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FERROALLOYS

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FERROALLOYS

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Ferroalloys are alloys with iron employed to add chemical elements into molten metal, usually during steelmaking. Ferroalloys impart distinctive qualities to steel and cast iron or serve important functions during production and are, therefore, closely associated with the iron and steel industry, the leading consumer of its products. The leading ferroalloy-producing countries in 2006 were, in decreasing order of production, China, South Africa, Ukraine, Russia, and Kazakhstan (table 6). These countries accounted for 74% of world ferroalloy production.

World production of bulk ferroalloys—chromium, manganese, and silicon—was estimated to be 26.3 million metric tons (Mt) in 2006, a 9% increase compared with the revised figure for 2005 (table 6). U.S. bulk ferroalloy reported consumption in 2006 was 0.8 Mt of manganese and silicon ferroalloys (table 2) and 0.3 Mt of contained chromium in ferrochromium (table 3). Comparing consumption with that of 2005, ferrochromium remained essentially constant, ferromanganese (including silicomanganese) increased by 5%, and ferrosilicon decreased by 8%. On a gross weight basis, U.S. total ferroalloy imports increased by 13% and exports increased 4%, which resulted in a net import increase of 13% (table 5).

Boron, chromium, cobalt, copper, molybdenum, nickel, niobium (columbium), phosphorus, silicon, titanium, tungsten, vanadium, zirconium, and the rare-earth elements are some of the alloying elements used for the characteristics they provide to steels and cast irons (Brown and Murphy, 1985, p. 265).

Ferrochromium

The major world chromite ore-producing countries in 2006 were India (more than 3 Mt), Kazakhstan (more than 3 Mt), and South Africa (more than 7 Mt). More than 95% of chromite ore production was smelted in electric-arc furnaces to produce ferrochromium for the metallurgical industry. The major world ferrochromium-producing countries were China (more than 1 Mt), Kazakhstan (more than 1 Mt), and South Africa (more than 3 Mt). Russia and India each produced in excess of one-half Mt of ferrochromium. Most of the 7.4 Mt of ferrochromium produced was consumed in the manufacture of stainless steel. The major stainless steel producing areas of the world—Europe (primarily Western Europe and Scandinavia including Belgium, Finland, France, Germany, Italy, Spain, Sweden, and the United Kingdom), Asia (primarily China, Japan, Republic of Korea, and Taiwan) and South America and North America (primarily Brazil and the United States)—accounted for about 80% of world stainless steel production. World stainless steel production exceeded 28 Mt in 2006 and was expected to reach about 29 Mt in 2007.

The world chromium industry in 2006 operated with production capacity in excess of demand. From 2002 through 2006, ferrochromium production increased from 5 to 7 million metric tons per year (Mt/yr) (an increase of about 8%/yr), while stainless steel production increased from 20 to 28 Mt/yr (an increase of about 8%/yr). Stainless steel production increased in Asia, North America, and South America and decreased in Europe. The Asian production increase was lead by China, whose stainless steel production increased by 37% compared with that of 2005. China became the world's leading stainless steel producer in 2006 when it surpassed Japan's production.

In response to anticipated future demand growth, new ferrochromium-producing plants were under construction or planned in Kazakhstan and South Africa. Four industry trends were evolving—ferrochromium was being increasingly produced using environmentally friendly, 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 between those two industries were being developed.

Factors affecting world ferrochromium supply in 2006 included electricity shortages, raw material availability, and transportation constraints. Growth in most metal industries in response to economic growth and infrastructure development in China during the past few years has put strains on world mine production, ferroalloy production, and transportation facilities. South Africa, the leading ferrochromium producer, experienced electricity shortages in 2006, which affected chromium ferroalloy producers. India's electrical power infrastructure was challenged to the extent that ferroalloy producers in India have constructed their own electrical power generation plants to assure electrical power supply. Coke, an essential ingredient in ferrochromium production, was also in short supply, and transportation delays were experienced owing to a shortage of rail haulage cars and port loading problems.

Ferromanganese

Two manganese ferroalloys, ferromanganese and silicomanganese, are a key ingredient for steelmaking (Matricardi and Downing, 1995, p. 970). In 2006, most of the U.S. supply was imported from South Africa, whose exports of manganese ferroalloys to the United States were 42% greater than those of the next five major exporting countries combined (Australia, Georgia, Mexico, Norway, and the Republic of Korea) on a gross weight basis. Manganese ferroalloys were produced domestically mainly at a plant near Marietta, OH, owned by France's Eramet Group.

Silicomanganese production was sporadic at the Felman Production Inc. (formerly Highlanders Alloys LLC) plant at New Haven, WV; the company reportedly reopened the plant on September 12 (Ryan's Notes, 2006). In 2006, the 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, the Eramet Group produced ferroalloys from plants in China, France, Italy, and Norway, while BHP Billiton owned plants in Australia and South Africa. China was the leading producer of manganese ferroalloys, with an output almost twice as great as that of the next three major producers—Brazil, South Africa, and Ukraine—combined (table 6).

Ferromolybdenum

Chile, China, and the United States accounted for about 80% of world production of molybdenite ore in 2006. Other molybdenite ore-producing countries, including Canada, Mexico, and Peru, supplied an additional 15% of world production. Molybdenite concentrates are roasted to form molybdic oxide, which can be converted into ferromolybdenum, molybdenum chemicals, or metal. About 46% of the molybdenum consumed in the United States was in the form of molybdic oxides, and about 23% was consumed as ferromolybdenum. Although the United States was the leading molybdenum-producing country in the world, it imported more than 71% of its ferromolybdenum requirements in 2006. The steel industry accounted for about 84% of all molybdenum consumed in the United States in 2006, principally in the production of stainless and full alloy steels.

Ferronickel

The major ferronickel-producing countries in 2006 were, in descending order of gross weight output, Japan, New Caledonia, and Colombia, with each country producing more than 100,000 metric tons (t) of ferronickel. These three countries accounted for about 57% of world production. Greece, Ukraine, Indonesia, the Dominican Republic, and Venezuela, in descending order of gross weight output, all produced between 55,000 t and 100,000 t of ferronickel, accounting for an additional 32%. Increased ferronickel production of 60,000 metric tons per year can be anticipated when Xstrata plc's Koniambo smelter in New Caledonia comes on stream within the next few years (Xstrata plc, 2007, p. 6).

At Cerro Matoso (Colombia), Doniambo (New Caledonia), and several other smelters, primary ferronickel was obtained by 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 small amounts by melting nickel-bearing scrap in an electric furnace and upgrading the melt with nickel cathode. Most of the world's ferronickel plants operated at full capacity in 2006 to meet strong demand from stainless steel producers.

In the United States, the steel industry accounted for virtually all the primary ferronickel consumed in 2006, with more than 99% used in stainless and heat-resistant steels. No primary ferronickel was produced in the United States in 2006, but International Metals Reclamation Company Inc. produced a remelt alloy typically averaging 14% chromium and 10% nickel from recycled materials at Ellwood City, PA. Stainless steel producers substituted the remelt alloy for ferrochromium and ferronickel. Almost all U.S. ferronickel exports were either re-exports or material upgraded for specialty purposes. U.S. ferronickel consumption in 2006 was 23% greater than that of 2005 on a contained basis, despite a global ferronickel shortfall. On a gross weight basis, ferronickel net imports were 39,800 t with an import-to-export ratio of 332 to 1.

Ferrosilicon

Silicon ferroalloy demand is driven by cast iron and steel production, where silicon alloys are used as deoxidizers (Dosaj, 1997, p. 1115). On the basis of silicon content, U.S. net production of silicon ferroalloys (ferrosilicon and miscellaneous silicon alloys) was 146,000 t, 17% more than that of 2005. On a gross weight basis, U.S. net production of ferrosilicon in 2006 increased by 21% compared with that of 2005 (table 6).

China produced more ferrosilicon than the rest of the world combined and more than four times that of the next two major producing countries—Brazil and Russia—combined. In 2006, 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. Steels with relatively high titanium content include interstitial-free, stainless, and high-strength low-alloy steels. Ferrotitanium is usually produced by induction melting of titanium scrap with iron or steel. The standard grades of ferrotitanium are 40% and 70% titanium. U.S. producers of ferrotitanium were Galt Alloys Inc. and Global Titanium Inc. Data on production of ferrotitanium were not available. World ferrotitanium producers include China, India, Japan, Russia, United Kingdom, and the United States.

In 2006, reported domestic consumption of titanium products in steel and other alloys was 11,300 t, a 3% increase compared with that of 2005. An increased supply of titanium sponge and scrap in 2006 caused ferrotitanium prices to decline. The yearend price for ferrotitanium with 70% contained titanium declined about 31% compared with the yearend price of 2005.

Ferrotungsten

Tungsten is an important alloying element in high-speed and other tool steels, and is used to a lesser extent in some stainless and structural steels. Tungsten can be added to steel melts as—(1) ferrotungsten, which is a master alloy containing between 75% and 80% tungsten; (2) tungsten melting base, which is a master alloy containing up to 36% tungsten; (3) tungsten metal scrap; or (4) scheelite ore concentrates (Lassner and Schubert,

1999, p. 307-312; Roskill Information Services Ltd., 2007, p. 167-168, 174, 178-179).

In 2006, world ferrotungsten production was dominated by China, which produced 11,464 t, gross weight; exported 5,833 t, gross weight; and consumed 5,631 t, gross weight, which was equivalent to 4,223 t of contained tungsten (Zhang, 2007). U.S. reported consumption was more than that of 2005. Tungsten prices remained high with the Platts Metals Week ferrotungsten price ranging between $27 and $36 per kilogram of contained tungsten during the year.

Ferrovanadium

In 2006, the major vanadium-producing countries were China and South Africa, accounting for 71% of world production, with Russia, the other significant vanadium-producing country, accounting for an additional 27%. 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 2006, there was no primary production of vanadium oxides in the United States. Rather, vanadium oxides were recovered from ash, petroleum residues, and poisoned refinery catalysts. Vanadium oxides were used to produce catalysts, chemicals, and 75% to 80% vanadium-content ferrovanadium.

The domestic steel industry accounted for 92% of U.S. vanadium consumption in 2006, principally in carbon, full alloy and high-strength, low-alloy steels. Of the vanadium consumed, 84% was ferrovanadium, and the United States imported 63% of its ferrovanadium requirements in 2006.

In 2006, the production of vanadium increased slightly in China, Russia, and South Africa owing to increased steel production. In the United States, two companies announced plans to expand recycling capacity to recover vanadium from spent Canadian tar sands catalysts. Production from petroleum-based vanadium recovery (ash, catalysts, residues) continued to increase.

Outlook

The use of some ferroalloys per ton of steel during the past 20 years has been displaced to a moderate extent by substitutes, principally alloy scrap and metal oxide. Unit ferroalloy consumption was expected to decline during the long term, but the effect will be moderated by an increase in ferroalloy consumption related to increasing steel production. This general decline in unit consumption of the major ferroalloys in steelmaking has been caused by a combination of factors, including changes in availability, costs, and technology improvements.

In the past, energy requirements were preferentially supplied to large-scale consumers, such as ferroalloy producers, especially by state-owned utilities. Recently, spare power capacity has been shrinking owing to the rising demand of the local populations. This trend was expected to continue to negatively affect ferroalloy producers, which need captive capacity and long-term energy supply contracts to remain competitive (Jones, 2007).

Growing U.S. customer needs for alloy and stainless steel is expected to continue to have a strong positive influence on ferroalloy demand. Improvements in process technology, reduced raw materials requirements, and development of steels with lower metal alloy content will permit industry to produce steels with equal or better performance, while lowering material costs. Improved technology and industry practices and increased demand through more innovative uses for ferroalloys are expected to more than offset any reduction in unit consumption. Substitute materials, such as plastics and nonferrous metals, especially in the transportation sector, are expected to compete with ferroalloys, although ferroalloys are expected to remain competitive for many years through the development and 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.

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TABLE 1
GOVERNMENT INVENTORY OF FERROALLOYS, DECEMBER 31, 2006[1, 2]

(Metric tons of alloys unless otherwise specified)

Alloy	Inventory
Ferrochromium:	
High-carbon	229,000
Low-carbon	118,000
Ferromanganese, high carbon	517,000

[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 2006[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	742	243,000	56,900	4,250	20,000 [3]	4,880
Stainless and heat-resisting	204	8,770	13,600	136	50,100 [3]	3,270
Other alloy	112	23,900	19,500	844	7,670 [3]	164
Tool	--	(3)	(3)	--	--	(4)
Unspecified	--	4,960	777	(4)	63,300 [5]	--
Total steel	1,060	281,000	90,700	5,230	141,000	8,310
Cast irons	--	7,210	390	1,300	70,500 [5]	(5)
Superalloys	36	(6)	--	(7)	364 [5, 7]	1,300
Alloys (excluding alloy steels and superalloys)	386	26,600	(8)	(7)	49,000 [5]	1,630
Miscellaneous and unspecified	--	(6)	(8)	--	178,000	47
Grand total	1,480	315,000	91,100	6,530	439,000	11,300
Total 2005	1,440	293,000	93,000	6,770	479,000	11,000
Percentage of 2005	103	107	98	96	92	103
Consumer stocks, December 31	331	31,300 [9]	10,400 [9]	1,110	16,300	1,020

-- 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 silicon 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]Included with 'Steel, other alloy."
[5]Part included with "Miscellaneous and unspecified."
[6]Included with "Alloys (excluding alloy steels and superalloys)."
[7]All or part included with "Cast irons."
[8]All or part withheld to avoid disclosing company proprietary data.
[9]Consumer and producer stock.

TABLE 3

REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2006[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	8,880	538	2,870	--	2,210	(3)
Stainless and heat-resisting	205,000	776	601	16,200	61	(3)
Other alloy	12,800 [4]	2,570	(5)	W	1,030	(3)
Tool	3,030	W	(5)	--	64	(3)
Unspecified	--	--	--	--	(4)	(3)
Total	230,000	3,880	3,470	16,200	3,370	280
Cast irons	--	194	W	W	--	--
Superalloys	12,600	33	1,580	--	35	(3)
Alloys (excluding alloy steels and superalloys)	12,600	87	W	W	W	(3)
Miscellaneous and unspecified	2,800 [6]	93	2	106	2	--
Grand total	258,000	4,290	5,050	16,300	3,410	280
Total 2005	257,000	4,820	4,170	13,300	3,290	250
Percentage of 2005	100	89	121	122	104	112
Consumer stocks, December 31	9,640	604	605	1,030	275	20

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, ferroniobium, including nickel niobium; FeNi, ferronickel; FeV, ferrovanadium, including other vanadium-carbon-iron ferroalloys; and FeW, ferrotungsten.

[3]Included with "Steel, total."

[4]Includes full alloy steel.

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

[6]Includes cast irons, electrical steel, and unspecified uses.

TABLE 4
FERROALLOY PRICES IN 2006

	High	Low	Average[1]
Chromium:			
Ferrochromium:			
0.05% carbon[2]	120.00	110.00	115.66
0.10% carbon[2]	112.00	90.00	99.80
0.15% carbon[2]	111.00	90.00	98.63
Over 4% carbon:			
50-55% chromium[2]	76.00	59.00	69.45
60-65% chromium[2]	68.00	53.00	63.32
Manganese:			
Medium-carbon ferromanganese[2]	75.00	46.00	66.83
Standard-grade ferromanganese[3]	1,075.00	710.00	867.51
Silicomanganese[4]	47.00	36.00	39.53
Molybdenum:			
Ferromolybdenum[5]	29.00	23.50	26.71
Molybdenum oxide[5]	28.40	20.50	24.77
Silicon:			
50% ferrosilicon[2]	71.00	51.00	62.93
75% ferrosilicon[2]	63.00	46.00	54.87
Silicon metal[5]	94.00	70.00	79.30
Vanadium, ferrovanadium[5]	23.00	16.00	18.81

[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 2006[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:						
Chromium ferroalloys:						
Ferrochromium containing:						
More than 4% carbon	393,000	230,000	$273,000	18,800	11,200	$15,600
Not more than 4% carbon	XX	XX	XX	16,600	9,960	22,000
More than 0.5% but not more than 3% carbon	29	23	35,500	XX	XX	XX
Not more than 0.5% carbon	28,100	19,300	48,000	XX	XX	XX
Ferrochromium-silicon	38,300	15,900	32,200	248	96	480
Total	460,000	265,000	389,000	35,700	21,300	38,100
Manganese ferroalloys:						
Ferromanganese containing:						
More than 4% carbon	233,000	180,000	152,000	XX	XX	XX
More than 2% but not more than 4% carbon	1,490	1,170	656	XX	XX	XX
More than 1% but not more than 2% carbon	79,000	63,900	70,800	XX	XX	XX
Not more than 1% carbon	44,800	37,500	51,500	XX	XX	XX
Ferromanganese, all grades	XX	XX	XX	21,700	XX	14,100
Silicomanganese	400,000	264,000	288,000	947	XX	888
Total	758,000	546,000	562,000	22,600	XX	15,000
Silicon ferroalloys:						
Ferrosilicon containing:						
More than 55% silicon	XX	XX	XX	5,890	3,550	6,610
More than 55% but not more than 80% silicon and more than 3% calcium	3,100	2,120	3,430	XX	XX	XX
Magnesium ferrosilicon	24,900	11,400	22,700	XX	XX	XX
Ferrosilicon, other[2]	299,000	209,000	218,000	3,440	1,710	3,810
Total	327,000	223,000	244,000	9,330	5,260	10,400
Other ferroalloys:						
Ferrocerium and other pyrophoric alloys and other	143	XX	2,110	XX	XX	XX
Ferromolybdenum	4,810	3,060	165,000	3,280	2,010	42,500
Ferronickel	40,000	14,600	316,000	120	67	986
Ferroniobium	12,500	XX	114,000	706	XX	6,680
Ferrophosphorus	11,400	XX	6,060	1,820	XX	2,270
Ferrotitanium and ferrosilicon-titanium	7,080	XX	63,400	2,320	XX	12,100
Ferrotungsten and ferrosilicon-tungsten	347	265	7,990	8	4	229
Ferrovanadium	2,690	2,140	90,500	515	389	11,400
Ferrozirconium	196	XX	506	491	XX	853
Ferroalloys, other	7,310	XX	13,700	3,150	XX	5,740
Total	86,500	XX	779,000	12,400	XX	82,700
Total ferroalloys	1,630,000	XX	1,970,000	80,000	XX	146,000
Metals:						
Chromium (total, all grades)	10,900	XX	89,000	1,020	XX	21,300
Manganese, other:						
Unwrought	30,400	XX	44,000	XX	XX	XX
Other	1,490	XX	2,300	XX	XX	XX
Silicon:						
Less than 99% silicon	21,700	20,300	30,100	7,740	7,480	28,900
Less than 99.99% but not less 99% silicon	125,000	124,000	196,000	2,660	2,630	6,900
Not less than 99.99% silicon	1,860	XX	168,000	16,700	XX	1,240,000
Total metals	192,000	XX	529,000	28,100	XX	1,290,000
Grand total	1,820,000	XX	2,500,000	108,000	XX	1,440,000

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 55% to 80% silicon, other.

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]	2002	2003	2004[e]	2005[e]	2006[e]
Albania, electric furnace, ferrochromium	22,100	37,800	47,700 [6]	35,780 [6]	35,000
Argentina, electric furnace:[e]					
Ferrosilicon	2,700	2,700	2,700	2,700	2,700
Silicomanganese	5,000	5,000	5,000	5,000	5,000
Silicon metal	8,000	8,000	8,000	8,000	8,000
Other[7]	17,289 [6]	15,000	15,000	15,000	15,000
Total	32,989 [6]	30,700	30,700	30,700	30,700
Australia, electric furnace:[e]					
Ferromanganese	115,000	115,000	115,000	120,000	125,000
Silicomanganese	135,000	135,000	135,000	140,000	140,000
Silicon metal	30,000	30,000	30,000	35,000	35,000
Total	280,000	280,000	280,000	295,000	300,000
Austria, electric furnace:[e]					
Ferronickel, including ferronickelmolybdenum	4,000 [r]	4,000 [r]	4,000 [r]	4,000 [r]	4,000
Other	4,000	4,000	4,000	4,000	4,000
Total	8,000 [r]	8,000 [r]	8,000 [r]	8,000 [r]	8,000
Bhutan, electric furnace, ferrosilicon[e]	21,000	21,000	21,147 [r, 6]	20,000	20,000
Bosnia and Herzegovina, electric furnace:[e]					
Ferrosilicon	500 [r, 6]	500 [r]	500 [r]	500 [r]	500
Silicon metal	50 [r]	50 [r]	50 [r]	50 [r]	50
Total	550 [r]	550 [r]	550 [r]	550 [r]	550
Brazil, electric furnace:					
Ferrochromium[8]	164,140	204,339	216,277 [6]	197,653 [r, 6]	200,000 [p]
Ferrochromiumsilicon	10,522	10,500	11,560 [6]	11,600 [6]	11,600 [p]
Ferromanganese	108,537 [r]	176,076 [r]	204,216 [r, 6]	182,400 [r, 6]	280,770 [p]
Ferronickel	19,874	21,167 [r]	20,338 [6]	26,340 [r, 6]	29,300 [p]
Ferrosilicon	145,910	146,000	146,000	146,000	146,000
Silicomanganese	190,463 [r]	261,924 [r]	303,784 [r, 6]	297,600 [r, 6]	292,230 [p]
Silicon metal	133,390 [6]	133,400	133,400	133,000	133,000
Other[e]	87,398	86,400	86,400	86,500	86,500
Total	860,234 [r]	1,039,806 [r]	1,121,975 [r, 6]	1,081,493 [r, 6]	1,180,000
Bulgaria, electric furnace:[e]					
Ferrosilicon	8,000	8,000	8,000	8,000	8,000
Other	10,000	10,000	10,000	10,000	10,000
Total	18,000	18,000	18,000	18,000	18,000
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, ferromolybdenum	3,160	4,070	5,760 [6]	6,500 [r]	7,400
China:[e]					
Blast furnace:					
Ferromanganese	500,000	550,000	590,000	500,000 [r]	500,000
Other	100,000	100,000	100,000	60,000 [r]	60,000

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]	2002	2003	2004[e]	2005[e]	2006[e]
China—Continued:[e]					
Electric furnace:					
Ferrochromium	330,000	500,000	640,000	850,000 [r]	1,000,000
Ferromanganese	490,000	700,000	1,120,000	1,150,000 [r]	1,300,000
Ferromolybdenum	29,600	60,000	70,000	80,000 [r]	90,000
Ferrosilicon	1,500,000	2,200,000	3,000,000	3,300,000 [r]	3,600,000
Silicomanganese	1,580,000	1,800,000	2,600,000	3,000,000 [r]	3,800,000
Other	310,400	460,600	800,000	1,760,000 [r]	3,980,000
Total	4,840,000	6,370,600	8,920,000	10,700,000 [r]	14,300,000
Colombia, electric furnace, ferronickel	111,952	111,324	113,647 [6]	122,000 [r]	119,000
Czech Republic, electric furnace, other[e]	3,000 [r]	3,000 [r]	3,000 [r]	3,500 [r]	3,500
Dominican Republic, electric furnace, ferronickel	58,101	69,628	75,763 [6]	61,057 [r, 6]	64,000
Egypt, electric furnace:[e]					
Ferromanganese	30,000	30,000	30,000	30,000	30,000
Ferrosilicon	55,000	55,000	55,000	55,000	50,000
Total	85,000	85,000	85,000	85,000	80,000
Finland, electric furnace, ferrochromium	248,181	250,490	264,492 [6]	234,881 [6]	243,350 [6]
France:[e]					
Blast furnace, ferromanganese	163,000 [r]	162,000 [r]	--	--	--
Electric furnace:					
Ferromanganese and speiegeleisen	100,000 [r]	120,000	110,000 [r]	113,000 [r]	139,000
Ferrosilicon	100,000	100,000	100,000	100,000	100,000
Silicomanganese[9]	66,215 [r, 6]	60,700 [r]	64,100 [r]	52,300 [r]	63,300
Silicon metal	84,768 [r, 6]	85,000 [r]	85,000 [r]	80,000 [r]	80,000
Other	65,000	65,000	65,000	65,000	65,000
Total	578,983 [r, 6]	593,000 [r]	424,000 [r]	410,000 [r]	447,000
Georgia, electric furnace:[e]					
Ferromanganese	4,200 [r]	12,400 [r]	12,800 [r]	13,900 [r]	5,130
Silicomanganese	30,400 [r]	50,900 [r]	98,800 [r]	109,000 [r]	117,000
Total	34,600 [r]	63,300 [r]	112,000 [r]	123,000 [r]	122,000
Germany, electric furnace:					
Ferrochromium	20,018	18,318	24,857 [6]	22,672 [6]	26,710 [6]
Silicon metal	25,257	27,870	28,773 [6]	29,349 [6]	30,000
Other[10]	60,000	61,700	55,000	55,000	60,000
Total	105,275 [r]	107,888 [r]	108,630 [r, 6]	107,021 [r, 6]	117,000
Greece, electric furnace, ferronickel	97,761	95,376	96,000	95,000	88,000
Hungary, electric furnace:[e, 11]					
Ferrosilicon	7,000	7,000	7,000	7,000	7,000
Silicon metal	1,000	1,000	500	500	500
Total	8,000	8,000	7,500	7,500	7,500
Iceland, electric furnace, ferrosilicon	120,624	117,171	118,000	120,000	113,798 [6]
India, electric furnace:[e]					
Ferrochromium[12]	311,927 [6]	468,677 [6]	527,100 [6]	611,373 [6]	634,200 [6]
Ferrochromiumsilicon	10,000	10,000	10,000	10,000	10,000
Ferromanganese	165,000	165,000	170,000	170,000	180,000
Ferrosilicon	52,000	54,000	55,000	56,000	58,000
Silicomanganese	150,000	160,000	160,000	170,000	180,000
Other	9,000	9,000	9,000	9,000	9,000
Total	698,000	867,000	931,000	1,030,000	1,070,000

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]	2002	2003	2004[e]	2005[e]	2006[e]
Indonesia, electric furnace:					
Ferromanganese[e]	12,000	12,000	12,000	12,000	12,000
Ferronickel	42,306	43,894	39,538 [6]	36,690 [6]	70,000
Silicomanganese[e]	7,000	7,000	7,000	4,000	5,000
Total	61,306	62,894	58,538 [6]	52,690 [6]	87,000
Iran, electric furnace:					
Ferrochromium[e]	8,000	10,000	7,750 [6]	8,000	8,000
Ferrosilicon[e]	41,700	40,297 [6]	50,150 [6]	50,000	50,000
Total	49,700	50,297	57,900 [6]	58,000	58,000
Italy, electric furnace:[e]					
Ferromanganese	40,000	40,000	40,000	40,000	40,000
Silicomanganese	100,000 [r]	100,000 [r]	100,000 [r]	100,000 [r]	100,000
Silicon metal	-- [r]	-- [r]	-- [r]	-- [r]	--
Other[13]	10,000	10,000	10,000	10,000	10,000
Total	150,000 [r]	150,000 [r]	150,000 [r]	150,000 [r]	150,000
Japan, electric furnace:					
Ferrochromium[14]	91,937	19,427	13,472 [6]	12,367 [6]	13,056 [6]
Ferromanganese	356,717	371,831	437,389 [6]	448,616 [6]	406,489 [6]
Ferronickel	370,973	369,099	374,213 [6]	391,074 [6]	335,884 [6]
Silicomanganese	70,965	58,043	73,041 [6]	94,725 [6]	59,604 [6]
Other[15]	12,352	10,007	12,822 [6]	16,436 [6]	19,394 [6]
Total	902,944	828,407	910,937 [6]	963,218 [6]	834,427 [6]
Kazakhstan, electric furnace:					
Ferrochromium	835,800	993,000	1,080,993 [6]	1,156,168 [6]	1,200,000
Ferrochromiumsilicon	102,200	98,130	104,800 [6]	97,870 [6]	100,000
Ferromanganese	2,278	1,931	2,000	2,100	2,100
Ferrosilicon	127,300	127,300	103,580 [6]	104,185 [6]	105,000
Silicomanganese	164,000	178,920	155,324 [6]	170,214 [6]	220,000
Other[e]	9,000	9,000	9,000	9,000	9,000
Total	1,240,578	1,408,281	1,455,697 [6]	1,539,537 [6]	1,640,000
Korea, North, electric furnace:[e]					
Ferromanganese[10]	-- [r]	-- [r]	-- [r]	-- [r]	--
Ferrosilicon	-- [r]	-- [r]	-- [r]	-- [r]	--
Other	10,000 [r]	10,000 [r]	10,000 [r]	10,000 [r]	10,000
Total	10,000	10,000	10,000	10,000	10,000
Korea, Republic of, electric furnace:					
Ferromanganese	136,514 [r]	141,480 [r]	165,525 [6]	124,434 [r, 6]	165,000
Silicomanganese	93,622 [r]	90,942	82,917 [6]	74,193 [r, 6]	80,000
Other	3,963 [r]	4,308 [r]	4,811 [r, 6]	3,670 [r, 6]	4,000
Total	234,099 [r]	236,730 [r]	253,253 [r, 6]	202,297 [r, 6]	249,000
Macedonia, electric furnace:[e]					
Ferronickel	17,000	19,000	18,800	28,000	36,000
Ferrosilicon	50,000	50,000	50,000	50,000	50,000
Total	67,000	69,000	68,800	78,000	86,000
Mexico, electric furnace:[16]					
Ferromanganese	38,532	55,903	72,471 [6]	89,641 [6]	90,000
Silicomanganese	73,263	81,223	103,206 [6]	104,780 [6]	105,000
Total	111,795	137,126	175,677 [6]	194,421 [6]	195,000
New Caledonia, electric furnace, ferronickel	162,973 [r]	167,208 [r]	151,296 [r, 6]	172,067 [r, 6]	179,000

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]	2002	2003	2004[e]	2005[e]	2006[e]
Norway, electric furnace:[e]					
Ferrochromium	61,100 [6]	--	--	--	--
Ferromanganese	240,000	245,000	245,000	250,000	245,000
Ferrosilicon	390,000	350,000	300,000	165,000 [r]	80,000
Silicomanganese	230,000	230,000	230,000	230,000	230,000
Silicon metal	105,000	100,000	105,000	105,000	100,000
Other[9]	15,000	15,000	15,000	15,000	15,000
Total	1,040,000	940,000	895,000	765,000 [r]	670,000
Peru, electric furnace, ferrosilicon[e]	600	600	600	600	600
Poland:					
Blast furnace, ferromanganese	600	1,000	46,900 [r, 6]	7,800 [r, 6]	10,000
Electric furnace:					
Ferrosilicon	41,800	92,700	83,600 [r]	65,100 [r, 6]	90,000
Silicomanganese	7,338 [r]	5,000 [r]	29,600 [r, 6]	10,242 [r, 6]	80,000
Total	49,738 [r]	98,700 [r]	160,100 [r, 6]	83,142 [r, 6]	180,000
Romania, electric furnace, silicomanganese	84,720	141,899	194,945 [6]	200,000	200,000
Russia:[e]					
Blast furnace:					
Ferromanganese	105,000	101,000	108,000	108,000	125,000
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	210,000 [6]	357,000 [6]	454,000	578,000 [6]	600,000
Ferrochromiumsilicon	4,000	4,000	4,000	4,000	4,000
Ferronickel:[17]					
High-nickel	15,400	15,900	14,900	14,800	16,085 [6]
Other	1,000	1,100	5,470	2,200	4,710
Ferrosilicon	701,000	760,000	721,000	742,000 [6]	750,000
Ferrovanadium	15,100	8,000	13,700	12,880 [6]	13,000
Silicomanganese	127,000	83,000	143,000	145,000	170,000
Silicon metal	85,000 [r]	75,000 [r]	75,000 [r]	58,000 [r]	54,500
Other	14,900	22,000	22,000	22,000	22,000
Total	1,290,000 [r]	1,440,000 [r]	1,570,000 [r]	1,700,000 [r]	1,770,000
Saudi Arabia, electric furnace, other[e]	75,000	75,000	85,000	85,000	90,000
Slovakia, electric furnace:					
Ferrochromium	5,695	1,924	1,784 [6]	867 [6]	19 [6]
Ferromanganese[e]	20,000	20,000	20,000	20,000	20,000
Ferrosilicon	35,920 [r]	41,539 [r]	34,600 [r, 6]	35,000 [r]	35,000
Silicomanganese	62,084 [r]	52,733 [r]	64,842 [r, 6]	65,000 [r]	65,000
Other	5,000	5,000	5,000	5,000	5,000
Total	128,699 [r]	121,196 [r]	126,226 [r, 6]	125,867 [r]	125,000
Slovenia, electric furnace:[e]					
Ferrosilicon	12,000 [r]	18,000 [r]	15,000 [r]	15,000 [r]	15,000
Other[7]	200	--	--	--	--
Total	12,200 [r]	18,000 [r]	15,000 [r]	15,000 [r]	15,000

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]	2002	2003	2004[e]	2005[e]	2006[e]
South Africa, electric furnace:					
Ferrochromium	2,351,122	2,813,000	2,965,000 [6]	2,812,000 [r, 6]	3,030,000 [6]
Ferromanganese	618,954	607,362	611,914 [r, 6]	570,574 [r, 6]	670,000
Ferrosilicon	141,700	135,300 [r]	140,600 [r, 6]	127,000 [r, 6]	140,000
Ferrovanadium	19,000 [r]	19,000 [r]	20,000 [r]	19,000 [r]	18,000
Silicomanganese	315,802	313,152	340,000	280,000	330,000
Silicon metal	42,500	48,500	50,500 [6]	53,500 [r, 6]	54,000
Other[e, 18]	85,000	80,000	80,000	80,000	80,000
Total	3,574,078 [r]	4,016,314 [r]	4,208,014 [r, 6]	3,942,074 [r, 6]	4,320,000
Spain, electric furnace:[e]					
Ferromanganese	10,000	10,000	10,000	10,000	10,000
Ferrosilicon	40,000	40,000	40,000	40,000	40,000
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	185,000	185,000	185,000	185,000	185,000
Sweden, electric furnace:					
Ferrochromium	118,823	110,529	128,191 [6]	127,451 [6]	136,374 [6]
Ferrosilicon[e]	21,500 [r]	17,100 [r]	18,500 [r]	9,800 [r]	4,000
Total	140,323 [r]	127,629 [r]	146,691 [r, 6]	137,251 [r, 6]	140,000
Turkey, electric furnace:					
Ferrochromium	11,200 [e]	35,393	33,686 [r, 6]	26,043 [6]	67,975 [6]
Ferrosilicon	7,245	7,000 [e]	--	--	5,000
Total	18,445	42,393	33,686 [r, 6]	26,043 [6]	73,000
Ukraine:					
Blast furnace:[e]					
Ferromanganese	85,000	85,000	79,000	30,000	30,000
Spiegeleisen	5,000	5,000	5,000	5,000	5,000
Electric furnace:					
Ferromanganese	250,617	250,000 [e]	375,990 [6]	359,000 [r, 6]	373,000 [6]
Ferronickel[e]	31,000	--	71,000 [r]	78,000	78,000
Ferrosilicon	250,617	250,000 [e]	248,060 [6]	180,000 [r]	122,000
Silicomanganese	732,592	740,000 [e]	1,060,000 [6]	1,040,000 [r, 6]	1,168,000 [6]
Silicon metal[e]	5,000	5,000	5,000	5,000	4,500
Other[e]	25,000	25,000	25,000	25,000	25,000
Total	1,384,826 [r]	1,360,000 [r, e]	1,869,050 [r, 6]	1,722,000 [r, 6]	1,810,000
United States, electric furnace:					
Ferrochromium[19]	W	W	W	W	W
Ferromanganese[20]	W	W	W	W	W
Ferrosilicon[21]	182,000	148,000	171,000 [6]	164,000 [6]	194,000 [6]
Silicon metal[21]	108,000	134,000	144,000 [6]	143,000 [6]	W
Other[22]	W	W	W	W	W
Total	290,000	282,000	315,000 [6]	307,000 [6]	194,000 [6]
Uruguay, electric furnace, ferrosilicon[e]	200	200	200	200	200

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]	2002	2003	2004[e]	2005[e]	2006[e]
Venezuela, electric furnace:					
Ferromanganese[e]	12,000	12,000	15,000	15,000	15,000
Ferronickel	51,700 [e]	57,300 [e]	58,000	56,300	56,300
Ferrosilicon	99,576	90,543	92,000	92,000	92,000
Silicomanganese	36,974	30,632	35,000	35,000	35,000
Total	200,250	190,475	200,000	198,000	198,000
Zimbabwe, electric furnace:					
Ferrochromium	258,164	245,200	193,077 [6]	235,000	200,000
Ferrochromiumsilicon	--	--	1,000	5,000	3,000
Total	258,164	245,200	194,077 [6]	240,000	203,000
Grand total	20,000,000 [r]	22,700,000 [r]	26,400,000 [r]	27,800,000 [r]	32,100,000
Of which:					
Blast furnace:					
Ferromanganese	854,000 [r]	899,000 [r]	824,000 [r]	646,000 [r]	665,000
Spiegeleisen	12,000	12,000	12,000	12,000	12,000
Other[23]	104,000	104,000	104,000	63,500 [r]	63,500
Total, blast furnace	969,000 [r]	1,010,000 [r]	939,000 [r]	721,000 [r]	741,000
Electric furnace:					
Ferrochromium[24]	5,050,000	6,070,000	6,600,000 [r]	6,910,000 [r]	7,390,000
Ferrochromiumsilicon	127,000	123,000	131,000	128,000	129,000
Ferromanganese	2,750,000 [r]	3,090,000 [r]	3,770,000 [r]	3,720,000 [r]	4,110,000
Ferronickel	984,000 [r]	975,000 [r]	1,040,000 [r]	1,090,000 [r]	1,080,000
Ferrosilicon	4,210,000 [r]	4,940,000 [r]	5,640,000 [r]	5,710,000 [r]	5,940,000
Silicomanganese	4,360,000 [r]	4,690,000 [r]	6,090,000 [r]	6,430,000 [r]	7,550,000
Silicon metal	688,000 [r]	708,000 [r]	726,000 [r]	711,000 [r]	560,000
Other[25]	904,000 [r]	1,080,000 [r]	1,440,000 [r]	2,410,000 [r]	4,660,000
Total, electric furnace	19,100,000 [r]	21,700,000 [r]	25,400,000	27,100,000 [r]	31,400,000

[e]Estimated. [p]Preliminary. [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, 2007.

[3]In addition to the countries listed, Iran is thought 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 thought 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. Awamura Metal Industry Co. Ltd., which was the sole producer of ferrotungsten in Japan, reportedly was liquidated at the end of 2003.

TABLE 6–Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

[16]Salable products from Cía Minera Autlán S.A. de C.V.
[17]In December 2001, Mechel OAO acquired a 79.9% interest in the South Urals Nickel Plant previously operated by Yuzhuralni Combine JSC. The new owner made substantial improvement to the Orsk ferronickel plant and produced a low-iron ferronickel (greater than 85% nickel). Excludes nickel-chromium remelt alloy produced from scrap. The remelt alloy typically has a nickel content of 20% to 50%.
[18]Includes, if any, ferronickel.
[19]U.S. output of ferrochromium includes chromium metal, high- and low-carbon ferrochromium, ferrochromiumsilicon, and other chromium materials.
[20]U.S. output of ferromanganese includes manganese metal and silicomanganese.
[21]Net production.
[22]May include ferroboron, ferrocolumbium, ferromolybdenum, ferrophosphorus, ferrotitanium, ferrovanadium, nickel columbium, and silvery pig iron.
[23]Includes ferrophosphorus and data contained in "Blast furnace: Other."
[24]Ferrochromium includes ferrochromiumsilicon, if any, for Japan, South Africa, and the United States.
[25]Includes ferromolybdenum and ferrovanadium.