

## VANADIUM

(Data in metric tons of contained vanadium unless otherwise noted)

**Domestic Production and Use:** Byproduct vanadium production in Utah from the mining of uraniumiferous sandstones on the Colorado Plateau ceased in early 2020 and was not restarted in 2021. Secondary vanadium production continued in Arkansas and Ohio where processed waste materials (petroleum residues, spent catalysts, and utility ash) were used to produce ferrovanadium, vanadium-bearing chemicals or specialty alloys, and vanadium pentoxide. Two additional secondary producers in Pennsylvania and Texas remained idle. Metallurgical use, primarily as an alloying agent for iron and steel, accounted for about 94% of domestic reported vanadium consumption in 2021. Of the other uses for vanadium, the major nonmetallurgical use was in catalysts to produce maleic anhydride and sulfuric acid.

<b><u>Salient Statistics—United States:</u></b>	<b><u>2017</u></b>	<b><u>2018</u></b>	<b><u>2019</u></b>	<b><u>2020</u></b>	<b><u>2021<sup>e</sup></u></b>
Production, mine, mill	—	—	460	17	—
Imports for consumption:					
Aluminum-vanadium master alloy	288	281	222	101	40
Ash and residues	4,530	5,020	3,780	60	100
Ferrovanadium	2,810	2,970	2,280	1,350	2,000
Oxides and hydroxides, other	148	98	105	67	25
Vanadium chemicals <sup>1</sup>	607	515	201	211	360
Vanadium metal <sup>2</sup>	54	28	45	(3)	1
Vanadium ores and concentrates	2	590	192	4	4
Vanadium pentoxide	3,400	4,600	3,620	1,670	2,000
Exports:					
Aluminum-vanadium master alloy	132	90	29	13	100
Ash and residues	322	287	354	159	260
Ferrovanadium	229	575	295	165	120
Oxides and hydroxides, other	148	53	750	51	270
Vanadium metal <sup>2</sup>	59	39	27	1	2
Vanadium ores and concentrates	37	29	170	164	200
Vanadium pentoxide	126	563	423	50	14
Consumption:					
Apparent <sup>4</sup>	10,800	12,400	8,850	2,860	3,600
Reported	4,670	5,640	4,840	5,010	4,500
Price, average, vanadium pentoxide, <sup>5</sup> dollars per pound	7.61	16.4	12.2	6.7	8.2
Stocks, yearend <sup>6</sup>	227	250	257	269	260
Net import reliance <sup>7</sup> as a percentage of apparent consumption	100	100	95	99	100

**Recycling:** The quantity of vanadium recycled from spent chemical process catalysts was significant and may compose as much as 40% of total vanadium catalysts.

**Import Sources (2017–20):** Ferrovanadium: Austria, 44%; Canada, 33%; Russia, 12%; Japan, 4%; and other, 7%. Vanadium pentoxide: Brazil, 47%; South Africa, 35%; China, 8%; Taiwan, 5%; and other, 5%. Total: Canada, 26%; China, 14%; Brazil, 10%; South Africa, 9%; and other, 41%.

<b><u>Tariff:</u></b>	<b><u>Item</u></b>	<b><u>Number</u></b>	<b><u>Normal Trade Relations</u></b>
			<b><u>12–31–21</u></b>
	Vanadium ores and concentrates	2615.90.6090	Free.
	Vanadium bearing ash and residues	2620.40.0030	Free.
	Vanadium bearing ash and residues, other	2620.99.1000	Free.
	Chemical compounds:		
	Vanadium pentoxide, anhydride	2825.30.0010	5.5% ad valorem.
	Vanadium oxides and hydroxides, other	2825.30.0050	5.5% ad valorem.
	Vanadium sulfates	2833.29.3000	5.5% ad valorem.
	Vanadates	2841.90.1000	5.5% ad valorem.
	Hydrides and nitrides of vanadium	2850.00.2000	5.5% ad valorem.
	Ferrovanadium	7202.92.0000	4.2% ad valorem.
	Vanadium metal	8112.92.7000	2.0% ad valorem.
	Vanadium and articles thereof <sup>8</sup>	8112.99.2000	2.0% ad valorem.

**Depletion Allowance:** 22% (domestic), 14% (foreign).

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**Government Stockpile:** None.

**Events, Trends, and Issues:** U.S. apparent consumption of vanadium in 2021 increased by 25% from that in 2020. The estimated average Chinese vanadium pentoxide price in 2021 increased by 22% compared with the 2020 price, and the estimated United States ferrovanadium price increased by 51% to \$16.30 per pound in 2021 compared with that in 2020. Governments globally announced different measures to revive their economies after they were negatively affected by the global COVID-19 pandemic.

China continued to be the world's top vanadium producer, producing the majority of its vanadium from vanadiferous iron ore processed for steel production. In response to the global pandemic, China's Government implemented stimulus measures which led to record steel production in China. As a result, Chinese steel mills used more domestic titaniferous magnetite ore and resulted in Chinese producers operating at near capacity. Despite the significant increase in vanadium slag production in China, several environmental restrictions by China's Government to cut pollution may impose further constraints on vanadium slag production at steel plants. The limited capacity of vanadium-producing steel plants was expected to continue to cause vanadium prices to fluctuate.

In the third quarter of 2021, a producer in Brazil announced the commissioning of a vanadium trioxide processing plant at its Maracas Menchen Mine. The company emphasized that its decision to include production of high purity vanadium would be key to supporting its vanadium redox flow battery technology business. A vanadium producer in South Africa announced that it was completing an expanded prefeasibility study of its facility to determine the most-capital-efficient manner to increase vanadium production. It aimed to increase its facility's capacity by approximately 50% by yearend 2022 and more than double capacity in the long term if market conditions continued to improve.

### **World Mine Production and Reserves:**

	<b>Mine production</b>		<b>Reserves<sup>9</sup></b> <b>(thousand metric tons)</b>
	<b><u>2020</u></b>	<b><u>2021<sup>e</sup></u></b>	
United States	17	—	45
Australia	—	—	<sup>10</sup> 6,000
Brazil	6,620	6,700	120
China	70,000	73,000	9,500
Russia	19,500	19,000	5,000
South Africa	<u>8,580</u>	<u>9,100</u>	<u>3,500</u>
World total (rounded)	105,000	110,000	24,000

**World Resources:**<sup>9</sup> World resources of vanadium exceed 63 million tons. Vanadium occurs in deposits of phosphate rock, titaniferous magnetite, and uraniumiferous sandstone and siltstone, in which it constitutes less than 2% of the host rock. Significant quantities are also present in bauxite and carboniferous materials, such as coal, crude oil, oil shale, and tar sands. Because vanadium is typically recovered as a byproduct or coproduct, demonstrated world resources of the element are not fully indicative of available supplies. Although domestic resources and secondary recovery are adequate to supply a large portion of domestic needs, almost all of U.S. demand is currently met by foreign sources.

**Substitutes:** Steels containing various combinations of other alloying elements can be substituted for steels containing vanadium. Certain metals, such as manganese, molybdenum, niobium (columbium), titanium, and tungsten, are to some degree interchangeable with vanadium as alloying elements in steel. Platinum and nickel can replace vanadium compounds as catalysts in some chemical processes. Currently, no acceptable substitute for vanadium is available for use in aerospace titanium alloys.

<sup>e</sup>Estimated. — Zero.

<sup>1</sup>Includes vanadium chlorides, hydrides, nitrides, and sulfates, as well as vanadates of vanadium.

<sup>2</sup>Includes waste and scrap.

<sup>3</sup>Less than ½ unit.

<sup>4</sup>Defined as production + imports – exports + adjustments for industry stock changes.

<sup>5</sup>The 2017 annual average vanadium pentoxide price includes U.S. monthly averages for January to June 2017 and China monthly average prices for July to December 2017. The prices for 2018–2021 are the China annual average vanadium pentoxide prices. Source: CRU Group.

<sup>6</sup>Includes chlorides, ferrovanadium, vanadates, vanadium-aluminum alloy, other vanadium alloys, vanadium metal, vanadium pentoxide, and other specialty chemicals.

<sup>7</sup>Defined as imports – exports + adjustments for industry stock changes.

<sup>8</sup>Aluminum-vanadium master alloy consisting of 35% aluminum and 64.5% vanadium.

<sup>9</sup>See Appendix C for resource and reserve definitions and information concerning data sources.

<sup>10</sup>For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 1.1 million tons.