SILICON

By Lisa A. Corathers

Domestic survey data and tables were prepared by Lisa D. Miller, statistical assistant.

Silicon (Si) is a light chemical element with metallic and nonmetallic characteristics. In nature, silicon combines with oxygen and other elements to form silicates. Silicon in the form of silicates constitutes more than 25% of the Earth's crust. Silica is a silicate consisting entirely of silicon and oxygen. Silica (SiO_2) as quartz or quartzite is used to produce silicon ferroalloys for the iron and steel industries, and silicon metal for the aluminum and chemical industries. Ferrosilicon and silicon metal are referred to by the approximate percentage of silicon contained in the material and the maximum amount of trace impurities present.

Almost all ferrosilicon products are consumed by the iron and steel industries. In terms of their nominal silicon contents, the two standard grades of ferrosilicon are 50% ferrosilicon and 75% ferrosilicon.

Silicon metal is used by the primary and secondary aluminum industries and the chemical industry, which uses it principally for silicones. Specifications for silicon metal used by the primary aluminum and chemical industries generally are more stringent than those for metal used by the secondary aluminum industry. In addition, the chemical industry requires that the metal be ground into a fine powder rather than the lump form used by the aluminum industry. Silicon metal that is refined into semiconductor-grade metal for use in making computer chips is crucial to modern technology, but the quantity is less than 5% of total silicon metal demand (Roskill's Letter from Japan, 2000). This report contains no information about this highest purity silicon except as it appears in the foreign trade statistics.

For 2001, an overall domestic silicon production of 282,000 metric tons (t) of contained silicon was the least since 1991. Decreases in production were the most notable in the ferrosilicon category of 25% to 65% silicon content (nominal 50% ferrosilicon) and silicon metal, for which the declines were about 27% and 26%, respectively, compared with that of 2000. Silicon metal and 50% ferrosilicon shipments decreased by 22% and 17%, respectively. On the basis of contained silicon, overall U.S. trade volumes decreased by about 36% for imports and 46% for exports. While silicon in the trade category corresponding to nominal 75% ferrosilicon decreased by over one-half that imported in 2000, it accounted for 44% of silicon imports in 2001. The export decline was associated mostly with 75% ferrosilicon and "other ferrosilicon." The combination of decreased domestic production with decreased net imports resulted in a decrease in apparent consumption levels for ferrosilicon, silicon metal, and silicon materials; for silicon overall the decrease was 27% to 502,000 t compared with 2000 levels. U.S. net import reliance for silicon materials decreased 6% compared with 2000 levels, declining overall from 47% to 44%. Year-average dealer import prices for standard grades of ferrosilicon and silicon metal decreased for the fifth successive year, by a range of 5% to 10% for ferrosilicon and 8% for metal.

Production

In terms of gross weight and in comparison with those of 2000, overall domestic gross production, net shipments, and stocks of silicon products decreased by about 23%, 21%, and 23%, respectively. Silicon metal had the most pronounced year-to-year percentage declines, for which production and shipments fell by 26% and 24%, respectively. For the ferrosilicon category of 25% to 65% (nominal 50% ferrosilicon), production and shipments decreased by about 27% and 17%, respectively. These comparisons are exclusive of silvery pig iron, statistics for which were not published to avoid disclosing proprietary data. In terms of silicon content, excluding silvery pig iron, overall production of silicon materials was the least since 1991.

Domestic production data for silicon are derived from monthly and annual voluntary surveys and estimates for nonrespondents by the U.S. Geological Survey (USGS). The figures in table 2 represent 100% of the production and shipments from the operations listed in table 3 that are canvassed by means of the Silicon Alloys survey.

Globe Metallurgical, Inc., shut its two-furnace silicon smelter at Niagara Falls, NY, indefinitely on December 29 due to poor market conditions and imports of Chinese and Russian silicon material (Mas, 2002). The company said the length of the shutdown would be determined by market conditions. At the beginning of 2001, Globe was operating five silicon metal furnaces, but by yearend had only two furnaces at its Selma, AL, smelter running. In the past 2 years, Globe converted furnaces at its Beverley, OH, plant from silicon to ferrosilicon/inoculents production, closed its one-furnace silicon metal smelter at Springfield, OR, and idled its Hafslund, Norway, ferrosilicon smelter (Ryan's Notes, 2001e). Globe's closure of its Springfield, OR, smelter may extend through 2003 due to regional power shortages in the Pacific Northwest (Conway, 2001b; Ryan's Notes, 2001g).

Other domestic producers curtailed production in 2001. In June, Simcala Inc. temporarily closed one of the three furnaces at its Mount Meigs plant (Ryan's Notes, 2001b). At Keokuk, IA, Keokuk Ferro-Sil Inc. stopped both furnaces with a total production capacity of 50,000 metric tons per year (t/yr) for 50% ferrosilicon and foundry alloys in August. The company said it would fulfill existing contract obligations during the production stoppage (Ryan's Notes, 2001d). Also in August, Elkem Metals Co. shut down one of its five silicon metal furnaces at Alloy, WV. Capacity of the closed furnace was 15,000 t/yr (Conway, 2001a).

Around the first of December, Israel's Ubex Group purchased the closed ferrosilicon plant of American Alloys through an affiliate, Highlanders Alloys LLC. The sale to Highlanders stipulated conversion of the plant to manganese ferroalloys production by mid-2002 (Ryan's Notes, 2001a, m).

Located at New Haven, WV, the former American Alloys plant ceased production in late January 2000.

Principal elements in the cost of silicon and ferrosilicon production are the delivered costs of the ore (quartz or quartzite) and costs of energy, reductant coke or low ash coal, iron in the form of steel scrap (if required), and labor. Production of silicon metal and silicon-containing alloys is extremely power intensive and can require up to 14,000 kilowatt hours of electric energy per metric ton of silicon contained in the final product (Dosaj, 1997, p. 1105). This high-energy demand can be offset somewhat by recovering heat energy from furnace offgases. Locations of ferrosilicon and silicon metal smelters are usually determined by balancing marketing costs against processing costs.

Silicon is not generally recovered from secondary sources. The only secondary possibility is recovery from metallic scrap, such as aluminum alloys, cast iron, and steel, from which recovery of contained silicon is incidental to that of the primary metal. Some silicon is recycled internally in smelters when fines or offgrade material are remelted.

Consumption

Ferrosilicon was used primarily as a deoxidizing and alloying agent in the production of iron and steel products. Silicon metal, which can be classified into metallurgical and chemical grades, was used by the aluminum industry in the production of cast and wrought products. It also served as the basic raw material in the manufacture of many chemical products and intermediates, such as silicones and silanes. Small quantities of silicon were processed into high-purity silicon for use in the semiconductor industry.

For 2001, total U.S. apparent consumption of silicon-containing ferroalloys and silicon metal was estimated to have decreased by about 27% to 502,000 t of contained silicon compared with that of 2000. Also in terms of contained silicon, apparent consumption decreased by about 35% to 258,000 t for ferrosilicon and miscellaneous silicon alloys and by 16% to 244,000 t for silicon metal. Declines in net imports, production, and stocks contributed to the decreases in apparent consumption. On the basis of silicon content, the share of total demand accounted for by ferrosilicon and miscellaneous silicon alloys dropped to 51%. Table 4 presents data on U.S. reported consumption and stocks of silicon materials in 2001.

Particularly in iron foundries, metallurgical-grade silicon carbide can substitute for ferrosilicon. Data on North American production and U.S. imports of silicon carbide are reported in the Manufactured Abrasives chapter of the 2001 USGS Minerals Yearbook.

Consumption of ferrosilicon and silicon metal was estimated by CRU International Ltd. to have decreased in 2001 throughout the Western World. In terms of contained silicon, ferrosilicon consumption decreased from 1.83 million metric tons (Mt) in 2000 to 1.70 Mt in 2001, and silicon metal consumption decreased from 1.03 Mt to 985,000 t. Domestic ferrosilicon consumption was at the lowest level since 1995, while silicon metal consumption was the lowest since 1999. The United States had the largest year-to-year decreases in ferrosilicon and silicon metal consumption in the Western World. Ferrosilicon consumption dropped 35% from 354,000 t in 2000 to 229,000 t in 2001 owing to the continued slump in steel production and increased destocking by domestic ferrosilicon producers. Silicon metal demand decreased by 16%, from 295,000 t in 2000 to 249,000 t in 2001, as a result of decreased consumption by the chemical and aluminum industries. In decreasing order of consumption, Western Europe, Japan, and other Asian countries accounted for 72% of the ferrosilicon consumption in 2001. Also in decreasing order of consumption, Western Europe, the United States, and Japan accounted for 83% of the silicon metal consumed in 2001 (CRU Bulk Ferroalloys Monitor, 2002a, b).

World demand for silicon wafers made from polycrystalline silicon in 2001 was estimated to fall by 21% due to a downturn in the information technology sector (Roskill's Letter from Japan, 2001).

Microsilica (silica fume) is a potential byproduct from furnaces making silicon metal or ferrosilicon with a silicon content of at least 75%. It is obtained by capturing furnace offgases and fines to use as binder and filler in cements. The amount of microsilica dust currently being generated from silicon metal furnaces per year worldwide has been estimated at greater than 300,000 t (Kendall, 2000). The global market for fumed silica is estimated to be around 110,000 t/yr (Industrial Minerals, 2001).

Prices

Demand for silicon ferroalloys and metal is determined in the short term less by their prices than by the level of activity in the steel, ferrous foundry, aluminum, and chemical industries. As a result, prices tend to vary widely with changes in demand and supply. The basis for U.S. prices of silicon materials was cents per pound of contained silicon.

Year-average import prices, as calculated from Platts Metals Week listings, were, in cents per pound, 31.9 for 75% ferrosilicon and 50.5 for silicon metal; these prices were 10% and 8% lower, respectively, than those of 2000. The year-average North American transaction price for 50% ferrosilicon as given by Ryan's Notes was 42.8 cents per pound, a 5% reduction from that of 2000.

The decline in year-average prices for silicon materials continued for the fifth consecutive year. The year-average prices for silicon metal and 75% ferrosilicon were the least of any year since 1990. The year-average price of 50% ferrosilicon was the lowest since 1994. The price range for silicon metal, in cents per pound, began the year at 49 to 51, about 5% below the range of 52 to 53 at the end of 2000, reached and maintained a plateau for 4 weeks of 51 to 56 starting in late June, then trended downward to 48.5 to 50.5 at yearend. The price range for 75% ferrosilicon declined from its highest point of 33 to 35 cents per pound at the beginning of the year to 30 to 31 cents per pound by September, where it remained until the end of the year. The price range for 50% ferrosilicon, in cents per pound, began the year at 42 to 48, reached and maintained a high of 44 to 48 for 10 weeks starting in late April, and then trended downward to end the year at 36 to 38.

Depressed 75% ferrosilicon prices were caused by poor market conditions in 2001. Low silicon metal prices were caused by the decline in consumption by the aluminum industry in the United States, Western Europe, and Japan (CRU Bulk Ferroalloys Monitor, 2001a, b).

Foreign Trade

Compared with those of 2000, total volumes of ferrosilicon and silicon metal exports and imports, on a content basis, decreased by 46% and 36%, respectively. The biggest year-to-year changes were for exports and imports of ferrosilicon. The export volumes of ferrosilicon and silicon metal were at their lowest since 1987 and 1994, respectively. Ferrosilicon and silicon metal import volumes were the least since 1989 and 1996, respectively.

U.S. ferrosilicon exports decreased by about 46% overall in gross weight from those of 2000, and their value decreased by 32%. In decreasing order of shipments, Canada, Japan, the Republic of Korea, Mexico, China, India, and the United Kingdom accounted for 92% of the total 2001 ferrosilicon exports (table 5). Exports of silicon metal decreased by 33% in gross weight and 21% in value. Although shipments of high-purity silicon containing more than 99.99% silicon decreased by about 13% from those in 2000, they still accounted for about 95% of total value for silicon metal exports. Exports in the category of "silicon, other" fell sharply (46%) from those in 2000. Combined shipments to Canada, Germany, Japan, and Mexico accounted for 68% of the total silicon exports. Shipments to Mexico in 2001 were only 9% of total silicon exports, falling by over 63% from those in 2000.

U.S. imports of silicon ferroalloys decreased by an overall 45% in gross weight and 43% in value compared with those in 2000. Import volumes decreased for all significant categories. The imports of nominally 75% ferrosilicon (ferrosilicon category of "55% to 80% silicon, other") accounted for 81% of total ferrosilicon imports and 75% of total ferrosilicon value, respectively (table 6). No ferrosilicon in the category of "over 90% silicon" was imported in 2001 as it was in 2000. Ferrosilicon in the category "55% to 80% silicon, over 3% calcium (Ca)," declined substantially (94%) from that of 2000. Norway was the leading source of ferrosilicon at over 22% of the total imports.

Overall imports, in gross weight, of silicon metal fell by about 10% in volume from 133,000 t to 120,000 t, and 20% in value from $249,000,000 to $200,000,000 compared with those in 2000. Import volumes decreased for all silicon metal categories, except for "other silicon," which increased 15% over that in 2000. The "99.00% to 99.99% silicon" category accounted for 63% of the total value for silicon metal imports, a decrease of 20% from those in 2000. However, the value of this category still accounted for 45% of the total value of silicon imports. South Africa provided the largest volume of the 99.00% to 99.99% silicon content, at 35%, followed by Brazil at 21%. For the category of "silicon, other," imports from Russia were 47% of the total, an increase of 78% from those of 2000.

Silicon metal imports from Spain during 2001 and part of 2002 are at the center of a probe by the U.S. Customs Service. Ferroatlántica, Spain's only significant silicon metal producer, told U.S. Customs officials that its U.S. exports were only 2,000 t during 2001, significantly less than that reported as imports by the U.S. Customs Service (Cooper, 2002).

For 2001, U.S. net import reliance for ferrosilicon was estimated to have decreased from 53% to 43% for ferrosilicon and increased for silicon metal from 38% to 45%. The overall import reliance for silicon was estimated to have declined from 47% in 2000 to 44% in 2001.

The general rates of duty that applied to U.S. imports during 2001 were the same as in 2000. These were, on an ad valorem basis, 1.5% for standard 75% ferrosilicon, 1.1% for nominal 75% ferrosilicon that contains more than 3% calcium, free for magnesium ferrosilicon and most other ferrosilicon, and 5.3% or 5.5% for metal exclusive of the high-purity grade (U.S. International Trade Commission, 2000).

In March 2001, the U.S. Court of International Trade (CIT) denied preliminary injunctive relief to several domestic ferrosilicon producers while they appealed the ITC's 1999 ruling on eliminating all penalty duties on ferrosilicon imports from Brazil, China, Kazakhstan, Russia, Ukraine, and Venezuela (*Elkem Metals Co.* v. *United States,* No. 99-10-00628, CIT Slip Opinion 2001-30). The penalty tariffs prior to the 1999 decision were: Venezuela-Venezolana de Ferrosilicio C.A. (Fesilven), 15.01%; Brazil-Companhia Ferroligas Minas Gerais-Minasligas (Minasligas), 2.54%; Italmagnesio S/A-Industria e Comercio (Italmagnesio), 88.68%; Companhia Brasileira Carbureto de Calcio (CBCC), zero; Companhia de Ferroligas de Bahia (Ferbasa), zero; all others, 42.17%; China, 137.73%; Kazakhstan, 104.18%; and Russia, 104.18% (Ryan's Notes, 2002b). In February 2002, the CIT remanded the 1999 ruling back to the ITC because the Commission had failed to adhere to its procedures by not according the domestic producers an opportunity to participate in a hearing on the matter (*Elkem Metals Co.* v. *United States,* No. 99-10-00628, CIT Slip Opinion 2002-18). Accordingly, the ITC reopened the reconsideration proceedings in April 2002. A hearing was conducted on June 6 (U.S. International Trade Commission, 2002). As of this publication, the ITC had yet to issue a final decision.

Effective August 24, 2001, the Office of the United States Trade Representative (USTR) suspended duty-free treatment under the Generalized System of Preferences (GSP) program for all products of Ukraine (Office of the United States Trade Representative, 2001a). The USTR imposed a 100% ad valorem duty on certain Ukraine products, among which were carbides of silicon, effective January 23, 2002 (Office of the United States Trade Representative, 2002).

The International Trade Administration (ITA) initiated and conducted various antidumping duty administrative reviews on silicon metal during 2001. On February 16, the ITA revoked the antidumping order on imports of silicon metal, excluding semiconductor-grade silicon (greater than 99.99% silicon content), from Argentina. The effective date of the revocation was January 1, 2000 (International Trade Administration, 2001c). Also on February 16, the ITA issued a notice that antidumping duty deposits would continue to be collected for silicon metal imports from Brazil and China, excluding semiconductor-grade silicon. The antidumping duty deposits will remain the same as those in effect at the time of import entry into the United States (International Trade Administration, 2001a).

On February 23, the ITA issued the final results of its antidumping duty administrative review for silicon metal, excluding semiconductor-grade silicon, from Brazil covering the period of July 1, 1998, through June 30, 1999. The ITA determined a margin of zero for Ligas de Aluminio S.A. (LIASA), Minasligas, and RIMA Industrial S.A. (RIMA); 0.63% for CBCC; and 93.2% for Eletrosilex S.A. (International Trade Administration, 2001d).

In August, the ITA issued a preliminary determination to maintain the antidumping duty order covering silicon metal imports, excluding semiconductor-grade silicon, from the following Brazilian companies for the Period of Review (POR) July 1, 1999, through June 30, 2000: CBCC, Minasligas, LIASA, and RIMA. The preliminary margins were zero for all companies (International Trade Administration, 2001e). In February 2002, the ITA announced the final results of this antidumping review, determining a margin of 0.02% for CBCC; zero for LIASA; 1.23% for Minasligas; and 0.35% for RIMA (International Trade Administration, 2002c).

Also in August, the ITA initiated an antidumping duty administrative review for silicon metal from Brazil for the July 1, 2000, to June 20, 2001, POR. Imports for the following companies are subject to this review: CBCC, Minasligas, and RIMA (International Trade Administration, 2001b). In March 2002, the ITA issued an extension of the review period to July 31, 2002 (International Trade Administration, 2002b).

On August 27, the CIT sustained the ITA's 1999 re-determination of the antidumping duty administrative review for imports of silicon metal by the following five Brazilian companies for the July 1, 1994, to June 20, 1995, POR: CBCC, Camargo Correa Metais (CCM), Eletrosilex, Minasligas, and RIMA (*American Silicon Technologies* v. *United States,* No. 97-02-00267, Slip Opinion 2001-109). CBCC appealed the CIT's judgment; in January 2002, the CIT stayed its earlier judgment and extended the injunction on the liquidation of CBCC's merchandise. Litigation in the case, however, was considered final for CCM, Eletrosilex, Minasligas, and RIMA. As a result, the ITA issued final antidumping margins for CCM (35.23%); Eletrosilex (13.18%); Minasligas (9.68%); and RIMA (81.61%) (International Trade Administration, 2002a).

World Trade

Data on annual world production of ferrosilicon and silicon metal by country during 1997 to 2001 are given in the "Ferroalloys" chapter of the 2001 USGS Minerals Yearbook. World production of ferrosilicon was estimated to have been 4.49 Mt in 2001 compared with a revised total of 4.26 Mt in 2000. The major ferrosilicon producers in 2001 were, in decreasing order, China, Russia, Norway, Ukraine, the United States, France, South Africa, and Kazakhstan, and accounted for about 86% of total production. World production of silicon metal, excluding that from China, was estimated to have been 638,000 t in 2001 compared with a revised total of 721,000 t in 2000. China's production of silicon metal is believed to have been the world's largest, but data are lacking. Available information indicates that China's annual output of silicon metal in 2001was a minimum of about 250,000 t (approximate net export level) and, considering consumption within China, may have been in excess of 300,000 t. Other major producers of silicon metal in 2001 were, in decreasing order, the United States, Brazil, Norway, France, Russia, South Africa, and Spain; they accounted for about 84% of total production as listed in table 1.

Australia.—Portman Ltd., an Australian iron ore producer, divested its 90% interest in the Australian Silicon Project (ASP) in Lithgow, New South Wales, to Quaestus Ltd. for a 61% stake in Quaestus (Mining Journal, 2001). As a result of the changes in ownership, the company name was changed to Australian Silicon Ltd. (Chemlink Pty. Ltd., 2001§[1]). The ASP involved the development of a 30,000-t/yr silicon metal smelter. Australian Silicon Ltd. assumed complete ownership control of the ASP by acquiring Doral Mineral Industries Ltd.'s 10% share in the project for $A1.4 million (Ryan's Notes, 2002c).

Brazil.—Beginning June 1, ferroalloys production was cut back because of a government-mandated program of electricity rationing. This program called for a 25% reduction in energy use because of a depletion of hydropower caused by severe drought conditions (Kepp, 2001). As a consequence, furnace shutdowns by a number of producers reduced production of silicon metal by about 5,000 tons per month (Ryan's Notes, 2001j). Nearly one-half of the 20 silicon metal electric furnaces were shut down in the second half of 2001 (TEX Report, 2002b). Due to the energy crisis, Norway's Elkem ASA delayed indefinitely its purchase of the Brazilian silicon metal producer Camargo Corrêa Metais S.A. (CCM) from Camargo Corrêa S.A., CCM's parent company (Ryan's Notes, 2001c). The Government completely lifted the power restriction at the beginning of March 2002.

The Brazilian Government challenged the USTR's de minimis level of 0.5% in cases of sunset and annual reviews. Under the U.S. government regulations, a 0.5% de minimis rate is applied to the reviews to determine whether an antidumping duty order should be revoked. The United States will not collect any duties for commodities whose dumping margins meet the de minimis standard. According to Brazil, the current U.S. methodology is inconsistent with the General Agreement on Tariffs and Trade 1994 (GATT) provisions, which Brazil maintains require a 2% de minimis standard (Office of the United States Trade Representative, 2001b). The Brazilian Government requested consultations under the World Trade Organization to resolve the issue. The ruling would have an immediate impact for Brazil's CBCC. As noted under the Foreign Trade section, the ITA gave CBCC a penalty duty of 0.63% on February 23, 2001. With the new duty, CBCC was not removed from ITA's annual tariff review (Ryan's Notes, 2001l).

Canada.—The Industrial Development Corporation of South Africa Ltd. (IDC) planned to develop a silicon metal project in Labrador West Region. The IDC, the Canadian Department of Minerals, and the Cape Nature Conservative backed the mine and smelter plan, which calls for shipment of 140,000 to 150,000 t of high-grade quartz from Shabogamo Mining & Exploration's Labrador Mine and construction of a 35,000-t/yr smelter. Exploratory drilling at the quartz mine was to start in July (Ryan's Notes, 2001f, i).

China.—In 2001, China's exports of ferrosilicon fell to about 470,000 t from about 490,000 t in 2000 (TEX Report, 2002a). China exported what was then a record quantity of silicon metal (325,000 t, exclusive of high-purity grades) in 2000 (TEX Report, 2001). While data in 2001 were not available at the time of this report, it was reported that Chinese silicon metal exports may have expanded during the year based on a 6% increase in silicon metal consumption in Japan, China's largest market (TEX Report, 2002b).

European Union.—In April, the European Commission removed antidumping duties placed on ferrosilicon imports

[1]References that include a section twist (§) are found in the Internet References Cited section

from Brazil, China, Kazakhstan, Russia, Ukraine, and Venezuela. The European ferroalloys producers association, Euroalliages, lodged a request with the European Union for the reinstatement of duties on ferrosilicon imports from China, Kazakhstan, Russia, and Ukraine (Platts Metals Week, 2001; Metal Bulletin, 2001b).

France.—Rhodia SA and Degussa AG started construction of their new Aerosil® fumed silica production unit at Rhodia's Roussilon site in France. The plant will have an annual capacity of 7,000 t, and will be operational in the second half of 2002 (Industrial Minerals, 2001).

India.—In July, the Indian Ministry of Commerce imposed antidumping duties on ferrosilicon imports from China and Russia. The recommended duty is the difference between the landed value of the commodity and $764 per ton (Metal Bulletin, 2001c).

In November, Bhutan Ferro Alloys reported plans to add capacity for either silicon metal or low- or medium-carbon silicomanganese production at its existing plant that currently has a ferrosilicon capacity of 15,000 t/yr. India does not produce silicon metal owing to high power costs; most of its silicon metal imports are from China (American Metal Market, 2001).

Norway.—Alcoa purchased 2,834,585 shares in Elkem, ASA, raising its interest in the company to 39.5%. After purchasing an additional 64,650 shares, Alcoa increased its share in Elkem to over 40%. The 40% share triggered a takeover bid of Elkem by Alcoa as required by Norwegian securities law (Ryan's Notes, 2001h, 2002a). As of July 2002, the takeover had not been settled.

Spain.—Ferroatlántica planned to expand production of ferrosilicon and ferromanganese by 25,000 t/yr at its Boo de Guarnizo plant in Santander, northern Spain (Metal Bulletin, 2001a).

Thailand.—General Electric Company and Shin-Etsu broke ground on their new silicones manufacturing plant in Map Ta Phut in late October. The facility will be largest silicones plant in the Asian Pacific region (Ryan's Notes, 2001k).

Current Research and Technology

Research at the University of Michigan indicated the possibility of developing a low-cost method for producing silicon chemicals as polymers and plastics from such silica sources as sand and rice hull, ethylene glycol from used antifreeze, and a caustic material. This work was conducted under the direction of Professor Richard Laine, who with some partners has formed a company, Tal Materials, to commercialize the technology (Advanced Materials & Processes, 2001).

Outlook

Demand for ferrosilicon follows trends in the iron and steel industries, for which the combined annual growth rates (CAGRs) have been typically in the range of 1% to 2%. Details of the outlook for the steel industry are discussed in the Outlook section of the annual review for 2001 for Iron and Steel. Raw steel production in 2001 increased by over 3% in the United States. The International Iron and Steel Institute's Spring 2002 short-term outlook for steel demand projected world steel consumption to increase 2.0% in 2002 and 3.5% in 2003 based on a world economic recovery starting in late 2002 (International Iron and Steel Institute, 2002§). For the foundry industry, ferrosilicon consumption in 2002 was expected to be roughly that of 2001, although improvements from the middle to the end of the year were projected to lead to a slight increase in consumption over that of 2001 (Raymond Monroe, Steel Founders' Society of America, written commun., 2002). World ferrosilicon consumption was not expected to have a CAGR greater than 1.5% to 2% (Roskill Information Services Ltd., 2000, p. 6).

Demand for silicon metal comes primarily from the aluminum and chemical industries. During the two decades leading up to 2000, Western World demand for silicon has had a CAGR of about 4.7%, and the chemicals sector of this demand has had a CAGR of nearly 7% (de Linde, 2000). From 1995 to 2000, Western World silicon consumption has varied by region, having suffered declines in Asia and uneven growth in the United States (Roskill's Letter from Japan, 2000, p. 4). The American Chemistry Council estimates a marginal increase of 1% in chemical shipments as a result of a continued recession in the U.S. chemical industry. An economic recovery had not emerged before the second half of 2002 (Westervelt, 2002).

On the basis of a forecast for the foundry industry, demand for silicon by the aluminum castings industry can be expected to increase by 9% in 2002 (Kirgin, 2002§). The growth may not translate directly into increased consumption of silicon metal because of an increase foreseen in recycling of automotive scrap. This adds to the uncertainty as to whether Western World demand for silicon metal can continue to experience a CAGR of greater than 4% (de Linde, 2000).

While consumption of polycrystalline silicon in semiconductors is projected to increase in 2002 in line with growth in production of silicon wafers, the demand will remain stable at 5,350 t because of high inventory levels (Roskill's Letter from Japan, 2002).

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TABLE 1
SALIENT SILICON STATISTICS 1/

(Thousand metric tons of silicon content, unless otherwise specified)

	1997	1998	1999	2000	2001
United States:					
Production	430	429	423	367	282
Exports:					
Ferrosilicon	27	24	24	22	10
Silicon metal	22	23	37	19	12
Imports for consumption:					
Ferrosilicon	135	142	173	231	115
Silicon metal	121	99	113	130	116
Apparent consumption:					
Ferrosilicon	351	349	374	397	258
Silicon metal	277	267	269	292	244
Price, average, cents per pound Si:					
Ferrosilicon, 50% Si 2/	54.8	52.1	49.1	45.0	42.8
Ferrosilicon, 75% Si 3/	48.0	43.1	40.2	35.4	31.9
Silicon metal 3/	81.4	70.5	58.1	54.8	50.5
World, production (gross weight): e/					
Ferrosilicon	4,110 r/	3,900	3,930 r/	4,260 r/	4,440
Silicon metal	694 r/	689 r/	698 r/	721 r/	630

e/ Estimated. r/ Revised.
1/ Data are rounded to no more than three significant digits.
2/ Ryan's Notes, North American transaction price.
3/ Platts Metals Week dealer import prices.

TABLE 2
PRODUCTION, SHIPMENTS, AND STOCKS OF SILICON ALLOYS AND METAL IN THE UNITED STATES 1/ 2/

(Metric tons, gross weight, unless otherwise specified)

Material	Silicon content (percentage) Range	Silicon content (percentage) Typical	Producers' stocks, December 31, 2000	2001 Gross production 3/	2001 Net shipments	2001 Producers' stocks, December 31
Ferrosilicon 4/	25-65 5/	48	48,300	167,000	125,000	31,900
Do.	56-95	76	27,000	89,000	73,800	30,400
Silicon metal (excluding semiconductor grades)	96-99	98	8,920	137,000	137,000	2,230

1/ Data are rounded to no more than three significant digits.
2/ Data for silvery pig iron (less than 25% silicon) withheld to avoid disclosing company proprietary data.
3/ Ferrosilicon production includes material consumed in the production of miscellaneous silicon alloys.
4/ Includes miscellaneous silicon alloys, which formerly was listed separately.
5/ 25% to 55% for ferrosilicon; 32% to 65% for miscellaneous silicon alloys.

TABLE 3
PRINCIPAL PRODUCERS OF SILICON ALLOYS AND/OR SILICON
METAL IN THE UNITED STATES IN 2001

Producer	Plant location	Product 1/
Applied Industrial Minerals Corp.	Bridgeport, AL	FeSi.
CC Metals and Alloys, Inc.	Calvert City, KY	Do.
Elkem Metals Co.	Alloy, WV	FeSi and Si.
Globe Metallurgical, Inc.	Beverly, OH	Do.
Do.	Niagara Falls, NY	Si.
Do.	Selma, AL	Do.
Do.	Springfield, OR 2/	Do.
Keokuk Ferro-Sil Inc.	Keokuk, IA	FeSi and silvery pig iron.
Simcala, Inc.	Mount Meigs, AL	Si.

1/ FeSi, ferrosilicon; Si, silicon metal.
2/ Plant was shut down in 2001 due to regional power concerns.

TABLE 4
REPORTED CONSUMPTION, BY END USE, AND STOCKS OF SILICON FERROALLOYS AND METAL IN THE UNITED STATES IN 2001 1/ 2/

(Metric tons, gross weight, unless otherwise specified)

End use	Silvery pig iron 3/	Ferrosilicon, 50% 4/	Ferrosilicon, 75% 5/	Silicon metal 6/	Miscellaneous silicon alloys 7/	Silicon carbide 8/
Steel:						
Carbon and high-strength, low-alloy	W	(9/)	15,400	715	913	(9/)
Stainless and heat-resisting	--	1,110	36,500	399	(9/)	(9/)
Full alloy	--	(9/)	7,630	154	(9/)	--
Electric and tool	--	(9/)	22,100	--	(9/)	(9/)
Unspecified	--	32,900	--	(10/)	439	7,660
Total	W	34,000	81,600	1,270	1,350	7,660
Cast irons	10,700	44,800	25,300	(10/)	21,300	45,600
Superalloys	--	(10/)	(10/)	95	--	--
Alloys (excluding superalloys and alloy steel)						
Miscellaneous and unspecified	--	2,020	94	176,000 11/	(12/)	--
Grand total	10,700	80,800	107,000	235,000	22,600	53,300
Consumers' stocks, December 31	803	3,460	6,700	1,550	1,020	1,600

W Withheld to avoid disclosing company proprietary data -- Zero.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.
2/ Includes U.S. Geological Survey estimates.
3/ Typically 18% silicon content but ranges between 5% to 24% silicon content.
4/ Typically 48% silicon content but ranges between 25% to 55% silicon content; includes briquets.
5/ Typically 76% silicon content but ranges between 56% to 95% silicon content; includes briquets.
6/ Typically 98% silicon content but ranges between 96% to 99% silicon content.
7/ Typically 48% silicon content. Primarily magnesium-ferrosilicon but also includes other silicon alloys.
8/ Typically 64% silicon content but ranges between 63% to 70% silicon content. Does not include silicon carbide for abrasive or refractory uses.
9/ Included with "Steel: Unspecified."
10/ Included with "Miscellaneous and unspecified."
11/ Primarily silicones, silanes, fumed silica, and other chemicals, plus aluminum alloys.
12/ Included with "Cast irons."

TABLE 5
U.S. EXPORTS OF FERROSILICON AND SILICON METAL,
BY GRADE AND COUNTRY, IN 2001 1/

(Metric tons)

Country	Gross weight	Contained weight	Value
Ferrosilicon:			
More than 55% silicon:			
Australia	1	1	$5,000
Belize	87	52	69,600
Brazil	132	79	106,000
Canada	3,430	2,060	2,370,000
Germany	4	2	3,000
Italy	368	211	239,000
Jamaica	3	2	2,610
Malaysia	21	15	36,500
Mexico	1,350	851	1,140,000
Total	5,400	3,270	3,970,000
Other ferrosilicon:			
Canada	6,060	3,030	3,970,000
China	1,000	502	1,730,000
Germany	248	129	394,000
India	786	388	1,340,000
Japan	4,470	452	9,900,000
Korea, Republic of	3,050	1,510	4,160,000
Malaysia	191	77	245,000
Mexico	527	264	647,000
Taiwan	570	280	1,230,000
United Kingdom	660	317	501,000
Other	315	159	393,000
Total	17,900	7,110	24,500,000
Grand total ferrosilicon	23,300	10,400	28,500,000

See footnotes at end of table.

TABLE 5--Continued
U.S. EXPORTS OF FERROSILICON AND SILICON METAL,
BY GRADE AND COUNTRY, IN 2001 1/

(Metric tons)

Country	Gross weight	Contained weight	Value
Metal:			
More than 99.99% silicon:			
Belgium	83	XX	$1,990,000
China	351	XX	10,500,000
France	104	XX	3,020,000
Germany	410	XX	16,200,000
Italy	88	XX	7,540,000
Japan	3,280	XX	161,000,000
Korea, Republic of	290	XX	11,800,000
Netherlands	64	XX	1,790,000
Norway	104	XX	2,740,000
United Kingdom	82	XX	10,400,000
Other	319	XX	23,700,000
Total	5,180	5,180 e/	251,000,000
99.00% - 99.99% silicon:			
Belgium	211	209	298,000
Denmark	65	65	92,100
France	52	51	78,000
Germany	39	39	107,000
Japan	65	64	94,400
Korea, Republic of	23	22	45,800
Mexico	135	134	145,000
Norway	575	570	811,000
Taiwan	29	29	41,600
United Kingdom	93	92	137,000
Other	78	77	178,000
Total	1,370	1,350	2,030,000
Other silicon:			
Australia	63	61	82,600
Canada	1,870	1,820	2,450,000
Denmark	86	84	114,000
Germany	1,280	1,240	1,770,000
Japan	88	85	259,000
Korea, Republic of	408	397	995,000
Mexico	1,210	1,170	2,580,000
Netherlands	333	324	440,000
Philippines	139	135	184,000
United Kingdom	356	346	508,000
Other	288	280	632,000
Total	6,120	5,950	10,000,000
Grand total silicon metal	12,700	12,500	263,000,000

e/ Estimated. XX Not applicable.
1/ Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2001 1/

(Metric tons)

Country	Gross weight	Contained weight	Value
Ferrosilicon:			
55% - 80% silicon, over 3% Ca:			
Argentina	116	86	$136,000
Brazil	80	59	42,500
Canada	19	14	11,600
France	162	98	259,000
Germany	8	5	8,130
Total	385	262	457,000
55% - 80% silicon, other:			
Canada	7,820	5,900	4,740,000
France	3,070	2,070	5,530,000
Iceland	20,100	15,300	10,800,000
Kazakhstan	9,180	6,980	3,700,000
Lithuania	9,520	7,290	5,000,000
Norway	29,100	20,400	18,500,000
Russia	3,570	2,700	1,760,000
South Africa	12,600	9,120	6,080,000
Ukraine	15,200	11,400	7,360,000
Venezuela	25,800	15,400	14,000,000
Other	5,570	3,940	5,190,000
Total	142,000	101,000	82,700,000
80% - 90% silicon:			
Germany	80	68	80,000
Norway	241	197	225,000
Total	321	265	305,000
Magnesium ferrosilicon:			
Argentina	1,480	644	1,080,000
Brazil	4,110	1,850	2,890,000
Canada	282	135	323,000
China	6,500	3,050	5,180,000
Germany	4	2	18,200
Japan	132	63	293,000
Netherlands	490	225	250,000
Norway	9,940	4,580	8,270,000
Total	22,900	10,500	18,300,000
Other ferrosilicon:			
Brazil	210	101	191,000
Canada	10,300	3,430	7,810,000
Germany	20	3	15,400
Japan	94	48	154,000
Norway	260	34	204,000
South Africa	114	19	116,000
Ukraine	157	76	73,100
Total	11,100	3,710	8,560,000
Grand total	176,000	115,000	110,000,000

See footnotes at end of table.

TABLE 6--Continued

U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2001 1/

(Metric tons)

Country	Gross weight	Contained weight	Value
Metal:			
More than 99.99% silicon:			
Denmark	4	XX	$901,000
Germany	385	XX	42,800,000
Italy	174	XX	8,770,000
Japan	548	XX	14,300,000
Korea, Republic of	183	XX	2,360,000
Malaysia	1	XX	62,900
Mexico	1	XX	48,300
Philippines	1	XX	66,800
Poland	7	XX	37,500
Taiwan	18	XX	169,000
Other	1	XX	237,000
Total	1,320	1,320 e/	69,800,000
99.00% - 99.99% silicon:			
Argentina	2,240	2,220	2,150,000
Brazil	15,800	15,700	20,300,000
Canada	6,590	6,550	8,340,000
China	1,330	1,320	1,060,000
Korea, Republic of	524	521	415,000
Norway	4,690	4,640	6,850,000
Russia	12,800	11,500	15,100,000
Saudi Arabia	1,000	993	968,000
South Africa	26,100	25,900	29,100,000
Spain	3,160	3,130	3,140,000
Other	1,030	1,010	1,790,000
Total	75,300	73,500	89,200,000
Other silicon:			
Arab Emirates	954	940	887,000
Argentina	580	574	549,000
Belgium	424	39	514,000
Canada	9,320	9,130	11,500,000
China	2,640	2,580	1,960,000
Germany	265	256	293,000
Korea, Republic of	1,680	1,650	1,490,000
Russia	20,300	19,500	18,000,000
South Africa	6,290	6,120	5,470,000
United Kingdom	340	335	454,000
Other	104	101	120,000
Total	42,900	41,200	41,200,000
Grand total	120,000	116,000	200,000,000

e/ Estimated. XX Not applicable.

1/ Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.