VANADIUM

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In 2003, vanadium consumption in the United States was 2,960 metric tons (t) of contained vanadium, about a 4% decrease from that of 2002, representing the sixth consecutive year consumption has decreased. The United States imported 1,690 t of ferrovanadium (FeV) (measured in vanadium (V) content), 679 t of vanadium pentoxide (V_2O_5), and 74 t of other vanadium products collectively valued at about $18.7 million. Total imports for consumption of these vanadium materials decreased about 18% from those of 2002. The United States exported 424 t of FeV (V content), 791 t of V_2O_5, and 438 t of other vanadium products valued at about $14.3 million. Total exports of these vanadium materials increased by about 60% from those of 2002.

The U.S. production of vanadium was solely by recovery of vanadium values from various industrial waste materials such as fly ash, petroleum residues, spent catalysts and vanadium-bearing iron slag. Fewer than 10 firms, primarily in Arkansas, Louisiana, and Texas, processed these materials to produce FeV, vanadium metal, and V_2O_5. Metallurgical applications in which vanadium was used as a minor alloying element with iron, steel, and titanium remained the dominant end use. Catalysts represent the largest nonmetallurgical use for vanadium.

Although vanadium has many uses, metallurgical applications accounted for more than 91% of domestic consumption in 2003. Most vanadium is consumed in the form of FeV, which is used as a means of introducing vanadium into steel where it gives additional strength and toughness. FeV is available as alloys containing 45% to 50% and 80% vanadium. The 45%- to 50%-grade FeV is produced by the silicothermic reduction of V_2O_5 in slag or other vanadium-containing materials. Most of the 80%-grade FeV is produced by the aluminothermic reduction of V_2O_5 in the presence of steel scrap or by direct reduction in an electric arc furnace. Vanadium-containing steels can be subdivided into microalloyed or low-alloy steels, which generally contain less than 0.15% vanadium, and high-alloy steels, which contain as much as 5% vanadium. Nonmetallurgical applications include catalysts (the dominant use), ceramics, electronics, and vanadium chemicals.

Legislation and Government Programs

The U.S. Department of Commerce (DOC) announced final antidumping duties on imports of FeV from China and South Africa in a November 21, 2002, final ruling (Ryan's Notes, 2002b). The U.S. International Trade Commission ruled on December 19, 2002, that FeV imports from China and South Africa would be subject to antidumping duties (Platts Metals Week, 2002). The DOC calculated antidumping margins of 116% for Xstrata South Africa (Proprietary) Ltd. (Xstrata), Highveld Steel & Vanadium Corp. Ltd. (Highveld), and other South African producers, and margins of 13.03% for Panzhihua Iron & Steel Co. Ltd. and 66.71% for other Chinese suppliers. These actions resulted in FeV imports from China and South Africa decreasing to 0 t from China and 59 t from South Africa in 2003, from 50 t and 200 t, respectively, in 2002.

Production

The major vanadium commodities are aluminum-vanadium master alloys, FeV, vanadium-bearing ash, residues and slag, vanadium chemicals, and V_2O_5 (and other oxides and hydroxides of vanadium). In 2003, companies in the United States produced all of these materials with the exception of vanadium-bearing slag from the manufacture of iron and steel.

Vanadium producer Strategic Minerals Corp. (Stratcor) would continue to meet most of its feedstock requirements at its Brits, South Africa, plant, with purchased vanadium-bearing slag rather than mined ore from its captive mine (Ryan's Notes, 2003b). The mine has produced sporadically since 2000. Stratcor renewed a contract for slag through 2006. Although the supplier was not named, Highveld had supplied slag to the Brits plant in the past. The Brits plant primarily produced Nitrovan, a proprietary additive to strengthen high-strength, low-alloy steels, at its Vametco subsidiary in Brits.

CS Metals continued to improve operations at its catalyst recovery plant in Port Nickel, LA, and sustained daily operation throughout the year (Ryan's Notes, 2003a). At its design capacity, the plant could recover 2,270 metric tons per year (t/yr) (5 million pounds per year) of V_2O_5, 1,800 t/yr (4 million pounds per year) of molybdenum oxide, and 2,270 t/yr (5 million pounds per year) of nickel from spent catalysts. The plant is 100% owned by CRI Metal Products (a subsidiary of Royal Dutch Shell Group) since Stratcor sold its interest in September 2002 (Ryan's Notes, 2002c). Stratcor will continue to market vanadium-containing materials produced by CS Metals and will also provide technical assistance.

Stratcor shut its Hot Springs, AR, vanadium plant for 3 weeks at the end of April owing to delays in receiving feedstock from Venezuela (Ryan's Notes, 2003e). In December 2002, the national strike in Venezuela reduced production of vanadium-bearing residues at refineries and also affected shipments from port facilities hit by strikes. Refinery residues and fly ash are the feedstock for the Hot Springs plant. The plant has a production capacity of 5,440 t/yr (12 million pounds per year) of $V_2 0_5$ and had gradually reduced production prior to the shutdown in April. Normal production resumed in May as port facilities, refineries, and utilities resumed normal operation.

Employees of the United Steelworkers of America (USWA) union went on strike at the Metallurg Vanadium Division of Shieldalloy Metallurgical Corporation's (Shieldalloy) Cambridge, OH, FeV plant on December 8, 2003 (Ryan's Notes, 2003c). Shieldalloy hired replacement workers on December 10, resumed operations at a reduced level, and avoided a force majeure. USWA workers had worked without a contract since June when they rejected a new contract owing to a provision that required workers to pay for a portion of their health benefits. The Cambridge plant has production capacity of 1,800 t/yr (4 million pounds per year) of FeV containing 42% to 48% vanadium.

Consumption

Metallurgical applications continued to dominate U.S. vanadium use in 2003, accounting for about 92% of reported consumption. Nonmetallurgical applications included catalysts, ceramics, electronics, and vanadium chemicals. The dominant nonmetallurgical use was in catalysts. Based on U.S. Geological Survey (USGS) surveys, domestic vanadium consumption in 2003 was 2,960 t, a decline of about 4% from that of 2002 (table 1). The decline reflected lower imports of FeV from China and South Africa owing to antidumping duties and reduced demand by steel producers.

The USGS derived vanadium consumption data from a voluntary survey of domestic consuming companies. For this survey, more than 80 companies were canvassed on a monthly or annual basis. Some industry estimates indicate that actual domestic consumption is much greater than reported consumption.

Prices

In 2003, the price for domestic FeV, as published in Platts Metals Week, ranged from $4.30 to $6.25 per pound of contained vanadium, compared with $3.45 to $4.49 per pound reported in 2002. The price rose from $4.30 per pound in January to $6.25 per pound in June, dropped in July, and then was steady at $5.55 to $5.60 per pound from July through December. The European FeV price ranged from $9.70 to $14.40 per kilogram, compared with $6.20 to $9.90 per kilogram in 2002. The European price rose from $9.70 per kilogram in January to $13.50 per kilogram in April, dropped to below $11.00 per kilogram by July, and rebounded to about $11.50 per kilogram through November. In December it spiked to reach its high of $14.40 per kilogram for the year.

The Platts Metals Week published price for domestic V_2O_5 ranged between $1.50 and $2.80 per pound in 2003, compared with $1.25 to $1.70 per pound in 2002. The price rose quickly from $1.50 per pound in January to $2.80 per pound in May, dropped to about $2.00 per pound by July, rose to about $2.20 per pound by November before it spiked to $2.80 per pound in December.

World Review

Nearly all the world's supply of vanadium is from primary sources. Six countries recovered vanadium from concentrates, ores, petroleum residues, or slag (table 7). In four of the six foreign countries, the mining and processing of magnetite-bearing ores was an important source of their vanadium production. The largest vanadium-producing nations remained China and South Africa. Japan and the United States were believed to be the only countries to recover significant quantities of vanadium from petroleum residues.

Recycling of vanadium-containing alloys for recovery of vanadium was negligible and involved mainly a small quantity of tool steel. Vanadium's major end use was as a minor alloying-element in iron, steel, and titanium-bearing alloys, from which it is lost to slag and not recovered when those metals are recycled. Only small quantities of vanadium were recovered from recycling vanadium-bearing catalysts, and that material was reused to make new catalysts.

Australia.—Xstrata, Plc. announced the closure of its Windimurra Mine in February citing chronic oversupply conditions in the vanadium market (Ryan's Notes, 2003h). The closure coincided with the expiration of Xstrata's offtake agreement with Glencore International AG that guaranteed a minimum price of $3.80 per pound of V_2O_5 compared with the average price of about $1.50 per pound in 2002. Windimurra produced about 12 million pounds of V_2O_5 in 2002. Removal of that capacity will reduce the oversupply from the market and put supply more in balance with demand of about 70,300 t/yr (155 million pounds per year).

China.—A new company named Chengde Vanadium & Titanium Jinzhou Vanadium Industry Co. Ltd., was formed by a joint venture between Chengde Xinxin Vanadium & Titanium Co. Ltd. and Jinzhou Ferro-Alloys Co. Ltd. (Anitake Precious & Minor Metals Monthly, 2003). The new venture was 70% capitalized by Chengde Xinxin and was located at the Jinzhou facility. The plant began operation in the first quarter of 2003 and produced low-vanadium alloy and hot-rolling strip steel, vanadium-containing screwed rebar, and vanadium-bearing slag.

Japan.—While U.S. FeV producers successfully blocked FeV imports from China and South Africa through trade actions, Japan's industry invested in offshore production facilities to meet domestic demand (Ryan's Notes, 2003d). South Africa Japan Vanadium (SAJ Vanadium) [a joint venture between Highveld (50%), Nippon Denko (40%), and Mitsui & Co. (10%)] commissioned a 3,500-t/yr FeV plant in Witbank, South Africa, on July 12, 2003. Nippon Denko reduced production at its Hokuriku smelter in Japan and planned to suspend operations once sufficient SAJ Vanadium plant production was received in Japan.

Russia.—In June 2003, pig iron producer JSC Tulachermet finalized purchase of controlling interest in Tulachermet Vanadium from Eastlink Lanker (Metal Bulletin, 2003b). In February, a dispute between the neighboring plants resulted in a blockade of the vanadium plant that cut them off from their power utility. The new management team slowly ramped up production to 50% of capacity and maintained that level through the rest of the year to keep the market steady. Management also appointed Switzerland-based Arpicom as their exclusive sales agent to market vanadium and vowed to sell directly to end users (Ryan's Notes, 2003f). Previously, most output from Tulachermet was sold through traders.

South Africa.—In November 2003, Xstrata announced the suspension of production at its Vantech operation in South Africa effective January 1, 2004, as the ore body at Vantech neared depletion (Ryan's Notes, 2003g). Xstrata said it decided to postpone development of the nearby Kennedy's Vale and Steelpoortdrift deposits until the market recovered. Xstrata reduced production at Vantech throughout the year while replacing some of the lost units by increased output at it Rhovan, South Africa, operation. Xstrata made capital expenditures of about $5 million on a vanadium trioxide plant and furnace project at Rhovan to reduce aluminum consumption at Rhovan by about 38%.

Highveld cut production of structural steel at its Witbank, South Africa, works in June 2003, which reduced vanadium-bearing slag production (Metal Bulletin, 2003a). Consumption of structural steel and hot-rolled flat steel in South Africa had dropped significantly as construction spending slowed owing to the strong rand and high interest rates. First-half earnings were considerably lower than for the same period in 2002, and Highveld also expected production to fall on a year-to-year basis. Highveld produced 74,395 t of vanadium slag in 2002, a 10-year high.

Swaziland.—U.S. Government import data showed that imports of FeV from the small southern African country of Swaziland began in June 2003 (Platts Metals Week, 2003). Swaziland is sandwiched between the northeastern section of South Africa and the southern border of Mozambique. U.S. vanadium industry sources were unaware of any vanadium production capability in Swaziland, and there were no FeV imports from there in 2000-02 or the first 5 months of 2003. Given that South Africa is the world's largest vanadium producer and that the United States imposed antidumping duties on imports of FeV from South Africa in 2003, these FeV imports may have been rerouted South African units.

Current Research and Technology

McKenzie Bay International Ltd. (2003a§[1]) acquired the outstanding 20% interest in the Lac Dore vanadium project from Soquem, Inc., to control 100% of the project. McKenzie Bay's experts developed the McKenzie Bay process to produce high-purity vanadium chemicals for use in vanadium battery applications. Lac Dore Mining Inc. (a wholly owned subsidiary) was developing the Lac Dore vanadium-titanium deposit near Quebec, Canada, the second largest vanadium deposit in the world, with 2.27 million metric tons (Mt) (5 billion pounds) of reserves.

McKenzie Bay reached agreement with SGS Lakefield Research to develop and build a "Special Production Unit" (SPU) at its Lakefields facility in Ontario, Canada, capable of producing 22.7 t/yr (50,000 pounds per year) of vanadium chemicals (McKenzie Bay International, Ltd., 2003c§). McKenzie Bay also filed an environmental impact study with Fisheries and Oceans Canada and the Quebec Ministry of Environment, an important step towards securing necessary permits to construct a mine and refinery at Lac Dore (McKenzie Bay International, Ltd., 2003d§). Parallel to SPU development, McKenzie Bay is planning to commission a vanadium demonstration plant in Canada to produce a high-purity (> 99.9% pure) V_2O_5 product to make vanadium electrolyte for vanadium redox batteries. Pilot-plant production is planned to be 1,800 t/yr (4 million pounds per year), for all products combined, with expansion possibilities. Commissioning of the plant was planned for 2004.

McKenzie Bay was building an integrated "products for energy" organization based on new vanadium-based, electricity storage devices and alternative electrical power generation systems (McKenzie Bay International, Ltd., 2003b§). Dermond Inc. (acquired by McKenzie Bay in 2002) is developing improvements to the vertical axis wind turbine (VAWT) and has filled an international patent, covering 130 countries, for 46 improvements on VAWT technology. WindStor Power Company (another wholly owned subsidiary of McKenzie Bay) is developing a wind energy generation, storage, and distribution system for use in off-grid markets. WindStor's system combines the VAWT technology with a vanadium-based battery storage system and a proprietary system integrator to provide stored electricity to users. WindStor systems, which would supply 400 kilowatts (kW) and 500 kW, respectively, and are scheduled for installation in 2004, have been sold to a medical center in Flint, MI, and to an apartment complex in southeastern Michigan.

Outlook

Xstrata's decision to close its Windimurra plant in Australia and the subsequent closure of its Vantech operation in South Africa removed 8,160 t/yr (18 million pounds per year) and 11,800 t/yr (26 million pounds per year), respectively, of V_2O_5 production capacity from the market. Continued strong demand from China and absence of exports from Australia caused Japanese FeV prices to rise at the end of the year. Tulacheramet's decision to market directly to end users together with limiting their production to 50% of capacity and reduced South African exports caused a shortage of vanadium units for traders in Europe and speculative upward price pressure. While these developments created local shortages, vanadium remains in oversupply as the capacity to recover vanadium from catalysts, petroleum residues, and slag worldwide was estimated to be about 81,700 t/yr (180 million pounds per year) and primary mines add another 36,300 t/yr (80 million pounds per year) of V_2O_5 capacity. With consumption estimated at about 70,300 t/yr (155 million pounds per year), the world supply and demand will not come into balance without additional reductions in capacity and/or increases in demand.

U.S. and world demand for vanadium will continue to fluctuate in response to changes in steel production. However, the overall trend for consumption is expected to increase as vanadium use in crude steel, which accounts for 85% of world consumption, continues to grow at a rate higher than the 2% to 3% per year in steel production (Ryan's Notes, 2002a). There are opportunities to increase the amount of vanadium consumed in microalloyed steels. In addition, if China, which produces more steel than the United States but only uses about one-half the vanadium, doubled its consumption, then it could boost demand by an additional 6,800 t/yr (15 million pounds per year). Finally, new applications, such as the vanadium redox battery, have the potential of lifting consumption by as much as 9,100 t/yr (20 million pounds per year).

The world vanadium reserve base, at more than 38 Mt, is sufficient to meet vanadium demand into the next century at the present rate of consumption. This does not account for the increased recovery of vanadium from fly ash, petroleum residues, slag, and spent catalyst that will extend the life of the reserve base significantly.

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TABLE 1
SALIENT VANADIUM STATISTICS[1]

(Metric tons of contained vanadium unless otherwise specified)

		1999	2000	2001	2002	2003
United States:						
Production, ore and concentrate:						
Recoverable vanadium[2]		W	--	--	--	--
Value	thousand dollars	W	--	--	--	--
Vanadium oxide recovered from ore[3]		W	--	--	--	--
Consumption		3,620	3,520	3,210	3,080	2,960
Exports:						
Ferrovanadium		213	172	70	142	424
Vanadium pentoxide (anhydride)		747	653	670	453	791
Other oxides and hydroxides of vanadium		70	100	385	443	438
Imports for consumption:						
Ferrovanadium		1,930	2,510	2,550	2,520	1,690
Ore, slag, ash, residues		1,650	1,890	1,670 r	1,870 r	2,220
Vanadium pentoxide (anhydride)		208	902	600	406	679
Other oxides and hydroxides of vanadium		--	21 r	57 r	66 r	74
Stocks:						
Ferrovanadium		328	278	239	197	195
Oxide		5	5	5	5	5
Other[4]		15	20	7	19	37
World, production from ore, concentrate, slag[5]		36,000 r	40,700 r	43,900 r	50,500 r	40,400 e

r Revised. e Estimated. W Withheld to avoid disclosing company proprietary data. -- Zero.
[1]Data are rounded to no more than three significant digits.
[2]Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mill, plus vanadium recovered from ferrophosphorous slag derived from domestic phosphate rock.
[3]Produced directly from all domestic ores and ferrophosphorous slag; includes metavanadates.
[4]Consists principally of vanadium-aluminum alloy, small quantities of other vanadium alloys, vanadium metal, and ammonium metavanadate.
[5]Excludes U.S. production.

TABLE 2

U.S. CONSUMPTION OF VANADIUM, BY END USE AND FORM[1]

(Kilograms of contained vanadium)

	2002	2003
End use:		
Steel:		
Carbon	731,000	783,000
Full alloy	748,000	799,000
High-strength low-alloy	900,000	924,000
Stainless and heat resisting	37,500	64,500
Tool	270,000	143,000
Total	2,690,000	2,710,000
Cast irons	W	W
Superalloys	12,400	10,000
Alloys (excluding steels and superalloys):		
Welding and alloy hard-facing rods and materials	W	W
Other alloys[2]	W	W
Chemical and ceramic uses:		
Catalysts	W	W
Pigments	W	W
Miscellaneous and unspecified	382,000	235,000
Total	3,080,000	2,960,000
Form:		
Ferrovanadium	2,730,000	2,130,000
Oxide	208,000	93,100
Other[3]	141,000	732,000
Total	3,080,000	2,960,000

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

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

[2]Includes magnetic alloys.

[3]Consists principally of vanadium-aluminum alloy, small quantities of other vanadium alloys, vanadium metal, and ammonium metavanadate.

TABLE 3

U.S. IMPORTS AND EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY AND VANADIUM METAL, INCLUDING WASTE AND SCRAP[1]

	Aluminum-vanadium master alloy		Vanadium metal, including waste and scrap	
	Quantity (kilograms, gross weight)	Value	Quantity (kilograms, gross weight)	Value
Imports for consumption:				
2002	97,500	$206,000	32,300	$1,270,000
2003:				
Brazil	60,400	97,900	--	--
Canada	170,000	308,000	--	--
China	--	--	500	2,410
Germany	1,500	19,400	168,000	2,410,000
Russia	--	--	3,880	293,000
United Kingdom	--	--	13,800	140,000
Total	232,000	425,000	186,000	2,850,000
Exports:				
2002	529,000	11,700,000	49,200	898,000
2003:				
Austria	--	--	4,570	402,000
Canada	3,100,000	8,820,000	254	6,960
France	2,280	61,700	5	7,070

See footnotes at end of table.

TABLE 3--Continued

U.S. IMPORTS AND EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY AND VANADIUM METAL, INCLUDING WASTE AND SCRAP[1]

	Aluminum-vanadium master alloy		Vanadium metal, including waste and scrap	
	Quantity (kilograms, gross weight)	Value	Quantity (kilograms, gross weight)	Value
Exports--Continued:				
2003--Continued:				
Germany	--	--	20,300	$243,000
Hong Kong	16,100	$296,000	--	--
India	6,730	43,700	--	--
Ireland	729	18,300	--	--
Italy	--	--	4	2,950
Japan	81,500	1,000,000	8,760	155,000
Korea, Republic of	44,400	319,000	185	38,200
Malaysia	2,920	71,100	29,000	65,400
Mexico	6,140,000	11,100,000	--	--
Netherlands	2,110	30,900	--	--
Norway	13,500	117,000	--	--
Russia	--	--	36,400	486,000
Senegal	--	--	39,100	2,100,000
Singapore	13,200	128,000	--	--
South Africa	--	--	48,000	176,000
Taiwan	17,200	71,700	50	7,910
Thailand	6,750	28,800	--	--
Ukraine	--	--	962	11,200
United Kingdom	149,000	728,000	3,610	138,000
Venezuela	--	--	9,430	70,800
Total	9,590,000	22,800,000	201,000	3,910,000

-- Zero.

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

Source: U.S. Census Bureau.

TABLE 4

U.S. IMPORTS AND EXPORTS OF FERROVANADIUM, VANADIUM PENTOXIDE (ANHYDRIDE) AND OTHER OXIDES AND HYDROXIDES OF VANADIUM[1]

	Ferrovanadium		Vanadium pentoxide (anhydride)[2]		Other oxides and hydroxides of vanadium	
	Quantity (kilograms, Va content)	Value	Quantity (kilograms, Va content)	Value	Quantity (kilograms, Va content)	Value
Imports for consumption:						
2002	2,520,000	$19,400,000	406,000	$1,990,000	65,800 r	$560,000
2003:						
Austria	213,000	1,830,000	--	--	--	--
Belgium	60,000	428,000	--	--	--	--
Canada	487,000	3,650,000	--	--	--	--
China	--	--	500	2,410	19,900	40,300
Czech Republic	317,000	2,870,000	--	--	--	--
Germany	--	--	5,630	169,000	41,000	522,000
India	11,100	59,600	--	--	--	--
Israel	--	--	--	--	13,400	205,000
Italy	--	--	--	--	45	2,340
Mexico	--	--	45,300	431,000	--	--
Russia	--	--	4	3,280	--	--
South Africa	58,700	462,000	614,000	2,940,000	--	--
Swaziland	547,000	5,010,000	--	--	--	--

See footnotes at end of table.

TABLE 4--Continued

U.S. IMPORTS AND EXPORTS OF FERROVANADIUM, VANADIUM PENTOXIDE (ANHYDRIDE) AND OTHER OXIDES AND HYDROXIDES OF VANADIUM[1]

	Ferrovanadium		Vanadium pentoxide (anhydride)[2]		Other oxides and hydroxides of vanadium	
	Quantity (kilograms, Va content)	Value	Quantity (kilograms, Va content)	Value	Quantity (kilograms, Va content)	Value
Imports for consumption--Continued:						
2003--Continued:						
Taiwan	--	--	13,400	$67,300	--	--
Total	1,690,000	$14,300,000	679,000	3,610,000	74,300	$769,000
Exports:						
2002	142,000	1,580,000	453,000	2,070,000	443,000	3,710,000
2003:						
Australia	688	8,000	--	--	--	--
Bahamas, The	--	--	450	4,050	--	--
Belgium	--	--	603,000	3,130,000	13,300	112,000
Brazil	805	24,000	--	--		
Canada	96,000	1,440,000	--	--	222,000	2,360,000
China	--	--	16,300	154,000	9,540	104,000
Estonia	12,700	161,000	--	--	--	--
Germany	--	--	1,590	36,500	5,990	50,200
India	--	--	--	--	16,100	162,000
Italy	--	--	26,800	141,000	--	--
Japan	--	--	71,400	678,000	1,700	15,100
Korea, Republic of	--	--	4,040	38,400	1,810	20,200
Malaysia	--	--	1,010	3,710	--	--
Mexico	162,000	2,190,000	2,490	22,200	6,700	24,000
Netherlands	76,000	992,000	30	3,630	67,500	628,000
Philippines	249	5,420	--	--	--	--
Saudi Arabia	--	--	27,900	190,000	--	--
South Africa	--	--	--	--	92,300	333,000
Spain	--	--	15,900	119,000	--	--
Taiwan	--	--	5,630	53,500	--	--
Trinidad and Tobago	--	--	8,990	95,700	908	8,950
United Kingdom	74,900	918,000	--	--	--	--
Venezuela	--	--	6,000	48,700	--	--
Total	424,000	5,740,000	791,000	4,720,000	438,000	3,810,000

[r]Revised. -- Zero.

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

[2]May include catalysts that contain vanadium pentoxide.

Source: U.S. Census Bureau.

TABLE 5

U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH, RESIDUES, AND SLAG[1]

	2002		2003	
Material and country	Quantity (kilograms, V_2O_5 content)	Value	Quantity (kilograms, V_2O_5 content)	Value
Ash and residues:				
Canada	2,010,000	$1,360,000	2,030,000	$2,540,000
Mexico	1,050,000	447,000	1,780,000	3,010,000
Netherlands	--	--	39,200	69,800
Spain	51,700	49,800	--	--
United Kingdom	216,000	219,000	120,000	143,000
Total	3,330,000	2,080,000	3,960,000	5,760,000
Slag, from the manufacture of iron and steel, South Africa[2]	--	--	--	--

See footnotes at end of table.

TABLE 5--Continued

U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH, RESIDUES, AND SLAG[1]

-- Zero.

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

[2]As adjusted by the U.S. Geological Survey.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS VANADIUM CHEMICALS[1, 2]

	2002		2003	
Material and country	Quantity (kilograms, V_2O_5 content)	Value	Quantity (kilograms, V_2O_5 content)	Value
Sulfates:				
Canada	68	$6,030	--	--
India	11	7,590	--	--
South Africa	14,000	376,000	--	--
Total	14,100	390,000	--	--
Vanadates:				
Germany	1,340	80,000	10,100	$205,000
Japan	370	83,200	384	19,300
South Africa	46,400	292,000	62,500	678,000
Total	48,100	455,000	72,900	902,000

-- Zero.

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

[2]Comprises vanadium ore and miscellaneous vanadium chemicals.

Source: U.S. Census Bureau.

TABLE 7

VANADIUM: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of contained vanadium)

Country	1999	2000	2001	2002	2003[e]
Production from ores, concentrates, slag:[3]					
Australia	--	2,720 r	4,760 r	3,100 r	--
China[4]	10,400 r	12,000 r	12,000 r	13,200 r	13,200
Kazakhstan[e]	1,000	1,000	1,000	1,000	1,000
Russia[e]	7,000	7,000	8,000	8,000	8,500
South Africa	17,612	18,021	18,184	25,227 r	17,700
United States, recoverable vanadium	W	--	--	--	--
Total	36,000 r	40,700 r	43,900 r	50,500 r	40,400
Production from petroleum residues, ash spent catalysts, Japan[5]	245	245	245	245	245
Grand total	36,300 r	41,000 r	41,000 r	44,200 r	40,600

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

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

[2]In addition to the countries listed, vanadium is also recovered from petroleum residues in Germany, the United States, and several other European countries but available information is insufficient to make reliable estimates. Table includes data available through June 7, 2004.

[3]Production in this section is credited to the country that was the origin of the vanadiferous raw material.

[4]Estimated 40% of vanadium recovered from vanadiferous slag.

[5]Production in this section is credited to the country where the vanadiferous product is extracted; available information is inadequate to permit crediting this output back to the country of origin of the vanadiferous raw material.