VANADIUM

By Henry E. Hilliard

In 1995, vanadium consumption was 4,640 metric tons of contained vanadium. U.S. supply consisted of vanadium-bearing ferrophosphorus slag, iron slag, fly ash, petroleum residues, and spent catalysts. The United States imported 1,950 tons of ferrovanadium (V-content), 547 tons of vanadium pentoxide anhydride (V-content) and 3,170 tons (V-content) of other vanadium products valued at about $64.3 million. The United States exported about 2,000 tons of vanadium products valued at about $24 million. Total imports of vanadium materials in 1995 increased about 20% over imports in 1994, while the volume of exports decreased by about 18%.

About 90% percent of vanadium demand was for steel products with titanium-vanadium alloys and vanadium chemicals accounting for most of the remainder. World steel production increased by about 2.5% in 1995 (from 730 million tons in 1994 to 748 million tons in 1995). There was a similar increase in demand for vanadium but, the increase was insufficient to have a positive effect on world prices.

The world pentoxide spot price began 1994 in the range $1.35-$1.40 per pound of vanadium pentoxide and continued at that level for most of the year. Prices began to increase somewhat in the third quarter, rising to the $2.81 to $3.18 range at yearend. The trend continued in 1995, as the spot price reached $4.50 per pound in March. Following the trend in pentoxide, FeV prices were mostly flat during first quarter 1994 at $8.10 to $8.40 per kilogram V. Unlike pentoxide, FeV recovered slightly to $8.39 to $8.58 in April and surged into 1995 at $16.2 per kg.

Domestic prices for vanadium pentoxide held to a range of $2.73 to $3.10 per pound for most of 1995 following a brief increase in the first few months of the year. The year began with prices in the $3.75 to $4.00 and rose to the $4.43 to 4.65 range by the end of March. Prices began to fall in April and the trend continued through October for a low of $2.95 to $3.05 per pound. Prices rallied in December closing out the year at $3.05 to $3.15. Domestic prices for FeV followed a similar path. By mid-September, consumption of FeV was running 10% to 12% percent ahead of consumption for the same period in 1994. Producers reported that demand for FeV, particularly for use in tool steel, increased in the third and fourth quarters as prices showed signs of moving toward the higher end of the price range $7.35 to $7.75 per lb V content. Antidumping duties, imposed last summer on FeV imports from Russia, were also instrumental in increasing prices. Shieldalloy Metallurgical Corp. argued successfully that imports from Russia were being marketed in the United States at below fair market value. After opening 1996 at the upper end of the $7.35 to $7.75 range, prices at the end of January had fallen slightly to $7.34 to $7.50 per lb V content; the free market price was $15.75 to $16.00 per kg V content.

Legislation and Government Programs

The Strategic and Critical Materials Stock Piling Act mandates that a stock of strategic and critical materials be maintained to decrease and eliminate, where possible, dependence upon foreign sources of supplies in times of national emergency. The urgency surrounding the security of supply of strategic and critical materials faded away after the collapse of the Soviet Union and the end of the Cold War. The result of this new world condition has been that the U.S. Government stopped acquiring most materials for the National Defense Stockpile. Moreover, the Government was pushing to dispose of excess stockpile inventories. The Defense Logistics Agency (DLA) has operational control of the NDS and identified vanadium as one of many materials for disposal. Vanadium in the NDS was valued at $2.448 million as of September 30, 1995. DLA sales in fiscal year 1995 totaled $427 million worth of excess stockpile materials, of which vanadium pentoxide sales represented only $2.7 million. Stockpile sales were expected to accelerate throughout the end of the century. Within these 4 years, DLA planned to sell all of the remaining vanadium pentoxide in the NDS.

No laws directly affecting the stockpile were enacted during the reporting period. As of September 30, 1995, neither the National Defense Authorization Act for fiscal year 1996 nor the fiscal year DOD Appropriations Act had been passed.

Production

The major marketplace vanadium materials are vanadium pentoxide, ferrovanadium, aluminum-vanadium alloys, vanadium chemicals, and vanadium-bearing iron slags. The United States produced vanadium pentoxide, ferrovanadium, aluminum-vanadium master alloys, and vanadium chemicals but no vanadium-bearing iron slags.

Domestic production data for vanadium were developed by the U.S. Geological Survey (USGS) from a voluntary survey of all U.S. operations. All five U.S. producers responded to the survey. In addition to the vanadium pentoxide mills, the US Geological Survey canvassed three other companies which produce ferrovanadium, vanadium metal, vanadium chemicals, and other specialty vanadium alloys, e.g. aluminum-vanadium master alloys. These three companies also responded to the voluntary survey. One of these companies, Strategic Minerals Corporation is a totally integrated vanadium producer.

Consumption

Metallurgical applications continued to dominate vanadium usage in 1995, accounting for more than 97% of total

consumption. Nonmetallurgical applications included catalysts, ceramics, and vanadium chemicals. The dominant nonmetallurgical use was in catalysts. Much less was consumed ceramic and electronics (batteries).

Consumption data for vanadium are developed by the USGS from a voluntary survey of all known domestic consumers. There were 61 respondents to the 1995 survey. The 61 respondents represented 77% of the total canvassed and were estimated to have accounted for 93% of total consumption, or about 4,320 metric tons. The consumption of nonrespondents, derived by using their past consumption relationships, trends, and data from nonsurvey sources, was estimated to be about 325 tons. The USGS estimate of total reported U.S. consumption of vanadium in 1995 was 4,640 tons as shown in table 1.

Current Research and Technology

Vanadium Foil Selected For Use In Superconducting Cables.—A process has been proposed for the manufacture of cables that contain the ceramic high-temperature-superconductor $YBa_2Cu_3O_{7-a}$. The cables would carry electrical current with little or no loss of power when cooled to or below temperatures of about -200 °C. The process would begin with mixing of oxides of yttrium, barium, and copper with water to form a slurry, followed by drying of the slurry, followed by calcining in a rotating kiln to obtain a stoichiometric precursor powder oxide. In the next few steps, a thin metal foil would be unspooled and formed into a V-channel, into which the precursor powder would be metered. The foil is required to be permeable by oxygen at high temperature (850° to 950 °C) to which the cable would be subsequently exposed, but to be impervious to oxygen and other environmental contaminants at lower temperatures at which the cable would be used. Vanadium was selected as the foil material because it exhibits the desired permeability-versus-temperature characteristic, plus a favorable thermal-expansion characteristic.[1]

New Vanadium Catalyst.—Innovations in vanadium catalysis, to be used by DuPont at its new plant in Asturias, Spain, reportedly have enabled DuPont to develop an environmentally friendly Tetrahydrofuran (THF) process. The innovations, which minimize by-product formation and waste, combine significant environmental improvements with greater economy and product quality. The best catalysts for THF production are based on vanadium phosphorus oxides (VPO), which also provide the oxygen for oxidation. VPOs are not inherently robust catalyst and are subject to high attrition loses. In conventional fluid-bed catalysts, attrition resistance is imparted by embedding the active catalyst particles in a matrix containing from 30% to 50% silica. While this does impart attrition resistance to the particles, it also decreases the effective surface of the catalyst. DuPont's new catalyst encapsulates the active VPO catalyst in a micro porous silica shell. The pores in the shell are large enough to pass reactants and products without affecting the selectivity of the interior catalyst. The attrition resistance of catalyst particles can also be conferred with a much smaller amount of matrix material (silica) if the material is distributed around the surface of the particle.[2]

New Magnetic Bearing Alloy Has High Suspension Capability.—A magnetic bearing alloy, designated Hiperco 50, is said to provide higher lifting or suspension capability per unit mass than any other magnetic alloy. Magnetic bearings use magnetic fields to support and control the position of components such as rotating shafts. Hiperco 50 is an iron-cobalt-vanadium soft magnetic alloy that exhibits a magnetic saturation of 24 kilogauss, high direct current maximum permeability, and low alternating current core loss. The alloy (49% Co, 1.9% V, balance Fe) is produced in strip form only, and contains a small columbium addition for grain refinement during mill processing and final heat treatment. It has been used primarily in rotor and stator laminations in motors and generators for aircraft power generation.[3]

Outlook

The outlook for the vanadium market in the nearterm is closely related to the steel industry. Most vanadium is used as an alloying agent in steel. For 1996, World Steel Dynamics was projecting a 2% rise in global steel production to 763 million metric tons; in 1997, the forecast was for an additional 4.2 percent increase to 795 million tons.[4] Looking at prospects for the U.S. market, strong growth is expected through 1996 and 1997. In 1995 the United States produced 93.1 million tons, 2% more than in 1994, and overtook China to become the world's second largest steel producer after Japan.[5] If the increase in U.S. demand for vanadium is similar to the increase in demand for steel, one can expect demand to rise to about 4,700 tons in 1996 and 4,900 tons in 1997.

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[1]NASA Tech Briefs, v. 20, No. 3, 1995, p. 88.
[2]Chemical & Engineering News, Apr. 3, 1995, p. 20.
[3]Advanced Materials & Processes, v. 146, No. 6, Dec. 1994, p. 8.
[4]American Metal Market, June 18, 1996, v. 104, No. 118.
[5]Skillings Mining Review, Feb. 17, 1996, p. 21.

OTHER SOURCES OF INFORMATION

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Other Sources

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Metalworking News.
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TABLE 1
SALIENT VANADIUM STATISTICS 1/

(Metric tons of contained vanadium unless otherwise specified)

	1991	1992	1993	1994	1995
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium 2/	W	W	W	W	W
Value thousands	W	W	W	W	W
Vanadium oxide recovered from ore 3/	W	W	W	W	W
Vanadium recovered from petroleum residues 4/	2,250	1,350	2,870	2,830	1,990 e/
Consumption	3,290	4,080	3,970	4,280 r/	4,640
Exports:					
Ferrovanadium	94	213	219	374	340
Vanadium pentoxide (anhydride)	700	26	126	335	229
Other oxides and hydroxides of vanadium	1,110	1,110	895	1,050	1,010
Imports for consumption:					
Ferrovanadium	420	592	1,630	1,910	1,950
Vanadium pentoxide (anhydride)	133	206	70	294	547
Other oxides and hydroxides of vanadium	110	103	19	3	36
Ore, slag, ash, and residues	882	838	1,450	1,900	1,900
World: Production from ore, concentrate, slag 5/	34,300	32,900 r/	34,600 r/	34,700 r/	34,900 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mill, plus vanadium recovered from ferrophosphorus slag derived from domestic phosphate rock.

3/ Produced directly from all domestic ores and ferrophosphorus slag; includes metavanadates.

4/ Includes vanadium recovered from fly ash, petroleum residues, and spent catalysts.

5/ Excludes U.S. production.

TABLE 2
U.S. VANADIUM PENTOXIDE PRODUCERS

Producer	Plant location	Capacity (metric tons pentoxide per year)
AMAX Metals Recovery Inc.	Braithwaite, LA	1,800
Energy Fuels Nuclear Inc.	Blanding, UT	6,800
Gulf Chemical & Metallurgical Corp.	Freeport, TX	1,400
Kerr-McGee Chemical Corp.	Soda Springs, ID	2,000
U.S. Vanadium Corp.	Hot Springs, AR	6,800

TABLE 3
U.S. CONSUMPTION AND CONSUMER STOCKS OF VANADIUM MATERIALS 1/

(Kilograms of contained vanadium)

	1994		1995	
Form	Consumption	Ending stocks	Consumption	Ending stocks
Ferrovanadium 2/	3,880,000 r/	446,000	4,300,000	416,000
Oxide	20,000 r/	10,600 r/	16,200	7,910
Ammonium metavanadate	W	W	W	W
Other 3/	376,000 r/	18,000 r/	315,000	14,000
Total	4,280,000 r/	474,000 r/	4,640,000	438,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes other vanadium-iron-carbon alloys as well as vanadium oxides added directly to steel.

3/ Consists principally of vanadium-aluminum alloy and small quantities of other vanadium alloys and vanadium metal.

TABLE 4
U.S. CONSUMPTION OF VANADIUM IN 1995, BY END USE 1/

(Kilograms of contained vanadium)

End use	Quantity
Steel:	
Carbon	1,870,000
Stainless and heat resisting	31,800
Full alloy	833,000
High-strength low-alloy	1,070,000
Tool	443,000
Unspecified	W
Total	4,240,000
Cast irons	39,600
Superalloys	20,400
Alloys (excluding steels and superalloys):	
Cutting and wear-resistant materials	271
Welding and alloy hard-facing rods and materials	3,440
Magnetic alloys	W
Other alloys	307,000
Chemical and ceramic uses:	
Catalysts	W
Pigments	W
Miscellaneous and unspecified	20,200
Grand total	4,640,000

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
1/ Data are rounded to three significant digits; may not add to total shown.

TABLE 5
U. S. EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY, FERROVANADIUM, OXIDES AND HYDROXIDES OF VANADIUM, AND VANADIUM METAL 1/

(Kilograms, vanadium content unless otherwise specified)

Material and country	1994		1995	
	Quantity	Value	Quantity	Value
Aluminum-vanadium master alloy: 2/ (gross weight)				
Australia	274	$3,570	336	$4,360
Austria	--	--	71,600	316,000
Brazil	20,900	30,700	216	2,810
Canada	127,000	1,680,000	120,000	1,620,000
China	--	--	26,300	355,000
Ecuador	--	--	465	12,500
France	172	18,500	11,200	146,000
Germany	8,520	107,000	11,400	151,000
Honduras	--	--	5,450	68,800
Hong Kong	1,990	25,900	--	--
India	1,590	20,700	1,440	18,700
Indonesia	1,540	20,000	--	--
Ireland	--	--	671	10,300
Italy	130	3,610	--	--
Japan	27,300	488,000	3,670	65,200
Korea, Republic of	256	29,100	6,420	84,200
Malaysia	2,160	28,000	--	--
Mexico	758,000	9,860,000	367,000	4,840,000
Netherlands	--	--	8,550	111,000
Norway	362	4,710	--	--
Philippines	--	--	535	7,000
Saudi Arabia	233	3,410	--	--
Singapore	3,200	41,500	7,380	93,700
Spain	10,300	7,940	--	--
Taiwan	7,960	96,900	--	--

See footnotes at end of table.

TABLE 5--Continued
U. S. EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY, FERROVANADIUM, OXIDES AND HYDROXIDES OF VANADIUM, AND VANADIUM METAL 1/

(Kilograms, vanadium content unless otherwise specified)

Material and country	1994		1995	
	Quantity	Value	Quantity	Value
Aluminum-vanadium master alloy: 2/ (gross weight)--Cont'd.				
United Kingdom	41,800	$233,000	16,800	$281,000
Venezuela	11,600	151,000	--	--
Total	1,030,000	12,900,000	660,000	8,190,000
Ferrovanadium:				
Canada	319,000	3,420,000	225,000	3,960,000
Colombia	375	9,600	--	--
Japan	4,100	137,000	5,910	137,000
Mexico	38,700	552,000	109,000	2,460,000
South Africa, Republic of	593	19,800	--	--
Sweden	2,970	99,000	--	--
Taiwan	4,260	44,000	--	--
United Kingdom	3,750	125,000	--	--
Total	374,000	4,410,000	340,000	6,550,000
Vanadium pentoxide (anhydride): 3/				
Australia	300	2,850	839	10,500
Belgium	207,000	1,160,000	--	--
Brazil	34,800	214,000	--	--
Chile	302	2,870	1,270	12,100
France	--	--	1,300	12,300
Germany	18,200	90,200	25,000	290,000
Italy	5,020	37,100	26,800	235,000
Japan	13,700	87,400	14,200	121,000
Mexico	16,900	137,000	29,500	314,000
Netherlands	15,900	87,800	95,200	594,000
Netherlands Antilles	363	3,450	--	--
Pakistan	3,970	50,800	5,170	76,100
Saudi Arabia	--	--	4,820	21,600
South Africa, Republic of	60	2,700	--	--
Spain	418	3,970	--	--
Switzerland	15,900	83,400	--	--
Taiwan	--	--	21,000	105,000
Trinidad and Tobago	2,500	38,500	--	--
United Kingdom	--	--	3,690	35,000
Venezuela	--	--	405	4,980
Total	335,000	2,000,000	229,000	1,830,000
Other oxides and hydroxides of vanadium:				
Australia	--	--	1,860	16,500
Austria	589	32,600	--	--
Belgium	--	--	15,900	105,000
Brazil	12,200	250,000	1,810	3,670
Canada	679,000	3,230,000	810,000	5,430,000
Chile	9,740	51,700	--	--
France	69,200	571,000	45,000	343,000
Germany	1,870	9,560	61,500	708,000
Hong Kong	17	2,920	--	--
Japan	14,500	71,600	37,100	271,000
Mexico	2,910	11,900	--	--
Netherlands	7,770	88,900	3,630	43,600
Nicaragua	5,340	36,100	--	--
Russia	2,600	274,000	--	--
South Africa, Republic of	156,000	630,000	20,000	168,000
Sweden	--	--	--	--
Taiwan	--	--	42	5,820
United Kingdom	4,970	36,700	--	--
Venezuela	84,400	575,000	11,300	101,000
Total	1,050,000	5,870,000	1,010,000	7,200,000

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Includes vanadium metal.
3/ May include catalysts containing vanadium pentoxide.

Source: Bureau of the Census.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM-VANADIUM MASTER ALLOY, FERROVANADIUM, OXIDES AND HYDROXIDES OF VANADIUM, AND VANADIUM METAL 1/

(Kilograms, vanadium content unless otherwise specified)

Material and country	1994		1995	
	Quantity	Value	Quantity	Value
Aluminum-vanadium master alloy: (gross weight)				
Germany	38,400	$948,000	36,300	$342,000
Ferrovanadium:				
Austria	78,400	628,000	113,000	2,030,000
Belgium	--	--	345,000	6,270,000
Canada	639,000	5,270,000	724,000	10,200,000
China	--	--	226,000	4,300,000
Czech Republic	--	--	288,000	3,390,000
Germany	31,000	181,000	31,000	604,000
Korea, South	--	--	18,200	363,000
Russia	1,110,000	6,480,000	160,000	1,950,000
South Africa	--	--	49,700	898,000
Ukraine	9,480	53,100	--	--
United Kingdom	37,300	238,000	--	--
Total	1,910,000	12,900,000	1,950,000	30,000,000
Vanadium pentoxide (anhydride): 2/				
Canada	138	2,300	--	--
China	--	--	92,500	945,000
France	851	152,000	5,830	384,000
Germany	848	24,300	4,790	23,400
Russia	80,700	250,000	--	--
South Africa	211,000	1,290,000	444,000	5,690,000
United Kingdom	14	47,700	--	--
Total	294,000	1,770,000	547,000	7,040,000
Other oxides and hydroxides of vanadium:				
Canada	238	4,020	153	2,600
China	3,230	35,700	--	--
France	--	--	26,100	442,000
Germany	2	1,630	4,660	86,500
South Africa	--	--	4,710	77,200
Total	3,470	41,300	35,600	608,000
Vanadium metal, including waste and scrap: (gross weight)				
Canada	73	9,260	--	--
Dominican Republic	--	--	50,700	33,500
Estonia	--	--	2,910	29,000
Germany	41,200	1,420,000	20,300	839,000
Korea, South	--	--	438	4,360
Russia	880	41,200	21,100	296,000
South Africa	528,000	4,400,000	700,000	13,000,000
United Kingdom	151	10,600	200	3,140
Total	570,000	5,880,000	796,000	14,200,000

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ May include catalysts containing vanadium pentoxide.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH, RESIDUES AND SLAG 1/

(Kilograms, vanadium pentoxide content)

Material and country	1994		1995	
	Quantity	Value	Quantity	Value
Ash and residues:				
Argentina	--	--	5,290	$2,910
Canada	295,000	$187,000	223,000	483,000
France	--	--	849	6,840
Germany	392,000	50,100	328,000	107,000
Italy	--	--	122,000	69,300
Korea, South	16,100	3,220	7,890	1,580
Mexico	1,390,000	523,000	997,000	4,690,000
Netherlands	6,730	9,300	3,530	18,800
Netherlands Antilles	170,000	58,900	381,000	136,000
Spain	--	--	13,000	8,890
United Kingdom	--	--	237,000	311,000
Venezuela	108,000	121,000	7,070	7,560
Total	2,380,000	954,000	2,330,000	5,840,000
Slag, from the manufacture of iron and steel: 2/				
South Africa	1,000,000	1,110,000	7,370,000	5,850,000
Other residues: (not advanced in value)				
Argentina	--	--	--	--
Canada	6,760	4,390	--	--
France	--	--	--	--
Total	6,760	4,390	--	--

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ As adjusted by the U.S. Geological Survey.

Source: Bureau of the Census.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS VANADIUM CHEMICALS 1/ 2/

(Kilograms, vanadium content)

Material and country	1994		1995	
	Quantity	Value	Quantity	Value
Vanadates:				
France	76	$159,000	--	--
Germany	7,490	71,300	576	$28,200
Japan	4,230	13,000	131	7,890
South Africa	17,900	96,700	43,100	246,000
United Kingdom	80	89,900	300	94,800
Total	29,700	449,000	44,100	376,000
Hydrides and nitrides:				
Canada	--	--	2,910	65,000
Japan	--	--	1	2,500
Sweden	3	5,090	--	--
Total	3	5,090	2910	67,500

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Comprises vanadium ore and miscellaneous vanadium chemicals.

Source: Bureau of the Census.

TABLE 9
WORLD VANADIUM PENTOXIDE ANNUAL PRODUCTION
CAPACITY, DECEMBER 31, 1995 1/ 2/

(Metric tons of contained vanadium)

Country	Rated capacity 3/
Austria	1,500
Canada	770
Chile	2,300
China	8,200
South Africa	27,200
Russia	9,500
United States	11,000
Venezuela	2,500
Other	550
Total	63,500

1/ Data are rounded to three significant digits; may not add to total shown.
2/ Includes vanadium pentoxide in vanadiferous iron slags and petroleum refinery residues.
3/ Includes capacity of operating plants as well as plants on standby status.

TABLE 10
VANADIUM: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons of contained vanadium)

Country	1991	1992	1993	1994	1995 e/
Production from ores, concentrates, slag: 3/					
China (in vanadiferous slag product) e/	4,500	4,700	5,000	5,000	5,000
Hungary e/	200	200	200	200	200
Kazakstan e/	XX	1,400	1,200	878 4/	924 4/
Russia e/	XX	11,000	10,000	10,000	11,000
South Africa: 5/					
Content of pentoxide and vanadate products e/	6,500	6,300	6,650 r/	6,050 r/	6,500
Content of vanadiferous slag product e/ 6/	8,460	7,730	8,400 r/	9,600 r/	9,000
Total	14,962	14,033	15,051	15,650 r/	15,500
U.S.S.R. e/ 3/ 7/	12,000	XX	XX	XX	XX
United States (recoverable vanadium)	W	W	W	W	W
Total	31,700	31,300 r/	31,500 r/	31,700 r/ e/	32,600
Production from petroleum residues, ash spent catalysts: 8/					
Japan e/	404	245	252	252 r/	245
United States	2,250	1,350	2,870	2,740	1,990
Total	2,650	1,590	3,120	2,990 r/	2,240
Grand total	34,300	32,900 r/	34,600 r/	34,700 r/	34,900

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ World totals, U.S. data, and estimated data are rounded to three sigificant digits; may not add to totals shown.

2/ In addition to the countries listed, vanadium is also recovered from petroleum residues in Germany and several other European countries, but available information is insufficient to make reliable estimates. Table includes data through July 16, 1996.

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

4/ Reported figure.

5/ Includes production for Bophuthatswana.

6/ Data on vanadium content of vanadium slag are estimated on the basis of a reported tonnage of vanadium-bearing slag (gross weight) multiplied by an assumed grade of 14.1% vanadium.

7/ Dissolved in Dec. 1991. Production in 1991 came from Kazakstan and Russia.

8/ 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.