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FERROALLOYS [ADVANCE RELEASE]

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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 2007 were, in decreasing order of production, China, South Africa, Ukraine, Russia, and Kazakhstan (table 6). These countries accounted for 78% of world ferroalloy production.

World production of bulk ferroalloys—chromium, manganese, and silicon—was estimated to have been 28.4 million metric tons (Mt) in 2007, a 7% increase compared with the revised figure for 2006 (table 6). U.S. reported consumption of bulk ferroalloys in 2007 was approximately 0.9 Mt of manganese and silicon ferroalloys (table 2) and about 0.3 Mt of contained chromium in ferrochromium (table 3). Comparing consumption with that of 2006, ferrochromium decreased by 2%, ferromanganese (including silicomanganese) decreased by 11%, and ferrosilicon increased by 16%. On a gross weight basis, U.S. total ferroalloy imports decreased by 2% and exports increased 20%, which resulted in a net import decrease of 3% (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 other alloying elements used for the characteristics they provide to steels and cast irons (Brown and Murphy, 1985, p. 265).

Ferrochromium

The leading world chromite ore-producing countries in 2007 were India (more than 3 Mt), Kazakhstan (more than 3 Mt), and South Africa (more than 9 Mt). More than 93% of chromite ore production was smelted in electric-arc furnaces to produce ferrochromium for the metallurgical industry. The world chromium industry in 2007 operated with production capacity near demand. The leading world ferrochromium-producing countries were China (more than 1 Mt), Kazakhstan (more than 1 Mt), and South Africa (more than 3 Mt). India and Russia each produced in excess of 0.5 Mt of ferrochromium. Most of the 8.37 Mt of ferrochromium produced was consumed in the manufacture of stainless steel. The leading stainless steel producing areas of the world—Asia (primarily China, India, Japan, Republic of Korea, and Taiwan), Europe (primarily Western Europe and Scandinavia including Belgium, Finland, France, Germany, Italy, Spain, Sweden, and the United Kingdom), and the Americas (primarily Brazil and the United States)—accounted for most of world stainless steel production. World stainless steel production exceeded 28 Mt in 2007.

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 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 included electricity shortages, raw material availability, and transportation constraints in 2007. 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 2007, 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 ensure 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 key ingredients for steelmaking. In 2007, most of the U.S. supply was imported from South Africa, whose exports of manganese ferroalloys to the United States were 50% greater than those of the next three major exporting countries combined (China, Georgia, and Norway) on a gross weight basis. Manganese ferroalloys were produced domestically mainly at a plant near Marietta, OH, owned by France's Eramet Group, with some sporadic silicomanganese production at the Felman Production Inc. plant at New Haven, WV.

In 2007, Brazilian producer Companhia Vale do Rio Doce (Vale), 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 at plants in China, France, Italy, and Norway, while BHP Billiton operated plants in Australia and South Africa, and Vale operated plants in Brazil, France, and Norway. China was the leading producer of manganese

ferroalloys, with an output more than 75% greater than 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 77% of world production of molybdenite ore in 2007. Three other molybdenite ore-producing countries—Canada, Mexico, and Peru—supplied an additional 17% of world production. Molybdenite concentrates are roasted to form molybdic oxide, which can be converted into ferromolybdenum, molybdenum chemicals, or molybdenum metal. About 45% of the molybdenum consumed in the United States was in the form of molybdic oxides, and about 26% was consumed as ferromolybdenum. Although the United States was the second leading molybdenum-producing country in the world, it imported more than 70% of its ferromolybdenum requirements in 2007. The steel industry accounted for about 89% of ferromolybdenum consumed in the United States in 2007, principally in the production of stainless and full alloy steels.

Ferronickel

In 2007, the major ferronickel-producing countries were, in descending order of gross weight output, Japan [344,000 metric tons (t)], Colombia (149,000 t), and New Caledonia (144,600 t). Together, these three countries accounted for about 54% of world production. Indonesia, Greece, Ukraine, and the Dominican Republic, in descending order of gross weight output, all produced between 70,000 t and 95,000 t of ferronickel, accounting for an additional 30%.

In February 2007, Société Minière du Sud Pacifique and its joint-venture partner, Xstrata plc, began development of the Koniambo laterite deposit in New Caledonia. Nickel was planned to be extracted from the saprolite and converted to ferronickel using an improved version of the pyrometallurgical process employed at Xstrata's Falcondo smelting and refining complex in the Dominican Republic. The Koniambo operation was expected to have a production capacity of 60,000 metric tons per year (t/yr) of nickel in ferronickel (Xstrata plc, 2009, p. 43, 67, 175).

In the United States, the steel industry accounted for virtually all the ferronickel consumed in 2007, with more than 98% used in stainless and heat-resistant steels. No ferronickel was produced in the United States in 2007 from either domestic or imported ores, but International Metals Reclamation Company Inc., Ellwood City, PA, produced a remelt alloy typically averaging 13% chromium and 12% nickel from recycled materials. 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.

Ferrosilicon

Silicon ferroalloy consumption is driven by cast iron and steel production, where silicon alloys are used as deoxidizers. Some silicon metal was also used as an alloying agent with iron. On the basis of silicon content, U.S. net production of silicon ferroalloys (ferrosilicon and miscellaneous silicon alloys) was 126,000 t, 3% more than the revised amount of 122,000 t in 2006. On a gross weight basis, U.S. net production of ferrosilicon in 2007 also increased by 3% compared with that of 2006 (table 6). China produced more ferrosilicon than the rest of the world combined and about four times that of the next two major producing countries—Norway and Russia—combined.

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; however, it also is produced directly from titanium mineral concentrates. The standard grades of ferrotitanium are 40% and 70% titanium. U.S. producers of ferrotitanium were Global Titanium Inc. and RTI International Metals, Inc. (formerly Galt Alloys, Inc.). Data on production of ferrotitanium were not available. The leading ferrotitanium producing countries included Brazil, China, India, Japan, Russia, United Kingdom, and the United States.

In 2007, reported domestic consumption of titanium products in steel and other alloys was 13,200 t, a 15% increase compared with that of 2006. An increased supply of titanium sponge and scrap in 2007 caused ferrotitanium prices to significantly decline. The yearend price for ferrotitanium with 70% contained titanium declined about 44% compared with the yearend price of 2006.

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 2007, world ferrotungsten production was dominated by China, which produced 12,000 t, gross weight, equivalent to 9,000 t of contained tungsten, and China exported ferrotungsten containing 5,038 t of tungsten (Huang, 2008). U.S. reported consumption was less than that of 2006. Tungsten prices remained high, with the Platts Metals Week ferrotungsten price ranging between $31 and $34 per kilogram of contained tungsten during the year.

Ferrovanadium

In 2007, the major vanadium-mining countries were China and South Africa, accounting for 74% of world production, with Russia, the other significant vanadium-producing country,

accounting for an additional 25%. 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 ferrovanadium containing 40% to 50% vanadium. Production of vanadium increased slightly in China and South Africa to meet increased steel industry demand.

In 2007, there was no primary (from mining) vanadium production in the United States; however, there was secondary (recycling) production. Vanadium oxides were recovered from ash, petroleum residues, and poisoned refinery catalysts. U.S. production from these sources continued to increase. 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 2007, principally in carbon, full alloy and high-strength, low-alloy steels. Of the vanadium consumed in the United States, 76% was ferrovanadium, a 9% decrease compared with that of 2006. Almost all ferrovanadium was consumed in steel manufacturing (table 3).

Outlook

The use of some ferroalloys per ton of steel during the past 21 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 and costs, as well as technological 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).

The trend for domestic ferroalloy consumption was expected to follow closely that of U.S. steel production. Crude steel production in the United States decreased 7% to 91.5 Mt in 2008 from 98.1 Mt in 2007. The World Steel Association projected that U.S. apparent steel use in 2009 would decrease by almost 37%, owing to global financial problems that began during the third quarter of 2008 (World Steel Association, 2009a, b).

Improvements in process technology, reduced raw materials requirements, and development of steels with lower metal alloy content will permit the 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, outlook, and U.S. Government stockpile information, 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, 2007[1, 2]

(Metric tons of alloys unless otherwise specified)

Alloy	Inventory
Ferrochromium:	
High-carbon	99,400
Low-carbon	55,400
Ferromanganese, high carbon	461,000

[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 2007[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	497	201,000 [3]	56,700	7,270	34,300 [3]	6,460
Stainless and heat-resisting	185	7,470	14,400	(3)	47,600 [3]	3,330
Other alloy	59	30,800	16,400	--	15,000 [3]	740
Tool	--	(3)	(3)	--	(3)	(4)
Unspecified	--	13,000	902	685	68,100 [5]	--
Total steel	741	253,000	88,400	7,960	165,000	10,500
Cast irons	--	7,020	455	1,190	112,000 [5]	14
Superalloys	62	(6)	(7)	(8)	(5), (8)	1,200
Alloys (excluding alloy steels and superalloys)	349	12,200	--	(8)	53,700 [5]	1,390
Miscellaneous and unspecified	--	(6)	(9)	--	179,000	41
Grand total	1,150	272,000	88,800	9,140	509,000	13,200
Total 2006	1,480	315,000	91,100	6,530	439,000	11,500 [r]
Percentage of 2006	78	86	98	140	116	115
Consumer stocks, December 31	258	15,600 [10]	4,480 [10]	1,150	17,700	1,170

[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 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]Less than ½ unit.
[8]All or part included with "Cast irons."
[9]All or part withheld to avoid disclosing company proprietary data.
[10]Consumer and producer stocks.

TABLE 3

REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2007[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	5,640	491	4,170	--	2,420	(3)
Stainless and heat-resisting	198,000	774	928	10,900	61	(3)
Other alloy	11,600 [4]	3,390	(5)	W	1,200	(3)
Tool	2,750	W	(5)	--	W	(3)
Unspecified	--	--	--	W	W [4]	--
Total	218,000	4,650	5,100	10,900	3,680	267
Cast irons	--	345	W	W	--	--
Superalloys	6,670	37	1,400	--	39	(3)
Alloys (excluding alloy steels and superalloys)	24,700	103	W	W	W	(3)
Miscellaneous and unspecified	4,530 [6]	91	3	111	64	--
Grand total	254,000	5,230	6,500	11,000	3,790	267
Total 2006	258,000	4,290	5,050	13,400 [r]	3,410	280
Percentage of 2006	98	122	128	82	111	95
Consumer stocks, December 31	9,640	329	623	822	253	16

[r]Revised. 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 2007

	High	Low	Average[1]
Chromium:			
Ferrochromium:			
0.05% carbon[2]	290.00	117.00	175.00
0.10% carbon[2]	255.00	110.00	156.00
0.15% carbon[2]	254.00	109.00	155.00
Over 4% carbon:			
50-55% chromium[2]	148.75	71.00	104.84
60-65% chromium[2]	175.00	66.00	119.59
Manganese:			
Medium-carbon ferromanganese[2]	170.00	66.00	104.98
Standard-grade ferromanganese[3]	1,950.00	840.00	1,422.79
Silicomanganese[4]	120.00	38.00	76.72
Molybdenum:			
Ferromolybdenum[5]	33.54	32.83	33.19
Molybdenum oxide[5]	30.61	30.02	30.31
Silicon:			
50% ferrosilicon[2]	80.00	67.00	73.96
75% ferrosilicon[2]	75.00	58.00	65.62
Silicon metal[5]	155.00	90.00	112.69
Vanadium, ferrovanadium[5]	18.84	18.41	18.62

[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: Platts Metals Week and Ryan's Notes.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF FERROALLOYS AND FERROALLOY METALS IN 2007[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	384,000	217,000	$398,000	24,700	15,500	$25,100
Not more than 4% carbon	XX	XX	XX	16,200	10,200	25,700
More than 0.5% but not more than 3% carbon	7,110	4,020	8,610	XX	XX	XX
Not more than 0.5% carbon	31,700	21,000	65,800	XX	XX	XX
Ferrochromium-silicon	42,700	16,700	42,700	328	94	434
Total	466,000	259,000	515,000	41,100	25,800	51,200
Manganese ferroalloys:						
Ferromanganese containing:						
More than 4% carbon	211,000	162,000	211,000	XX	XX	XX
More than 2% but not more than 4% carbon	--	--	--	XX	XX	XX
More than 1% but not more than 2% carbon	53,900	43,600	65,400	XX	XX	XX
Not more than 1% carbon	50,600	42,000	81,300	XX	XX	XX
Ferromanganese, all grades	XX	XX	XX	29,100	XX	25,000
Silicomanganese	415,000	278,000	489,000	3,310	XX	3,230
Total	730,000	525,000	847,000	32,400	XX	28,200
Silicon ferroalloys:						
Ferrosilicon containing:						
More than 55% silicon	XX	XX	XX	8,360	5,040	9,850
More than 55% but not more than 80% silicon and more than 3% calcium	7,890	5,670	8,070	XX	XX	XX
Magnesium ferrosilicon	19,800	9,080	21,000	XX	XX	XX
Ferrosilicon, other[2, 3]	282,000	193,000	253,000	3,250	1,530	4,280
Total	309,000	208,000	282,000	11,600	6,580	14,100
Other ferroalloys:						
Ferrocerium and other pyrophoric alloys and other	800	XX	4,120	XX	XX	XX
Ferromolybdenum	6,360	4,100	270,000	1,760	1,220	67,900
Ferronickel	38,600	13,500	529,000	25	14	408
Ferroniobium	12,900	XX	184,000	1,580	XX	17,200
Ferrophosphorus	6,890	XX	4,000	815	XX	1,610
Ferrotitanium and ferrosilicon-titanium	7,620	XX	35,300	2,120	XX	11,500
Ferrotungsten and ferrosilicon-tungsten	508	357	9,580	29	14	559
Ferrovanadium	2,810	2,220	81,300	206	154	5,810
Ferrozirconium	400	XX	1,070	259	XX	414
Ferroalloys, other	6,740	XX	14,100	4,620	XX	7,110
Total	83,600	20,200	1,130,000	11,400	1,400	113,000
Total ferroalloys	1,590,000	1,010,000	2,780,000	96,500	33,800	206,000
Metals:						
Chromium (total, all grades)	11,700	XX	97,400	1,210	XX	23,200
Manganese:						
Metal, including alloys and waste and scrap	XX	XX	XX	3,280	XX	8,880
Unwrought	35,900	XX	91,400	XX	XX	XX
Other manganese, wrought	958	XX	3,890	XX	XX	XX
Silicon:						
Less than 99% silicon	11,500	10,500	21,000	5,360	5,200	17,600
Less than 99.99% but not less 99% silicon	135,000	134,000	249,000	2,170	2,160	5,680
Not less than 99.99% silicon	2,410	XX	258,000	21,100	XX	1,850,000
Total metals	198,000	144,000	721,000	33,100	7,350	1,900,000
Grand total	1,790,000	1,160,000	3,500,000	130,000	41,100	2,110,000

XX Not applicable. -- Zero.

[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.

[3]Includes imports of ferrosilicon containing 80% to 90% silicon and more than 90% 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]	2003	2004	2005	2006	2007[e]
Albania, electric furnace, ferrochromium	37,800	34,650 [r]	34,400 [r]	17,040 [r]	17,000
Argentina, electric furnace:[e]					
Ferrosilicon	2,700	10,000 [r]	10,000 [r]	10,000 [r]	10,000
Silicomanganese	5,000	24,000 [r]	24,000 [r]	24,000 [r]	24,000
Silicon metal	8,000	-- [r]	-- [r]	-- [r]	--
Other[6]	15,000	-- [r]	-- [r]	-- [r]	--
Total	30,700	34,000 [r]	34,000 [r]	34,000 [r]	34,000
Australia, electric furnace:[e]					
Ferromanganese	115,000	115,000	120,000	125,000	125,000
Silicomanganese	135,000	135,000	140,000	140,000	140,000
Silicon metal	30,000	30,000	35,000	35,000	35,000
Total	280,000	280,000	295,000	300,000	300,000
Austria, electric furnace:[e]					
Ferronickel, including ferronickelmolybdenum	4,000	4,000	4,000	4,000	4,000
Other	4,000	4,000	4,000	4,000	4,000
Total	8,000	8,000	8,000	8,000	8,000
Bhutan, electric furnace, ferrosilicon[e]	21,000	21,147 [7]	20,000	20,000	21,000
Bosnia and Herzegovina, electric furnace:[e]					
Ferrosilicon	500	500	500	500	500
Silicon metal	50	50	50	50	50
Total	550	550	550	550	550
Brazil, electric furnace:					
Ferrochromium[8]	204,339	216,277	197,653	166,577 [r]	170,000 [p]
Ferrochromiumsilicon	10,500	11,560	11,600	11,600 [e]	11,600
Ferromanganese	176,076	162,216 [r]	182,400 [r]	280,000 [r, p]	310,000 [p]
Ferronickel	21,167	20,338	26,340	27,636 [r]	29,223 [p, 7]
Ferroniobium (ferrocolumbium)	36,450	25,169	38,819	41,566	42,000
Ferrosilicon	146,000	156,824 [r]	177,245 [r]	177,000 [r]	128,000
Silicomanganese	261,924	303,784	297,600	292,230	350,370 [p, 7]
Silicon metal	133,400	180,937 [r]	219,813 [r]	187,950 [r]	186,000
Other[e]	50,000 [r]	61,200 [r]	60,200 [r]	44,900 [r]	44,500
Total	1,039,806	1,138,336 [r]	1,211,630 [r]	1,229,493 [r]	1,270,000
Bulgaria, electric furnace:[e]					
Ferrosilicon	10,000 [r]	10,000 [r]	10,000 [r]	10,000 [r]	10,000
Other	-- [r]	-- [r]	-- [r]	-- [r]	--
Total	10,000 [r]	10,000 [r]	10,000 [r]	10,000 [r]	10,000
Canada, electric furnace:[e]					
Ferroniobium (ferrocolumbium)	1,000	1,000	1,000	1,000	1,000
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	88,000 [r]	88,000 [r]	88,000 [r]	88,000 [r]	88,000
Chile, electric furnace, ferromolybdenum	4,070	5,760	9,250 [r]	14,000 [r]	14,800
China:[e]					
Blast furnace:					
Ferromanganese	550,000	590,000	500,000	600,000 [r]	620,000
Other	100,000	100,000	60,000	60,000	80,000
Electric furnace:					
Ferrochromium	500,000	640,000	850,000	1,000,000	1,400,000
Ferromanganese	700,000	1,120,000	1,150,000	1,400,000 [r]	1,500,000
Ferromolybdenum	60,000	70,000	80,000	90,000	100,000
Ferrosilicon	2,200,000	3,000,000	3,300,000	4,020,000 [r]	4,200,000

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]	2003	2004	2005	2006	2007[e]
China—Continued:[e]					
Electric furnace—Continued:					
Silicomanganese	1,800,000	2,600,000	3,000,000	3,600,000 [r]	3,800,000
Other[9]	460,600	800,000	1,760,000	3,530,000 [r]	4,050,000
Total	6,370,000	8,920,000	10,700,000	14,300,000	15,800,000
Colombia, electric furnace, ferronickel	111,324	113,647	138,000 [r, e]	154,000 [r, e]	149,000
Czech Republic, electric furnace, other[e]	3,000	3,500 [r]	2,700 [r]	2,800 [r]	2,800
Dominican Republic, electric furnace, ferronickel	69,628	75,763	61,057	76,659 [r]	74,000
Egypt, electric furnace:[e]					
Ferromanganese	30,000	30,000	30,000	30,000	30,000
Ferrosilicon	55,000	55,000	55,000	50,000	50,000
Total	85,000	85,000	85,000	80,000	80,000
Finland, electric furnace, ferrochromium	250,490	264,492	234,881	243,350	241,760 [7]
France:[e]					
Blast furnace, ferromanganese	162,000	--	--	--	--
Electric furnace:					
Ferromanganese and speiegeleisen	120,000	106,000 [r]	109,000 [r]	146,000 [r]	103,000
Ferrosilicon	100,000	87,000 [r]	67,000 [r]	67,000 [r]	71,000
Silicomanganese[10]	60,700	64,100	52,300	63,300	65,000
Silicon metal	85,000	85,000	100,000 [r]	100,000 [r]	120,000
Other	65,000	65,000	65,000	60,000 [r]	60,000
Total	593,000	407,000 [r]	393,000 [r]	436,000 [r]	419,000
Georgia, electric furnace:					
Ferromanganese	12,400	12,800	13,945 [r]	5,130	5,000
Silicomanganese	50,900	91,900 [r]	109,414 [r]	116,945 [r]	120,000
Total	63,300	104,700 [r]	123,359 [r]	122,075 [r]	125,000
Germany, electric furnace:					
Ferrochromium	18,318	24,857	22,672	26,710	22,030 [7]
Silicon metal	27,870	28,773	29,349	30,000 [e]	30,000
Other[e, 11]	32,000 [r]	26,000 [r]	25,000 [r]	20,500 [r]	20,000
Total	78,188 [r]	79,630 [r]	77,021 [r]	77,210 [r]	72,000
Greece, electric furnace, ferronickel[e]	95,376 [7]	96,000	95,000	88,000	90,000
Hungary, electric furnace:[e, 12]					
Ferrosilicon	7,000	7,000	7,000	7,000	7,000
Silicon metal	1,000	500	500	500	500
Total	8,000	7,500	7,500	7,500	7,500
Iceland, electric furnace, ferrosilicon	117,171	118,000 [e]	120,000 [e]	113,798	114,000
India, electric furnace:[e]					
Ferrochromium[13]	468,677 [7]	527,100 [7]	611,373 [7]	634,200 [7]	820,000
Ferrochromiumsilicon	10,000	10,000	10,000	10,000	10,000
Ferromanganese	165,000	204,800 [r, 7]	192,900 [r, 7]	180,000	180,000
Ferroniobium (ferrocolumbium)	60	60	65	65	65
Ferrosilicon	54,000	55,000	56,000	58,000	60,000
Silicomanganese	160,000	96,893 [r, 7]	69,224 [r, 7]	180,000	180,000
Other	8,940 [r]	8,940 [r]	8,940 [r]	8,940 [r]	8,940
Total	867,000	903,000 [r]	948,000 [r]	1,070,000	1,260,000
Indonesia, electric furnace:					
Ferromanganese[e]	12,000	12,000	12,000	12,000	12,000
Ferronickel	43,894	39,538	36,690	72,300 [r]	92,500
Silicomanganese[e]	7,000	7,000	4,000	5,000	6,000
Total	62,894	58,538	52,690	89,300 [r]	111,000

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]	2003	2004	2005	2006	2007[e]
Iran, electric furnace:					
Ferrochromium[e]	10,000	7,750 [7]	8,000	7,000 [r]	8,000
Ferromanganese	35,909	36,700	NA	NA	NA
Ferrosilicon[e]	40,297 [7]	50,150 [7]	50,000	45,000 [r]	45,000
Total	86,206 [r]	94,600 [r]	58,000 [e]	52,000 [r]	53,000
Italy, electric furnace:[e]					
Ferromanganese	25,000 [r]	38,000 [r]	32,000 [r]	13,000 [r]	15,000
Silicomanganese	100,000	100,000	100,000	96,600 [r]	95,000
Other[14]	10,000	10,000	10,000	10,000	10,000
Total	135,000 [r]	148,000 [r]	142,000 [r]	120,000 [r]	120,000
Japan, electric furnace:					
Ferrochromium[15]	19,427	13,472	12,367	13,056	12,000
Ferromanganese	371,831	437,389	448,616	406,162 [r]	420,151 [7]
Ferronickel	369,099	374,213	391,074	335,884	344,000
Silicomanganese	58,043	73,041	94,725	59,424 [r]	52,901 [7]
Other[16]	10,007	12,822	16,436	19,394	23,730 [7]
Total	828,407	910,937	963,218	833,920 [r]	853,000
Kazakhstan, electric furnace:					
Ferrochromium	993,000	1,080,993	1,156,168	1,200,000 [e]	1,200,000
Ferrochromiumsilicon	98,130	104,800	97,870	100,000 [e]	105,000
Ferromanganese[e]	1,931 [7]	2,000	2,100	2,100	2,100
Ferrosilicon	127,300	103,580	104,185	105,000 [e]	105,000
Silicomanganese	178,920	155,324	170,214	220,000 [e]	220,000
Other[e]	9,000	9,000	9,000	9,000	9,000
Total	1,408,281	1,455,697	1,539,537	1,640,000 [e]	1,640,000
Korea, North, electric furnace, other[e]	10,000	10,000	10,000	10,000	10,000
Korea, Republic of, electric furnace:					
Ferromanganese	141,480	165,525	124,434	169,202 [r]	209,321 [7]
Silicomanganese	90,942	82,917	74,193	94,119 [r]	105,607 [7]
Other	4,308	4,811	3,670	3,653 [r]	4,224 [7]
Total	236,730	253,253	202,297	266,974 [r]	319,152 [7]
Macedonia, electric furnace:					
Ferronickel[e]	25,250 [r]	24,100 [r]	34,419 [r, 17]	45,048 [r, 17]	68,200
Ferrosilicon	50,000 [e]	56,000 [r, e]	71,249 [r]	59,023 [r]	60,000
Total	75,250 [r]	80,100 [r]	105,668 [r]	104,071 [r]	128,000
Mexico, electric furnace:[18]					
Ferromanganese	55,903	72,471	89,642 [r]	62,485 [r]	62,000
Silicomanganese	81,223	103,206	104,780	97,457 [r]	97,000
Total	137,126	175,677	194,422 [r]	159,942 [r]	159,000
New Caledonia, electric furnace, ferronickel	167,208	151,296	155,800 [r]	162,400 [r]	144,600 [7]
Norway, electric furnace:[e]					
Ferromanganese	245,000	245,000	250,000	245,000	245,000
Ferrosilicon	350,000	300,000	165,000	93,000 [r]	215,000
Silicomanganese	230,000	230,000	230,000	230,000	225,000
Silicon metal	100,000	105,000	105,000	100,000	100,000
Other[9]	15,000	15,000	15,000	15,000	15,000
Total	940,000	895,000	765,000	683,000 [r]	800,000
Peru, electric furnace, ferrosilicon[e]	600	600	600	600	600
Poland:					
Blast furnace, ferromanganese	1,000	46,900	7,800	4,100 [r]	4,000
Electric furnace:					
Ferrosilicon	92,700	83,600	65,100	13,000 [r]	13,000

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]	2003	2004	2005	2006	2007[e]
Poland—Continued:					
Electric furnace—Continued:					
Silicomanganese	5,000	29,600	10,242	3,310 [r]	3,000
Total	98,700	160,100	83,142	20,410 [r]	20,000
Romania, electric furnace:					
Ferromanganese	NA	191	18,625	3,329	-- [7]
Silicomanganese	141,899	194,745 [r]	100,957 [r]	53,085 [r]	26,868 [7]
Total	141,899	194,936 [r]	119,582 [r]	56,414 [r]	26,868 [7]
Russia:[e]					
Blast furnace:					
Ferromanganese	101,000	110,000 [r]	110,000 [r]	130,000 [r]	120,000
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	357,000 [7]	454,000	578,000 [7]	600,000	570,000
Ferrochromiumsilicon	4,000	4,000	4,000	4,000	4,000
Ferronickel:[e, 19]					
High-nickel	14,900 [r]	9,640 [r]	12,900 [r]	11,330 [r, 7]	14,000
Other	4,230 [r]	20,900 [r]	8,160 [r]	18,800 [r]	20,000
Ferroniobium (ferrocolumbium)	--	--	--	--	80
Ferrosilicon	760,000	721,000	742,000 [7]	882,300 [r, 7]	896,100 [7]
Ferrovanadium	8,000	13,700	12,880 [7]	11,000 [r]	12,000
Silicomanganese	63,000 [r]	141,000 [r]	48,000 [r]	40,000 [r]	40,000
Silicon metal	75,000	75,000	58,000	54,500	54,000
Other	22,000	22,000	22,000	22,000	22,000
Total	1,420,000 [r]	1,580,000 [r]	1,610,000 [r]	1,780,000 [r]	1,760,000
Saudi Arabia, electric furnace, other[e]	75,000	85,000	85,000	90,000	90,000
Slovakia, electric furnace:					
Ferrochromium	1,924	1,784	867	19	20
Ferromanganese	43,434 [r]	66,959 [r]	43,458 [r]	59,391 [r]	60,000
Ferrosilicon	41,539	34,600	16,512 [r]	-- [r]	--
Silicomanganese	52,733	64,842	47,843 [r]	59,128 [r]	60,000
Other[e]	5,000 [7]	5,000	5,000	5,000	5,000
Total	144,630 [r]	173,185 [r]	113,680 [r]	123,538 [r]	125,000
Slovenia, electric furnace, ferrosilicon[e]	9,000 [r]	9,000 [r]	9,000 [r]	9,000 [r]	9,000
South Africa, electric furnace:					
Ferrochromium	2,813,000	2,965,000	2,812,000	3,030,000	3,561,491 [7]
Ferromanganese	607,362	611,914	570,574	656,235 [r]	750,000
Ferrosilicon	135,300	140,600	127,000	148,900 [r]	150,000
Ferrovanadium[e]	19,000 [7]	20,000	19,000	18,000	18,000
Silicomanganese[e]	270,000 [r]	330,000 [r]	230,000 [r]	250,000 [r]	280,000
Silicon metal	48,500	50,500	58,000 [r]	58,000 [r]	53,000
Other[e, 20]	80,000	80,000	80,000	80,000	80,000
Total	3,973,162 [r]	4,198,014 [r]	3,896,574 [r]	4,241,135 [r]	4,890,000
Spain, electric furnace:[e]					
Ferromanganese	10,000	10,000	10,000	10,000	10,000
Ferrosilicon	60,000 [r]	60,000 [r]	70,000 [r]	67,000 [r]	71,000
Silicomanganese	100,000	100,000	100,000	100,000	100,000
Silicon metal	30,000	30,000	32,000 [r]	32,000 [r]	32,000
Other	5,000	5,000	5,000	5,000	5,000
Total	205,000 [r]	205,000 [r]	217,000 [r]	214,000 [r]	218,000

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]	2003	2004	2005	2006	2007[e]
Sweden, electric furnace:					
Ferrochromium	110,529	128,191	127,451	136,374	124,403 [7]
Ferrosilicon[e]	17,100	18,500	9,800	4,000	5,000
Total	127,629	146,691	137,251	140,374 [r]	129,000
Turkey, electric furnace:					
Ferrochromium	35,393	33,686	26,043	67,975	69,730 [7]
Ferrosilicon	7,000 [e]	--	--	5,000 [e]	5,000
Total	42,393	33,686	26,043	72,975 [r]	74,700
Ukraine:					
Blast furnace:[e]					
Ferromanganese	85,000	79,000	30,000	30,000	30,000
Spiegeleisen	5,000	5,000	5,000	5,000	5,000
Electric furnace:					
Ferromanganese	250,000 [e]	375,990	359,000	373,000	368,000
Ferronickel[e]	--	60,000 [r]	60,000 [r]	90,000 [r]	90,000
Ferrosilicon	250,000 [e]	248,060	228,000 [r]	168,000 [r]	167,300 [7]
Silicomanganese	740,000 [e]	1,060,000	1,040,000	1,168,000	1,281,000 [7]
Silicon metal[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Other[e]	25,000	25,000	25,000	25,000	25,000
Total	1,360,000 [r, e]	1,853,050 [r]	1,747,000 [r]	1,859,000 [r]	1,970,000
United States, electric furnace:					
Ferrochromium[21]	W	W	W	W	W
Ferromanganese[22]	W	W	W	W	W
Ferroniobium (ferrocolumbium)	NA	NA	NA	NA	NA
Ferrosilicon[23]	148,000	171,000	164,000	194,000	201,000 [7]
Silicon metal[23]	134,000	144,000	143,000	W	W
Other[24]	W	W	W	W	W
Total	282,000	315,000	307,000	194,000	201,000
Uruguay, electric furnace, ferrosilicon[e]	200	200	200	200	200
Venezuela, electric furnace:[e]					
Ferromanganese	12,000	15,000	15,000	15,000	15,000
Ferronickel	57,300	58,000 [7]	56,300	57,000 [r, 7]	53,500
Ferrosilicon	90,543 [7]	92,000	95,000 [r]	95,000 [r]	94,000
Silicomanganese	30,632 [7]	35,000	35,000	35,000	35,000
Total	190,475 [7]	200,000	201,000 [r]	202,000 [r]	198,000
Zimbabwe, electric furnace:[e]					
Ferrochromium	245,200 [7]	193,077 [7]	235,000	200,000	150,000
Ferrochromiumsilicon	--	1,000	5,000	3,000	2,000
Total	245,200 [7]	194,077 [7]	240,000	203,000	152,000
Grand total	22,600,000 [r]	26,400,000	27,700,000 [r]	31,800,000 [r]	34,400,000
Of which:					
Blast furnace:					
Ferromanganese	899,000	826,000 [r]	648,000 [r]	764,000 [r]	774,000
Spiegeleisen	12,000	12,000	12,000	12,000	12,000
Other[25]	104,000	104,000	63,500	63,500	83,500
Total, blast furnace	1,010,000	941,000 [r]	723,000 [r]	840,000 [r]	870,000
Electric furnace:					
Ferrochromium[26]	6,070,000	6,590,000 [r]	6,910,000	7,340,000 [r]	8,370,000
Ferrochromiumsilicon	123,000	131,000	128,000	129,000	133,000
Ferromanganese	3,130,000 [r]	3,840,000 [r]	3,770,000 [r]	4,190,000 [r]	4,420,000
Ferronickel	983,000 [r]	1,050,000 [r]	1,080,000 [r]	1,140,000 [r]	1,170,000
Ferroniobium (ferrocolumbium)	37,500	26,200	39,900	42,600	43,100

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]	2003	2004	2005	2006	2007[e]
Zimbabwe, electric furnace—Continued:[e]					
Electric furnace—Continued:					
Ferrosilicon	4,950,000 [r]	5,660,000 [r]	5,800,000 [r]	6,480,000 [r]	6,760,000
Silicomanganese	4,620,000 [r]	6,020,000 [r]	6,080,000 [r]	6,930,000 [r]	7,310,000
Silicon metal	703,000 [r]	760,000 [r]	811,000 [r]	628,000 [r]	641,000
Other[27]	1,000,000 [r]	1,360,000 [r]	2,330,000 [r]	4,100,000 [r]	4,630,000
Total, electric furnace	21,600,000 [r]	25,400,000	27,000,000 [r]	31,000,000 [r]	33,500,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." NA Not available. -- 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 15, 2008.

[3]In addition to the countries listed, ferrotungsten is produced in China and Russia; Austria and Germany are thought to have produced ferroniobium (ferrocolumbium); and 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]Includes calcium-silicon.

[7]Reported figure.

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

[9]In 2006, China began reporting production data for ferronickel and nickeliferous pig iron (1.6% to 14.5% nickel). The production figures were under review at the time of publication.

[10]Includes, if any, silicospiegeleisen.

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

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

[13]Includes charge chrome and ferrochrome.

[14]Excludes calcium-silicon.

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

[16]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.

[17]Reported gross weight of exports.

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

[19]In December 2001, Mechel OAO acquired a 79.9% interest in the South Urals Nickel Plant previously operated by Yuzhuralnikel 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%.

[20]Includes, if any, ferronickel.

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

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

[23]Net production.

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

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

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

[27]Includes ferromolybdenum and ferrovanadium.