FERROALLOYS

By John D. Jorgenson, Lisa A. Corathers, Joseph Gambogi, Peter H. Kuck, Michael J. Magyar, and John F. Papp

Domestic survey data and tables were prepared by Jo-Ann S. Sterling, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Ferroalloys, alloys of iron, are used to add one or more chemical elements into molten metal, usually during steelmaking. They impart distinctive qualities to steel and cast iron or serve important functions during production. Manganese is essential to the production of virtually all steels and is important to the production of cast iron. Manganese neutralizes the harmful effect of sulfur and is an important alloying element. Silicon's primary alloying use is to deoxidize steel, but it is also an alloying element in cast iron. Boron, chromium, cobalt, columbium (niobium), copper, molybdenum, nickel, phosphorus, the rare-earth elements, titanium, tungsten, vanadium, and zirconium are among the other elements contributing to the character of the various alloy steels and cast irons (Brown and Murphy, 1985, p. 265).

The leading five ferroalloy-producing countries in 2004, in decreasing order of production, were China, South Africa, Ukraine, Russia, and Kazakhstan, with Russia moving ahead of Kazakhstan compared with 2003.

The ferroalloy industry is closely associated with the iron and steel industry, the leading consumer of its products. World production of bulk ferroalloys—chromium, manganese, and silicon—was estimated to be 23.0 million metric tons (Mt) in 2004, a 14% increase compared with the revised figure for 2003. U.S. bulk ferroalloy reported consumption in 2004 was 0.9 Mt of manganese and silicon ferroalloys and 0.3 Mt of contained chromium in ferrochromium. Compared with that of 2003, ferrochromium consumption increased by 9%; ferromanganese (including silicomanganese), by 25%; and ferrosilicon, by 1%. U.S. total ferroalloy production increased by 12% (table 6); total ferroalloy imports decreased by 6% and exports decreased by 11% (table 5). These percentages were reflected in continued recovery in the U.S. steel industry and growth in worldwide alloyed steel production during 2004.

U.S. ferroalloy production was relatively low in ferroalloy metals other than silicon and manganese compared with that of the major ferroalloy-producing countries. Consequently, domestic ferroalloy production provides only a small percentage of U.S. demand with the exception of silicon ferroalloys. U.S. ferrosilicon net production, which included miscellaneous silicon alloys, was approximately 38% of U.S. ferrosilicon apparent consumption in 2004 on a silicon content basis. U.S. silicon metal net production, excluding semiconductor-grade material, was about 57% of U.S. silicon metal apparent consumption in 2004 on a silicon content basis.

Ferrochromium

The major world chromite-ore-producing countries in 2004 were South Africa (more than 7 Mt), Kazakhstan (more than 3 Mt), and India (nearly 3 Mt). More than 90% of chromite ore was smelted in electric arc furnaces to produce ferrochromium for the metallurgical industry. The major world ferrochromium-producing countries were South Africa (more than 3 Mt) and Kazakhstan (1 Mt). China and India each produced in excess of 0.5 Mt of ferrochromium. Most of the 6.7 Mt of ferrochromium produced was consumed in the manufacture of stainless steel. Europe (primarily Scandinavia and Western Europe including Belgium, Finland, France, Germany, Italy, Spain, Sweden, and the United Kingdom), Asia (China, Japan, the Republic of Korea, and Taiwan), and South America and North America (Brazil and the United States)—the major stainless steel producing areas of the world—accounted for about 80% of world stainless steel production. As a result of increased Chinese stainless steel production during the past 2 years, China's and the Republic of Korea's stainless steel production were about the same in 2004, and Asia accounted for about one-half of world stainless steel production.

The Western World ferrochromium industry developed in close physical proximity to the stainless steel industry. However, the closing of ferrochromium facilities in historic stainless-steel-producing areas has resulted in the migration of ferrochromium production to areas where chromite is mined. China is an exception to this model because its ferrochromium industry preceded its stainless steel industry. In 2004, the world chromium industry operated with production capacity in excess of demand; however, it had to use previously marginal capacity to meet demand. Ferrochromium demand increased by nearly 0.5 Mt in 2002 from 2001, by 1 Mt in 2003 from 2002, and by 0.5 Mt in 2004 from 2003. Ferrochromium production increased by nearly 2 Mt, or more than 40%, during those years. During the same time period, stainless steel production increased to about 25 Mt from about 19 Mt, representing an increase in consumption of about 2 Mt of contained chromium. While stainless steel production increased in all three geographic regions, growth was greatest in Europe, where Finland and Belgium dominated, and in Asia, where China was the major force.

In response to increased demand and in anticipation of further increases, new ferrochromium-producing plants were under construction or planned in Kazakhstan and South Africa. The following four industry trends were evolving: ferrochromium was being increasingly produced using environmentally friendly (lower emissions), energy- and recovery-efficient prereduction closed-furnace processes; chromium was being recovered more often from ferrochromium slag; the ferrochromium and stainless steel production industries were consolidating ownership; and strategic alliances were being formed between these two industries.

Ferromanganese

Manganese ferroalloys consist of various grades of ferromanganese and silicomanganese used to provide a key ingredient for steelmaking (Matricardi and Downing, 1995, p. 970). Most U.S. supply was imported in 2004. The leading foreign source of ferromanganese and silicomanganese, on a gross-weight basis, was South Africa, whose exports of manganese ferroalloys to the United States exceeded those of the next four major exporting countries combined (Australia, China, Norway, and Romania). Manganese ferroalloys were produced domestically mainly at a plant near Marietta, OH, which was owned by France's Eramet Group. Some production came from Highlanders Alloys LLC plant at New Haven, WV, which resumed operations in October after having ceased production in January 2003. In 2004, Eramet Group, Ukrainian producer Nikopol Ferroalloys Plant, and BHP Billiton plc of the United Kingdom accounted for a significant portion of the world's production of manganese ferroalloys. In addition to its U.S. plant, Eramet Group controlled plants in China, France, Italy, and Norway, while BHP Billiton owned plants in Australia and South Africa. China continued to be by far the leading producer of manganese ferroalloys with an output greater than that of the next major producers, South Africa and Ukraine, combined (table 6).

Ferromolybdenum

Chile, China, and the United States accounted for about 80% of world production of molybdenum in 2004. Other significant molybdenum-producing countries, including Armenia, Canada, Mexico, Peru, and Russia, supplied an additional 9% of world production. Molybdenite concentrates are roasted to form molybdic oxide, which can be converted into ferromolybdenum, molybdenum chemicals, or metal. About 45% of the molybdenum consumed in the United States was in the form of molybdic oxides, and about 27% was as ferromolybdenum. Although the United States was the leading molybdenum-producing country in the world, it imported more than 94% of its ferromolybdenum requirements in 2004. Overall, the steel industry accounted for about 83% of all molybdenum consumed in the United States in 2004, principally in the production of stainless and full alloy steels.

Ferrosilicon

Cast iron and steel production, where silicon alloys are used as deoxidizers, drive silicon ferroalloy demand (Dosaj, 1997, p. 1115). On the basis of silicon content, U.S. net production of silicon ferroalloys (ferrosilicon and miscellaneous silicon alloys) and silicon metal increased by 9% to 275,000 metric tons (t) from the revised figure of 253,000 t in 2003. On a gross weight basis, U.S. net production of silicon ferroalloys and metal in 2004 increased by 12% compared with that of 2003 (table 6).

China was estimated to be the world's leading producer of ferrosilicon, with production greater than that of the rest of the world combined and almost three times that of the next two major producing countries, Norway and Russia, combined. In 2004, most silicon metal was used as an alloying agent with aluminum and in the production of chemicals, especially silicones. Some silicon metal was also used as an alloying agent with iron.

Ferrotitanium

Titanium is used in steelmaking for deoxidation, grain-size control, and carbon and nitrogen control and stabilization. During steelmaking, titanium is usually introduced as ferrotitanium because of its lower melting temperature and higher density compared with those of titanium scrap. World ferrotitanium production capacity is led by, in descending order, the United Kingdom, Russia, Japan, and the United States. Domestic producers of ferrotitanium in 2004 were Global Titanium, Inc. (Detroit, MI) and Galt Alloys Inc. (North Canton, OH). Producers of interstitial-free, stainless, and high-strength low-alloy steels are the major consumers of titanium within the steel industry.

In 2004, increased demand for titanium metal by commercial aerospace and military markets combined with demand for ferrotitanium for steel production exceeded the available supply of metal. Ferrotitanium prices dramatically increased partly because of the increased steel industry demand. The yearend price for ferrotitanium with 70% contained titanium was about $6.40 per pound, almost double the yearend price of 2003. U.S. imports of ferrotitanium and ferrosilicon titanium were 6,940 t, a 54% increase compared with those of 2003.

Ferrovanadium

The major vanadium-producing countries in 2004 were China and South Africa, accounting for about 77% of world production, with Russia, the other significant vanadium-producing country, accounting for an additional 20%. In these three countries, vanadium is primarily recovered from titanium-bearing magnetite ore processed to produce liquid pig iron. The process produces a slag containing 20% to 24% vanadium pentoxide, which can be further processed to 40%- to 50%-vanadium-content ferrovanadium.

In the United States, vanadium oxides were recovered from petroleum residues, ashes, and poisoned refinery catalysts. This represented the only vanadium recovered in 2004, as there was no primary production. Vanadium oxides were used to produce catalysts, chemicals, and 75%- to 80%-vanadium-content ferrovanadium.

The domestic steel industry accounted for about 95% of U.S. vanadium consumption in 2004, principally in carbon, full alloy, and high-strength low-alloy steels. About 89% of the vanadium consumed was as ferrovanadium, and the United States imported about 96% of its ferrovanadium requirements in 2004.

In 2004, the world vanadium industry lost the capacity of the Windimurra Mine in Australia and the VanTec Mine in South Africa as these operations permanently closed. The production of vanadium in 2004 was insufficient to meet strong demand, and the balance was made up from excess inventory. Production from petroleum-base vanadium recovery (residues, ashes, catalysts) continued to grow.

Ferronickel

The major ferronickel-producing countries in 2004, in descending order of contained nickel output, were Japan, Colombia, New Caledonia, and the Dominican Republic. These four countries accounted for more than two-thirds of world production, with Greece, the fifth ranked producer, accounting for an additional 6%. Key producing companies included Anglo American Plc, BHP Billiton Group, Eramet Group, Falconbridge Ltd., Hyuga Smelting Co. Ltd., Larco G.M.M. S.A., and Pacific Metals Co., Ltd.

At Cerro Matoso (Colombia), Doniambo (New Caledonia), and several other smelters, primary ferronickel is obtained by first calcining the iron- and nickel-bearing laterite ore in a kiln and then smelting the calcined ore in an electric furnace. In Austria and Russia, secondary ferronickel was produced in relatively small amounts by melting nickel-bearing scrap in an electric furnace and upgrading the melt with nickel cathode. The nickel content of marketable ferroalloy typically ranges from 19% (PT Aneka Tambang) to 38% (Falconbridge Dominicana C. por A.). In 2004, most of the world's ferronickel operations were operating at full capacity to meet strong demand from stainless steel producers.

In the United States, the steel industry accounted for virtually all primary ferronickel consumed in 2004, with more than 99% used in stainless and heat-resistant steels. No primary ferronickel was produced in the United States in 2004. Almost all U.S. ferronickel exports were either reexports or material upgraded for specialty purposes. U.S. ferronickel consumption in 2004 was 6% less than that of 2003 owing to the global ferronickel shortfall, with scrap and nickel cathode being used as substitutes. On a gross weight basis, ferronickel net imports were 38,900 t with an import-to-export ratio of 346:1.

Falconbridge Ltd. and its joint-venture partners were planning to construct a ferronickel smelter at Koniambo on the main island of New Caledonia. The partners have applied for the necessary regulatory permits and were finalizing a financial support package with the French Government. The smelter would have a capacity of 54,000 metric tons per year of nickel in ferronickel and would use lateritic ores from the Koniambo massif as feedstock. Commissioning of the Koniambo smelter was scheduled for 2009 or 2010.

Outlook

The trend in countries that competitively produced minerals is toward increased production of value-added products, such as ferroalloys. U.S. minerals production operations for most of the ferroalloy metals are not able to compete successfully on an operating cost basis in world markets, and, therefore, U.S. production is unlikely to expand. The trend in domestic ferroalloy production is declining. By 1999, U.S. production of ferronickel and common grades of ferrochromium had been shut down. In both cases, production ceased owing to low-grade resources, reliance on imported ore for feedstock, and high production cost. In contrast, domestic ferrosilicon and manganese ferroalloy production have fluctuated. Ferrosilicon production decreased, and manganese ferroalloy production generally increased during the past 5 years, with the exception of 2003.

Substitutes, principally alloy scrap and oxide (for some ferroalloys), have gained moderately on ferroalloy use per ton of steel produced during the past 20 years. A decline in unit consumption is significant over the long term for the ferroalloy industry because such a decline moderates any increase in ferroalloy consumption resulting from increased steel production. A combination of factors, including technology, availability, and price, is responsible for this general decline in unit consumption of the major ferroalloys in steelmaking.

Increasing U.S. customer needs for alloy and stainless steel for many applications have been and will continue to be a strong positive influence on the demand for ferroalloys. The steel industry will continue to improve process technology, reducing raw material needs and developing steels with lower alloying metal content with equal or better performance, while lowering material costs. Many stainless steel applications have no acceptable substitutes, and their key constituents, chromium and nickel, are essential. Technology and industry practices will continue to find more innovative uses for ferroalloys, resulting in strong demand for ferroalloy metals used in steel for construction, the chemical industry, transportation, and household appliances. This is expected to more than offset any reduction in unit consumption. Competition from substitute materials, such as plastics and nonferrous metals, especially in the transportation sector, will be strong, but the ferroalloys industry is expected to remain competitive for many years through the use of lightweight, high-strength steel (Sibley and others, 2001, p. 40).

Chromium, manganese, silicon, and other ferroalloy metals are discussed in more detail, including domestic data coverage and outlook and U.S. Government stockpile, in the respective mineral commodity chapters in the U.S. Geological Survey Minerals Yearbook, Volume I, Metals and Minerals.

References Cited

Brown, R.E., and Murphy, G.F., 1985, Ferroalloys, *in* Mineral facts and problems: U.S. Bureau of Mines Bulletin 675, p. 265-275.

Dosaj, Vishu, 1997, Silicon and silicon alloys—Chemical and metallurgical, *in* Kirk-Othmer encyclopedia of chemical technology (4th ed.): New York, NY, John Wiley and Sons, v. 15, p. 1104-1122.

Matricardi, L.R., and Downing, James, 1995, Manganese and manganese alloys, *in* Kirk-Othmer encyclopedia of chemical technology (4th ed.): New York, NY, John Wiley and Sons, v. 15, p. 963-990.

Sibley, S.F., Blossom, J.W., Cunningham, L.D., Fenton, M.D., Gambogi, Joseph, Jones, T.S., Kuck, P.H., Papp, J.F., Reese, R.G., Jr., and Shedd, K.B., 2001, Trends in U.S. customer needs for ferroalloys, *in* International Ferroalloys Congress and Manganese 2001 Health Issues Symposium, 9th, Quebec City, Quebec, Canada, June 3-6, 2001, Proceedings: Washington, DC, Ferroalloys Association, p. 29-58.

TABLE 1

GOVERNMENT INVENTORY OF FERROALLOYS, DECEMBER 31, 2004[1, 2]

(Metric tons of alloys unless otherwise specified)

Alloy	Inventory
Ferrochromium:	
High-carbon	390,000
Low-carbon	191,000
Ferromanganese, high carbon	676,000
Ferrotungsten, contained tungsten	233

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

[2]Data are uncommitted inventory.

Source: Defense National Stockpile Center.

TABLE 2

REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2004[1, 2]

(Metric tons of alloys unless otherwise specified)

		Manganese				
End use	FeB	FeMn	SiMn	FeP	FeSi	FeTi
Steel:						
Carbon and high-strength low-alloy	773	268,000 [3]	71,600	4,500	15,200 [3, 4]	5,380
Stainless and heat-resisting	308	12,100 [3]	15,100	46	54,900 [3]	3,130
Other alloy	(5)	26,200 [3]	21,800	865	7,680 [3]	226
Tool	--	(3)	(3)	--	29,100 [3]	(6)
Unspecified	4	3,370	939	(6)	37,000 [7]	--
Total steel	1,090	309,000	109,000	5,410	144,000	8,740
Cast irons	--	8,140	634	1,200	89,400	53
Superalloys	16	(4)	--	(7)	261 [7, 8]	628
Alloys (excluding alloy steels and superalloys)	323	17,800	(4)	(7)	60,100 [4, 8]	807
Miscellaneous and unspecified	--	(4)	(4)	--	177,000 [7]	(7)
Grand total	1,420	335,000	110,000	6,600	471,000	10,200
Total 2003[r]	1,240	272,000	84,200	5,890	466,000	9,360
Percentage of 2003	115	123	86	112	101	109
Consumer stocks, December 31	318	16,700 [9]	5,220 [9]	934	15,100	774

[r]Revised. -- Zero.

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

[2]FeB, ferroboron, including other boron materials; FeMn, ferromanganese, including manganese metal and other manganese alloys; SiMn, silicomanganese; FeP, ferrophosphorus, including other phosphorus materials; FeSi, ferrosilicon, including silico metal, silvery pig iron, silicon carbide, and inoculant alloys; FeTi, ferrotitanium, including titanium scrap and other titanium materials.

[3]All or part included with "Steel, unspecified."

[4]All or part withheld to avoid disclosing company proprietary data.

[5]Included with "Steel, stainless and heat-resisting."

[6]Included with "Steel, other alloy."

[7]All or part included with "Cast irons."

[8]Part included with "Miscellaneous and unspecified."

[9]Consumer and producer stock.

TABLE 3

REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2004[1, 2]

(Metric tons of contained elements unless otherwise specified)

End use	FeCr	FeMo	FeNb	FeNi	FeV	FeW
Steel:						
Carbon and high-strength low-alloy	3,920 [3]	546	2,060	--	2,460	(4)
Stainless and heat-resisting	219,000	836	639	12,700	60	(4)
Other alloy	16,600 [5]	2,200	(6)	W	1,060	(4)
Tool	3,580	W	(6)	--	239	(4)
Unspecified	W	--	--	--	--	(4)
Total	243,000	3,580	2,700	12,700	3,820	248
Cast irons	W	920	W	--	W	--
Superalloys	10,700	20	1,245	--	17	(4)
Alloys (excluding alloy steels and superalloys)	1,410	96	W	W	W	(4)
Miscellaneous and unspecified	13,000 [7]	79	(8)	68	215	--
Grand total	268,000	4,690	3,940	12,800	4,060	248
Total 2003	245,000 [r]	4,420 [r]	3,650	13,700	3,240 [r]	288
Percentage of 2003	109	106	108	94	125	86
Consumer stocks, December 31	7,890	656	NA	765	276	21

[r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified." -- Zero.

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

[2]FeCr, ferrochromium, including other chromium ferroalloys and chromium metal; FeMo, ferromolybdenum, including calcium molybdate; FeNb, ferrocolumbium, including nickel columbium; FeNi, ferronickel; FeV, ferrovanadium, including other vanadium-carbon-iron ferroalloys; and FeW, ferrotungsten.

[3]All or part included with "Steel, other alloy."

[4]Included with "Steel, total."

[5]Includes full alloy and high-strength low-alloy steel.

[6]Included with "Carbon and high-strength low-alloy."

[7]Included with "Alloys (excluding alloy steels and superalloys)."

[8]Less than ½ unit.

TABLE 4
FERROALLOY PRICES IN 2004

	High	Low	Average[1]
Chromium:			
Ferrochromium:			
0.05% carbon[2]	145.00	80.00	117.00
0.10% carbon[2]	133.00	70.00	102.97
0.15% carbon[2]	117.00	65.00	95.16
Over 4% carbon:			
50-55% chromium[2]	75.00	55.00	68.95
60-65% chromium[2]	75.00	55.00	68.55
Manganese:			
Medium-carbon ferromanganese[2]	102.00	50.00	85.49
Standard-grade ferromanganese[3]	1,850.00	600.00	1,326.54
Silicomanganese[4]	80.00	32.00	59.72
Molybdenum:			
Ferromolybdenum[5]	37.00	8.00	17.75
Molybdenum oxide[5]	33.25	7.20	16.02
Silicon:			
50% ferrosilicon[2]	70.00	46.00	58.16
75% ferrosilicon[2]	70.00	44.00	55.35
Silicon metal[5]	89.00	65.00	81.92
Vanadium, ferrovanadium[5]	23.00	5.65	12.55

[1]Annual time-weighted average.
[2]Cents per pound of contained element.
[3]Dollars per long ton.
[4]Cents per pound.
[5]Dollars per pound of contained element.

Sources: American Metal Market, Platts Metals Week, and Ryan's Notes.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF FERROALLOYS AND FERROALLOY METALS IN 2004[1]

	Imports			Exports		
Alloy	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)
Ferroalloys:						
Chromium ferroalloys:						
Ferrochromium containing:						
More than 4% carbon	398,000	223,000	$275,000	6,580	4,060	$7,570
Not more than 4% carbon	XX	XX	XX	1,410	852	3,090
More than 3% but not more than 4% carbon	30	16	18	XX	XX	XX
More than 0.5% but not more than 3% carbon	5,720	3,830	8,250	XX	XX	XX
Not more than 0.5% carbon	31,400	21,100	44,900	XX	XX	XX
Ferrochromium-silicon	30,600	12,500	31,500	1,150	403	1,300
Total	466,000	261,000	360,000	9,140	5,320	12,000
Manganese ferroalloys:						
Ferromanganese containing:						
More than 4% carbon	308,000	235,000	279,000	XX	XX	XX
More than 2% but not more than 4% carbon	6,470	6,030	6,180	XX	XX	XX
More than 1% but not more than 2% carbon	96,700	78,000	104,000	XX	XX	XX
Not more than 1% carbon	17,600	15,100	24,600	XX	XX	XX
Ferromanganese, all grades	XX	XX	XX	9,120	XX	10,600
Silicomanganese	422,000	269,000	386,000	502	XX	632
Total	851,000	603,000	800,000	9,620	XX	11,300

See footnotes at end of table.

TABLE 5—Continued

U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF FERROALLOYS AND FERROALLOY METALS IN 2004[1]

Alloy	Imports			Exports		
	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)
Ferroalloys—Continued:						
Silicon ferroalloys:						
Ferrosilicon containing:						
More than 90% silicon	21	20	49	XX	XX	XX
More than 55% but not more than 80% silicon and more than 3% calcium	1,210	796	1,690	XX	XX	XX
More than 55% but not more than 80% silicon and not more than 3% calcium	XX	XX	XX	XX	XX	XX
Magnesium ferrosilicon	30,500	14,100	24,500	XX	XX	XX
Ferrosilicon, other[2]	11,900	3,870	8,160	4,360	2,180	4,430
Total	43,600	18,800	34,400	4,360	2,180	4,430
Other ferroalloys:						
Ferrocerium and other pyrophoric alloys and other	118	XX	1,770	XX	XX	XX
Ferrocolumbium	7,130	XX	59,700	294	XX	2,920
Ferromolybdenum	NA	5,310	158,000	1,540	925	21,200
Ferronickel	39,100	13,900	168,000	113	68	466
Ferrophosphorus	7,280	XX	1,840	388	XX	335
Ferrotitanium and ferrosilicon-titanium	6,940	XX	38,800	2,790	XX	7,690
Ferrotungsten and ferrosilicon-tungsten	523	392	3,510	179	99	261
Ferrovanadium	NA	3,760	62,500	NA	285	9,210
Ferrozirconium	165	XX	318	913	XX	1,310
Ferroalloys, other	8,520	XX	12,700	1,620	XX	2,670
Total	69,800	XX	507,000	7,830	XX	46,000
Total ferroalloys	1,430,000	XX	1,700,000	31,000	XX	73,700
Metals:						
Chromium (total, all grades)	9,650	XX	56,100	931	XX	17,600
Manganese, other:						
Unwrought	31,500	XX	47,000	XX	XX	XX
Other	676	XX	1,650	XX	XX	XX
Silicon:						
Less than 99% silicon	31,700	30,600	41,300	5,110	4,950	13,700
Less than 99.99% but not less 99% silicon	133,000	132,000	173,000	1,930	1,910	4,290
Not less than 99.99% silicon	1,810	XX	99,800	11,600	XX	471,000
Total metals	208,000	XX	419,000	19,500	XX	507,000
Grand total	1,640,000	XX	2,120,000	50,500	XX	580,000

NA Not available. XX Not applicable.

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

[2]Includes less than 55% silicon and greater than 80% silicon.

Source: U.S. Census Bureau.

TABLE 6

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons of gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2000	2001	2002	2003	2004[e]
Albania, electric furnace, ferrochromium	12,500	11,900	22,100	37,800	34,650 [6]
Argentina, electric furnace:					
Ferrosilicon[e]	2,500	2,740 [6]	2,700 [r]	2,700 [r]	2,700
Silicomanganese	4,900	5,150	5,000 [e]	5,000 [e]	5,000
Silicon metal[e]	8,000	8,000	8,000	8,000	8,000
Other[7]	16,900	9,925	17,289	15,000 [e]	15,000
Total	32,300	25,815	32,989 [r]	30,700 [r, e]	30,700
Australia, electric furnace:[e]					
Ferromanganese	115,000	115,000	115,000	115,000	115,000
Silicomanganese	135,000	135,000	135,000	135,000	135,000
Silicon metal	30,000	30,000	30,000	30,000	30,000
Total	280,000	280,000	280,000	280,000	280,000
Austria, electric furnace:[e]					
Ferronickel	4,200	4,000	4,000	4,000	4,000
Other	5,000	4,000	4,000	4,000	4,000
Total	9,200	8,000	8,000	8,000	8,000
Bhutan, electric furnace, ferrosilicon[e]	15,000	16,000	21,000	21,000	20,000
Bosnia and Herzegovina, electric furnace:[e]					
Ferrosilicon	1,000	1,000	1,000	1,000	1,000
Silicon metal	200	200	200	--	--
Total	1,200	1,200	1,200	1,000	1,000
Brazil, electric furnace:					
Ferrochromium[8]	172,443 [r]	110,468 [r]	134,140 [r]	204,339 [r]	204,626 [6]
Ferrochromiumsilicon	7,790 [r]	5,899 [r]	10,522 [r]	10,500 [r]	10,500
Ferromanganese	121,277	96,016	156,435 [r]	149,000 [r]	149,000
Ferronickel	19,315	17,966	19,874	21,167 [r]	21,200
Ferrosilicon	189,935 [r]	159,345	145,910 [r]	146,000 [r]	146,000
Silicomanganese	171,304	180,235	182,731 [r]	180,200 [r]	180,000
Silicon metal	166,344	112,123	133,390 [r]	133,400 [r]	133,000
Other[e]	92,439 [r]	79,750 [r]	87,398 [r]	86,400 [r]	86,400
Total	940,847 [r]	761,802 [r]	870,400 [r]	931,006 [r]	931,000
Bulgaria, electric furnace:[e]					
Ferrosilicon	8,000	8,000	8,000	8,000	8,000
Other	2,000	2,000	2,000	2,000	2,000
Total	10,000	10,000	10,000	10,000	10,000
Canada, electric furnace:[e]					
Ferrosilicon	56,000	56,000	56,000	56,000	56,000
Ferrovanadium	1,000	1,000	1,000	1,000	1,000
Silicon metal	30,000	30,000	30,000	30,000	30,000
Total	87,000	87,000	87,000	87,000	87,000
Chile, electric furnace:					
Ferromanganese	4,011	2,213	-- [r]	-- [r]	--
Ferromolybdenum	1,454	1,784	1,784	3,170	3,200
Ferrosilicon	-- [r]	-- [r]	-- [r]	-- [r]	--
Silicomanganese[e]	1,800 [6]	-- [r]	-- [r]	-- [r]	--
Total	7,265 [r]	3,997 [r]	1,784 [r]	3,170 [r]	3,200
China:[e]					
Blast furnace:					
Ferromanganese	500,000	500,000	500,000	550,000	500,000
Other	100,000	100,000	100,000	100,000	100,000
Electric furnace:					
Ferrochromium	450,000	310,000	330,000	500,000	600,000
Ferromanganese	520,000	670,000	490,000	700,000	1,000,000
Ferromolybdenum	44,400	37,700	29,600	29,400	50,000

See footnotes at end of table.

TABLE 6—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons of gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2000	2001	2002	2003	2004[e]
China—Continued:[e]					
Electric furnace—Continued:					
Ferrosilicon	1,400,000	1,320,000	1,500,000	2,200,000	3,000,000
Silicomanganese	900,000	1,170,000	1,580,000	1,800,000	2,600,000
Other	115,600	392,300	310,400	460,600	800,000
Total	4,030,000	4,500,000	4,840,000	6,340,000	8,650,000
Colombia, electric furnace, ferronickel	59,129	91,475	111,952	111,324	114,000 [6]
Croatia, electric furnace, ferrochromium	15,753	361	-- [e]	-- [e]	--
Czech Republic, electric furnace, other[e]	1,000	1,000	1,000	1,000	1,000
Dominican Republic, electric furnace, ferronickel	84,900	60,654	59,654	69,800	75,600 [6]
Egypt, electric furnace:[e]					
Ferromanganese	30,000	30,000	30,000	30,000	30,000
Ferrosilicon	55,000 [r]	55,000 [r]	55,000 [r]	55,000 [r]	55,000
Total	85,000 [r]	85,000 [r]	85,000 [r]	85,000 [r]	85,000
Finland, electric furnace, ferrochromium	260,605	236,710	248,181	250,490 [r]	264,492 [6]
France:[e]					
Blast furnace, ferromanganese	300,000	300,000	300,000	180,000	--
Electric furnace:					
Ferromanganese	140,000	130,000	130,000	120,000	106,000
Ferrosilicon	110,000	100,000	100,000	100,000	100,000
Silicomanganese[9]	60,000	50,000	50,000	107,000	64,000
Silicon metal	75,000	75,000	75,000	75,000	75,000
Other	20,000	65,000	65,000	65,000	65,000
Total	705,000	720,000	720,000	647,000	410,000
Georgia, electric furnace:[e]					
Ferromanganese	600 [r, 6]	100 [r, 6]	-- [r, 6]	-- [r]	--
Silicomanganese	25,000	25,000	25,000	25,000	25,000
Total	25,600 [r]	25,100 [r]	25,000 [r]	25,000 [r]	25,000
Germany, electric furnace:					
Ferrochromium	21,600	19,308	20,018	18,318	24,857 [6]
Silicon metal[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Other[10]	58,400 [r, e]	52,692 [r]	59,982 [r]	61,682 [r]	61,500
Total	80,000 [r]	72,000 [r]	80,000 [r]	80,000 [r]	86,400
Greece, electric furnace, ferronickel	81,662	88,755 [r]	97,761 [r]	95,376 [r]	96,000
Hungary, electric furnace:[e, 11]					
Ferrosilicon	7,000	7,000	7,000	7,000	7,000
Silicon metal	1,000	1,000	1,000	1,000	500
Total	8,000	8,000	8,000	8,000	7,500
Iceland, electric furnace, ferrosilicon	70,000 [e]	111,948	120,624 [r]	115,000 [e]	120,000
India, electric furnace:[e]					
Ferrochromium[12]	376,693 [6]	267,395 [6]	311,927 [6]	468,677 [6]	527,100 [6]
Ferrochromiumsilicon	10,000	10,000	10,000	10,000	10,000
Ferromanganese	160,000	165,000	165,000	165,000	170,000
Ferrosilicon	60,000	50,000	52,000	54,000	55,000
Silicomanganese	185,000	150,000	150,000	160,000	160,000
Other	9,000	9,000	9,000	9,000	9,000
Total	801,000	651,000	698,000	867,000	931,000
Indonesia, electric furnace:					
Ferromanganese[e]	12,000	12,000	12,000	12,000	12,000
Ferronickel	47,749	47,769	42,306	44,660	39,721 [6]
Silicomanganese[e]	7,000	7,000	7,000	7,000	7,000
Total	66,749	66,769	61,306	63,660	58,700

See footnotes at end of table.

TABLE 6—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons of gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2000	2001	2002	2003	2004[e]
Iran, electric furnace:					
Ferrochromium	11,505	8,430	15,000 [e]	17,000	17,000
Ferrosilicon[e]	40,000	40,000	41,700	40,000	40,000
Total	51,505	48,430	56,700	57,000 [e]	57,000
Italy, electric furnace:[e]					
Ferromanganese	40,000	40,000	40,000	40,000	40,000
Silicomanganese	90,000	90,000	90,000	90,000	90,000
Silicon metal	5,000	6,000	6,000	6,000	6,000
Other[13]	10,000	10,000	10,000	10,000	10,000
Total	145,000	146,000	146,000	146,000	146,000
Japan, electric furnace:					
Ferrochromium[14]	130,074	111,167	91,937	19,427 [r]	16,600
Ferromanganese	337,694	368,293	356,717	371,831 [r]	456,000
Ferronickel	367,181	367,739	370,973	369,098 [r]	375,800 [6]
Silicomanganese	67,926	62,238	70,965	58,043 [r]	75,100
Other[15]	15,020	12,940	12,352	10,007 [r]	14,300
Total	917,895	922,377	902,944	828,406 [r]	938,000
Kazakhstan, electric furnace:					
Ferrochromium	799,762	761,900	835,800	993,000	1,050,000
Ferrochromiumsilicon	55,634	79,800	102,200	98,130	100,000
Ferromanganese	1,075	5,349	2,278	1,931	2,000
Ferrosilicon	133,269	145,800	127,300	127,300 [r]	103,620 [6]
Silicomanganese	102,719	141,200	164,000	178,920	180,000
Other[e]	9,000	9,000	9,000	9,000	9,000
Total	1,101,459	1,143,049	1,240,578	1,408,281 [r]	1,440,000
Korea, North, electric furnace:[e]					
Ferromanganese[10]	6,000	6,000	6,000	6,000	6,000
Ferrosilicon	3,000	3,000	3,000	3,000	3,000
Other	1,000	1,000	1,000	1,000	1,000
Total	10,000	10,000	10,000	10,000	10,000
Korea, Republic of, electric furnace:					
Ferromanganese	146,373	143,525	137,000 [e]	141,000 [r]	145,000
Silicomanganese	103,522	101,877	94,000 [e]	-- [r]	--
Other	4,676	4,452	--	--	--
Total	254,571	249,854	231,000 [e]	141,000 [r]	145,000
Macedonia, electric furnace:[e]					
Ferronickel	--	10,300	17,000	19,000	18,800
Ferrosilicon	50,000	50,000	50,000	50,000	50,000
Total	50,000	60,300	67,000	69,000	68,800
Mexico, electric furnace:[16]					
Ferromanganese	90,501	60,014	38,532	55,903	72,471 [6]
Silicomanganese	107,922 [r]	74,290	73,263	81,223	103,206 [6]
Total	198,423 [r]	134,304	111,795	137,126	175,677 [6]
New Caledonia, electric furnace, ferronickel[e]	157,000	162,000	171,000	175,000	149,000 [6]
Norway, electric furnace:[e]					
Ferrochromium	153,500 [6]	82,600 [6]	61,100 [6]	--	--
Ferromanganese	235,000	240,000	240,000	245,000	245,000
Ferrosilicon	460,000	450,000	390,000	350,000	300,000
Silicomanganese	230,000	230,000	230,000	230,000	230,000
Silicon metal	100,000	100,000	105,000	100,000	105,000
Other[9]	15,000	15,000	15,000	15,000	15,000
Total	1,190,000	1,120,000	1,040,000	940,000	895,000
Peru, electric furnace, ferrosilicon[e]	600	600	600	600	600

See footnotes at end of table.

TABLE 6—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons of gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2000	2001	2002	2003	2004[e]
Poland:					
Blast furnace, ferromanganese[e]	--	500	600	600	500
Electric furnace:					
Ferrosilicon	56,000	48,600	41,800 [r, e]	45,000 [e]	42,000
Silicomanganese	19,000	20,000	7,500 [r, e]	10,000 [e]	10,000
Silicon metal[e]	1,500	1,500	1,500	1,500	4,500
Other[e]	2,700	--	--	--	--
Total	79,200	70,600	51,400 [r, e]	57,100 [e]	57,000
Romania, electric furnace:					
Ferromanganese	1,044	384	--	-- [e]	--
Ferrosilicon	5,000 [e]	5,823	--	-- [e]	--
Silicomanganese	21,158	71,921	88,665	85,000 [e]	80,000
Total	27,202	78,128	88,665	85,000 [e]	80,000
Russia:[e]					
Blast furnace:					
Ferromanganese	88,000 [r]	55,000 [r]	105,000 [r]	101,000 [r]	108,000
Ferrophosphorus	3,500	3,500	3,500	3,500	3,500
Spiegeleisen	7,000	7,000	7,000	7,000	7,000
Electric furnace:					
Ferrochromium	274,000 [6]	210,600 [6]	210,000 [6]	357,000 [6]	454,000
Ferrochromiumsilicon	4,500	4,000	4,000	4,000	4,000
Ferronickel	35,000 [6]	30,000 [6]	45,000 [r]	51,000 [r]	53,000
Ferrosilicon	652,000 [6]	707,100 [6]	701,000	760,000	721,000
Ferrovanadium	20,500	18,800	15,100	8,000	10,000
Silicomanganese	122,000	124,000	127,000	83,000	143,000
Silicon metal	40,000	40,000	40,000	45,000	45,000
Other	19,500	16,200	14,900	22,000	22,000
Total	1,270,000 [r]	1,220,000 [r]	1,270,000 [r]	1,440,000 [r]	1,570,000
Saudi Arabia, electric furnace, other[e]	83,000	78,000	75,000	75,000	75,000
Slovakia, electric furnace:[e]					
Ferrochromium	17,702 [6]	5,968 [6]	5,695 [6]	1,924 [6]	1,784 [6]
Ferromanganese	20,000	20,000	20,000	20,000	20,000
Ferrosilicon	70,000	50,000	50,000	50,000	50,000
Silicomanganese	35,000	35,000	35,000	35,000	35,000
Other	5,000	5,000	5,000	--	--
Total	148,000	116,000	116,000	107,000	107,000
Slovenia, electric furnace:					
Ferrosilicon[e]	8,000	8,000	8,000	9,000	9,000
Other[e, 7]	200	200	200	--	--
Total[e]	8,200	8,200	8,200	9,000	9,000
South Africa, electric furnace:					
Ferrochromium	2,574,000	2,141,000	2,351,122	2,813,000 [r]	3,100,000
Ferromanganese	596,873	498,000	618,954 [r]	607,362 [r]	640,000
Ferrosilicon	108,500	107,600	141,700	139,800 [r]	155,000
Ferrovanadium	18,000 [e]	18,184	25,227	27,172 [r]	28,000
Silicomanganese	310,000	253,000	315,802 [r]	313,152 [r]	340,000
Silicon metal	40,600	39,400	42,500 [r]	48,900 [r]	49,000
Other[e, 17]	30,000	64,000	-- [r]	5,386 [r]	6,000
Total	3,677,973	3,121,184	3,495,305 [r]	3,954,772 [r]	4,320,000
Spain, electric furnace:[e]					
Ferrochromium	905 [6]	--	--	--	--
Ferromanganese	10,000	10,000	10,000	10,000	10,000
Ferrosilicon	40,000	40,000	40,000	40,000	40,000

See footnotes at end of table.

TABLE 6—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons of gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2000	2001	2002	2003	2004[e]
Spain, electric furnace—Continued:[e]					
Silicomanganese	100,000	100,000	100,000	100,000	100,000
Silicon metal	30,000	30,000	30,000	30,000	30,000
Other	5,000	5,000	5,000	5,000	5,000
Total	186,000	185,000	185,000	185,000	185,000
Sweden, electric furnace:					
Ferrochromium	135,841	109,198	118,823	110,529	128,191 [6]
Ferrosilicon[e]	20,000 [6]	22,000	23,000	24,000	24,000
Total	155,841	131,198	141,823	134,529	152,000
Taiwan, electric furnace, ferrosilicon	2,975	1,181	--	--	--
Turkey, electric furnace:					
Ferrochromium	97,640	50,735	11,200 [e]	35,393	33,686 [6]
Ferrosilicon	--	5,895	7,245	7,000 [e]	10,000
Total	97,640	56,630	18,445	42,393	43,700
Ukraine:					
Blast furnace:[e]					
Ferromanganese	85,400	85,000	85,000	85,000	85,000
Spiegeleisen	5,400	5,000	5,000	5,000	5,000
Electric furnace:					
Ferromanganese	252,679	231,000	250,617	250,000 [e]	375,990 [6]
Ferronickel[e]	10,800	41,000	31,000	52,000	78,000
Ferrosilicon	323,417	231,000	250,617	250,000 [e]	248,060 [6]
Silicomanganese	684,040	702,389	732,592	740,000 [e]	1,060,000 [6]
Other[e]	25,000	25,000	25,000	25,000	25,000
Total	1,386,736	1,320,389	1,379,826	1,410,000 [e]	1,880,000
United States, electric furnace:					
Ferrochromium[18]	W	W	W	W	W
Ferromanganese[19]	W	W	W	W	W
Ferrosilicon	250,000 [e]	190,827	181,832	147,964 [r]	170,592 [6]
Silicon metal	175,000 [e]	131,047	108,494	133,680 [r]	144,489 [6]
Other[20]	W	W	W	W	W
Total	425,000 [e]	321,874	290,326	281,644 [r]	315,081 [6]
Uruguay, electric furnace, ferrosilicon[e]	200	200	200	200	200
Venezuela, electric furnace:					
Ferromanganese	15,655	12,715	12,000 [e]	12,000 [e]	15,000
Ferronickel	133	32,300	51,700	57,300	57,300
Ferrosilicon	56,926	46,236	99,576	90,543	92,000
Silicomanganese	69,735	56,640	36,974	30,632	35,000
Total	142,449	147,891	200,250	190,475	199,000
Zimbabwe, electric furnace:					
Ferrochromium	246,324	243,584	258,164	245,200	193,077 [6]
Ferrochromiumsilicon	19,631	16,848	--	--	--
Total	265,955	260,432	258,164	245,200	193,077 [6]

See footnotes at end of table.

TABLE 6—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons of gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2000	2001	2002	2003	2004[e]
Grand total	19,800,000 [r]	19,000,000 [r]	20,100,000 [r]	22,300,000 [r]	25,500,000
Of which:					
Blast furnace:					
Ferromanganese	973,000 [r]	941,000 [r]	991,000 [r]	917,000 [r]	694,000
Spiegeleisen	12,400	12,000	12,000	12,000	12,000
Other[21]	104,000	104,000	104,000	104,000	104,000
Total, blast furnace	1,090,000 [r]	1,060,000 [r]	1,110,000 [r]	1,030,000 [r]	810,000
Electric furnace:					
Ferrochromium[22]	5,750,000	4,680,000	5,030,000 [r]	6,070,000 [r]	6,650,000
Ferrochromiumsilicon	97,600 [r]	117,000 [r]	127,000 [r]	123,000 [r]	125,000
Ferromanganese[23]	2,860,000	2,860,000	2,830,000	3,050,000 [r]	3,610,000
Ferronickel	867,000	954,000 [r]	1,020,000 [r]	1,070,000 [r]	1,080,000
Ferrosilicon	4,250,000 [r]	4,040,000 [r]	4,230,000 [r]	4,900,000	5,630,000
Silicomanganese	3,550,000 [r]	3,780,000 [r]	4,300,000 [r]	4,450,000 [r]	5,660,000
Silicon metal	703,000 [r]	604,000 [r]	611,000 [r]	642,000	660,000
Other[23]	631,000 [r]	939,000 [r]	801,000 [r]	951,000 [r]	1,320,000
Total, electric furnace	18,700,000 [r]	18,000,000 [r]	18,900,000 [r]	21,300,000 [r]	24,700,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through August 16, 2005.

[3]In addition to the countries listed, Iran is believed to have produced ferromanganese, ferromolybdenum, and silicomanganese, but production information is inadequate for the formulation of estimates of output levels.

[4]To the extent possible, ferroalloy production of each country has been separated according to the furnace from which production is obtained; production derived from metallothermic operation is included with electric furnace production.

[5]To the extent possible, ferroalloy production of each country has been separated to show the following individual major types of ferroalloys: ferrochromium, ferrochromiumsilicon, ferromanganese, ferronickel, ferrosilicon, silicomanganese, silicon metal, and spiegeleisen. Ferroalloys other than those listed that have been identified specifically in sources, as well as those ferroalloys not identified specifically, but which definitely exclude those listed previously in this footnote, have been reported as "Other." Where one or more of the individual ferroalloys listed separately in this footnote have been inseparable from other ferroalloys owing to a nation's reporting system, deviations are indicated by individual footnotes.

[6]Reported figure.

[7]Includes calcium-silicon.

[8]Includes high- and low-carbon ferrochromium.

[9]Includes, if any, silicospiegeleisen.

[10]Includes, if any, ferrochromiumsilicon, ferronickel, and silicomanganese.

[11]Hungary is believed to produce some blast furnace ferromanganese.

[12]Includes charge chrome and ferrochrome.

[13]Excludes calcium-silicon.

[14]Includes high- and low-carbon ferrochromium and ferrochromiumsilicon.

[15]Includes calcium-silicon, ferrocolumbium, ferromolybdenum, ferrotungsten, ferrovanadium, and other ferroalloys.

[16]Salable products from Cía Minera Autlán S.A. de C.V.

[17]Includes, if any, ferronickel.

[18]U.S. output of ferrochromium includes chromium metal, high- and low-carbon ferrochromium, ferrochromiumsilicon, and other chromium materials.

[19]U.S. output of ferromanganese includes manganese metal and silicomanganese.

[20]May include ferroboron, ferrocolumbium, ferromolybdenum, ferrophosphorus, ferrotitanium, ferrovanadium, nickel columbium, and silvery pig iron.

[21]Includes ferrophosphorus and data contained in "Blast furnace: Other."

[22]Ferrochromium includes ferrochromiumsilicon, if any, for Japan, South Africa, and the United States.

[23]Includes ferromolybdenum and ferrovanadium.