



2011 Minerals Yearbook

VANADIUM

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In 2011, reported vanadium consumption in the United States was 5,120 metric tons (t) of contained vanadium, a slight increase from that of 2010 (table 1). The United States imported (measured in vanadium content) 2,220 t of ferrovandium (FeV); 2,810 t of vanadium pentoxide (V_2O_5); 886 t of other oxides and hydroxides of vanadium collectively valued at \$128 million (table 4). Total imports for consumption of these vanadium materials increased by 7% from those of 2010. The United States exported 314 t of FeV, 89 t of V_2O_5 , and 254 t of other oxides and hydroxides of vanadium collectively valued at \$13.8 million (table 4). Total exports of these vanadium-bearing materials decreased by 64% from those of 2010.

Vanadium's primary use is as a hardening agent in steel, in which it is critical in imparting toughness and wear resistance. These properties are especially important in high-strength low-alloy (HSLA) steels. Catalysts represented the leading nonmetallurgical use for vanadium.

Secondary vanadium production from various industrial waste materials, such as vanadium-bearing fly ash, petroleum residues, pig iron slag, and spent catalysts, was the leading source of U.S. vanadium production. A small amount of vanadium was obtained as a coproduct from the mining of uraniumiferous sandstones on the Colorado Plateau. Fewer than 10 firms, primarily in Arkansas, Ohio, Pennsylvania, and Texas, processed waste materials to produce FeV, V_2O_5 , and vanadium metal.

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 2011, 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-containing steels can be subdivided into microalloy or low-alloy steels that generally contain less than 0.15% vanadium and high-alloy steels that contain as much as 5% vanadium.

Uranium production from carnotite ores creates a vanadium-bearing waste solution that must be neutralized to fix the heavy metals before waste disposal. An alternative treatment is a circuit which extracts vanadium and produces V_2O_5 . Denison Mines Corp. (Toronto, Ontario, Canada) owned the White Mesa uranium processing mill near Blanding, UT. White Mesa processed feed from Denison's mine properties on the Colorado Plateau as well as uranium/vanadium ores purchased from independent miners. For every 0.45 kilogram (kg) of triuranium octoxide concentrate (yellowcake) produced, White Mesa's vanadium coproduct recovery circuit produced approximately 1.8 kg of vanadium in the form of V_2O_5 . The facility produced 590 t of V_2O_5 in 2011, a 44% decrease from the 1,060 t of V_2O_5 produced in 2010. According to the company, 1,800,000 pounds (lbs) (816 t) of V_2O_5 was sold at

an average price of \$6.21 per lb V_2O_5 . Denison forecast vanadium production to be 272 t V_2O_5 in 2012. The company was expected to process only nonvanadium ores at its facility until late 2012 (Denison Mines Corp., 2012).

In September, American Vanadium Corp. (Vancouver, British Columbia, Canada) announced the completion of a feasibility study for its Gibellini vanadium project in Eureka County, NV. According to the study results, annual production would be 5,170 t of V_2O_5 with a total capital cost of \$95.5 million, including contingencies. In August, American Vanadium completed pilot-scale metallurgical tests on material from its Gibellini Mine that resulted in the production of V_2O_5 and vanadium electrolyte. The company planned to use the resultant material to pursue deals with steel producers as well as partnerships and joint ventures with vanadium flow battery technology and manufacturing companies. American Vanadium announced that the mine could open in the next 18 months, depending on the completion of a bankable feasibility study and successful permitting through the Bureau of Land Management (Metal-Pages, 2011a).

Evrz Highveld Steel and Vanadium Ltd. (Moscow, Russia) announced a 20% increase in vanadium slag production in the fourth quarter of 2011 compared with production in the third quarter of 2011. The company attributed the increase to higher steel production in Russia and South Africa as well as more efficient vanadium production (Ryan's Notes, 2012). Evraz comprises Evraz Highveld Steel and Vanadium in South Africa, Nikom in the Czech Republic, Strategic Minerals Corp. (Stratcor Inc.) in the United States and South Africa, and Vanady-Tula in Russia. Stratcor operated a facility in Hot Springs, AR, where vanadium ash, residues, and other raw materials are converted into vanadium alloys and vanadium chemicals used by the chemical, steel, and titanium industries. The main goal of Stratcor for 2011 was to reduce costs and to find additional sources of feedstock to satisfy the company's requirements. Several alternative solutions for alternative feedstock were defined. The company also announced the development of a new specialty product—an electrolyte for vanadium redox batteries (Evrz Group S.A., 2012, p. 38).

AMG Vanadium Inc., formerly Metallurg Vanadium Corp., installed a solar photovoltaic system at its spent catalyst recycling facility in Cambridge, OH. The solar system was expected to produce 230,000 kilowatt-hours of power, the amount of electricity consumed by about 20 to 25 homes for a year and was estimated to eliminate more than 200 metric tons per year (t/yr) of CO_2 compared to traditional fossil fuels. According to the company, AMG was the world's leading recycler of spent refinery catalysts used to produce FeV and ferronickel-molybdenum for the carbon steel and stainless steel industries (AMG Vanadium Inc., 2011).

The Vanadium Technology Partnership estimated that approximately 2,700 t/yr of vanadium was recycled from

spent catalysts (Vanadium Technology Partnership, undated). Vanadium's major end use was as an alloying element in iron, steel, and titanium-bearing alloys, from which it is lost to slag and usually not recovered when those metals are recycled.

Consumption

The U.S. Geological Survey (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.

Metallurgical applications continued to dominate U.S. vanadium use in 2011, accounting for 93% of reported consumption. Nonmetallurgical applications included catalysts, ceramics, electronics, and vanadium chemicals. The dominant nonmetallurgical use was in catalysts.

Most vanadium is consumed in the form of FeV, which is used as a means of introducing vanadium into steel, in which it provides additional strength and toughness. FeV is available as alloys containing either 45% to 50%, or 80% vanadium. The 45%- to 50%-grade FeV is produced by silicothermic reduction of V_2O_5 in slag or other vanadium-containing materials. Most of the 80%-grade FeV is produced by aluminothermic reduction of V_2O_5 in the presence of steel scrap or by direct reduction in an electric arc furnace.

Prices

In 2011, the annual average price for domestic FeV, as published in Ryan's Notes, ranged from \$14.606 to \$15.004 per pound of vanadium content, compared with \$14.155 to \$14.688 per pound reported in 2010. In 2011, the European annual average price for FeV, ranged from \$28.533 to \$29.273 per kilogram, compared with \$29.811 to \$30.817 per kilogram in 2010. The Ryan's Notes published annual average price for domestic V_2O_5 ranged from \$6.563 to \$6.960 per pound in 2011, compared with \$6.285 to \$6.636 per pound in 2010.

World Review

A large majority of the world's supply of vanadium was derived from mined ore, either directly as mineral concentrates derived from vanadiferous titanomagnetite (VTM) or from steelmaking slags, where the steel has been produced from VTM. Five countries recovered vanadium from ores, concentrates, slag, or petroleum residues (table 7). The leading vanadium-producing nations remained China, Russia, and South Africa. Japan and the United States were thought to be the only countries to recover significant quantities of vanadium from petroleum residues.

World vanadium reserves, at more than 13 million metric tons (Mt), are sufficient to meet vanadium needs into the next century at the present rate of consumption. Increased recovery of vanadium from fly ash, petroleum residues, slag, and spent catalyst is not taken into account and is expected to extend the life of the reserves significantly.

Australia.—Atlantic Ltd. (Perth, Western Australia) announced that it made strong progress on the funding, construction, and development of its Windimurra vanadium project in Western Australia. The primary, secondary, and tertiary crushers of the crushing, milling, and beneficiation

plant circuit were wet commissioned in September. Following completion of construction, expected in early 2012, Windimurra was expected to ramp up to a capacity of 6,300 t/yr of contained vanadium (Atlantic Ltd., 2011, p. 14–15).

Brazil.—Largo Resources Ltd. (Toronto) announced that its Maracas vanadium project has been fully licensed for construction, which was expected to commence in March 2012. The company set a production target for the summer of 2013, with expected production of 5,000 t/yr of FeV. The Maracas property is located 813 kilometers northeast of Brasilia (Largo Resources, 2011).

Canada.—Apella Resources Inc. (Vancouver) owned two vanadiferous magnetite deposits in Canada—the Iron-T vanadium project in central Quebec and the Lac Dore vanadium project in northern Quebec. According to the company, the Lac Dore project is an advanced vanadium project and was expected to be the leading vanadium deposit in North America, and the second ranked in the world (Apella Resources, 2011b). Apella was expected to continue exploration and development on the Lac Dore project in 2011. Simultaneously, Apella was expected to complete a feasibility study of its Iron-T vanadium project, which was expected to take 12 to 18 months at a cost of about \$18 million (Apella Resources, 2011a).

China.—The Chinese vanadium industry continued to feel pressure from niobium, particularly in HSLA steels. The additive amount of niobium in steel production is only one-half of that of vanadium, so every 3,000 t of ferroniobium can substitute as much as 7,000 t of 50% grade FeV (Metal-Pages, 2010). The substitution of ferroniobium however, is only economic at very high vanadium prices.

China's exports of FeV increased 14% to 6,733 t in 2011, according to official customs data. China's main FeV export destinations were the Netherlands (2,690 t), the Republic of Korea (1,253 t), Japan (1,209 t), Taiwan (898 t), and India (358 t) (Metal-Pages, 2012).

India.—Vedanta Aluminium Ltd. (Mumbai) announced it was using internally developed technology to recover vanadium from effluent red mud from its alumina refinery project at Lanjigarh, Orissa. The company announced that it produced 100 t of 17% to 18% grade V_2O_5 in June, and was expected to continue V_2O_5 production for the remainder of the year (Metal-Pages, 2011b).

Japan.—In 2011, Japan's imports of V_2O_5 increased to 2,011 t V_2O_5 compared with 1,954 t V_2O_5 in 2010. In 2011, Japan's imports of FeV increased to 4,791 t FeV compared with 4,587 t FeV in 2010. Japanese FeV production decreased to 3,980 t FeV in 2010, down from 4,190 t FeV in 2010 and 2,560 t FeV in 2009 (TEX Report, The, 2011).

Madagascar.—Energizer Resources Inc. (Toronto) announced that it signed a formal agreement with South Africa's DRA Mineral Projects, an engineering and mining project development management company, to develop its Green Giant vanadium project in Madagascar. Since acquiring the property in August 2007, Energizer had spent more than \$10 million on exploration and development of the project. The company estimated an indicated resource of 49.5 Mt at an average grade of 0.693% V_2O_5 based on drilling of only 25% of the vanadium trend that had been identified to date (Energizer Resources Inc., 2011).

According to the company, the Green Giant vanadium deposit is a sedimentary-hosted deposit, in contrast to most vanadium deposits that are magnetite hosted. As a result, the metallurgical process for the Green Giant vanadium would be different from that used by other vanadium producers. The unique characteristics of the Green Giant vanadium would allow the company to produce a high-purity V_2O_5 , which is required in battery power and in battery storage for both automotive and large-scale applications. FeV, which is the usual end product from magnetite-hosted deposits, can only be used for steel applications (Energizer Resources Inc., 2011).

Russia.—Evraz announced that all of its vanadium facilities operated at 100% capacity. Continued improvement and standardization of the company's manufacturing performance at Evraz's newly acquired Vanady-Tula refinery in 2010–11 led to an increase in V_2O_5 production capacity of 7% compared with that of 2010. In 2011, Vanady-Tula's production capacity was 12,500 t/yr of V_2O_5 and up to 7,100 t/yr of FeV (Evraz Group S.A., 2012, p. 40).

For 2011, Evraz's slag output of 20,741 t was about the same as in 2010. Evraz's FeV production in 2011 increased by 24% to 16,708 t compared with 13,507 t of FeV produced in 2010 (Ryan's Notes, 2012).

South Africa.—Xstrata plc (Zug, Switzerland) announced that its Rhovan vanadium facility, 30 km northwest of Brits, produced 1,790 t of FeV in 2011, an 8% decrease compared with 1,960 t of FeV produced in 2010. The facility produced 9,540 t of V_2O_5 in 2011, a 4% decrease compared with 9,920 t of V_2O_5 produced in 2010 (Xstrata plc, 2012, p. 97).

Vametco Alloys (Brits) (a division of Stratcor), improved production efficiency at its Vametco plant by optimizing the mix of vanadium ore and vanadium slag to process feed. Several projects designed to reduce atmospheric emissions were implemented. Operational improvements in 2011 allowed Vametco to increase V_2O_5 production by 5% compared with that of 2010. Vametco's primary end product was Nitrovan vanadium, a specialty vanadium-nitrogen alloy, which, according to the company, strengthens steel more efficiently than FeV (Evraz Group S.A., 2012, p. 38).

Outlook

Vanadium consumption is heavily influenced by steel production, high-strength steel grades in particular. In 2011, vanadium benefited from an improvement in the global economy and a consequent improvement in the demand for steel. High-strength steels are increasing in use as the construction, energy, and transportation industries seek to maximize the strength and minimize the weight of their products. Other end-use industries for vanadium also show potential growth. Aerospace applications are rapidly expanding, and vanadium consumption has been increasing with the introduction of the next generation of commercial aircraft. The quest for fuel efficiency is key in the aerospace industry but also extends to automobiles, high-speed drilling, powerplants, and rail cars.

Vanadium is becoming more widely used in green technology applications, especially in battery technology. One battery technology showing continued promise in stabilizing energy distribution in renewable systems is the vanadium redox battery (VRB), which consists of an assembly of power cells

in which two vanadium-based electrolytes are separated by a proton exchange membrane. The main advantages of the VRB are that it can offer almost unlimited capacity simply by using sequentially larger storage tanks, can be left completely discharged for long periods of time with no ill effects, can be recharged by replacing the electrolyte if no power source is available to charge it, and suffers no permanent damage if the electrolytes are accidentally mixed (Johnstone, 2008). The VRB has also been shown to have the lowest disturbance to the environment of all energy storage technologies.

Another emerging technology is the use of lithium-vanadium phosphate or fluorophosphate cathodes and lithium-vanadium oxide anodes in rechargeable lithium batteries. These batteries exhibit much improved safety compared with the more generic lithium-cobalt oxide type cathodes seen in cellular telephone or laptop batteries, which have higher operating voltages and higher rates of energy storage. The vanadium phosphate cathode material can support 20% more energy storage than the conventional cobalt oxide, as much as 26% more than iron phosphate, and 56% more than manganese oxide. However, in order for such a battery to be practical, the cost of the battery is key. Subaru (owned by Fuji Heavy Industries Ltd.) has unveiled a prototype of its G4e electric car, powered by lithium-vanadium phosphate batteries. This concept car has a 200-km range that is provided by a relatively small vanadium phosphate battery pack, double what its earlier R1e concept car could achieve (Hykawy, 2009).

Nissan Motor Company Ltd. announced in November that in conjunction with Kansai University in Japan, it had developed a car charger that can charge the batteries of its Nissan Leaf and the Mitsubishi iMiEV in a record time of 10 minutes. The interior electrode of the capacitor in the battery was changed from carbon oxide to tungsten oxide and vanadium oxide. This improved the power charge dramatically with no negative or significant effect on the batteries storage capacity or voltage. According to some analysts, commercialization of this technology could take up to a decade (Curtis, 2011).

The outlook for the vanadium market in 2012 appears to be strong. Increasing steel demand, projected through at least 2015, mandates for higher quality steel in emerging markets, and the potential for a whole new battery market were expected to contribute to increased vanadium consumption (World Steel Association, 2011).

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TABLE 1
SALIENT VANADIUM STATISTICS¹

(Metric tons of contained vanadium, unless otherwise specified)

	2007	2008	2009	2010	2011
United States:					
Production, ore and concentrate, recoverable vanadium ²	--	520	230	1,060	590
Consumption, reported	4,970	5,170	4,690	5,030	5,120
Imports for consumption:					
Ferrovandium	2,220	2,800	353	1,340	2,220
Vanadium pentoxide (anhydride)	2,390	3,700	1,120	4,000	2,800
Other oxides and hydroxides of vanadium	42	144	25	167	886
Ash and residues ³	1,000	1,040	791	521	1,420
Exports:					
Ferrovandium	206	452	672	611	314
Vanadium pentoxide (anhydride)	327	249	401	140	89
Other oxides and hydroxides of vanadium	626	1,040	506	1,100	254
Stocks:					
Ferrovandium	253	229	232	181	122
Oxide	22	24	5	5	W
Other ⁴	49	82	58	62	63
World, production from ore, concentrate, slag ⁵	58,500	56,900	51,600	62,200 ^f	62,400

⁵Estimated. ^fRevised. -- Zero.

¹Data are rounded to no more than three significant digits.

²In 2008, Denison Mines Corp. began producing vanadium as a coproduct from mining uraniumiferous sandstones. Source: Denison Mines Corp. Web site.

³Ash and residues from the manufacture of iron and steel.

⁴Consists principally of vanadium-aluminum alloy, small quantities of other vanadium alloys, vanadium metal, and ammonium metavanadate.

TABLE 2
U.S. CONSUMPTION OF VANADIUM, BY END USE AND FORM¹

(Kilograms of contained vanadium)

	2010	2011
End use:		
Steel:		
Carbon	843,000	677,000
Full alloy	2,030,000	2,120,000
High-strength low-alloy	W	W
Stainless and heat resisting	120,000	61,500
Tool	W	W
Total	2,990,000	2,860,000
Cast irons	W	W
Superalloys	9,230	15,300
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	2,030,000	2,240,000
Grand total	5,030,000	5,120,000
Form:		
Ferrovanadium	4,210,000	4,240,000
Other ³	818,000	882,000
Total	5,030,000	5,120,000

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

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

²Includes magnetic alloys.

³Consists of vanadium-aluminum alloy, vanadium pentoxide, 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 SCRAP¹

	Aluminum-vanadium master alloy		Vanadium metal, including waste and scrap	
	Quantity, gross weight (kilograms)	Value	Quantity, gross weight (kilograms)	Value
Imports for consumption:				
2010	951,000 ^r	\$2,180,000 ^r	9,660	\$434,000
2011:				
Belgium	15,000	106,000	--	--
Canada	6,890	47,000	--	--
China	92,600	555,000	550	298,000
Egypt	5	3,200	--	--
France	201	6,890	--	--
Germany	--	--	43,200	1,630,000
Mexico	119,000	288,000	--	--
Netherlands	14,600	95,400	--	--
United Kingdom	29,500	109,000	100	3,430
Total	278,000	1,210,000	43,900	1,930,000
Exports:				
2010 ^f	1,190,000	6,500,000	21,300	675,000
2011:				
Brazil	11,500	300,000	--	--
Canada	394,000	1,060,000	2,500	84,300
Chile	1,360	19,500	--	--
China	25,900	169,000	--	--
Colombia	--	--	14,500	309,000
Czech Republic	742	3,840	--	--
Hong Kong	255	7,500	--	--
India	73,900	708,000	--	--
Israel	7,150	104,000	--	--
Italy	7,010	80,100	--	--
Japan	66,400	1,470,000	66,700	2,310,000
Korea, Republic of	15,100	216,000	8,680	369,000
Macao	20,000	55,300	--	--
Malaysia	2,240	29,200	--	--
Mexico	62,100	204,000	--	--
New Zealand	4,390	33,000	--	--
Panama	476	6,180	--	--
Philippines	664	4,640	--	--
Poland	3,850	50,000	--	--
Saudi Arabia	414	5,390	--	--
Singapore	1,020	13,200	--	--
Taiwan	37,400	125,000	--	--
Trinidad and Tobago	107,000	611,000	--	--
Turkey	280	3,780	--	--
United Kingdom	61,300	1,550,000	9,360	266,000
Vietnam	15,500	92,000	--	--
Total	920,000	6,930,000	102,000	3,340,000

^rRevised. -- Zero.

^fData are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 4
U.S. IMPORTS AND EXPORTS OF FERROVANADIUM, VANADIUM PENTOXIDE (ANHYDRIDE), AND
OTHER OXIDES AND HYDROXIDES OF VANADIUM¹

	Ferrovanadium		Vanadium pentoxide (anhydride) ²		Other oxides and hydroxides of vanadium	
	Quantity, V content (kilograms)	Value	Quantity, V content (kilograms)	Value	Quantity, V content (kilograms)	Value
	Imports for consumption:					
2010	1,340,000	\$41,100,000	4,000,000	\$53,700,000	167,000	\$3,330,000
2011:						
Austria	591,000	16,400,000	15,000	234,000	126,000	3,360,000
Brazil	54,900	1,000,000	--	--	--	--
Canada	761,000	22,200,000	5,880	48,200	--	--
China	--	--	580,000	10,400,000	--	--
Czech Republic	186,000	4,930,000	--	--	--	--
Germany	2,990	196,000	1,200	59,900	--	--
India	3,600	203,000	--	--	--	--
Korea, Republic of	621,000	19,600,000	--	--	--	--
Russia	--	--	1,200,000	14,100,000	--	--
South Africa	--	--	881,000	17,600,000	760,000	14,100,000
Taiwan	--	--	117,000	3,430,000	--	--
Total	2,220,000	64,600,000	2,800,000	45,800,000	886,000	17,400,000
Exports:						
2010	611,000	18,100,000	140,000	2,020,000 ^r	1,100,000	10,600,000
2011:						
Austria	--	--	--	--	16,000	142,000
Brazil	17,400	424,000	54,400	774,000	22,500	222,000
Canada	194,000	6,100,000	--	--	1,700	26,100
China	--	--	--	--	17,700	267,000
Columbia	1,080	46,000	--	--	--	--
Germany	--	--	279	5,560	42,700	435,000
India	32,800	800,000	421	4,000	--	--
Japan	--	--	--	--	899	8,000
Korea, Republic of	17,900	967,000	--	--	1,750	29,400
Mexico	22,600	768,000	3,560	87,400	95,800	774,000
Netherlands	10,200	300,000	5,000	83,800	54,500	485,000
Peru	3,620	161,000	--	--	--	--
Saudi Arabia	--	--	12,700	238,000	--	--
Singapore	--	--	950	16,800	--	--
Spain	--	--	8,700	134,000	--	--
Trinidad and Tobago	--	--	2,720	60,000	--	--
United Arab Emirates	14,700	411,000	--	--	--	--
United Kingdom	--	--	45	3,040	436	3,880
Total	314,000	9,970,000	88,700	1,410,000	254,000	2,390,000

^rRevised. -- Zero.

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

²May include catalysts that contain vanadium pentoxide.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH AND RESIDUES^{1,2}

Country	2010		2011	
	Quantity, V ₂ O ₅ ³ content (kilograms)	Value	Quantity, V ₂ O ₅ ³ content (kilograms)	Value
Belgium	48,700	\$274,000	43,400	\$257,000
Canada	89,800	69,800	1,300,000	781,000
Mexico	361,000	5,190,000	7,580	30,300
Saudi Arabia	6,090	31,200	62,200	459,000
Trinidad and Tobago	15,400	4,710	--	--
United Kingdom	--	--	5,950	43,000
Total	521,000	5,570,000	1,420,000	1,570,000

-- Zero.

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

²Ash and residues from the manufacture of iron and steel.

³V₂O₅ vanadium pentoxide.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS VANADIUM CHEMICALS^{1,2}

Material and country	2010		2011	
	Quantity, V content (kilograms)	Value	Quantity, V content (kilograms)	Value
Sulfates:				
Austria	1,180	\$24,000	--	--
Belgium	--	--	18,900	\$439,000
China	46,400	575,000	23,100	290,000
Germany	600	8,860	--	--
Japan	--	--	144	8,680
Total	48,200 ^r	608,000 ^r	42,200	738,000
Vanadates:				
Austria	410	13,700	7,010	140,000
China	25,600	887,000	46,600	1,560,000
Germany	61,700	1,990,000	7,790	312,000
India	390	7,790	99	4,750
Japan	214	44,000	49	2,610
Netherlands	--	--	5,620	131,000
South Africa	69,500	1,100,000	224,000	5,100,000
Taiwan	293	10,200	12,000	147,000
Total	158,000	4,050,000	303,000	7,400,000

^rRevised. -- Zero.

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

²Comprises vanadium ore and miscellaneous vanadium chemicals.

Source: U.S. Census Bureau.

TABLE 7
VANADIUM: ESTIMATED WORLD PRODUCTION, BY COUNTRY^{1,2}

(Metric tons, vanadium content)

Country	2007	2008	2009	2010	2011
Production from ores, concentrates, slag: ³					
China ⁴	19,000	20,000	21,000	22,000	23,000
Kazakhstan	1,000	1,000	1,000	1,000	1,000
Russia	14,500	14,500	14,500	15,000	15,200
South Africa	23,486 ⁵	20,295 ⁵	14,353 ⁵	22,606 ^{r,5}	22,000
United States ⁶	--	520	230	1,060	590
Total	58,000	56,300	51,100	61,700 ^r	61,800
Petroleum residues, ash, and spent catalysts, Japan ⁷	560	560	560	560	560
Grand total	58,500	56,900	51,600	62,200 ^r	62,400

¹Revised. -- Zero.

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

²In 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 available through May 2, 2012.

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

⁴Estimated 40% of vanadium recovered from vanadiferous slag.

⁵Reported figure.

⁶In 2008, Denison Mines Corp. began producing vanadium as a coproduct from mining uraniumiferous sandstones. Source: Denison Mines Corp. Web site.

⁷Production 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.