SALT

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Salt, also known as sodium chloride, is composed of the elements sodium and chlorine. Sodium is a silver-colored metal, which is so unstable that it reacts violently in the presence of water, and chlorine is a greenish-colored gas that is dangerous and lethal. Yet the combination of these two elements forms sodium chloride, which is a white-colored compound essential to life itself. Virtually every person in the world has some direct or indirect contact with salt daily. People routinely add salt to their food as a flavor enhancer or apply rock salt to walkways to remove ice in the winter. Salt is used as feedstock for chlorine and caustic soda manufacture; these two inorganic chemicals are used to make many consumer-related end-use products, such as polyvinyl chloride (PVC), a plastic made from chlorine and paper-pulping chemicals manufactured from sodium hydroxide (caustic soda).

Production

U.S. production data for salt are developed by the U.S. Geological Survey (USGS) from an annual voluntary survey of U.S. salt-producing sites and company operations. The four types of salt that are surveyed are classified according to the method of recovery: rock salt, from the surface or underground mining of halite deposits; solar salt, from the solar evaporation of seawater, landlocked bodies of saline water, or primary or byproduct brines; vacuum pan salt, from the mechanical evaporation of a purified brine feedstock; and brine, from the solution mining of underground halite deposits. Data for brine production and consumption represent the anhydrous salt content only and not the weight of the water.

The structure of the U.S. salt industry has changed throughout the years. In 1970, 50 companies operated 95 salt-producing plants in the United States. Market competition, energy and labor costs, less expensive imports, currency exchange rates, and an excess of production capacity (resulting in the downsizing of the industry through mergers and acquisitions) reduced the size of the industry to 32 companies and 69 plants by 2000. The information and data are fundamental resources for analysis both within and outside the Government. The salt data and information are needed by the public and private sectors to better understand minerals and materials use and the ultimate disposition of materials in the economy and in the environment and to develop public and private sector policies and practices that better utilize our mineral and material resources. Some of the clients that use the salt data and information are financial institutions, State and Federal agencies, salt-consuming industries (e.g., agricultural, chemical, and food processing), educational institutions, and the general public.

Of the 32 companies to which a survey request was sent, all but 3 responded, representing 95% of the total production shown in this report. Data for nonrespondents were estimated based on their prior responses to previous annual surveys, the 2000 production estimate survey, or brine production capabilities for chloralkali manufacture based upon published chlorine production capacities [1.75 metric tons (t) of salt required per ton of chlorine capacity].

Total U.S. salt production increased by 2% in 2000 to 45.6 million metric tons (Mt) compared with that of 1999. According to the USGS canvass for 2000, 32 companies operated 69 salt-producing plants in 15 States. Of these, 9 companies and 17 plants produced more than 1 Mt each and accounted for 90% and 69%, respectively, of total U.S. production and 90% and 33%, respectively, of total value. Several companies and plants produced more than one type of salt. In 2000, 11 companies (14 operations) produced solar-evaporated salt; 6 companies (18 operations), vacuum pan salt; 11 companies (16 operations), rock salt; and 13 companies (32 operations), salt brine (tables 1-3).

Salt in the 20th Century

In 1900, the United States led the world as the largest salt-producing country, representing about 23% of total world output, followed by the United Kingdom, France, the German Empire, and Italy. Imports of fine salt decreased to 6% of domestic consumption in 1900 from 37% in 1880, because U.S. salt manufacturers steadily increased their production of table, dairy, and other special grades of salt. The major uses of salt at that time were food applications for humans and animals, leather tanning, and fish and meat preservation; however, use of salt as a chemical feedstock was beginning to increase with the development of the first soda ash plant in Syracuse, NY, in 1884 and the first electrolytic chlorine facility in Rumford, ME, in 1892. Although the first domestic automobile was not invented until 1896, the use of salt for road deicing would not begin until the 1930s.

In 2000, the top five salt-producing nations that collectively accounted for 55% of total world output, in descending order of quantity produced, were the United States, China, Germany, India, and Australia. The United States was the largest salt-producing nation, representing about 22% of total world output. The five leading States, in terms of total salt sold or used, were Louisiana, Texas, New York, Kansas, and Utah. The chemical industry, primarily the chlorine and caustic soda sectors, was the largest consumer of salt. Salt for domestic synthetic soda ash manufacture declined and eventually ceased in the last quarter of the 20th century because of environmental and energy issues and competition from natural soda ash. Salt for human consumption, which had been a major end use in the past century, declined to about 3% of total domestic consumption.

The five leading States in terms of total salt sold or used were Louisiana with 31%; Texas, 25%; New York, 13%; Kansas, 6%; and Utah, 5% (table 4). Other Eastern States (Alabama, Michigan, Ohio, Tennessee, and West Virginia) accounted for 17% of the domestic total salt sold or used. Other Western States (Arizona, California, Nevada, New Mexico, and Oklahoma) represented 3%.

Since the loss of the Retsof Mine in New York in 1995, progress continued on developing a new mine at Hampton Corners, NY. A group of investors formed American Rock Salt Co. LLC in 1997 and acquired the assets of the Retsof Mine, including a large salt stockpile, and mineral rights at Hampton Corners. On October 2, 1997, American Rock Salt shipped its first truckload of salt from the stockpile, while the company went forward with plans to sink a mineshaft to the underground salt formation. In late 1998, construction began on the mineshaft, and on November 18, 1999, salt was reached in the service shaft. On January 26, 2000, the first truckload of salt was delivered from the new mine. The mine was expected to reach its full capacity of 2.3 Mt by mid-2001 (American Rock Salt Co. LLC, 2001, Company biography and history, accessed May 22, 2001, via URL http://americanrocksalt.com).

In February, IMC Global Inc. announced it was interested in divesting its salt company IMC Salt Co. to refocus on its core crop-nutrient businesses. This divestment would include the rock salt operations in Louisiana and Canada, the vacuum pan salt plants in Kansas, and the solar salt facility in Utah (Chemical Market Reporter, 2000). In a cost-reduction effort, IMC closed its Hutchinson, KS, vacuum pan salt facility and increased vacuum pan salt production at its Lyons, KS, and Hersey, MI, plants (Bertram, 2000). Further capacity reductions in the domestic salt industry also occurred in late 1999 and into 2000, when Cargill Inc. closed its Redwood City, CA, solar salt plant, which had capacity of about 315,000 metric tons per year (t/yr).

Consumption

In 2000, apparent consumption (salt sold or used, plus imports, minus exports) was 51.6 Mt, whereas reported consumption (sales or use as reported by the salt companies including their imports and exports) was 54 Mt, which was an increase of 8% compared with that of 1999. Although these two measures of consumption are not necessarily supposed to be identical, they normally are similar. The 2.4-Mt difference between the two types of consumption for 2000 and 1999, however, can only be explained by stockpiling of imported salt by producers, distributors, and consumers during the year.

The direct and indirect uses of salt number about 14,000, according to industry sources. The USGS annually surveys 8 major categories comprising 29 end uses. The 2000 reported percentage distribution of salt by major end use was chemicals, 42%; ice control, 36%; distributors (grocery and other wholesalers and retailers, etc.), 7%; general industrial, 6%; agricultural, 4%; food processing, 3%; primary water treatment, 1%; and other uses combined with exports, 1%. Distributors represented a substantial share of salt sales by the salt industry; all of this salt is ultimately resold to many different end-users. For a more complete analysis of end-use markets, specific sectors of distribution in table 5 can be combined, such as agricultural and water treatment with agricultural and water conditioning distribution, respectively.

Aside from the different types of salt, there are various distinctions in the packaging and applications of salt. Salt for human consumption is packaged in different sized containers for several specialized purposes. Table salt may contain 0.01% potassium iodide as an additive, which provides a source of iodine that is essential to the oxidation processes in the body. Kosher salt, sea salt, condiment salt, and salt tablets are special varieties of salt.

Water conditioning and animal feed salt are made into 22.7-kilogram (50-pound) pressed blocks. Sulfur, iodine, trace elements, and vitamins are occasionally added to salt blocks to provide missing nutrients not found naturally in the diet of certain livestock. Salt is also compressed into pellets and used for water conditioning.

Chemical.—The largest consumer of salt, primarily salt brine, is the chemical industry. Within this industry, the chloralkali sector remains the major consumer of salt for manufacturing chlorine, coproduct sodium hydroxide, and synthetic soda ash. Since 1986, when the last synthetic soda ash plant closed because of high production costs and competition with less expensive natural soda ash, no synthetic soda ash has been manufactured in the United States; many countries, however, still produce synthetic soda ash and use vast quantities of salt brine as feedstock.

Salt is used as the primary raw material in chlorine manufacture because it is an inexpensive and widely available source of chlorine ions. For sodium hydroxide production, salt is the main source of the sodium ions. About 98% of the domestic chlorine and sodium hydroxide produced is obtained from the electrolysis of salt brine feedstock by using three-cell technologies. The types of cells and the percentages of chlorine manufactured by them are diaphragm, 78%; mercury, 14%; and membrane, 6%. The remaining 2% of chlorine and caustic soda production is recovered as a byproduct from magnesium and sodium metal manufacture.

It takes about 1.75 t of salt to make 1.0 t of chlorine and 1.1 t of coproduct caustic soda. The electrolytic process ionizes the sodium chloride compound and selectively allows the ions to migrate through special membranes. Chlorine gas forms at the anode, while sodium ions bond with water molecules at the cathode to form sodium hydroxide with hydrogen gas evolving.

Chlorine and caustic soda are considered to be the first generation of products made from salt. These two chemicals are further used to manufacture other materials, which are considered to be the second generation of products from salt. Although most salt brine is produced by the same companies that use it, many chloralkali manufacturers now purchase brine from independent brine supply companies. In certain cases, brine is produced by a chemical company that uses some of it and sells the excess to neighboring competitors. According to a survey of domestic salt-based chlorine facilities, about 48% of the salt used to manufacture chlorine was produced by manufacturing companies, and 31% was purchased brine. Solar salt, rock salt, and vacuum pan salt are also used to manufacture many chemicals (tables 5, 6).

In 2000, according to U.S. Census Bureau data, 12 Mt of chlorine and 11 Mt of sodium hydroxide (caustic soda or lye) were produced. Based on the industry average ratio of 1.75 t of salt required to produce 1.0 t of chlorine and 1.1 t of coproduct sodium hydroxide, the chlorine and caustic soda industry consumed about 21 Mt of salt for feedstock. Reported consumption of total domestic and imported salt for chlorine manufacture was 21.3 Mt (table 5). The difference between the calculated and reported quantities was the amount of salt not

reported to the USGS from imports or captive brine production of chloralkali producers.

Salt also is used as a feedstock in chemical establishments that make sodium chlorate (by the electrolysis of an acidified salt brine using hydrochloric acid adjusted to a pH of 6.5), metallic sodium (by the electrolysis of a molten salt mixture containing 33.2% sodium chloride and 66.8% calcium chloride, which is added to reduce the melting temperature of salt), and other downstream chemical operations. In powdered soaps and detergents, salt is used as a bulking agent and a coagulant for colloidal dispersion after saponification. In pharmaceuticals, salt is a chemical reagent and is used as the electrolyte in saline solutions. It also is used with sulfuric acid to produce sodium sulfate and hydrochloric acid. This subsector is relatively small, representing only 5% of domestic salt sales for the entire chemical sector and only 2% of total domestic salt consumption.

The consumption of salt for metallic sodium has declined during the past several years. Since the 1970s, the number of producers has decreased from three to one; Ethyl Corp. and RMI Titanium Corp. exited the market in 1985 and 1992, respectively, leaving E. I. du Pont de Nemours & Co., Inc., as the sole manufacturer of metallic sodium in the United States. In 1998, the domestic market was less than 30,000 t having decreased from about 126,000 t in 1978. The phasing out of tetraethyl lead and tetramethyl lead gasoline additives were the main reasons for the decline in consumption. In 1978, sodium usage in gasoline represented about 80% of the domestic market. Although there is no information about sodium consumption in 2000, the largest use of sodium in 1998 was for sodium borohydride production, which is the feedstock for sodium dithionite that is used as a reductive bleaching agent by the pulp and paper industry and accounted for about 38% of metallic sodium consumption. Sodium metal also is used to manufacture sodium azide, which is used in automotive airbags. Other promising uses of sodium metal are in the remediation of chemical weapons, pesticides, polychlorinated biphenyls, and chlorofluorocarbons.

Ice Control and Road Stabilization.—The second largest end use of salt is for highway deicing. The developer of the Fahrenheit temperature scale discovered that salt mixed with ice at a temperature below the freezing point of water creates a solution (brine) with a lower freezing point than water by itself. The brine forms below the surface of the ice and snow and prevents the water from freezing into ice and bonding with the road surface, thus causing the snow and ice to melt. Salt is an inexpensive, widely available, and effective ice control agent. It does, however, become less effective as the temperature decreases below about -9.5° C to -6.5° C (15° F to 20° F). At lower temperatures, more salt would have to be applied to maintain higher brine concentrations to provide the same degree of melting. Most winter snowstorms and ice storms occur when temperatures are between -4° C and 0° C (25° F and 32° F), the range in which salt is most effective. An anticaking agent, such as ferric ferrocyanide (Prussian Blue) or sodium ferrocyanide (Yellow Prussiate of Soda), is used to prevent the salt from agglomerating. Both additives are nontoxic and harmless to humans. In fact, sodium ferrocyanide is approved for use in food-grade salt by the U.S. Food and Drug Administration (Food and Nutrition Board, 1966).

In highway deicing, salt has been associated with corrosion of motor vehicles, bridge decks, unprotected steel structures, and reinforcement bar and wire used in road construction. Surface runoff, vehicle spraying, and windblown actions also affect roadside vegetation, soil, and local surface- and ground-water supplies. Although evidence of environmental loading of salt has been found during peak usage, the spring rains and thaws usually dilute the concentrations of sodium in the area where salt was applied.

Salt is also added to stabilize the soil and to provide firmness to the foundation on which highways are built. The salt acts to minimize the effects of shifting caused in the subsurface by changes in humidity and traffic load.

The quantity of salt consumed for road deicing each year is directly related to the severity or mildness of the winter weather conditions. Long-range forecasting of salt consumption in this application is extremely difficult because of the complexities in long-range forecasting of the weather. Meteorologists, however, are becoming more aware of the dynamics of certain weather phenomena that influence the climate in various parts of the world. One of these phenomena is El Niño, which is now believed to be the largest single weather influence on Earth. The mild winters of 1997 and 1998 were attributed to El Niño effects. In 1998, highway deicing salt sales were the lowest since about 1992, which also was an El Niño year (National Broadcast Co., 1998, El Niño facts, accessed July 15, 1998, at URL http://wxnet4.nbcr.com/elnino.html). The winters of 1999 and 2000 were colder and produced more precipitation that required more salt for road deicing as shown in the rock salt production statistics in tables 1 and 2 and the rock salt consumption data in tables 5 and 6.

Distributors.—A tremendous amount of salt is marketed through various distributors, some of which specialize in markets such as agricultural and water treatment services, two sectors where the salt companies sell directly as well (table 5). Distributor sales also include grocery wholesalers and/or retailers, institutional wholesalers, U.S. Government resale, and other wholesalers and retailers.

General Industrial.—The industrial uses of salt are diverse. They include, in descending order, oil and gas exploration, textiles and dyeing, other industrial applications, metal processing, pulp and paper, tanning and leather treatment, and rubber manufacture.

In oil and gas exploration, salt is an important component of drilling fluids in well drilling. It is used to flocculate and increase the density of the drilling fluid to overcome high down-well gas pressures. Whenever a drill hits a salt formation, salt is added to the drilling fluid to saturate the solution and to minimize the dissolution within the salt strata. Salt is also used to increase the set rate of concrete in cemented casings.

In textiles and dyeing, salt is used as a brine rinse to separate organic contaminants, to promote “salting out” of dyestuff precipitates, and to blend with concentrated dyes to standardize them. One of its main roles is to provide the positive ion charge to promote the absorption of negatively charged ions of dyes.

In metal processing, salt is used in concentrating uranium ore into uranium oxide (yellow cake). It is also used in processing aluminum, beryllium, copper, steel, and vanadium.

In the pulp and paper industry, salt is used to bleach wood pulp. It also is used to make sodium chlorate, which is added along with sulfuric acid and water to manufacture chlorine dioxide, an excellent oxygen-based bleaching chemical. The chlorine dioxide process, which originated in Germany after World War I, is becoming more popular because of environmental pressures to reduce or eliminate chlorinated

bleaching compounds.

In tanning and leather treatment, salt is added to animal hides to inhibit microbial activity on the underside of the hides and to replace some of the moisture in the hides. In rubber manufacture, salt is used to make buna, neoprene, and white types. Salt brine and sulfuric acid are used to coagulate an emulsified latex made from chlorinated butadiene.

Agricultural Industry.—Since prehistoric times, humankind has noticed that animals satisfied their salt hunger by locating salt springs, salt licks, or playa lake salt crusts. Barnyard and grazing livestock need supplementary salt rations to maintain proper nutrition. Veterinarians advocate adding loose salt in commercially mixed feeds or in block forms sold to farmers and ranchers because salt acts as an excellent carrier for trace elements not found in the vegetation consumed by grazing livestock; selenium, sulfur, and other essential elements are commonly added to salt licks, or salt blocks, for free-choice feeding.

Food Processing.—Every person uses some quantity of salt in their food. The salt is added to the food by the food processor or by the consumer through free choice, as a flavor enhancer, preservative, binder, fermentation-control additive, texture-control agent, and color developer. This major category is subdivided, in descending order of salt consumption, into meat packers, canning, other food processing, grain mill products, baking, and dairy.

In meat packing, salt is added to processed meats to promote color development in bacon, ham, and other processed meat products. As a preservative, salt inhibits the growth of bacteria, which would lead to spoilage of the product. Early pioneers stored their perishable food in salt barrels for protection and preservation. Salt acts as a binder in sausages to form a binding gel composed of meat, fat, and moisture. Salt also acts as a flavor enhancer and a tenderizer.

In the dairy industry, salt is added to cheese as a fermentation-control agent and as a color- and texture-control agent. The dairy subsector includes companies that manufacture creamery butter, natural and processed cheese, condensed and evaporated milk, ice cream, frozen desserts, and specialty dairy products.

In canning, salt is primarily added as a flavor enhancer and preservative. It also is used as a dehydrating agent, tenderizer, enzyme inhibitor, and carrier for other ingredients.

In baking, salt is added to control the rate of fermentation in bread dough. It also is used to strengthen the gluten (the elastic protein-water complex in certain doughs) and as a flavor enhancer, such as a topping on baked goods.

The food-processing category also contains grain mill products, which consist of milling flour and rice and manufacturing cereal breakfast food and blended or prepared flour.

In the "other food processing" category, salt is used mainly as a seasoning agent. Other food processing includes miscellaneous establishments that make food for human consumption (e.g., potato chips, pretzels) and for domestic pet consumption (e.g., cat and dog food).

Water Treatment.—Many areas of the United States have hard water, which contains excessive calcium and magnesium ions that contribute to the buildup of a scale or film of alkaline mineral deposits in household and industrial equipment. Commercial and residential water-softening units use salt to remove the ions causing the hardness. The sodium ions captured on a resin bed are exchanged for the calcium and magnesium ions. Periodically, the water-softening units must be recharged because the sodium ions become depleted. Salt is added and dissolved, and the brine replenishes the lost sodium ions.

Stocks

Because bulk salt is stored at many different locations, such as at the plants, warehouses, ports, and terminals, data on the quantity of salt stockpiled by the salt industry is not reliable enough to formulate accurate inventory totals; however, yearend stocks of producers were estimated to be 2 Mt, and consumer inventories also were estimated to be high. Most of these inventories were imported rock salt and solar salt. Many salt producers, States, municipalities, distributors, and road deicing contractors stockpiled additional quantities of salt in anticipation of adverse weather conditions. Deicing salt inventories were extremely large by yearend because the mild winter in the domestic snow belt did not require as much salt as had been stockpiled. For the reasons discussed above, salt stocks are assumed to be the difference between salt production and salt sold or used in calculating apparent consumption.

Transportation

Because the locations of the salt supplies are not often near consumers, transportation can become an important cost. Pumping salt brine through pipelines is an economic means of transportation but cannot be used for dry salt. Large bulk shipments of dry salt in ocean freighters or river barges are low in cost but are restricted in points of origin and consumption. River and lake movement of salt in winter is often severely curtailed because of frozen waterways. As salt is packaged, handled, and shipped in smaller units, the costs increase and are reflected in higher selling prices.

Transoceanic imports of salt have been increasing in some areas of the United States because they are less expensive with respect to transportation costs than that which could be purchased from domestic suppliers using rail transportation. Although shipping in larger vessels reduces shipping costs, transportation costs significantly add to the price of salt. In some cases, shipping costs are higher than the actual price of the salt. Another problem is that many ports are not deep enough to accommodate the larger ships.

Prices

The four types of salt that are produced have unique production, processing, and packaging factors that determine the selling prices. Generally, salt sold in bulk is less expensive than salt that has been packaged, pelletized, or pressed into blocks. Salt in brine is the least expensive salt sold because mining and processing costs are less. Vacuum pan salt is the most expensive because of the higher energy costs involved in processing and the purity of the product.

Price quotations are not synonymous with average values reported to the USGS. The quotations do not necessarily represent prices at which transactions actually took place or bid and asked prices. Yearend prices for salt are no longer quoted in Chemical Market Reporter; this information was last available for 1997. The average annual values, as collected by the USGS and listed in table 7, represent a national average value for each of the types of salt and the various product forms.

Foreign Trade

Under Harmonized Tariff Schedule of the United States (HTS) nomenclature, imports are aggregated under one category named "Salt (including table and denatured salt) and pure sodium chloride, whether or not in aqueous solution, seawater." The same classification also applies to exports. The HTS code for salt is 2501.00.0000. The trade tables in this report list the previous and current identification codes for salt. Although several other HTS codes pertain to various salt classifications, the United States aggregates shipments under one code because the sums of individual subclassifications fail to meet the minimum dollar requirements necessary for individual listings.

Using The Journal of Commerce's Port Import Export Reporting Service (PIERS), which provides additional information on trade data on ocean commerce (no rail or truck traffic between the United States and Canada and Mexico is included) not available from other sources, the U.S. salt industry accounted for 38% of all U.S. salt imports in 2000. The three companies that imported salt were Cargill, IMC Salt, and Morton Salt Co.. Six salt distributors represented 41% of total imports, and the domestic chloralkali industry imported 9% of total salt. Therefore, the salt industry, salt distributors, and the chloralkali industry accounted for 88% of all salt imported in 2000. The majority of U.S. salt exports in 2000 was by five domestic salt producers: Cargill, Morton Salt, U.S. Salt, United Salt, and Western Salt, Inc. According to PIERS data, these five companies exported 84% of the total.

Based on U.S. Census Bureau data, in 2000, the United States exported 642,000 t; this was a 28% decrease compared with that of 1999 (table 8). Salt was shipped to 62 countries through 32 U.S. Customs districts; the Detroit, MI, district exported the most and represented 35% of the U.S. total (table 9). In 2000, the majority of exports, or 77% of the total, was to Canada.

Based on U.S. Census Bureau statistics, the United States imported 8.96 Mt of salt from 37 countries in 2000, which was slightly more than was imported during 1999 (table 10). Table 11 lists the imports of salt by Customs districts. The quantity of imported salt was about 14 times more than that of exports. This indicates the magnitude of the United States' reliance on salt imports. The majority of imported salt was brought into the country by foreign subsidiaries of major U.S. salt producers. Generally, imported salt can be purchased and delivered to many customers at a cost lower than the comparable domestic product because production costs are lower abroad, currency exchange rates are more favorable, and ocean freight rates are less expensive than overland rail or truck rates.

World Review

Table 12 lists world salt production statistics for 111 nations based on reported and estimated information. In 2000, total world production increased slightly compared with that of 1999. The United States remained the world's leading salt-producing country, representing 21% of total world output.

Most countries possess some form of salt production capability with production levels set to meet their own domestic demand requirements and with additional quantities available for export. Many developing nations tend to develop their agricultural resources to feed their population first. Development of easily extractable mineral resources follows, and salt is one of the first commodities to be mined. Some countries, such as the United States, import a substantial amount of salt to meet total demand requirements because of economic factors.

Australia.—Intense rain and floods from Cyclone Steve in March severely affected Dampier Salt Ltd.'s solar salt production ponds at Dampier and Lake MacLeod in the northwestern part of the country. Although the storm caused production to decline by about 15%, operations were back into full production later in the year (Industrial Minerals, 2000a)

Portugal.—VA Tech Ltd. of Switzerland and Uniteca S.A., a chloralkali producer in Portugal, formed a joint venture to construct a salt plant at Carrico. The plant, with production capacity of 170,000 t/yr, was scheduled to start up in late 2001. The majority of the salt will be used as feedstock for the chlorine facility, with the remainder sold to local markets. The salt will be solution-mined from an underground deposit and crystalized in surface evaporation ponds that will be heated by a natural gas-fired cogeneration plant (Industrial Minerals, 2000e).

Russia.—A solution mining project was scheduled to begin at Koverninsky District, Nizhegorodsky Oblast, where the Belbazh salt deposit with reserves of 711 Mt was discovered in 1973. The salt brine would provide feedstock to the local chloralkali facility. Although the plan was to mine about 1 million tons per year (Mt/yr), the initial output was scheduled to be between 80,000 t/yr to 100,000 t/yr (Industrial Minerals, 2000b). In addition, a new salt facility was commissioned by the joint stock company Silvinit at Solikamsk, Perm Oblast. The plant will produce 500,000 t/yr of technical-grade salt (Industrial Minerals, 2000c).

United Kingdom.—U.S. Salt Holdings L.L.C. of the United States acquired from Stavely Industries, plc, the vacuum pan salt operation operated by British Salt Ltd. The plant at Middlewich, Cheshire, had a capacity of 825,000 t/yr. The majority of salt sales were to the chemical, food processing, and water treatment industries. The only other vacuum pan operation in England was owned by Salt Union Inc., which was purchased by IMC Global, another U.S.-owned salt company, in 1999. IMC was the world's third largest salt producer with more than 15 Mt/yr of world salt capacity (Industrial Minerals, 2000d).

Vietnam.—Two new solar salt projects were announced at Quan The and Ninh Thuan. The domestic chemical industry anticipated that its demand for salt would increase to 1 Mt/yr by 2010 from its current level of 300,000 t/yr (Bertram, 2000).

Outlook

Supplies of salt are more than adequate to meet any surge in demand for the foreseeable future. The new rock salt mines in Michigan and New York that opened recently should increase domestic rock salt production and cause rock salt imports to decline. After a couple of mild winter seasons that reduced the demand for deicing salt, it is estimated that winter weather conditions will return to traditional precipitation patterns that will require greater quantities of rock salt. U.S. production of total salt for 2001 is estimated to be 47 Mt.

References Cited

Bertram, B.M., 2000, Salt: Mining Engineering, v. 52, no. 6, June, p. 57-60.
Chemical Market Reporter, 2000, IMC Global reports weak 2Q results; prospects dim for sale of salt biz: Chemical Market Reporter, v. 258, no. 7, August 14, p. 6.
Food and Nutrition Board, 1966, Sodium chloride, *in* Food chemicals codex

(1st ed): Washington, DC, National Academy Press, p. 613-614.
Industrial Minerals, 2000a, Cyclone Steve disrupts Dampier salt: Industrial Minerals, no. 393, June, p. 9.
———2000b, Exploitation of Belbazh salt deposit to start: Industrial Minerals, no. 396, September, p. 28.
———2000c, Jt.St.Co. Silvinit commissions 0.5m tpa salt complex: Industrial Minerals, no. 393, June, p. 25.
———2000d, Stavely sells British Salt: Industrial Minerals, no. 394, July, p. 93.
———2000e, Wabag and Uniteca join forces in salt: Industrial Minerals, no. 396, September, p. 17.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Evaporites and Brines. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Salt. Ch. in Mineral Commodity Summaries, annual.
Salt. Ch. in Minerals Yearbook, annual.

Other

The Chlorine Institute.
Handbook of World Salt Resources. S.J. Lefond, Plenum Press, 1969.
The Material Flow of Salt. U.S. Bureau of Mines Information Circular 9343, 1993.
Salt. Ch. in Canadian Minerals Yearbook, annual.
Salt. Ch. in Industrial Minerals and Rocks, Society of Mining, Metallurgy, and Exploration, Inc., 6th ed., Carr, D.D., ed., 1994.
Salt. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
Salt Institute.
Salt. Mining Engineering, annual review of industrial minerals.
Sodium Chloride. American Chemical Society Monograph No. 145, Kaufmann, D.W., ed., Reinhold Publishing Corp., 1960.
Solution Mining Research Institute.