

VANADIUM

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In 2001, all U.S. vanadium production was from various industrial waste streams. Fewer than 10 firms, primarily in Arkansas, Louisiana, and Texas, processed materials such as vanadium-bearing iron slag, fly ash, petroleum residues, and spent catalysts to produce vanadium pentoxide, ferrovanadium, and vanadium metal. Recycling of vanadium was negligible.

Vanadium consumption in the United States decreased for the fourth consecutive year. Metallurgical applications in which vanadium was used as a minor alloying element with iron, steel, and titanium remained the dominant use and accounted for more than 80% of domestic consumption. The largest nonmetallurgical use for vanadium was in catalysts.

Six foreign countries produced vanadium from ores, concentrates, slag, or petroleum residues (table 7). China and South Africa were the leading producers. In five of the six foreign countries, the mining and processing of magnetite-bearing ores was an important source of vanadium production.

The U.S. Geological Survey (USGS) estimates that the world vanadium reserve base at more than 27 million metric tons is sufficient to meet vanadium demand for several hundred years at the present rate of consumption. Recovery of vanadium from spent catalyst, fly ash, and petroleum residues will extend the viability of the reserve base significantly.

Legislation and Government Programs

The U.S. International Trade Commission (ITC) decided in May to continue antidumping duties on Russian ferrovanadium and nitrided vanadium, finding that revoking the duties would likely lead to a continuation or recurrence of material injury in the future (American Metal Market, 2001a). The duties range from 3.75% to 108%, depending on the producing company.

In late November, the Ferroalloys Association filed a petition with the U.S. Department of Commerce and the ITC seeking antidumping duties on imports of ferrovanadium from China and South Africa (American Metal Market, 2001b). A decision was expected in 2002.

Production

Shieldalloy Metallurgical Corp. temporarily halted ferrovanadium production at its Cambridge, OH, plant in mid-August for installation of a new electric arc furnace baghouse (Ryan's Notes, 2001); the plant was reopened before yearend.

The new baghouse was one of several projects planned to increase Shieldalloy's flexibility in recovering and using different raw materials. Other projects (planned for completion in 2002) were installation of a flue-gas desulfurization system

for the roaster and a feed briquette system.

Consumption

Based on a USGS survey, 2001 domestic vanadium consumption declined to 3,210 metric tons. The decline was partly in response to reduced demand by steel producers. Although vanadium has many uses, metallurgical applications account for essentially all domestic consumption. Most vanadium is consumed in the form of ferrovanadium, which is used as a means of introducing vanadium into steels where it gives additional strength and toughness. Ferrovanadium is available as alloys containing 45% to 50% and 80% vanadium. The 45% to 50% grade is produced from slag and other vanadium-containing materials by the silicothermic reduction of vanadium pentoxide. Most of the 80% grade is produced by the aluminothermic reduction of vanadium pentoxide in the presence of steel scrap or by direct reduction in an electric arc furnace. Vanadium 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 (which is the dominant use), ceramics, vanadium chemicals, and electronics.

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 the consumption reported.

Prices

In 2001, the domestic price for ferrovanadium, as published in Metal Bulletin, ranged from \$3.60 to \$4.50 per pound, a lower and narrower range than the \$3.85 to \$6.60 range reported for 2000. The price reached its high in March and remained at this level through July before declining as demand from steel producers decreased. The lowest price was reported in December. The European ferrovanadium price recorded its high for the year during May and June, and its low in December. The European price ranged from \$6.25 to \$8.70 per kilogram compared with \$7.45 to \$13.50 per kilogram in 2000.

Metal Bulletin's published price for domestic vanadium pentoxide ranged between \$1.10 and \$1.50 per pound in 2001. The price remained at its peak from April through July before steadily declining during the remainder of the year. In 2000, Metal Bulletin's vanadium pentoxide price ranged from \$1.25 to \$2.65 per pound.

World Review

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

Recycling of vanadium was negligible. Its major use was as a minor element in iron, steel, and titanium-bearing alloys from which it is not extracted when those metals are recycled. Only small quantities of vanadium-based catalysts and vanadium-aluminum alloy were processed to recover vanadium.

Outlook

United States 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 owing to anticipated growth in demand for stronger and lighter steels and the demand created by new applications, such as the vanadium battery.

References Cited

- American Metal Market, 2001a, Ferrovandium duties retained: American Metal Market, v. 109, no. 89, May 8, p. 2.
American Metal Market, 2001b, S. Africa, China said dumping ferrovandium: American Metal Market, v. 109, no. 230, November 28, p. 1.
Ryan's Notes, 2001, [untitled]: Ryan's Notes, v. 7, no. 33, August 6, p. 3.

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

- Vanadium. Ch. in Mineral Commodity Summaries, annual.
Vanadium. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Vanadium. International Strategic Minerals Inventory Summary Report, Circular 930-K, 1992.
Vanadium. Mineral Industry Surveys, monthly.

Other

- Chemical & Engineering News.
Engineering and Mining Journal.
Metal Bulletin.
Metal Bulletin Monthly [London, United Kingdom].
Metalworking News.
Roskill Reports [London, United Kingdom].

TABLE 1
SALIENT VANADIUM STATISTICS 1/

(Metric tons of contained vanadium, unless otherwise specified)

	1997	1998	1999	2000	2001
United States:					
Production, ore and concentrate:					
Recoverable vanadium 2/	W	W	W	--	--
Value thousand dollars	W	W	W	--	--
Vanadium oxide recovered from ore 3/	W	W	W	--	--
Consumption	4,710	4,380	3,620	3,520	3,210
Exports:					
Ferrovandium	446	579	213	172	70
Vanadium pentoxide (anhydride)	614	681	747	653	71
Other oxides and hydroxides of vanadium	385	232	70	100	63
Imports for consumption:					
Ferrovandium	1,840	1,620	1,930	2,510	2,550
Vanadium pentoxide (anhydride)	711	847	208	902	600
Other oxides and hydroxides of vanadium	126	33	--	14	1,080
Ore, slag, ash, residues	2,950	2,400	1,650	1,890	1,670
Stocks:					
Ferrovandium	311	324	328	278 r/	239
Oxide	8	8	5	5	5
Other 4/	4	4	15	20	2
World, production from ore, concentrate, slag 5/	40,700	44,500	53,600 r/	58,000 r/	58,000 e/

e/ Estimated. r/ Revised. 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 ferrophosphorus slag derived from domestic phosphate rock.

3/ Produced directly from all domestic ores and ferrophosphorus 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)

	2000	2001
End use:		
Steel:		
Carbon	1,090,000 r/	1,030,000
Stainless and heat resisting	W	W
Full alloy	773,000 r/	701,000
High-strength low-alloy	944,000 r/	785,000
Tool	225,000	146,000
Total	3,030,000	2,660,000
Cast irons	W	W
Superalloys	17,000	17,600
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	471,000 r/	523,000
Total	3,520,000	3,210,000
Form:		
Ferrovandium	3,100,000 r/	2,760,000
Oxide	189,000	133,000
Other 3/	221,000 r/	312,000
Total	3,520,000	3,210,000

r/ Revised. 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
AND VANADIUM METAL, INCLUDING WASTE AND SCRAP 1/

(Kilograms, gross weight)

	Aluminum-vanadium master alloy		Vanadium metal, including waste and scrap	
	Quantity	Value	Quantity	Value
Imports for consumption:				
2000	16,400	\$83,200	44,800	\$939,000
2001:				
China	--	--	10,000	66,400
Germany	--	--	18,800	453,000
Netherlands	10,100	45,100	--	--
Russia	--	--	1,550	80,900
United Kingdom	--	--	19,600	38,700
Total	10,100	45,100	50,000	639,000
Exports:				
2000	677,000	9,120,000	105,000	1,680,000
2001:				
Australia	--	--	7,800	28,600
Austria	--	--	200	71,500
Belgium	940	27,600	2,870	45,200
Canada	143,000	2,910,000	363	7,320
China	258	3,350	--	--
Egypt	403	5,240	--	--
El Salvador	8,950	242,000	--	--
Germany	--	--	7,980	84,700
Hong Kong	4,790	119,000	--	--
India	--	--	1	5,340
Israel	18,300	260,000	--	--
Japan	113,000	1,840,000	4,770	85,400
Korea, Republic of	5,710	141,000	103	4,080
Kuwait	793	10,300	--	--
Malaysia	4,500	120,000	--	--
Mexico	35,500	684,000	1,280	8,480
Norway	169	4,970	--	--
Philippines	2,500	68,700	--	--
Singapore	96	2,820	433	8,440
Taiwan	2,200	46,900	--	--
Trinidad and Tobago	651	19,100	--	--
United Kingdom	20,500	476,000	521	30,900
Other	593	7,710	--	--
Total	363,000	6,990,000	26,300	380,000

-- 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/

(Kilograms, contained vanadium)

	Ferrovanadium		Vanadium pentoxide (anhydride) 2/		Other oxides and hydroxide of vanadium	
	Quantity	Value	Quantity	Value	Quantity	Value
Imports for consumption:						
2000	2,510,000	\$24,900,000	902,000	\$6,260,000	13,500	\$231,000
2001:						
Austria	177,000	1,430,000	--	--	--	--
Belgium	154,000	1,230,000	--	--	--	--
Canada	247,000	1,920,000	--	--	--	--
China	450,000	3,530,000	--	--	--	--
Czech Republic	335,000	2,740,000	--	--	--	--
France	--	--	--	--	9,840	103,000
Germany	--	--	--	--	12,600	157,000
Korea, Republic of	14,400	130,000	--	--	--	--
Japan	32,400	388,000	1,120	25,100	--	--
Luxembourg	--	--	--	--	--	--
Mexico	--	--	--	--	1,050,000	248,000
Netherlands	--	--	9,770	128,000	--	--
South Africa	1,120,000	9,000,000	579,000	3,290,000	--	--
United Kingdom	15,600	120,000	10,400	15,200	2	2,080
Total	2,550,000	20,500,000	600,000	3,460,000	1,080,000	510,000
Exports:						
2000	172,000	2,360,000	653,000	3,360,000	99,800	741,000
2001:						
Australia	171	3,390	365	6,320	--	--
Canada	37,200	417,000	--	--	38,200	396,000
France	--	--	10,100	51,600	--	--
India	--	--	--	--	5,140	33,000
Italy	--	--	33,200	161,000	--	--
Korea, Republic of	--	--	--	--	1,040	11,900
Mexico	18,800	208,000	4,290	54,700	14,900	81,000
Netherlands	1,050	35,000	--	--	--	--
Niger	--	--	--	--	1,700	21,700
Spain	--	--	10,100	52,500	--	--
Sweden	12,800	105,000	10,300	40,000	--	--
Switzerland	--	--	--	--	--	--
Trinidad and Tobago	--	--	1,000	11,000	--	--
United Kingdom	--	--	--	--	2,060	18,300
Venezuela	--	--	2,050	29,800	--	--
Total	70,000	768,000	71,400	407,000	63,000	562,000

-- Zero.

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

2/ May include catalysts containing vanadium pentoxide.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH, RESIDUES, AND SLAG 1/

(Kilograms, vanadium pentoxide content)

Material and country	2000		2001	
	Quantity	Value	Quantity	Value
Ash and residues:				
Canada	91,600	\$80,500	178,000	\$108,000
Italy	807,000	584,000	188,000	508,000
Mexico	1,100,000	869,000	867,000	604,000
Spain	--	--	18,600	27,600
United Kingdom	421,000	673,000	729,000	760,000
Venezuela	--	--	3,510	219,000
Total	2,420,000	2,210,000	1,980,000	2,230,000
Slag, from the manufacture of iron and steel, South Africa 2/	959,000	1,650,000	998,000	1,170,000

-- 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/

(Kilograms of vanadium content)

Material and country	2000		2001	
	Quantity	Value	Quantity	Value
Sulfates:				
China	397	\$26,500	--	--
India	475	4,570	--	--
Total	872	31,000	--	--
Vanadates:				
China	--	--	4,350	46,500
Germany	47,600	328,000	6,050	126,000
Japan	78	165,000	26	73,400
South Africa	89,900	500,000	83,400	377,000
Switzerland	1	5,170	--	--
Taiwan	10,700	38,000	--	--
Total	148,000	1,040,000	93,800	623,000

-- 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
WORLD PRODUCTION OF VANADIUM, BY COUNTRY 1/ 2/

(Metric tons of contained vanadium)

Country	1997	1998	1999	2000	2001 e/
Production from ores, concentrates, slag: 3/					
Australia	--	--	--	NA	NA
China (in vanadiferous slag product) e/	15,000	15,500	26,000 r/	30,000 r/	30,000
Hungary e/	200	100	--	--	--
Kazakhstan e/	900	1,000	1,000	1,000	1,000
Russia e/	9,000	9,000	9,000	9,000	9,000
South Africa	15,590	18,868	17,612	18,021 r/	18,000
United States (recoverable vanadium)	W	W	W	-- r/	-- 4/
Total	40,700	44,500	53,600 r/	58,000 r/	58,000
Production from petroleum residues, ash spent catalysts, Japan 5/ e/					
Grand total	40,900	44,700	53,900	58,300	58,200

e/ Estimated. r/ Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

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

2/ 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, 2002.

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

4/ Reported figure.

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.