine industry have formed the Bromine Science and Environmental Forum, an industry cooperative program designed to conduct

research and provide information about bromine compounds used in a variety of products around the world. The forum plans to publish balanced, science-based information on bromine industry products (Chemical Marketing Reporter, 1997c). In September, the Senate Environmental and Public Works Committee and the administration met to work out a consensus agreement to reform the Superfund program. One of the most difficult issues is retroactive liability exemptions for certain parties at codisposal sites that contain both municipal solid waste as well as industrial waste (Chemical Marketing Reporter, 1997g). In November, a bipartisan compromise that may clear the way for action in 1998 was announced. Introduced by 18 Democrat and 18 Republican cosponsors, the bill would settle the long-disputed question of who should pay for cleaning up toxic waste sites. The legislation has been strongly endorsed by the CMA (Hess, 1997b).

## Production

Domestic production data for bromine were developed by the U.S. Geological Survey from a voluntary survey of U.S. operations. Of the operations to which a survey request was sent, six responded, representing 100% of total elemental bromine sold or used. (*See table 2.*)

Albemarle Corp. announced the construction of a tetrabromobisphenol-A (TBBA), a flame retardant marketed as SAYTEX RB-100, plant to be operational by early 1999 in Magnolia, AR. TBBA is used in epoxies, phenolic, acrylonitrile-butadiene-styrene, polystyrene, polycarbonate, and unsaturated polyesters. Bromine flame retardants are used in electronic equipment to increase the fire resistance of the plastic housings and the computer printed circuit boards. TBBA is also used in computer housings and electrical connectors and in carpet and office furniture (European Chemical News, 1997d). The 25,000-ton-per-year plant is expected to involve a capital expenditure in the range of $30 to $40 million (North American Minerals News, 1997). Albemarle reported a 13% increase in bromine and specialty and fine chemicals sales, which was driven by strong performances for flame retardants and bromine fine chemicals, and other fine chemicals (Peaff, 1997).

On November 3, 1995, Great Lakes filed an application with the Arkansas Oil and Gas Commission to establish a third brine production unit consisting of 24,000 hectares (60,000 acres). Under Arkansas law, the company can form a unit if it owns 75% of the mining rights to the brine. The unitization of the brine field was upheld by the U.S. District Court in 1997.

In July, Great Lakes announced a plan to spinoff its petroleum additives business. The independent company created by the spinoff will consist of Octel Associates and Octel America. Octel is the largest producer worldwide of tetraethyl lead antiknock compounds, which use bromine as a "scavenger" to prevent lead from depositing in engines.

Great Lakes earned one-half of its operating income, $497 million in 1995, from its tetraethyl lead (TEL) business that uses bromine as a scavenger. In July, Great Lakes announced the planned spinoff of Octel into an independent publicly traded company. The new Octel will consist of Octel Associates, the leading manufacturer of TEL antiknock compounds, and Octel America, a developer and marketer of nonlead fuel additives. Great Lakes also signed a memorandum of understanding with Chevron Chemical Co., under which Octel will buy Chevron's 10.65% interest in Octel. The bromine and derivatives business will be transferred to Great Lakes as well as
Palmer Research (Chang, 1997).

TETRA Technologies Inc., specialty inorganic chemicals division supplied about one-half of the chemicals for its oil and gas services division. The 10 chemical facilities produce calcium chloride, bromine products, and micronutrient. TETRA entered the bromine business in 1987 with a plant near West Memphis, AR, that produced zinc and calcium bromide using zinc-containing sludges from electroplating operations and byproduct hydrobromic acid from the bromination processes of other chemical companies. In 1992, TETRA expanded the zinc bromide operation and added calcium bromide. TETRA continued a long-term requirement contract with Bromine Compounds Ltd., Israel, that will supply 90% of external calcium bromide needs by the company's worldwide Oil & Gas Services operations. The company acquired leases in 1988 in Arkansas when it purchased a calcium bromide plant from Dow Chemical Co. (Dow). In 1996, TETRA acquired the clear brine fluids business of Dow and entered into a contract to purchase crude bromine and produce purified bromine and bromine derivatives at its facility in Ludington, MI (Chemical Marketing Reporter 1997h).

Dow's founder invented the "blowing-out" process for liberating bromine from brine that is still in use. In another process, instead of a chemical treatment, Dow used an electric current to oxidize the bromide salts in the brine. Successful application of electrochemistry made Dow and his Midland Chemical Co. the world's most efficient manufacturer. The Dow process for producing bromine electrolytically was designated by the American Chemical Society as a National Historic Chemical Landmark in 1997 at the Herbert H. Dow Museum in Midland, MI (Schultz, 1997).

Ambar Inc. planned to have on-stream early in the second quarter of 1998 a 14-million-kilogram (30-million-pound) elemental bromine facility in Manistee, MI, to produce elemental bromine and brominated salts. This will be the first new elemental bromine plant since the mid-1970's when two separate plants began producing elemental bromine. The next decade brought the closure of four plants in Michigan and California as bromine use in gasoline was phased out. Ambar would be supplied by pipeline with bromine containing brines after production of magnesium hydroxide from Martin Marietta Magnesia Specialties Inc. Ambar planned to manufacture and consume brominated well drilling fluids, but was considering selling excess elemental bromine (Chemical Marketing Reporter, 1997f). Earth-Tech designed the plant and Meridian Technologies Inc. was to market the bromine produced (Chemical Marketing Reporter, 1997b).

## Consumption

Many government regulations, insurance company requirements, building codes, and voluntary industry standards define when and where flame-retardant chemicals must be used. Except where Federal Government standards exist, such as automotive and airplane components, and in the State of California for mattress upholstery materials, the decision to use a flame-retardant resides with the manufacturer.

A paper on minerals growth in use of flame retardants in

plastics cited consumption of brominated flame retardants in thousand tons as follows: the United States, 60; Western Europe, 44; Japan, 41; other Asia, 46. This represented a total volume of 191,000 tons valued at $712 million (Mureinik, 1997).

## Prices

A book of industrial minerals prices and data through 1996 included data on bromine. The book reported that world bromine production has increased since 1991 about 1% per year. Flame retardants now account for 47% of world bromine consumption (Cameron and Russell, 1997).

## Foreign Trade

Major chemical companies have begun using Internet sites for corporate information, news releases, financial data, and product descriptions. In the past few years, several Internet sites have been created for chemical trading. Buyers and seller are matched up to make deals through what are essentially electronic bulletin boards. Chemical trading sites offer a wide variety of services, such as, chemicals or equipment trading exchanges, supplier directories, industry news and events, e-mail newsletters, links to company home pages, on-line catalogs, software, employment ads, chemical data, and reference libraries. One U.S. company based in Atlanta, started in July 1995. The 2-year old operation claimed 1,500 members from 74 countries. The company offers a means for buyers and sellers to communicate for the small- to medium-sized companies that do not have the infrastructure to access global markets. Other countries included India, the Netherlands, Portugal, and the United Kingdom. Internet companies' highest concerns are for security of the trading sites and the Internet in general. One way that companies can increase credibility is through links to home web pages (Thayer, 1997). (*See tables 3 and 4.*)

## World Review

***France.***—Elf Atochem continued to switch from bromide derivatives to fine chemicals at its Port-de-Bouc plant in southeast France. The plant had been threatened with closure because 70% of plant capacity is in bromides-dibromethane and methyl bromide that will be banned after 2005. Great Lakes announced a withdrawal from its European bromine-related joint venture with Elf at yearend (European Chemical News, 1997a). (*See table 6.*)

***Israel.***—The first production of bromine and potash began in 1931 at Kalia. The soluble minerals exist mainly as chloride and bromine anions and magnesium, sodium, and potassium cations. Bromine has been produced as a byproduct from waste bitterns associated with potash production from the Dead Sea since 1957 by Dead Sea Works (DSW) (accessed January 14, 1997, at URL http://www.cbp.gov.il:80/economy/Done-vol1/dead.html). After potash is removed in solar ponds, the waste bitterns are processed with chlorine to recover bromine. The bromine-free bitterns are then processed to recover magnesium.

The Israeli Government began efforts in 1985 to sell a share of Israeli Chemical Co. Ltd. (ICL) to offset an investment program. ICL is a group of chemical and mineral industrial companies, with research institutes, technical facilities, and commercial and marketing services. Israel Corp. (IC), Tel Aviv, bought an additional 17% stake in March 1997, which brought its share of ICL to 41.9%. The family of an Israeli business controlled 50% of IC and 50% is owned by an offshore corporation also controlled by the businessman. In 1997, the businessman died and his son, became chairman of the Eisenberg Group and chairman of the board of ICL effective April 9 (Phosphorus & Potassium, 1997a). In 1997, the Israeli government announced a decision to sell off its 31.5% stake of ICL. The Tel Aviv stock exchange has a 25% share and 1.6% of shares are held in trust for the employees of ICL (Fertilizer Markets, 1997).

Approximately 70% of ICL's activities are devoted to the fertilizer industry. The crude carnallite is harvested and the waste brines produce chlorine and magnesium products. The chlorine is used to change the bromide to bromine as part of the bromine recovery process. In 1997, ICL announced plans for its three subsidiaries to be organized as business groups under the management of a son-in-law of the late businessman to head the three groups: DSW, Bromine Business Group, and the Rotem Business Group. Dead Sea Bromine (DSB) was to abolish its organic division and amalgamate the functions in the other three divisions (European Chemical News, 1997c; Phosphorus & Potassium, 1997a).

Greenpeace was against construction of a hazardous waste incinerator being built at Ramat Hovav in the Negev region. Since the early 1970's, five subsidiaries of ICL, including Bromine Compounds, have dumped 45,000 tons of hazardous waste (European Chemical News, 1997b).

***Jordan***.—DSB Group and Jordan's Arab Potash Corp. signed a memorandum of understanding to construct a bromine plant on the Jordanian side of the Dead Sea in 1995. It is reported to be nearing a final decision at the governmental level. The 50-50 joint venture would be managed by the Jordanians and be built with the technical assistance by DSB. The project would produce up to 35,000 tons per year of bromine, 20,000 tons per year of tetrabromobisphenol, and 20,000 tons per year of calcium bromide at a cost between $90 and $100 million (Phosphorus & Potassium, 1997b).

## Current Research and Technology

A brominated catalyst is very selective by allowing interaction at one location at a rate to 400 to 1 compared with 5 to 1 for a nonrigid catalyst. During the reaction, the catalyst and the substrate are dissolved in methylene chloride (Chemical & Engineering News, 1997d).

A team of chemists in England has shown that zinc-bromide supported on muciparous silica or acid-activated montmorillonite clay is a fast, efficient, selective, and reusable catalyst at room-temperature for bromination. The catalyst gives higher selectivity and minimizes the use of the bromine waste. Brominated intermediates that could benefit from this process are used in the manufacture of pharmaceuticals, agrochemicals, and other specialty chemical products (Chemical & Engineering News, 1997a).

Between 6.8 to 9 million kilograms (15 to 20 million pounds) of methyl bromide are used each year in California, primarily for preplant soil fumigation. Although methyl bromide is important to agriculture, its absence would have a small effect on most of California's agriculture. The United Nations Methyl Bromide Technical Options Committee concluded that alternatives exist or

are at an advanced stage of development for more than 90% of methyl bromide uses (James Liebman, Pesticide Action Network North American Regional Center, San Francisco, CA, unpub. data accessed on May 8, 1997, at URL http://www.cdpr.ca.gov/doc/ dprdocs/methbrom/mb4chg.html).

Researchers at the University of California, Riverside, proposed methyl iodide as a replacement for methyl bromide in soil fumigation (S.R. Yates, U.S. Salinity Laboratories, Riverside, CA, unpub. data accessed May 8, 1997, at URL http://www.ars.usda.gov/is/mba/april96/yatest.html). However, there is little information regarding methyl iodide's behavior in agricultural soils. It is important that any decision to use alternative fumigants should balance environmental consequences and economic implications. Because methyl iodide takes longer to decompose, this may cause delays in planting. If the soil needs venting to reduce photo toxicity, an increase in total emissions into the atmosphere related to methyl bromide may result.

## Outlook

***Petroleum.***—Demand for bromine as a gasoline additive has declined each year since the EPA issued regulations in the 1970's to reduce and eliminate the lead in automotive gasoline. In the United States, bromine, in the form of ethylene dibromide or EDB, is used as a "scavenger" for the lead to keep it from depositing in the engine. In 1979, the amount of bromine sold reached a peak of 225 million kilograms. The rapid decline to 141 million kilograms in 1986 was a direct result of the limits on lead in leaded automotive gasoline. The European Community continued discussions to reduce lead levels in gasoline. Bromine in petroleum additives is expected to continue to decline over the long term. Federal laws enacted to encourage alternative forms of power in automotive engines are likely to have a depressive effect on bromine demand. The Clean Air Act Amendments of 1990 require mobile sources, such as cars and trucks, to use the most effective technology possible to control emission. Electric cars that do not require bromine gasoline additives are already on the market in California. Newer prototypes of the fuel cell that burn gasoline can double the mileage and thereby decrease emissions using unleaded gasoline.

***Sanitary Preparations.***—Bromine has found usage in indoor swimming pools, hot tubs, and whirlpools. The sanitary preparation field is an area where bromine has been found to be safer than its substitutes because bromine has a higher biocidal activity level for the same amount of product. Growth areas are in the pulp and paper industry, in cooling towers, and Government-regulated food-washing applications. The use of bromine will continue to grow in sanitary preparation, closely following the gross national product in real growth.

***Fire Retardants***.—Bromine is a synergist with many other fire-retardant materials, that is, it increases the effectiveness of the fire retardant. Use of bromine in this area is expected to continue to increase as the demand for safer materials grows at 4% per year. According to a report from Frost & Sullivan, the European flame retardant chemicals market is anticipated to grow by 2% between 1997 and 2003, from 291,000 to 335,000 tons per year, because the market is mature with well-established standards and regulations (Industrial Minerals, 1997). Roskill put the world growth rate at about 8% per year through 2000 (Roskill, 1997).

***Other Uses.***—Usage of calcium, sodium, and zinc bromides in well-drilling fluids decreased during the 1980's as the domestic petroleum industry suffered a severe recession, but in 1997, the oil-services sector posted another strong performance with drilling rig counts up 18% over 1996. Oil field chemicals used in drilling, completion and work over, and production operations have remained significantly more profitable internationally than in the United States. Competitive markets includedcorrosion inhibitors, bactericides, viscosities and defoamers, as well as commodities such as calcium chloride and calcium bromide brines used to maintain well productivity. Because of the significant benefits of bromine compounds in the well-drilling fluids area, usage is expected to grow at the rate of 2% per year.

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[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT BROMINE AND BROMINE COMPOUNDS STATISTICS 1/

(Thousand kilograms and thousand dollars)

| | HTSUS 2/ number | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|
| United States: | | | | | | |
| Bromine sold or used: 3/ | | | | | | |
| Quantity | | 177,000 | 195,000 | 218,000 | 227,000 | 247,000 |
| Value | | $123,000 | $155,000 | $186,000 | $150,000 | $198,000 |
| Exports: 4/ 5/ | | | | | | |
| Elemental bromine: | 2801.30.2000 | | | | | |
| Quantity | | 6,010 | 6,470 | 3,220 | 2,920 | 2,330 |
| Value | | $7,440 | $7,270 | $3,790 | $3,970 | $3,590 |
| Bromine compounds: 6/ | (7/) | | | | | |
| Gross weight | | 15,800 | 13,700 | 13,300 | 13,100 | 10,700 |
| Contained bromine | | 13,400 | 11,500 | 11,200 | 11,100 r/ | 9,052 |
| Value | | $21,800 | $21,100 | $19,900 | $22,100 | $21,200 |
| Imports: 4/ 8/ | | | | | | |
| Elemental bromine: | 2801.30.2000 | | | | | |
| Quantity | | 850 | 319 | 2,220 | 415 | 1,650 |
| Value | | $513 | $194 | $1,460 | $305 | $1,200 |
| Bromine compounds: | | | | | | |
| Ammonium bromide: | 2827.59.2500 | | | | | |
| Gross weight | | 1,240 | 1,120 | 288 9/ | 11,700 10/ | 33,000 |
| Contained bromine | | 1,010 | 917 | 235 9/ | 9,370 10/ | 2,690 |
| Value | | $2,020 | $1,850 | $832 e/ 9/ | $9,580 10/ | $22,000 |
| Calcium bromide: | 2827.59.2500 | | | | | |
| Gross weight | | 9,650 | 14,700 | 730 9/ | -- | 803 9/ |
| Contained bromine | | 7,720 | 11,700 | 584 9/ | -- | 642 |
| Value | | $3,740 | $5,380 | $262 e/ 9/ | -- | $289 |
| Potassium bromate: | 2829.90.0500 | | | | | |
| Gross weight | | 280 | 166 | 275 | 301 r/ 9/ | 378 9/ |
| Contained bromine | | 134 | 79 | 132 | 144 r/ 9/ | 181 |
| Value | | $892 | $538 | $933 | $1,140 r/ 9/ | $1,645 |
| Potassium bromide: | 2827.51.0000 11/ | | | | | |
| Gross weight | | 1,180 | 1,280 | 171 9/ | 733 9/ | 705 9/ |
| Contained bromine | | 790 | 858 | 115 9/ | 493 | 474 |
| Value | | $2,170 | $2,270 | $420 e/ 9/ | $1,775 | $1,707 |
| Sodium bromate: | 2829.90.2500 | | | | | |
| Gross weight | | 290 | 276 | 944 | 1,200 | 1,220 |
| Contained bromine | | 153 | 146 | 500 | 634 | 646 |
| Value | | $725 | $714 | $2,360 | $3,030 | $3,170 |
| Sodium bromide: | 2827.51.0000 11/ | | | | | |
| Gross weight | | 1,270 | 1,400 | 1,400 9/ | 1,242 9/ | 2,732 9/ |
| Contained bromine | | 983 | 1,090 | 1,070 9/ | 965 | 2,122 |
| Value | | $1,730 | $1,770 | $2,550 9/ | $1,913 | $4,207 |
| Other compounds: | 2903.30.1550 | | | | | |
| Gross weight | | 12,500 | 14,300 | 5,850 12/ | 6,520 | 8,910 |
| Contained bromine | | 7,600 | 8,680 | 4,880 12/ | 5,090 | 6,900 |
| Value | | $36,500 | $42,600 | NA | $14,900 | $16,700 |
| World: Production: e/ | | 392,000 r/ | 421,000 r/ | 434,000 r/ | 444,000 r/ | 468,000 |

e/ Estimated. r/ Revised. NA Not available.

1/ Data are rounded to three significant digits.

2/ Harmonized Tariff Schedule of the United States.

3/ Elemental bromine sold as such to nonproducers, including exports, or used by primary U.S. producers in preparing bromine compounds.

4/ Bureau of the Census.

5/ Export values are free alongside ship (f.a.s.).

6/ Bureau of the Census. Includes methyl bromine and ethylene dibromide.

7/ Data for these compounds are derived from HTSUS numbers 2903.30.0500 and 2903.30.1500 information.

8/ Import values are cost, insurance, and freight (c.i.f.).

9/ The Journal of Commerce Port Import/Export Reporting Service.

10/ The respective data for "bromides/bromines and oxides" of ammonium, calcium and zinc are combined and reported here; imports for 1996 included 568 thousand kilograms and imports for 1997 included 83 thousand kilograms of zinc bromide.

11/ "Bromides of sodium" or of "potassium" import data are usually reported by a mutual HTSUS number, 2827.51.0000.

12/ Certain compounds reported for 1995 are not included in the total.

TABLE 2
ELEMENTAL BROMINE-PRODUCING PLANTS IN THE UNITED STATES, 1997

| State and company | County | Plant | Production source | Capacity 1/ (million kilograms) |
|---|---|---|---|---|
| Arkansas: | | | | |
| Albemarle Corp. | Columbia | Magnolia (a) | Well brines | |
| Do. | do. | Magnolia (b) | do. | 140 |
| Arkansas Chemicals, Inc. | Union | El Dorado | do. | 25 |
| Great Lakes Chemical Corp. | do. | Catesville | do. | |
| Do. | do. | El Dorado | do. | 93 |
| Do. | do. | Marysville | do. | 59 |
| Michigan: | | | | |
| The Dow Chemical Co. | Mason | Ludington 3/ | do. | 20 |
| Total 4/ | | | | 337 |

1/ Actual production capacity is limited by brine availability.
2/ This represents the cumulative capacity of the two identified plant sites.
3/ Bromine produced at this plant is reprocessed in Arkansas.
4/ Chemical Marketing Reporter, v. 251, no. 13, p. 37.

TABLE 3
YEAREND 1997 PRICES 1/ FOR ELEMENTAL BROMINE AND SELECTED COMPOUNDS

| Product | Value (cents) Per pound | Per kilogram |
|---|---|---|
| Ammonium bromide, National Formulary (N.F.), granular, drums, carlots, truckloads, f.o.b. works | 110-131 | 242-289 |
| Bromine: | | |
| Drums, truckloads, works 2/ | 123 | 271 |
| Bulk, tank cars, works 2/ | 56-68 | 123-150 |
| Bromochloromethane, drums, bulk, f.o.b. Magnolia, AR | 127 | 280 |
| Ethyl bromide, technical, 98%, drums, truckloads | 127 | 280 |
| Ethylene dibromide, drums, carloads | 57 | 126 |
| Hydrobromic acid, 48%, drums, carloads, truckloads, f.o.b. | 42 | 93 |
| Hydrogen bromide, anhydrous, cylinders, 2,500 pounds, truckloads | 475 | 1,047 |
| Methyl bromide, tank cars | 77 | 170 |
| Potassium bromate, granular, powdered, 200-pound drums, carloads, f.o.b. works | 179 | 395 |
| Potassium bromide, N.F., granular, drums, carloads, f.o.b. works | 110-112 | 242-247 |
| Sodium bromide, technical, truckloads | 70 | 154 |

1/ Source: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials, v. 252, no. 26, December 29, 1997, p. 18-25.
2/ Delivered prices for drums and bulk shipped west of the Rocky Mountains, 1 cent per pound higher. Bulk truck prices 1 to 2 cents higher per pound for 30,000-pound minimum.

TABLE 4
U.S. IMPORTS OF OTHER BROMINE COMPOUNDS 1/ 2/

| Compounds | HTSUS 3/ Number | 1996 Gross weight (kilograms) | 1996 Value 4/ (thousands) | 1997 Gross weight (kilograms) | 1997 Value 4/ (thousands) | Principal sources, 1997 |
|---|---|---|---|---|---|---|
| Hydrobromic acid | 2811.19.3000 | 179 | $215 | 188 | $175 | Israel 100% |
| Ethylene dibromide | 2903.30.0500 | 3 | 43 | 2,050 | 1,350 | Israel 51%; United Kingdom 49%. |
| Methyl bromide | 2903.30.1520 | 3,530 | 6,230 | 3,370 | 6,360 | Israel 100%. |
| Dibromoneopentyl glycol | 2905.50.3000 | 1,000 | 3,480 | 1,550 | 4,970 | Do. |
| Tetrabromobisphenol A | 2908.10.2500 | 349 | 699 | 306 | 526 | Do. |
| Decabromodiphenyl oxide and octabromodiphenyl oxide | 2909.30.0700 | 1,460 | 4,190 | 1,450 | 3,310 | Do. |
| Total | | 6,520 | 14,900 | 8,910 | 16,700 | |

1/ These data detail the information included in table 1, imports of "Other bromine compounds."
2/ Data are rounded to three significant digits.
3/ Harmonized Tariff Schedule of the United States.
4/ Declared cost, insurance, and freight valuation (c.i.f.).

Source: Bureau of the Census.

TABLE 5
WORLD BROMINE ANNUAL PLANT CAPACITIES 1/ AND SOURCES, DECEMBER 31, 1997

| Country and company | Location | Capacity (thousand kilograms) | Source |
|---|---|---|---|
| Azerbaijan: | | | |
| Neftechala Bromine Plant | Baku | 5,000 | Underground brines. |
| China: | | | |
| Laizhou Bromine Works | Shandong | 30,000 | Do. |
| France: | | | |
| Atochem | Port-de-Bouc | 13,600 | Seawater. |
| Mines de Potasse d'Alsace S.A. | Mulhouse | 2,300 | Bitterns of mined potash. |
| India: | | | |
| Hindustan Salts Ltd. | Jaipur | | Seawater bitterns from salt |
| Mettur Chemicals | Mettur Dam | 1,500 | production. |
| Tata Chemicals | Mithapur | | |
| Israel: | | | |
| Dead Sea Bromine Co. Ltd. | Sdom | 190,000 | Bitterns of potash production from surface brines. |
| Italy: | | | |
| Societa Azionaria Industrial Bromo Italiana | Margherita di Savoia | 900 | Seawater bitterns from salt production. |
| Japan: | | | |
| Toyo Soda Manufacturing Co. Ltd. | Tokuyama | 20,000 | Seawater. |
| Spain: | | | |
| Derivados del Etilo S.A. | Villaricos | 900 | Do. |
| Turkmenistan | | | |
| Nebitag Iodine Plant | Vyshka | 3,200 | Underground mines. |
| Cheicken Chemical Plant | Balkan | 6,400 | Do. |
| Ukraine | | | |
| Perekopskry Bromine Plant | Krasnoperckopsk | 3,000 | Do. |
| United Kingdom: | | | |
| Associated Octel Co. Ltd. | Amlwch | 30,000 | Seawater. |

1/ Excludes U.S. production capacity. See table 2.

TABLE 6
BROMINE: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY 1/ 2/

(Thousand kilograms)

| Country 3/ | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|
| Azerbaijan | 4,000 | 3,000 | 2,000 | 2,000 | 2,000 |
| China | 24,600 | 31,400 | 30,000 | 30,000 | 31,000 |
| France | 2,290 | 2,190 | 2,260 | 2,024 r/ 4/ | 2,000 |
| India | 1,400 | 1,400 | 1,500 | 1,500 | 1,500 |
| Israel | 135,000 | 135,000 | 135,000 | 135,000 | 135,000 |
| Italy | 300 | 300 | 300 | 300 | 300 |
| Japan | 15,000 | 15,000 | 15,000 | 15,000 | 20,000 |
| Spain | 200 | 200 | 200 | 100 r/ | 100 |
| Turkmenistan | 100 r/ | 100 r/ | 100 r/ | 102 r/ 4/ | 130 4/ |
| Ukraine | 5,000 | 4,000 | 3,500 | 3,000 | 3,000 |
| United Kingdom | 27,423 4/ | 33,800 | 26,200 | 28,000 | 26,000 |
| United States 5/ | 177,000 4/ | 195,000 4/ | 218,000 4/ | 227,000 4/ | 247,000 4/ |
| Total | 392,000 r/ | 421,000 r/ | 434,000 r/ | 444,000 r/ | 468,000 |

r/ Revised.
1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.
2/ Table includes data available through April 17, 1998.
3/ In addition to the countries listed, several other nations produce bromine, but output data are not reported; available general information is inadequate to formulate reliable estimates of output levels.
4/ Reported figure.
5/ Sold or used by producers.