

VANADIUM

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

Domestic Production and Use: Vanadium production in Utah from the mining of uraniferous sandstones on the Colorado Plateau ceased in early 2020 and was not restarted in 2022. Secondary vanadium production continued in Arkansas, Ohio, and Pennsylvania where processed waste materials (petroleum residues, spent catalysts, utility ash) were used to produce ferrovanadium, vanadium-bearing chemicals or specialty alloys, and vanadium pentoxide. Metallurgical use, primarily as an alloying agent for iron and steel, accounted for about 94% of domestic reported vanadium consumption in 2022. Of the other uses for vanadium, the major nonmetallurgical use was in catalysts to produce maleic anhydride and sulfuric acid.

Salient Statistics—United States:	2018	2019	2020	2021	2022^e
Production from primary ore and concentrate	—	460	17	—	—
Production from ash, residues, and spent catalysts ^e	2,600	3,000	2,900	3,200	4,400
Imports for consumption:					
Aluminum-vanadium master alloy	281	222	101	35	30
Ash and residues ^{1, 2}	2,810	2,120	1,550	1,680	1,800
Ferrovanadium	2,970	2,280	1,360	2,170	2,700
Oxides and hydroxides, other	98	105	67	69	100
Vanadium chemicals ³	992	733	942	957	790
Vanadium metal ⁴	28	45	(5)	1	2
Vanadium ores and concentrates ¹	330	108	2	4	67
Vanadium pentoxide	4,600	3,620	1,670	1,740	1,500
Exports:					
Aluminum-vanadium master alloy	90	29	13	72	40
Ash and residues ¹	1,430	1,280	503	930	910
Ferrovanadium	575	295	210	173	220
Oxides and hydroxides, other	53	750	51	235	400
Vanadium metal ⁴	39	27	1	4	10
Vanadium ores and concentrates ¹	48	95	92	81	140
Vanadium pentoxide	563	423	50	17	170
Consumption:					
Apparent ⁶	11,900	9,790	7,670	8,340	9,500
Reported	9,280	9,900	7,920	8,030	8,400
Price, average, vanadium pentoxide, ⁷ dollars per pound	16.40	12.17	6.68	8.17	9.20
Stocks, yearend ⁸	250	257	269	271	270
Net import reliance ⁹ as a percentage of apparent consumption	78	65	62	62	54

Recycling: Recycling of vanadium is mainly associated with reprocessing vanadium catalysts into new catalysts. The range in vanadium content in spent catalysts varies depending on the crude oil feedstock and the uncertainty associated with the quantity of vanadium recycled from spent chemical process catalysts was significant.

Import Sources (2018–21): Ferrovanadium: Austria, 38%; Canada, 38%; Russia, 10%; Japan, 4%; and other, 10%. Vanadium pentoxide: Brazil, 50%; South Africa, 32%; China, 6%; Russia, 4%; and other, 8%. Total: Canada, 31%; China, 13%; Brazil, 8%; South Africa, 7%; and other, 41%.

Tariff:	Item	Number	Normal Trade Relations 12–31–21
	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.
	Vanadium pentoxide, anhydride	2825.30.0010	5.5% ad valorem.
	Vanadium oxides and hydroxides, other	2825.30.0050	5.5% ad valorem.
	Ferrovanadium	7202.92.0000	4.2% ad valorem.
	Vanadium metal	8112.92.7000	2% ad valorem.
	Vanadium and articles thereof ¹⁰	8112.99.2000	2% ad valorem.
	Vanadium chemicals	(3)	5.5% ad valorem.

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

Government Stockpile: None.

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Events, Trends, and Issues: Estimated U.S. apparent consumption of vanadium in 2022 increased by 11% from that in 2021. The estimated average Chinese vanadium pentoxide price in 2022 increased by 12% compared with the 2021 price, and the estimated United States ferrovandium price increased by 55% to \$24.00 per pound in 2022 compared with that in 2021.

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 the first half of 2022, a rise in coronavirus disease 2019 (COVID-19) cases led the Chinese Government to impose COVID-19 restrictions, causing a decrease in China's steel production. The vanadium market had anticipated vanadium disruptions owing to the ongoing conflict between Russia and Ukraine. However, according to analysts, vanadium pentoxide trade flows between Russia and Czechia have been relatively unaffected by the conflict and Czechian ferrovandium exports to customers in China, India, Japan, the Netherlands, Turkey, Ukraine, and the United States have also had limited disruptions. Uncertainty surrounding the supply of Russian material was expected to continue.

Vanadium redox flow battery (VRFB) technology continued to be an increasingly important part of large-scale energy storage as it allows for high-safety, large-scale, environmentally friendly, medium- and long-term energy storage. Installations of VRFB projects increased worldwide as energy companies looked to support renewable energy projects as many countries attempt to lower their carbon emissions.

World Mine Production and Reserves: Reserves for Australia were revised based on company and Government reports.

	Mine production		Reserves¹¹ (thousand metric tons)
	2021	2022^e	
United States	—	—	45
Australia	—	—	127,400
Brazil	5,780	6,200	120
China	70,300	70,000	9,500
Russia	20,100	17,000	5,000
South Africa	8,800	9,100	3,500
World total (rounded)	105,000	100,000	26,000

World Resources:¹¹ World resources of vanadium exceed 63 million tons. Vanadium occurs in deposits of phosphate rock, titaniferous magnetite, and uraniferous 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.

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.

^eEstimated. — Zero.

¹Reported by the U.S. Census Bureau as metric tons of vanadium pentoxide. To convert vanadium pentoxide content to vanadium content multiply by 0.56.

²Includes estimates for data suppressed by U.S. Census Bureau in the years 2020 through 2022.

³Includes Harmonized Tariff Schedule of the United States codes for chloride oxides and hydroxides of vanadium (2827.49.1000), hydrides and nitrides of vanadium (2850.00.2000), vanadium sulfates (2833.29.3000), vanadium chlorides (2827.39.1000) and vanadates (2841.90.1000).

⁴Includes waste and scrap.

⁵Less than ½ unit.

⁶Defined as primary production + secondary production + imports – exports ± adjustments for industry stock changes.

⁷Chinese annual average vanadium pentoxide prices. Source: CRU Group.

⁸Includes ferrovandium, vanadium-aluminum alloy, other vanadium alloys, vanadium metal, vanadium pentoxide, and other specialty chemicals.

⁹Defined as imports – exports ± adjustments for industry stock changes.

¹⁰Aluminum-vanadium master alloy consisting of 35% aluminum and 64.5% vanadium and is the main master alloy for the vanadium industry.

Unwrought aluminum-vanadium master alloy (Harmonized Tariff Schedule of the United States code 7601.20.9030) was not included.

¹¹See Appendix C for resource and reserve definitions and information concerning data sources.

¹²For Australia, Joint Ore Reserves Committee or equivalent reserves were 1.7 million tons.