

# SILICON

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**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<sub>2</sub>) 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 quantities are quite small in relation to total silicon metal demand (Gill, 1997). This report contains no information about this highest purity silicon except as it appears in the foreign trade statistics.

For 1999, an overall domestic silicon production of 423,000 metric tons (t) of contained silicon was only slightly less than that of 1998; production declined for ferrosilicon but was virtually unchanged for silicon metal. Apparent consumption of silicon increased by about 4%, to 643,000 t; most of the increase was associated with ferrosilicon. For the third successive year, year-average dealer import prices for standard grades of ferrosilicon and silicon metal decreased by 6% to 7% for ferrosilicon and 18% for metal from those of the prior year. On the basis of contained silicon, overall U.S. trade volumes rose by about 30% for exports and 19% for imports. U.S. net import reliance for silicon products was estimated to have increased to 34% from 30%.

## Legislation and Government Programs

Alleged price fixing by domestic producers for ferrosilicon and silicon metal sold in the U.S. market from 1989 to 1991 led to ongoing legal actions. In the first part of 1999, of three domestic producers involved in civil class-action suits, one settled out of court and the other two were found not guilty in a

jury trial (Ryan's Notes, 1999a, e). In October 1999, sentences handed down in January 1998 to SKW Metals and Alloys Inc. and that company's vice president for fixing prices of ferrosilicon were upheld by the U.S. Court of Appeals for the Second Circuit in New York City (Platt's Metals Week, 1999a). The sentence for SKW Metals and Alloys, however, was remanded to the presiding judge for the original criminal trial for consideration of whether to keep or change the sentence (Ryan's Notes, 1999d).

## Production

In comparison with those of 1998, overall domestic gross production and net shipments of silicon products decreased by only about 1% and 2%, respectively, whereas overall stocks increased by 11%. The most significant year-to-year percentage changes were for 50% ferrosilicon; production and shipments declines ranged from 5% to 6%, and stocks rose by 30%. For silicon metal, production and shipments advanced slightly, and stocks decreased by 14%. These comparisons are exclusive of silvery pig iron, statistics for which were not published to avoid disclosing proprietary data.

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.

The number of domestic plants that produce silicon metal dropped by one in mid-September when American Silicon Technologies indefinitely suspended smelting operations at its Rock Island, WA, plant. The closing was a consequence of depressed market conditions and low prices for silicon (Ryan's Notes, 1999b).

Earlier in the year, the name of SKW Metals and Alloys Inc. was changed to CC Metals and Alloys, Inc., as part of an ongoing reorganization of VIAG AG, its German parent. CC Metals and Alloys included the ferrosilicon plant at Calvert City, KY, and its trading affiliate at Amherst, NY (Ryan's Notes, 1999c).

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 off-gases. 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 off-grade 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 wrought and cast 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 1999, total U.S. apparent consumption of silicon metal and silicon-containing ferroalloys was estimated to have increased by about 4% to 643,000 t of contained silicon. Principal cause of the increase was an increase in apparent consumption of ferrosilicon and miscellaneous silicon alloys of about 7% to 374,000 t, the greatest such total since 1995. Apparent consumption of silicon metal increased marginally to 269,000 t. On the basis of silicon content, the share of total demand accounted for by ferrosilicon and miscellaneous silicon alloys increased again, to 58%. Tables 4 and 5 present data on U.S. reported consumption and stocks of silicon materials in 1998 and 1999, respectively. The data in table 4 are revised somewhat from those published in the silicon report for October 1999 of the Mineral Industry Surveys series of the USGS.

Some signs were noted that the depressing effect on ferrosilicon demand from use of metallurgical-grade silicon carbide as a substitute was abating, particularly in the steel industry (CRU Bulk Ferroalloys Monitor, 1999). North American production and U.S. imports of silicon carbide were reported in the 1999 annual review of Manufactured Abrasives in the Mineral Industry Surveys series of the USGS and in the Manufactured Abrasives chapter of the 1999 Minerals Yearbook.

Demand for silicon metal as a starting material for production of silicones and semiconductors was still recovering from the effects of economic decline in Asia during recent years. As a result, 5% or less growth in demand during 1999 for silicon in chemicals was projected (Ryan's Notes, 1998). Germany's Wacker-Chemie GmbH deferred plans for a siloxanes project in the United States (Chemical Week, 1999d). Demand for chemicals and materials by the U.S. electronics industry was projected to grow between 1999 and 2003 about one-fourth less than that between 1993 and 1998; annual growth rate in demand for polysilicon was projected to be 7% (Chemical Week, 1999b).

## Prices

Demand for metallurgical-grade 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, in cents per pound, of 49.1 for 50% ferrosilicon, 40.2 for 75% ferrosilicon, and 58.1 for silicon metal were about 6%, 7%, and 18% lower, respectively, than those of 1998, as given by Platt's Metals Week or as calculated from Platt's weekly listings. In 1999, yearend prices for these materials were lower than those at the beginning of the year by about 13% for 50% ferrosilicon, 10% for 75% ferrosilicon, and 21% for silicon metal.

In 1999, year-average prices for silicon materials declined for the third successive year. The year-average price for silicon metal was the least of any year since 1990. For 50% ferrosilicon, the price range, in cents per pound, of 50 to 53 continued from 1998 into 1999 and remained at that level until late May, after which it decreased in several stages to reach a level of 43 to 47 in early November, where it remained through yearend. For 75% ferrosilicon, the price range, in cents per pound, moved upwards unevenly from 1998's ending range of 39 to 40 to reach the level of 42 to 44 that held for most of August. This was followed by a decline, particularly in September and December, that was interrupted by a rally in October-November. The price level recovered to 37.5 to 40 in the rally, but then decreased to a yearend range of 34 to 37. For silicon metal, the price range, in cents per pound, began the year at 63 to 70 and decreased progressively, most rapidly in June and July, until it reached 50 to 51 in mid-September, the year's lowest level. An upward trend that began in November produced a yearend range of 52 to 53.

## Foreign Trade

Total volumes for exports and imports of ferrosilicon and silicon metal were greater for 1999 than for 1998, on a content basis. Silicon units in exports increased by 30% and in imports, by 18%. The biggest year-to-year increase was for exports of silicon metal.

U.S. exports of ferrosilicon increased by about 4% overall in gross weight and by about 12% in value. Canada, India, Japan, the Republic of Korea, Mexico, and the United Kingdom were the recipients of about 88% of total 1999 exports (table 6). Combined exports of silicon metal increased by about 59% in gross weight but only by about 1% in value. Combined shipments to Canada, Germany, Japan, Mexico, and Taiwan accounted for about 94% of total shipments. Although shipments of high-purity silicon that contained more than 99.99% silicon constituted only about 11% of total volume, they accounted for about 84% of total value because of their high unit value. For the category of "silicon, other," shipments to Canada and Mexico were significantly greater, and those to Mexico nearly quadrupled the 1998 quantity.

U.S. imports of silicon ferroalloys increased overall by about 22% in gross weight and by about 12% in value compared with those for 1998. Import volumes increased for all significant categories except "ferrosilicon, other." On a content basis, overall imports of ferrosilicon seemingly were the highest ever.

Imports of material that contained 55% to 80% silicon accounted for most of the increase. About 80% of total quantity and 76% of total value were accounted for by imports in the ferrosilicon category of “55% to 80% silicon, other” (table 7). Norway was again the leading overall source of ferrosilicon, and its share of the total rose to 44%.

Overall imports of silicon metal increased by about 10% in volume, 14% in content, and 5% in value compared with those for 1998. Imports of high-value silicon metal that contained more than 99.99% silicon constituted not much more than 1% of total volume, but accounted for the largest share (41%) of total value. For the category of “silicon content from 99.00% to 99.99%,” about one-half was from Canada and South Africa combined; receipts from Brazil were nearly triple the 1998 quantity. For the category of “silicon content less than 99%,” imports from Russia decreased by nearly one-half to account for only one-third of total volume, whereas those from Saudi Arabia increased twelvefold. In decreasing order of silicon content, the year-to-year percentage changes in import volumes were +21% for “silicon content more than 99.99%,” +36% for “silicon content from 99.00% to 99.99%,” and -13% for “silicon, other.”

For 1999, U.S. net import reliances were estimated to have risen from 32% to 38% for ferrosilicon, and to have remained at 29% for silicon metal. The overall import reliance for silicon was estimated to have increased to 34% from 30%.

The general rates of duty that applied to U.S. imports during 1999 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, 1998). The Generalized System of Preferences (GSP) Program was allowed to expire after June 30, 1999, thus temporarily ending duty-free treatment for imports of selected goods from qualifying developing countries and territories. Effective December 17, the GSP Program was extended retroactively from July 1, 1999, through September 30, 2001, when the President signed the Ticket To Work and Work Incentives Improvement Act of 1999 (Customs Service, 2000). The extension provided for reimbursement of duties paid during the period when the program was not in effect. Categories of U.S. imports that may have been affected by these developments included all grades of silicon metal and ferrosilicon except those for which the general rate of duty already was zero. These duty-free materials were silicon metal with a silicon content of at least 99.99%, magnesium ferrosilicon, and ferrosilicon, other.

In February, the International Trade Administration (ITA) of the U.S. Department of Commerce published the results of its final antidumping duty administrative review for silicon metal from Brazil for the period of review of July 1, 1996, through June 30, 1997. The margins were 93.2% for Eletrosilex Belo Horizonte; 9.47% for Companhia Ferroligas Minas Gerais; 0.00% for Companhia Brasileira Carbureto de Calcio, Ligas de Alumínio S.A., and Rima Eletrometalurgia S.A.; and 91.06% for “all others” (International Trade Administration, 1999b).

In August, in a significant and unique action, the U.S. International Trade Commission reversed its 1993-94

determinations of injury to the domestic industry from imports of ferrosilicon from Brazil, China, Kazakhstan, Russia, Ukraine, and Venezuela. Conspiracy by domestic producers to fix prices was stated by the Commission as a major factor influencing its redetermination (U.S. International Trade Commission, 1999b). The Commission’s reconsideration came after its May suspension of the changed circumstances review of its previous affirmative determinations concerning countervailing duties on ferrosilicon from Venezuela and antidumping duties on ferrosilicon from Brazil, China, Kazakhstan, Russia, Ukraine, and Venezuela that it had initiated in July 1998 (U.S. International Trade Commission, 1999a). Five domestic ferrosilicon producers subsequently filed appeals of the Commission’s redetermination with the U.S. Court of International Trade in New York (Platt’s Metals Week, 1999b).

As a consequence of the Commission’s redetermination, the ITA rescinded the antidumping duty orders and countervailing duty order it had issued in 1993 and 1994 on ferrosilicon from Brazil, China, Kazakhstan, Russia, Ukraine, and Venezuela and terminated administrative reviews related to these orders. This action by the ITA did not, however, apply to unliquidated entries of ferrosilicon still subject to a court-ordered injunction (International Trade Administration, 1999a; Ryan’s Notes, 1999f).

## World Review<sup>1</sup>

Data on annual world production of ferrosilicon and silicon metal by country during 1995 to 1999 are given in Fenton [in press (a)]. World production of ferrosilicon was estimated to have been about 4.1 million metric tons (Mt) in 1999 compared with a revised total of about 3.9 Mt in 1998. The major producers of ferrosilicon in 1999 were, in decreasing order, China, Russia, Norway, the United States, Ukraine, Brazil, Kazakhstan, and France and accounted for more than 80% of total production. World production of silicon metal was estimated to have been about 671,000 t in 1999 compared with a revised total of about 696,000 t in 1998. This is exclusive of China’s production, which is believed to have been the world’s largest but for which data are lacking. China’s effective annual capacity for silicon metal production was estimated by an industry source as 250,000 t (Ryan’s Notes, 2000). The other major producers of silicon metal in 1999 were, in decreasing order, the United States, Brazil, Norway, France, Russia, and South Africa; they accounted for about 80% of total production as listed in table 1.

Western consumption of ferrosilicon in 1999 was estimated by CRU International Ltd. to have increased marginally to 1.73 Mt of contained silicon from a revised figure of 1.72 Mt for 1998. Consumption was estimated to have increased for the United States, Japan, and other Asian areas and decreased for Western Europe and other Western countries. Western

<sup>1</sup>In a number of instances, discussions of the more significant developments during 1999 for specific countries were based on news items in trade journals, such as American Metal Market, Metal Bulletin, Platt’s Metals Week, Ryan’s Notes, and TEX Report. These items have not been acknowledged individually because the information they conveyed often was aggregated, possibly with that from other sources.

consumption of silicon metal was estimated to be have increased in all areas to produce an all-time high of 925,000 t. This was an advance of about 5% from a revised figure of 883,000 t for 1998. In decreasing order, Western Europe, the United States, and Japan accounted for 70% of the 1999 consumption total for ferrosilicon and 84% of that for silicon metal (CRU Bulk Ferroalloys Monitor, 2000).

**Canada.**—In the first half of the year, SKW Canada, Inc., was sold to Safeguard International Fund, L.P., which was an international private equity fund with offices in Wayne, PA, and Frankfurt, Germany. The sale was not expected to change SKW Canada's program for producing ferrosilicon and silicon metal. SKW Canada, which was Canada's sole producer of silicon metal and formerly a subsidiary of Germany's VIAG AG, subsequently became known as Becancour Silicon Inc.

**China.**—In 1999, China's exports of 350,000 t of ferrosilicon again were about 30% greater than those for the prior year. For 1998, approximately 60% and 20% of ferrosilicon exports had gone to Japan and the Republic of Korea, respectively. Also for 1998, exports of silicon metal exclusive of high-purity grades were 272,000 t, which was about 5% less compared with 1997; about 40% of 1998 exports were reported to have gone to Japan.

**European Union.**—As of March, the European Commission removed antidumping duties on imports of ferrosilicon from South Africa. Duties had been in effect for the past 5 years at rates that ranged from 34.7% to 49.7% for specific producers.

**France.**—Merger of the silicon metal activities of France's Pechiney Electrometallurgie (PEM) and South Africa's Samancor Ltd. was approved by the European Commission in January. The resulting joint venture, in which PEM had a majority interest, took on the name Invensil. It comprised PEM's three silicon plants (Anglefort, Les Clavaux, and Montricher) in France and Samancor's Silicon Smelters plant at Pietersburg in South Africa. The combined annual output of more than 100,000 t by these four plants was said to correspond to 15% of Western production.

**Iceland.**—The first of two furnaces for production of 75% ferrosilicon that Icelandic Alloys Ltd. had shut down in November 1998 was restarted on January 1, and the second, about 1 month later. In September, Icelandic Alloys started up a third, new ferrosilicon furnace, which raised its plant's annual capacity for ferrosilicon by 40,000 t to more than 100,000 t.

**Norway.**—Fesil ASA reduced its annual production level for silicon metal by about 26,000 t, or about 50% of capacity for more than one-half of the year. Production was cut back first by shutting down one furnace at the Lilleby plant in March and then by shutting down two furnaces at the Holla plant in April. One of the furnaces at the Holla plant was restarted in early December, which then increased Fesil's operating rate to about 70% of capacity.

**Silicon Chemicals.**—Production capacities were being increased in several foreign countries. One expansion in Germany, by Degussa-Hüls AG at Bitterfeld was for production of silicon tetrachloride. A new plant with an annual capacity of 20,000 t was brought on-stream in the first part of the year, which raised the company's total capacity by one-fourth (Chemical Week, 1999a). Also in Germany, Wacker-Chemie

began a program that would raise its annual capacity for production of siloxanes at Nünchritz to 80,000 t from 30,000 t within a period of about 5 years (Chemical Week, 1999d). In Japan, siloxanes annual capacity also was being increased to 90,000 t from 70,000 t at the Isobe plant of Shin-Etsu Chemical Co., Ltd. (Chemical Week, 1999c).

## Current Research and Technology

Studies related to production of ferrosilicon and silicon materials and their properties included mathematical analysis and simulation directed at development of electrode paste for the Persson type of continuous electrode used to produce silicon metal (Halvorsen, Valderhaug, and Fors, 1999); experimentation and mathematical modeling of the carbothermic reduction of silica such as might take place in a cupola (Agarwal and Pal, 1999); development of experimental techniques for study of steam explosions when molten (75%) ferrosilicon is water-granulated (Nelson and others, 1999); and study of the extent to which hydrogen evolves from wet 75% ferrosilicon (Jeong and others, 1999).

The thermodynamics of the iron-silicon and iron-silicon-chromium systems was being investigated because of their relevance to silicon deoxidation of stainless steels (Slye and Fruehan, 1999). Also, fracture mechanisms were studied for an aluminum-silicon castings alloy, A356, with a nominal silicon content of 7%, that is used by the automotive industry (Gall and others, 1999).

## Outlook

Demand for ferrosilicon follows trends in the iron and steel industries, for which relatively modest growth rates that would range from 1% to 2% per year are foreseen for the medium term. Details of the outlook for the steel industry are discussed in the Outlook section of the annual review for 1999 for Iron and Steel (Fenton [in press (b)]). The October 1999 forecast of the International Iron and Steel Institute projected an annual growth rate in steel consumption from 1995 through 2005 for the North American Free Trade Agreement countries of 1.8% (Iron & Steelmaker, 1999). For iron castings, annual trends in shipments from 2000 through 2009 were forecast to be -0.2% per year for gray iron and +2.4% per year for ductile iron (Kirgin, 2000). From this, an overall growth rate of about 1% for ferrosilicon demand in iron castings can be estimated. The future course of antidumping duties on imports could affect the extent to which domestic production is determined by these levels of demand (Trickett, 1999).

Demand for silicon metal comes mainly from the aluminum and chemical industries. During the period from 1980 through 1995, silicon consumption grew at an annual rate of about 3.5% for the aluminum industry and 8% for the chemical industry to give an overall annual growth rate for worldwide silicon metal consumption of about 5.5% (Dosaj, 1997, p. 1110). According to one forecast, the outlook for the aluminum castings industry is for an annual growth rate of about 5% from 2000 through 2009 (Kirgin, 2000). This suggests that growth in demand by the aluminum industry should be at least as great as during the two previous decades.

Demand by the chemical sector, principally for silicones and related materials, has been set back in recent years by economic turmoil in Asia, but conditions have been improving (Munford and Brooks, 2000). For the near term, an annual growth rate more modest than the former 8% thus seems likely.

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- 1999b, Ferrosilicon from Brazil, China, Kazakhstan, Russia, Ukraine, and Venezuela: U.S. International Trade Commission Publication 3218, August, 48 p.

## GENERAL SOURCES OF INFORMATION

### U.S. Geological Survey Publications

- Silicon. Ch. in *Metal Prices in the United States Through 1998, 1999*.
- Silicon. Ch. in *Mineral Commodity Summaries*, annual.<sup>2</sup>
- Silicon. Ch. in *Minerals Yearbook*, annual.<sup>2</sup>
- Silicon. *Mineral Industry Surveys*, monthly.<sup>2</sup>

### Other

- Advanced Materials & Processes, monthly.
- American Metal Market, daily.
- Chemical and Engineering News, weekly.
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- Chemical Week, weekly.
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- Company reports, annual and quarterly.
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<sup>2</sup>Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1  
SALIENT SILICON STATISTICS 1/

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

	1995	1996	1997	1998	1999
<b>United States:</b>					
Production	396	412	430	429	423
<b>Exports:</b>					
Ferrosilicon	22	27	27	24	24
Silicon metal	25	17	22	23	37
<b>Imports for consumption:</b>					
Ferrosilicon	158	148	135	142	173
Silicon metal	92	79	121	99	113
<b>Apparent consumption:</b>					
Ferrosilicon	381	361	351	349	374
Silicon metal	228	233	277	267	269
<b>Price, average, cents per pound Si: 2/</b>					
Ferrosilicon, 50% Si	57.9	64.0	54.8	52.1	49.1
Ferrosilicon, 75% Si	58.1	62.2	48.0	43.1	40.2
Silicon metal	69.5	89.7	81.4	70.5	58.1
<b>World:</b>					
<b>Production (gross weight): e/</b>					
Ferrosilicon	4,000	4,200 r/	4,100	3,900	4,100
Silicon metal	610 r/	670 r/	690 r/	700 r/	670

e/ Estimated. r/ Revised.

1/ Data are rounded to no more than three significant digits.

2/ Platt's Metals Week dealer import prices.

TABLE 2  
PRODUCTION, SHIPMENTS, AND STOCKS OF SILICON ALLOYS AND METAL  
IN THE UNITED STATES IN 1999 1/ 2/

(Metric tons, gross weight, unless otherwise specified)

Material	Silicon content (percentage)		1998	1999		Producers' stocks December 31
	Range	Typical	Producers' stocks December 31	Gross production 3/	Net shipments	
Ferrosilicon 4/	25-65	48	38,600	252,000	177,000	46,800
Do.	56-95	76	28,300	145,000	139,000	30,400
Silicon metal (excluding semiconductor grades)	96-99	98	10,500	195,000	192,000	9,010

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.

TABLE 3  
PRINCIPAL PRODUCERS OF SILICON ALLOYS AND/OR SILICON METAL  
IN THE UNITED STATES IN 1999

Producer	Plant location	Product 1/
American Alloys Inc.	New Haven, WV	FeSi.
American Silicon Technologies	Rock Island, WA	Si.
Applied Industrial Minerals Corp.	Bridgeport, AL	FeSi.
CC Metals and Alloys, Inc. 2/	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	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/ Formerly SKW Metals and Alloys Inc.

TABLE 4  
REPORTED CONSUMPTION, BY MAJOR END USE, AND STOCKS OF SILICON ALLOYS  
AND METAL IN THE UNITED STATES IN 1998 1/ 2/

(Metric tons, gross weight, unless otherwise specified)

Silicon content (percentage)	Silvery pig iron	Ferrosilicon 3/		Silicon metal	Miscel- laneous silicon alloys 4/	Silicon carbide 5/
Range	5-24	25-55	56-95	96-99	--	63-70
Typical	18	48	76	98	48	64
<b>Steel:</b>						
Carbon and high-strength, low-alloy	(6/)	19,100	21,400	--	4,150	(6/)
Stainless and heat-resisting	--	(6/)	47,600	454	(6/)	(6/)
Full alloy	--	(6/)	10,000	--	(6/)	--
Electric and tool	--	(6/)	25,200	--	(6/)	(6/)
Unspecified	22	15,800	--	--	880	601
Total	22	34,900	104,000	454	5,030	601
Cast irons	23,400	47,600	25,000	108	20,900	44,400
Superalloys	--	(7/)	(7/)	171	--	--
Alloys (excluding superalloys and alloy steel)	--	(7/)	(7/)	(7/)	--	(8/)
Miscellaneous and unspecified	(8/)	4,130	1,420	234,000 9/	(8/)	(8/)
Grand total	23,400	86,600	131,000	235,000	26,000	45,000
Consumers' stocks, December 31	1,190	4,970	11,300	1,790	895	1,870

-- 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/ Includes briquets.

4/ Primarily magnesium-ferrisilicon but also includes other silicon alloys.

5/ Does not include silicon carbide for abrasive or refractory uses.

6/ Included with "Steel: Unspecified."

7/ Included with "Miscellaneous and unspecified."

8/ Included with "Cast irons."

9/ Primarily silicones, silanes, fumed silica, and other chemicals, plus aluminum alloys.

TABLE 5  
 REPORTED CONSUMPTION, BY MAJOR END USE, AND STOCKS OF SILICON ALLOYS  
 AND METAL IN THE UNITED STATES IN 1999 1/ 2/

(Metric tons, gross weight, unless otherwise specified)

Silicon content (percentage)	Silvery pig iron	Ferrosilicon 3/		Silicon metal	Miscel- laneous silicon alloys 4/	Silicon carbide 5/
Range	5-24	25-55	56-95	96-99	--	63-70
Typical	18	48	76	98	48	64
<b>Steel:</b>						
Carbon and high-strength, low-alloy	(6/)	16,000	23,600	(6/)	1,290	(6/)
Stainless and heat-resisting	--	(6/)	49,600	212	(6/)	(6/)
Full alloy	(6/)	(6/)	11,500	--	(6/)	--
Electric and tool	--	(6/)	25,800	--	(6/)	209
Unspecified	32	8,600	--	6	909	4,910
<b>Total</b>	32	24,600	111,000	218	2,200	5,120
Cast irons	13,000	41,400	29,200	22	20,000	60,800
Superalloys	--	(7/)	(7/)	177	--	--
Alloys (excluding superalloys and alloy steel)	--	(7/)	(7/)	(7/)	--	(8/)
Miscellaneous and unspecified	(8/)	3,480	442	235,000 9/	(8/)	(8/)
<b>Grand total</b>	13,000	69,500	140,000	236,000	22,200	65,900
Consumers' stocks, December 31	981	3,890	7,780	1,950	913	2,080

-- 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/ Includes briquets.

4/ Primarily magnesium-ferrasilicon but also includes other silicon alloys.

5/ Does not include silicon carbide for abrasive or refractory uses.

6/ Included with "Steel: Unspecified."

7/ Included with "Miscellaneous and unspecified."

8/ Included with "Cast irons."

9/ Primarily silicones, silanes, fumed silica, and other chemicals, plus aluminum alloys.



TABLE 6  
U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 1999 1/

(Metric tons)

Country	Gross weight	Contained weight	Value
<b>Ferrosilicon:</b>			
<b>More than 55% silicon:</b>			
Canada	5,210	3,130	\$3,340,000
Chile	11	7	8,940
Costa Rica	3	2	2,810
Dominican Republic	19	11	21,900
Japan	5	3	3,880
Korea, Republic of	2,300	1,380	1,970,000
Malaysia	5	4	5,880
Mexico	2,910	1,850	3,070,000
Taiwan	44	26	35,100
United Kingdom	15	9	28,800
Other	6	4	11,500
<b>Total</b>	<b>10,500</b>	<b>6,420</b>	<b>8,500,000</b>
<b>Other ferrosilicon:</b>			
Belgium	2,020	1,010	2,190,000
Canada	6,410	3,210	4,380,000
China	1,120	563	935,000
Germany	508	257	553,000
India	5,530	2,760	5,260,000
Japan	11,500	5,750	10,600,000
Korea, Republic of	2,050	1,030	1,620,000
Mexico	1,290	647	1,540,000
Taiwan	776	388	618,000
United Kingdom	3,900	1,950	3,010,000
Other	974	487	836,000
<b>Total</b>	<b>36,100</b>	<b>18,100</b>	<b>31,600,000</b>
<b>Total ferrosilicon</b>	<b>46,600</b>	<b>24,500</b>	<b>40,100,000</b>

See footnotes at end of table.

TABLE 6--CONTINUED  
 U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 1999 1/

(Metric tons)

Country	Gross weight	Contained weight	Value
<b>Metal:</b>			
<b>More than 99.99% silicon:</b>			
China	151	XX	\$5,280,000
Czech Republic	63	XX	2,470,000
France	69	XX	1,390,000
Germany	33	XX	2,230,000
Japan	2,550	XX	144,000,000
Korea, Republic of	629	XX	17,800,000
Malaysia	154	XX	32,600,000
Poland	32	XX	1,540,000
Taiwan	194	XX	9,910,000
United Kingdom	42	XX	9,550,000
Other	179	XX	9,370,000
<b>Total</b>	<b>4,090</b>	<b>4,090 e/</b>	<b>236,000,000</b>
<b>99.00% - 99.99% silicon:</b>			
Australia	7	7	10,400
Belgium	6	6	8,290
Brazil	44	44	62,000
France	4	4	5,500
Germany	5	5	6,970
Japan	151	150	220,000
Mexico	217	215	294,000
Netherlands	11	11	33,200
Spain	7	7	9,300
Taiwan	13	12	9,790
Other	19	19	38,800
<b>Total</b>	<b>484</b>	<b>480</b>	<b>698,000</b>
<b>Other silicon:</b>			
Argentina	74	72	98,200
Canada	9,560	9,280	9,590,000
China	132	128	182,000
Germany	1,050	1,020	1,420,000
Israel	48	46	95,300
Japan	2,890	2,800	6,130,000
Korea, Republic of	237	230	378,000
Mexico	17,700	17,200	24,200,000
Taiwan	1,140	1,110	1,510,000
United Kingdom	51	50	67,900
Other	324	315	859,000
<b>Total</b>	<b>33,200</b>	<b>32,200</b>	<b>44,500,000</b>
<b>Total silicon metal</b>	<b>37,700</b>	<b>36,800</b>	<b>281,000,000</b>

e/ Estimated. XX Not applicable.

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

Source: Bureau of the Census.

TABLE 7  
U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL,  
BY GRADE AND COUNTRY, IN 1999 1/

(Metric tons)

Country	Gross weight	Contained weight	Value
<b>Ferrosilicon:</b>			
55% - 80% silicon, over 3% Ca:			
Argentina	255	154	\$280,000
Brazil	28	18	32,100
France	148	83	237,000
Germany	17	6	28,800
Macedonia	13,200	10,000	7,280,000
United Kingdom	10	7	75,900
Total	13,700	10,300	7,930,000
55% - 80% silicon, other:			
Brazil	11,000	8,220	5,990,000
Canada	8,090	6,110	5,980,000
Egypt	2,610	1,900	1,430,000
France	2,250	1,480	4,680,000
Iceland	11,600	8,700	6,200,000
Kazakhstan	14,100	9,880	6,640,000
Norway	95,400	72,300	59,300,000
Poland	4,960	3,750	3,000,000
South Africa	34,800	26,400	19,900,000
Venezuela	8,720	6,570	4,660,000
Other	4,300	3,200	4,430,000
Total	198,000	149,000	122,000,000
80% - 90% silicon:			
Canada	73	65	5,830
Over 90% silicon:			
Canada	17	17	24,700
<b>Magnesium ferrosilicon:</b>			
Argentina	1,060	503	945,000
Brazil	5,280	2,420	3,840,000
Canada	327	156	303,000
China	4,000	1,880	3,020,000
Japan	133	66	309,000
Norway	13,100	5,850	12,600,000
Total	23,900	10,900	21,000,000
<b>Other ferrosilicon:</b>			
Brazil	8	4	13,300
Canada	9,760	3,300	7,920,000
France	81	41	191,000
Germany	80	12	102,000
Italy	202	27	71,400
Japan	64	36	121,000
Norway	342	114	430,000
South Africa	203	30	182,000
Total	10,700	3,560	9,030,000
Total ferrosilicon	246,000	173,000	160,000,000

See footnotes at end of table.

TABLE 7--Continued  
 U.S. IMPORTS FOR CONSUMPTION OF FERROSILICON AND SILICON METAL,  
 BY GRADE AND COUNTRY, IN 1999 1/

(Metric tons)

Country	Gross weight	Contained weight	Value
<b>Metal:</b>			
<b>More than 99.99% silicon:</b>			
Canada	3	XX	\$61,900
Denmark	2	XX	116,000
Germany	402	XX	50,600,000
Italy	556	XX	24,600,000
Japan	469	XX	15,800,000
Korea, Republic of	97	XX	2,530,000
Russia	60	XX	51,800
Switzerland	3	XX	64,700
Taiwan	87	XX	410,000
United Kingdom	12	XX	1,180,000
Other	2	XX	132,000
Total	1,690	1,690 e/	95,600,000
<b>99.00% - 99.99% silicon:</b>			
Australia	2,020	2,010	2,620,000
Brazil	12,000	10,800	14,600,000
Canada	13,200	13,100	19,900,000
China	777	715	702,000
France	2,190	2,170	3,150,000
Norway	6,900	6,900	10,300,000
Russia	8,270	8,130	8,760,000
Saudi Arabia	1,950	1,930	1,880,000
South Africa	20,800	20,600	25,500,000
Spain	582	577	606,000
Other	612	558	981,000
Total	69,300	67,500	89,000,000
<b>Other silicon:</b>			
Brazil	939	924	1,040,000
Canada	9,820	9,660	14,000,000
China	2,240	2,220	1,900,000
Korea, Republic of	399	388	364,000
Norway	405	393	445,000
Russia	15,100	14,700	15,400,000
Saudi Arabia	10,000	9,800	10,100,000
South Africa	5,090	4,920	5,010,000
Spain	282	278	357,000
United Kingdom	433	420	581,000
Other	656	513	778,000
Total	45,300	44,200	50,000,000
Total silicon metal	116,000	113,000	235,000,000

e/ Estimated. XX Not applicable.

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

Source: Bureau of the Census.