

FERROALLOYS

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Ferroalloys are alloys of iron in which one or more chemical elements are added into molten metal, usually in steelmaking. The top six ferroalloy-producing countries in 2003, in decreasing order of production, were China, South Africa, Ukraine, Kazakhstan, Russia, and Norway, the same as in 2002. Ferroalloys impart distinctive qualities to steel and cast iron or serve important functions during the production cycle.

The ferroalloy industry is closely associated with the iron and steel industry, the largest consumer of its products. World production in 2003 of the bulk ferroalloys—chromium, manganese, and silicon—was estimated to be 19.9 million metric tons (Mt), an 11% increase compared with the revised figure for 2002. U.S. bulk ferroalloy reported consumption in 2003 was 1.1 Mt. Compared with that of 2002, ferrochromium consumption increased 5%, while other bulk ferroalloys—manganese (including silicomanganese) and ferrosilicon—consumption decreased 9% and 5%, respectively. U.S. total ferroalloy production, as reported in table 6, decreased by 5%, while U.S. total ferroalloy imports (table 5) rose by 31% and exports (table 5) dropped by 49%. These percentages reflect a recovery in the U.S. steel industry in the latter part of 2003.

The principal ferroalloys are those of chromium, manganese, and silicon. Manganese is essential to the production of virtually all steels and is important to the production of cast iron. Manganese is used to neutralize the harmful effect of sulfur and as an alloying element. Silicon is used primarily for deoxidation in steel and as an alloying element in cast iron. Boron, chromium, cobalt, columbium (niobium), copper, molybdenum, nickel, phosphorus, titanium, tungsten, vanadium, zirconium, and the rare-earth elements are among the other elements contributing to the character of the various alloy steels and cast irons (Brown and Murphy, 1985, p. 265).

Compared with that of major ferroalloy-producing countries, U.S. ferroalloy production was moderate in silicon and manganese and relatively low in other ferroalloy metals. Consequently, U.S. ferroalloy production meets only a small percentage of domestic demand. One important exception is silicon ferroalloys. U.S. production of ferrosilicon, which included miscellaneous silicon alloys, was approximately 40% of apparent consumption of ferrosilicon in 2003. U.S. production of silicon metal, excluding semiconductor-grade material, was about 60% of apparent consumption of silicon metal in 2003.

In countries with competitive mineral resources, the trend is toward increased production of value-added products, particularly in the case of chromium. U.S. production is unlikely to expand because U.S. mineral resources for most of the ferroalloy metals are less competitive. The overall domestic ferroalloy production trend, therefore, is one of decline. By 1999, U.S. production of ferronickel and common grades of ferrochromium had ceased. In both cases, production stopped because resources were low grade, producers were relying on imported ore for feedstock, and operating costs were high. In

contrast, ferrosilicon and manganese ferroalloy production have fluctuated, with ferrosilicon production decreasing and manganese ferroalloy production generally increasing during the past 7 years, with the exception of 2003.

Chromium, manganese, silicon, and other ferroalloys 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. The tables in this chapter contain information on all ferroalloys for which data are available.

Ferrochromium

The major world chromite ore-producing countries in 2003 were India (more than 2 Mt), Kazakhstan (also more than 2 Mt), and South Africa (more than 7 Mt). In excess of 90% of chromite ore was smelted in electric-arc furnaces to produce ferrochromium for use by the metallurgical industry. The major world ferrochromium-producing countries were Kazakhstan (1 Mt), and South Africa (more than 2 Mt). Stainless steel manufacture consumed most of the 5.7 Mt of ferrochromium produced. Europe (primarily Western Europe and Scandinavia including Belgium, Finland, France, Germany, Italy, Spain, Sweden, and the United Kingdom), Asia (Japan, Korea, and Taiwan) and the United States—the major stainless steel producing areas of the world—account for about 80% of world stainless steel production.

The ferrochromium industry developed in close proximity to the stainless steel industry. However, the closing of ferrochromium facilities in these historically producing areas has resulted in the migration of ferrochromium production to chromite-producing areas. The world chromium industry in 2003 operated with production capacity in excess of demand. In anticipation of demand growth, new ferrochromium-producing plants were brought into production, under construction, or planned in South Africa. Four industry trends were evolving—ferrochromium production using environmentally friendly, energy- and recovery-efficient, prerreduction, closed-furnace processes; chromium recovery from ferrochromium slag; consolidation of ownership in both the ferrochromium and stainless steel production industries; and strategic alliances between the latter two industries.

Ferromanganese

Manganese ferroalloys, consisting of various grades of ferromanganese and silicomanganese, are used to provide a key ingredient for steelmaking (Matricardi and Downing, 1995, p. 970). Most U.S. supply was imported. The leading foreign source of ferromanganese and silicomanganese was South Africa, whose exports of manganese ferroalloys to the United States were greater than those of the next five largest importing

countries combined (Australia, Brazil, France, Mexico, and Norway). Manganese ferroalloys were produced domestically mainly at a plant near Marietta, OH, which was owned by France's Eramet Group, with some production at Highlanders Alloys LLC plant located at New Haven, WV, which ceased production in January 2003. Eramet Group 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, the Eramet Group controlled plants in China, France, Italy, and Norway, and BHP Billiton controlled plants in Australia and South Africa. On a country basis, China continued to be by far the largest producer of manganese ferroalloys, with an output greater than that of South Africa and Ukraine combined, the countries with the next largest production (table 6).

Ferromolybdenum

The major molybdenite ore-producing countries in 2003 were Chile, China, and the United States, accounting for about 75% of world production. Other significant ore-producing countries, including Armenia, Canada, Mexico, and Peru, supplied an additional 19% of world production. Molybdenite ore is roasted to form molybdic oxide which can be converted into ferromolybdenum, molybdenum chemicals, or metal. About one-third of the molybdenum consumed in the United States was in the form of molybdic oxides, and about one-fourth was as ferromolybdenum. Although the United States was the leading molybdenum-producing country in the world, it imported more than 98% of its ferromolybdenum requirements in 2003. Overall, the steel industry accounted for about 75% of all molybdenum consumed in the United States in 2003, principally in the production of stainless steel and full alloy steel.

Ferrosilicon

Demand for silicon ferroalloys is driven principally by the production of steel and cast iron (Dosaj, 1997, p. 1115). On the basis of silicon content, U.S. production of silicon ferroalloys (ferrosilicon and miscellaneous silicon alloys) and silicon metal decreased by 5% to 248,000 metric ton (t) from 261,000 t in 2002. Ferrosilicon imports in 2003 increased significantly. U.S. net production of silicon ferroalloys and metal in 2003 decreased by 6% from that of 2002 (table 6). China was estimated to be the world's largest producer of ferrosilicon, with production almost twice that of the next two largest producing countries combined, Norway and Russia. While some silicon metal was used as an alloying agent with iron in 2003, the bulk of it was used as an alloying agent with aluminum and in the production of chemicals, especially silicones.

Ferrotitanium

Titanium is used in steelmaking for deoxidation, grain-size control, and carbon and nitrogen control and stabilization. During steelmaking, titanium is introduced usually in the form of ferrotitanium because of its lower melting point and higher density when compared with those of titanium scrap. World

ferrotitanium production capacity is led by, in descending capacity order, the United Kingdom, Russia, Japan, and the United States. Domestic producers of ferrotitanium were Global Titanium, Inc. (Detroit, MI) and Galt Alloys Inc. (North Canton, OH). Consumption by the steel industry was largely associated with the production of stainless steels. In 2003, a shortage of titanium scrap caused ferrotitanium prices to rise. The yearend price for ferrotitanium with 70% contained titanium was about \$3.10 per pound, a 43% increase compared with that of 2002. Imports of ferrotitanium and ferro-silicon-titanium were 3,160 t, a 15% decrease compared with those of 2002.

Ferrovandium

The major vanadium-producing countries in 2003 were China and South Africa, accounting for about 84% of world production, with Russia, the other significant vanadium-producing country, accounting for an additional 14%. Vanadium is primarily recovered from titaniferous magnetite ore processed to produce liquid pig iron in these three countries. The process also produces a vanadium-bearing slag, which can be further processed to 40% to 50% vanadium-content ferrovandium. Vanadium oxides, recovered from petroleum residues, ashes, and poisoned refinery catalysts, represented the only vanadium recovered in the United States in 2003 as there was no primary production. Vanadium oxides were used to produce catalysts, chemicals, and 75% to 80% vanadium-content ferrovandium. The world vanadium industry in 2003 operated with production capacity in excess of demand with petroleum-based vanadium recovery (residues, ashes, catalysts) continuing to grow. The steel industry accounted for about 92% of all vanadium consumed in the United States in 2003, principally in carbon, full alloy and high-strength, low-alloy steels. About 72% of the vanadium consumed was as ferrovandium, and the United States imported about 80% of its ferrovandium requirements in 2003.

Outlook

Alternative materials, principally alloy scrap and oxide, 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.

U.S. customer needs for ferroalloys in alloy and stainless steel for many applications have been and will continue to be strong. The steel industry will continue to improve processing technology to reduce raw material needs and develop steel grades with lower alloying metal content that equals or betters performance, while lowering materials costs. For many stainless steel applications, there are no acceptable substitutes, and their key constituents, chromium and nickel, are essential. As technology and industry practices result in more efficient use of ferroalloys, strong demand for metals in construction, the chemical industry, transportation, and household appliances

is expected to more than offset any basic reduction in unit consumption. Competition from other materials, such as plastics and nonferrous metals in the transportation sector, will be strong, but the use of lightweight, high-strength steel is expected to keep the ferroalloys industry competitive for many years (Sibley and others, 2001, p. 40).

References Cited

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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, 2003^{1,2}

(Metric tons of alloy unless otherwise specified)

Alloy	Inventory
Ferrochromium:	
High-carbon	466,000
Low-carbon	217,000
Ferromanganese, high carbon	700,000
Ferrotungsten, contained tungsten	kilograms 263,000

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

²Data are uncommitted inventory.

Source: Defense National Stockpile Center.

TABLE 2
REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2003^{1,2}

(Metric tons of alloys unless otherwise specified)

End use	Manganese					
	FeB	FeMn	SiMn	FeP	FeSi	FeTi
Steel:						
Carbon and high-strength low-alloy	576	208,000	58,900	3,870	16,300 ^{3,4}	3,690
Stainless and heat-resisting	244	8,550	11,700	--	46,800 ³	3,050
Other alloy	(5)	21,200	19,500	830	5,850 ³	153
Tool	--	(3)	(3)	--	26,800 ³	(6)
Unspecified	--	1,600	738	(6)	35,100 ⁷	--
Total steel	820	239,000	90,800	4,700	131,000	6,890
Cast irons	--	7,930	700	1,150	114,000	38
Superalloys	66	(4)	--	(7)	82 ^{7,8}	1,160
Alloys (excluding alloy steels and superalloys)	415	1,240	(4)	(7)	177,000 ^{4,8}	734
Miscellaneous and unspecified	--	(4)	(4)	--	55,100 ⁷	(7)
Grand total	1,300	248,000	91,500	5,850	477,000	8,820
Total 2002	1,260 ^r	272,000 ^r	84,200 ^r	6,080 ^r	500,000	8,170 ^r
Percentage of 2002	103	91	109	96	95	108
Consumer stocks, December 31	263	24,500	6,050	877	14,100	756

^rRevised. NA Not available. -- Zero.

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

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

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

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

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

⁶Included with "Steel, other alloy."

⁷All or part included with "Cast irons."

⁸Part included with "Miscellaneous and unspecified."

TABLE 3
REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2003^{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	3,550 ³	474	2,100	--	1,710	(4)
Stainless and heat-resisting	205,000	830	612	13,600	64	(4)
Other alloy	14,400 ⁵	1,920	(6)	W	799	(4)
Tool	3,480	W	(6)	W	143	(4)
Unspecified	W	--	--	--	--	(4)
Total	226,000	3,230	2,710	13,600	2,710	288
Cast irons	W	321	W	(7)	W	--
Superalloys	6,550	20	933	--	10	(4)
Alloys (excluding alloy steels and superalloys)	1,290	78	W	18	W	(4)
Miscellaneous and unspecified	13,200 ⁸	99	8	--	235	--
Grand total	247,000	3,750	3,650	13,700	2,960	288
Total 2002	236,000 ^r	3,560 ^r	3,150	12,500	3,080	285
Percentage of 2002	105	105	116	109	96	101
Consumer stocks, December 31	9,970	206	NA	745	195	32

^rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified." -- Zero.

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

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

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

⁴Included with "Steel, total."

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

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

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

⁸Includes cast irons, electric steel, and unspecified uses.

TABLE 4
FERROALLOY PRICES IN 2003

	High	Low	Average ¹
Chromium:			
Ferrochromium:			
0.05% carbon ²	83.00	70.00	73.07
0.10% carbon ²	75.00	60.00	62.39
0.15% carbon ²	70.00	56.00	59.76
Over 4% carbon:			
50-55% chromium ²	57.00	34.00	44.29
60-65% chromium ²	57.00	33.50	43.67
Columbium, ferrocolumbium ³	6.70	6.45	6.58
Manganese:			
Medium-carbon ferromanganese ²	53.00	40.00	43.29
Standard-grade ferromanganese ⁴	605.00	455.00	493.78
Silicomanganese ⁵	33.00	23.00	27.26
Molybdenum:			
Ferromolybdenum ⁶	9.00	4.50	5.90
Molybdenum oxide ⁶	7.80	3.15	5.29
Silicon:			
50% ferrosilicon ²	56.00	42.00	47.74
75% ferrosilicon ²	50.00	38.00	45.22
Silicon metal ⁵	66.00	58.00	61.27
Vanadium, ferrovandium ⁶	6.00	4.00	5.26

See footnotes at end of table.

TABLE 4--Continued
FERROALLOY PRICES IN 2003

- ¹Annual time-weighted average.
²Cents per pound of contained element.
³Yearend average value in dollars per pound of contained columbium (niobium), standard (steelmaking) grade.
⁴Dollars per long ton.
⁵Cents per pound.
⁶Dollars 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 2003¹

(Metric tons unless otherwise specified)

Alloy	Imports			Exports		
	Gross weight	Contained weight	Value (thousands)	Gross weight	Contained weight	Value (thousands)
Ferroalloys:						
Chromium ferroalloys:						
Ferrochromium containing:						
More than 4% carbon	366,000	210,000	\$162,000	3,180	1,930	\$2,720
Not more than 4% carbon	XX	XX	XX	1,230	733	2,000
More than 3% but not more than 4% carbon	--	--	--	XX	XX	XX
More than 0.5% but not more than 3% carbon	5,340	3,420	3,200	XX	XX	XX
Not more than 0.5% carbon	19,500	13,400	24,100	XX	XX	XX
Ferrochromium-silicon	38,700	16,200	24,900	481	168	511
Total	429,000	243,000	214,000	4,890	2,830	5,240
Manganese ferroalloys:						
Ferromanganese containing:						
More than 4% carbon	167,000	130,000	65,200	XX	XX	XX
More than 2% but not more than 4% carbon	59	50	27	XX	XX	XX
More than 1% but not more than 2% carbon	48,600	39,100	32,600	XX	XX	XX
Not more than 1% carbon	22,400	19,000	19,500	XX	XX	XX
Ferromanganese, all grades	238,000	187,000	117,000	10,600	XX	8,840
Silicomanganese	267,000	182,000	133,000	606	XX	554
Total	743,000	557,000	367,000	11,200	XX	9,390
Silicon ferroalloys:						
Ferro-silicon containing:						
More than 90% silicon	66	53	30	5,820	3,500	5,070
More than 55% but not more than 80% silicon and more than 3% calcium	2,040	1,310	1,810	XX	XX	XX
More than 55% but not more than 80% silicon and not more than 3% calcium	225,000	169,000	151,000	XX	XX	XX
Magnesium ferro-silicon	30,300	13,900	22,700	XX	XX	XX
Ferro-silicon, other ²	12,200	4,910	7,570	5,780	2,860	5,370
Total	269,000	189,000	183,000	11,600	6,370	10,400
Other ferroalloys:						
Ferrocerium and other pyrophoric alloys and other	115	XX	1,650	XX	XX	XX
Ferrocolumbium	6,280	XX	54,700	143	XX	1,430
Ferromolybdenum	5,740	3,690	37,500	1,030	617	8,660
Ferronickel	33,000	13,100	109,000	277	182	2,520
Ferrophosphorus	11,700	XX	2,250	787	XX	511
Ferrotitanium and ferro-silicon-titanium	3,160	XX	9,670	967	XX	2,930
Ferrotungsten and ferro-silicon-tungsten	488	377	2,380	105	59	214
Ferrovandium	1,690	1,360	14,300	538	397	5,420
Ferrozirconium	154	XX	245	1,930	XX	2,030
Ferroalloys, other	16,200	XX	19,000	1,350	XX	2,470
Total	78,500	18,500	251,000	7,130	1,250	26,200
Total ferroalloys	1,520,000	1,010,000	1,020,000	34,800	10,500	51,200

See footnotes at end of table.

TABLE 5--Continued
U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF FERROALLOYS AND FERROALLOY METALS IN 2003¹

(Metric tons unless otherwise specified)

Alloy	Imports			Exports		
	Gross weight	Contained weight	Value (thousands)	Gross weight	Contained weight	Value (thousands)
Metals:						
Chromium (total, all grades)	8,570	XX	\$45,200	941	XX	\$11,900
Manganese, other:						
Unwrought	17,000	XX	18,200	XX	XX	XX
Other	2,790	XX	2,610	XX	XX	XX
Silicon:						
Less than 99% silicon	41,000	39,900	35,500	9,600	9,320	16,800
Less than 99.99% but not less 99% silicon	104,000	104,000 ³	125,000	2,250	2,230	4,330
Not less than 99.99% silicon	1,410	XX	75,900	8,290	XX	347,000
Total	175,000	144,000	303,000	21,100	11,500	380,000
Grand total	1,690,000	1,150,000	1,320,000	55,900	22,100	431,000

XX Not applicable. -- Zero.

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

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

³Data adjusted by the U.S. Geological Survey.

Source: U.S. Census Bureau.

TABLE 6
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1,2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3,4,5}	1999	2000	2001	2002	2003 ^e
Albania, electric furnace ferrochromium	28,120	12,500	11,900	22,100 ^r	37,800 ⁶
Argentina, electric furnace:					
Ferrosilicon	2,568	2,500 ^e	2,740	1,072 ^r	1,100
Silicomanganese	--	4,900	5,150	5,000 ^e	5,000
Silicon metal ^e	8,000 ⁶	8,000	8,000	8,000	8,000
Other ⁷	13,850	16,900	9,925	17,289 ^r	15,000
Total	24,418	32,300	25,815	31,361 ^r	29,100
Australia, electric furnace:^e					
Ferromanganese	98,000	115,000	115,000	115,000	115,000
Silicomanganese	116,000	135,000	135,000	135,000	135,000
Silicon metal	30,000	30,000	30,000	30,000	30,000
Total	244,000	280,000	280,000	280,000	280,000
Austria, electric furnace:^e					
Ferronickel	4,250	4,200	4,000	4,000	4,000
Other	5,000	5,000	4,000	4,000	4,000
Total	9,250	9,200	8,000	8,000	8,000
Bhutan, electric furnace, ferrosilicon^c					
	18,000	15,000	16,000	21,000 ^r	21,000
Bosnia and Herzegovina, electric furnace:^c					
Ferrosilicon	1,000	1,000	1,000	1,000	1,000
Silicon metal	200	200	200	200	--
Total	1,200	1,200	1,200	1,200	1,000
Brazil, electric furnace:					
Ferrochromium ⁸	90,784	172,443 ^r	110,468 ^r	164,140 ^r	196,032 ⁶
Ferrochromiumsilicon ^c	5,000	5,000	5,000	5,000	5,000
Ferromanganese	110,000 ^r	121,277	96,016	149,000 ^r	145,000
Ferronickel	19,807	19,315	17,966	19,874 ^r	19,378 ⁶
Ferrosilicon	200,833	188,735	159,345	159,400 ^r	160,000
Silicomanganese	116,822	171,304	180,235	180,200 ^r	180,000
Silicon metal	120,000	166,344	112,123	112,100 ^r	112,000
Other ^e	76,000	76,000	76,000	76,000	76,000
Total	739,246 ^r	920,418 ^r	757,153 ^r	865,714 ^r	893,000

See footnotes at end of table.

TABLE 6--Continued
 FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1,2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3,4,5}	1999	2000	2001	2002	2003 ^c
Bulgaria, electric furnace:^c					
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:^c					
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	2,833	4,011	2,213 ^r	2,500 ^{r, e}	2,600
Ferromolybdenum	2,079	1,454	1,784 ^r	1,784 ^r	3,170 ⁶
Ferrosilicon	1,000	1,100	1,100 ^e	1,100 ^e	1,100
Silicomanganese	2,048	1,800	1,800 ^e	1,800 ^e	1,800
Total	7,960	8,365	6,897 ^r	7,184 ^r	8,670
China:^c					
Blast furnace:					
Ferromanganese	550,000	500,000	500,000	500,000	550,000
Other	100,000	100,000	100,000	100,000	100,000
Electric furnace:					
Ferrochromium	400,000	450,000	310,000	330,000 ^r	500,000
Ferromanganese	550,000	520,000	670,000	490,000 ^r	700,000
Ferromolybdenum	38,500	44,400	37,700	29,600	29,400
Ferrosilicon	1,120,000	1,400,000	1,320,000	1,500,000	2,200,000
Silicomanganese	822,000	900,000	1,170,000	1,580,000 ^r	1,800,000
Other	220,000 ^r	116,000 ^r	392,000 ^r	310,000 ^r	461,000
Total	3,800,000	4,030,000	4,500,000	4,840,000	6,340,000
Colombia, electric furnace, ferronickel	61,137 ^r	59,129 ^r	91,475 ^r	111,952 ^r	111,324 ⁶
Croatia, electric furnace, ferrochromium	--	15,753	361	-- ^e	--
Czech Republic, electric furnace, other ^c	1,000	1,000	1,000	1,000	1,000
Dominican Republic, electric furnace, ferronickel	85,000	84,900	60,654	59,654	69,800
Egypt, electric furnace:^c					
Ferromanganese	30,000	30,000	30,000	30,000	30,000
Ferrosilicon	44,000	45,000	40,000 ^r	40,000 ^r	40,000
Total	74,000	75,000	70,000 ^r	70,000 ^r	70,000
Finland, electric furnace, ferrochromium	256,290	260,605	236,710	248,181	250,040 ⁶
France:^c					
Blast furnace, ferromanganese	302,000 ⁶	300,000	300,000	300,000	180,000
Electric furnace:					
Ferromanganese	138,000	140,000	130,000	130,000	120,000
Ferrosilicon	110,000	110,000	100,000	100,000	100,000
Silicomanganese ⁹	55,000	60,000	50,000	50,000	107,000
Silicon metal	75,000	75,000	75,000	75,000	75,000
Other	20,000	20,000	65,000	65,000	65,000
Total	700,000	705,000	720,000	720,000	647,000
Georgia, electric furnace:^c					
Ferromanganese	6,500	7,000	7,000	7,000	7,000
Silicomanganese	25,000	25,000	25,000	25,000	25,000
Total	31,500	32,000	32,000	32,000	32,000
Germany, electric furnace:^c					
Ferrochromium	16,960 ⁶	21,600 ⁶	19,308 ⁶	20,018 ⁶	18,318 ⁶
Silicon metal	20,000	26,000	25,000	25,000	25,000
Other ¹⁰	30,000	30,000	32,000	30,000	30,000
Total	67,000	77,600	76,300	75,000	73,300
Greece, electric furnace, ferronickel	59,545	81,662	84,200 ^e	91,600 ^e	90,000
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	1,000
Total	8,000	8,000	8,000	8,000	8,000

See footnotes at end of table.

TABLE 6--Continued
 FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1,2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3,4,5}	1999	2000	2001	2002	2003 ^c
Iceland, electric furnace, ferrosilicon	70,900	70,000 ^e	111,948	112,000 ^e	115,000
India, electric furnace:^e					
Ferrochromium ¹²	312,140 ⁶	376,693 ⁶	267,395 ⁶	311,927 ⁶	468,677 ⁶
Ferrochromiumsilicon	10,000	10,000	10,000	10,000	10,000
Ferromanganese	160,000	160,000	165,000	165,000	165,000
Ferrosilicon	55,000	60,000	50,000	52,000	54,000
Silicomanganese	190,000	185,000	150,000	150,000	160,000
Other	9,000	9,000	9,000	9,000	9,000
Total	736,000	801,000	651,000	698,000	867,000
Indonesia, electric furnace:					
Ferromanganese ^e	12,000	12,000	12,000	12,000	12,000
Ferronickel	44,068	47,749	47,769	42,306	44,660 ⁶
Silicomanganese ^e	7,000	7,000	7,000	7,000	7,000
Total	63,068	66,749	66,769	61,306 ^r	63,700
Iran, electric furnace:					
Ferrochromium	13,680	11,505	8,430	15,000	17,000 ⁶
Ferrosilicon ^e	46,000	40,000	40,000	41,700 ^r	40,000
Total ^e	59,700	51,500	48,400	56,700 ^r	57,000
Italy, electric furnace:^e					
Ferromanganese	19,000 ⁶	40,000	40,000	40,000	40,000
Silicomanganese	67,000	90,000	90,000	90,000	90,000
Silicon metal	6,257 ⁶	5,000	6,000	6,000	6,000
Other ¹³	10,000	10,000	10,000	10,000	10,000
Total	102,000	145,000	146,000	146,000	146,000
Japan, electric furnace:					
Ferrochromium ¹⁴	119,777	130,074	111,167	91,937	26,000
Ferromanganese	315,152	337,694	368,293	356,717	375,000
Ferronickel	332,293	367,181	367,739	370,973	369,099 ⁶
Ferrosilicon	1,452	--	--	--	--
Silicomanganese	65,744	67,926	62,238	70,965	60,000
Other ¹⁵	12,860	15,020	12,940	12,352	12,000
Total	847,278	917,895	922,377	902,944	842,000
Kazakhstan, electric furnace:					
Ferrochromium	731,563	799,762	761,900	835,800	993,000 ⁶
Ferrochromiumsilicon	49,282	55,634	79,800	102,200	98,130 ⁶
Ferromanganese	--	1,075	5,349	2,278	1,931 ⁶
Ferrosilicon	140,263	133,269	145,800	127,300	127,160 ⁶
Silicomanganese	78,495	102,719	141,200	164,000	178,920 ⁶
Other ^e	9,000	9,000	9,000	9,000	9,000
Total	1,008,603	1,101,459	1,143,049	1,240,578	1,408,141 ⁶
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	140,208	146,373	143,525	137,000 ^{r,c}	140,000
Silicomanganese	116,091	103,522	101,877	94,000 ^{r,c}	100,000
Other	4,639	4,676	4,452	-- ^r	--
Total	260,938	254,571	249,854	231,000 ^{r,c}	240,000
Macedonia, electric furnace:^e					
Ferronickel	5,000 ⁶	--	10,300	17,000	19,000
Ferrosilicon	50,000	50,000	50,000	50,000	50,000
Total	55,000	50,000	60,300	67,000	69,000
Mexico, electric furnace:¹⁶					
Ferromanganese	79,552	90,501	60,014	38,532 ^r	55,903 ⁶
Silicomanganese	113,917	107,923	74,290	73,263 ^r	81,223 ⁶
Total	193,469	198,424	134,304	111,795 ^r	137,126 ⁶

See footnotes at end of table.

TABLE 6--Continued
 FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1,2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3,4,5}	1999	2000	2001	2002	2003 ^c
New Caledonia, electric furnace, ferronickel ^e	157,592 ⁶	157,000	162,000	171,000	175,000
Norway, electric furnace: ^c					
Ferromanganese	159,714 ⁶	153,500 ⁶	82,600 ⁶	61,100 ⁶	--
Ferrosilicon	235,000	235,000	240,000	240,000	245,000
Silicomanganese	460,000	460,000	450,000	390,000 ^r	350,000
Silicomanganese	230,000	230,000	230,000	230,000	230,000
Silicon metal	100,000	100,000	100,000	105,000 ^r	100,000
Other ⁹	15,000	15,000	15,000	15,000	15,000
Total	1,200,000	1,190,000	1,120,000	1,040,000 ^r	940,000
Peru, electric furnace, ferrosilicon ^e	600	600	600	600	600
Poland:					
Blast furnace, ferromanganese ^e	100	--	500	600 ^r	600
Electric furnace:					
Ferrosilicon	62,481	56,000	48,600	42,000 ^{r,c}	45,000
Silicomanganese	10,000	19,000	20,000	7,000 ^{r,c}	10,000
Silicon metal ^c	1,200	1,500	1,500	1,500	1,500
Other ^c	2,700	2,700	--	--	--
Total	76,481	79,200	70,600	51,100 ^{r,c}	57,100
Romania, electric furnace:					
Ferromanganese	25 ^c	1,044	384	--	--
Ferrosilicon	5,000 ^c	5,000 ^c	5,823	--	--
Silicomanganese	550 ^c	21,158	71,921	88,665	85,000
Total	5,575	27,202	78,128	88,665	85,000
Russia: ^e					
Blast furnace:					
Ferromanganese	90,000	70,700	70,000	80,000	85,000
Ferrophosphorus	3,500	3,500	3,500	3,500	3,500
Spiegeleisen	7,000	7,000	7,000	7,000	7,000
Electric furnace:					
Ferromanganese	249,000 ⁶	274,000 ⁶	210,600 ⁶	210,000 ⁶	357,000 ⁶
Ferromanganese	4,500	4,500	4,000	4,000	4,000
Ferrochromium	33,000	35,000	30,000	30,000	30,000
Ferrosilicon	601,000 ⁶	652,000 ⁶	707,100 ⁶	701,000	760,000
Ferrovanadium	16,000	20,500	18,800	15,100	8,000
Silicon metal	40,000	40,000	40,000	40,000	45,000
Other	24,000 ^r	19,500 ^r	16,200 ^r	14,900 ^r	22,000
Total	1,070,000	1,130,000	1,110,000	1,110,000	1,320,000
Saudi Arabia, electric furnace, other ^e	83,000	83,000	78,000	75,000	75,000
Slovakia, electric furnace: ^e					
Ferromanganese	6,986 ⁶	17,702 ⁶	5,968 ⁶	5,695 ⁶	1,924 ⁶
Ferromanganese	20,000	20,000	20,000	20,000	20,000
Ferrosilicon	50,000	70,000	50,000	50,000	50,000
Silicomanganese	35,000	35,000	35,000	35,000	35,000
Other	5,000	5,000	5,000	5,000	--
Total	117,000	148,000	116,000	116,000	107,000
Slovenia, electric furnace:					
Ferromanganese	560	--	--	--	--
Ferrosilicon ^c	8,000	8,000	8,000	8,000	9,000
Other ^{c,7}	200	200	200	200	--
Total ^c	8,760	8,200	8,200	8,200	9,000
South Africa, electric furnace:					
Ferromanganese	2,155,202	2,574,000	2,141,000	2,351,122 ^r	2,470,000
Ferromanganese	527,000	596,873	498,000	619,000 ^r	650,000
Ferrosilicon	106,000	108,500 ^r	107,600 ^r	141,700 ^r	145,000
Ferrovanadium	6,000 ^c	18,000 ^c	18,184 ^r	25,227 ^r	28,000
Silicomanganese	267,000	310,000	253,000	276,000 ^r	375,000
Silicon metal	35,800	40,600	39,400 ^r	43,000 ^r	45,000
Other ^{c,17}	32,000	30,000	64,000 ^r	82,000 ^r	87,000
Total	3,129,002	3,677,973 ^r	3,121,184 ^r	3,538,049 ^r	3,800,000

See footnotes at end of table.

TABLE 6--Continued
 FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1,2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3,4,5}	1999	2000	2001	2002	2003 ^c
Spain, electric furnace: ^e					
Ferrochromium	935 ⁶	905 ⁶	--	--	--
Ferromanganese	10,000	10,000	10,000	10,000	10,000
Ferrosilicon	40,000	40,000	40,000	40,000	40,000
Silicomanganese	95,000	100,000	100,000	100,000	100,000
Silicon metal	28,000	30,000	30,000	30,000	30,000
Other	5,000	5,000	5,000	5,000	5,000
Total	179,000	186,000	185,000	185,000	185,000
Sweden, electric furnace:					
Ferrochromium	113,140	135,841	109,198	118,823	110,529 ⁶
Ferrosilicon	21,440	20,000	22,000 ^e	23,000 ^e	24,000
Total	134,580	155,841	131,198	141,823	135,000
Taiwan, electric furnace, ferrosilicon					
	3,212	2,975	1,181	--	--
Turkey, electric furnace:					
Ferrochromium	99,105	97,640	50,735	11,200 ^e	35,393 ⁶
Ferrosilicon	420	--	5,895	7,245	7,000
Total	99,525	97,640	56,630	18,445	42,400
Ukraine:					
Blast furnace: ^e					
Ferromanganese	57,800	85,400	85,000	85,000	85,000
Spiegeleisen	2,500	5,400	5,000	5,000	5,000
Electric furnace:					
Ferromanganese	199,539	252,679	231,000 ^f	250,617 ^f	250,000
Ferronickel ^e	--	10,800	41,000	31,000 ^f	52,000
Ferrosilicon	243,600	323,417	231,000 ^f	250,617 ^f	250,000
Silicomanganese	498,905	684,040	702,389 ^f	732,592 ^f	740,000
Other ^e	25,000	25,000	25,000	25,000	25,000
Total	1,027,344	1,386,736	1,320,389 ^f	1,379,826 ^f	1,410,000
United States, electric furnace:					
Ferrochromium ¹⁸	W	W	W	W	W
Ferromanganese ¹⁹	W	W	W	W	W
Ferrosilicon	325,000	250,000 ^e	191,000	182,000	143,000 ⁶
Silicon metal	186,000	175,000 ^e	131,000	108,000	133,000 ⁶
Other ²⁰	W	W	W	W	W
Total	511,000	425,000 ^e	322,000	290,000	276,000 ⁶
Uruguay, electric furnace, ferrosilicon ^e					
	200	200	200	200	200
Venezuela, electric furnace:					
Ferromanganese	10,694	15,655	12,715	12,000 ^e	12,000
Ferronickel	--	133	32,300	51,700 ^e	57,300
Ferrosilicon	38,886	56,926	46,236	99,576 ^f	90,543 ⁶
Silicomanganese	47,635	69,735	56,640	36,974 ^f	30,632 ⁶
Total	97,215	142,449	147,891	200,250 ^f	190,475 ⁶
Zimbabwe, electric furnace:					
Ferrochromium	244,379	246,324	243,584	258,164	245,200 ⁶
Ferrochromiumsilicon	16,267	19,631	16,848	--	--
Total	260,646	265,955	260,432	258,164	245,200 ⁶
Grand total:	17,900,000	19,600,000	18,900,000 ^f	19,900,000 ^f	22,100,000
Of which:					
Blast furnace:					
Ferromanganese	1,000,000	956,000	956,000	966,000	901,000
Spiegeleisen	9,500	12,400	12,000	12,000	12,000
Other ²¹	104,000	104,000	104,000	104,000	104,000
Total, blast furnace	1,110,000	1,070,000	1,070,000	1,080,000	1,020,000

See footnotes at end of table.

TABLE 6--Continued
 FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE^{1,2}

(Metric tons, gross weight)

Country, furnace type, and alloy type ^{3,4,5}	1999	2000	2001	2002	2003 ^c
Grand total--Continued:					
Of which--Continued:					
Electric furnace:					
Ferrochromium ²²	5,000,000	5,750,000 ^r	4,680,000	5,060,000 ^r	5,730,000
Ferrochromiumsilicon	85,000	94,800	116,000	121,000	117,000
Ferromanganese ²³	2,670,000 ^r	2,860,000	2,860,000 ^r	2,830,000 ^r	3,100,000
Ferronickel	802,000 ^r	867,000 ^r	949,000	1,000,000	1,040,000
Ferrosilicon	3,900,000	4,240,000	4,030,000 ^r	4,220,000 ^r	4,900,000
Silicomanganese ²³	2,960,000	3,430,000	3,660,000 ^r	4,130,000 ^r	4,540,000
Silicon metal	681,000	729,000	629,000	615,000 ^r	642,000
Other ²⁴	669,000	586,000	914,000 ^r	842,000 ^r	993,000
Total, electric furnace	16,800,000	18,600,000 ^r	17,800,000 ^r	18,800,000 ^r	21,100,000

⁶Estimated. ^rRevised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

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

²Table includes data available through August 20, 2004.

³In 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.

⁴To 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.

⁵To 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.

⁶Reported figure.

⁷Includes calcium-silicon.

⁸Includes high- and low-carbon ferrochromium.

⁹Includes, if any, silicospiegeleisen.

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

¹¹Hungary is believed to produce some blast furnace ferromanganese.

¹²Includes charge chrome and ferrochrome.

¹³Excludes calcium-silicon.

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

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

¹⁶Salable products from Autlán.

¹⁷Includes, if any, ferronickel.

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

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

²⁰May include ferroboration, ferrocolumbium, ferromolybdenum, ferrophosphorus, ferrotitanium, ferrotungsten, ferrovanadium, nickel columbium, and silvery pig iron.

²¹Includes ferrophosphorus and data contained in "Blast furnace, other."

²²Ferrochromium includes ferrochromium silicon, if any, for Japan, South Africa, and the United States.

²³U.S. production is included in "Other."

²⁴Includes calcium-silicon, ferromolybdenum, ferrovanadium, and silicomanganese for the United States.