

VANADIUM

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

Domestic Production and Use: In 2016, six U.S. firms that compose most of the domestic vanadium industry produced ferrovanadium, vanadium pentoxide, vanadium metal, and vanadium-bearing chemicals or specialty alloys by processing materials such as petroleum residues, spent catalysts, utility ash, and vanadium-bearing pig iron slag. In 2009–13, small quantities of vanadium were produced as a byproduct from the mining of uraniumiferous sandstones on the Colorado Plateau. All byproduct vanadium production has been suspended since 2014. Metallurgical use, primarily as an alloying agent for iron and steel, accounted for about 94% of the domestic vanadium consumption in 2016. Of the other uses for vanadium, the major nonmetallurgical use was in catalysts for the production of maleic anhydride and sulfuric acid.

| Salient Statistics—United States: | 2012 | 2013 | 2014 | 2015 | 2016^e |
|--|-------------|-------------|-------------|-------------|-------------------------|
| Production, mine, mill | 106 | 591 | — | — | — |
| Imports for consumption: | | | | | |
| Ferrovanadium | 4,190 | 3,710 | 3,230 | 2,010 | 2,300 |
| Vanadium pentoxide, anhydride | 1,640 | 2,040 | 3,410 | 2,870 | 2,400 |
| Oxides and hydroxides, other | 905 | 205 | 104 | 94 | 115 |
| Aluminum-vanadium master alloys (gross weight) | 115 | 169 | 431 | 204 | 260 |
| Ash and residues | 2,210 | 4,190 | 6,160 | 9,440 | 7,200 |
| Sulfates | 29 | 30 | 19 | 13 | 15 |
| Vanadates | 280 | 276 | 197 | 173 | 340 |
| Vanadium metal ¹ (gross weight) | 154 | 35 | 161 | 182 | 25 |
| Exports: | | | | | |
| Ferrovanadium | 337 | 299 | 253 | 122 | 665 |
| Vanadium pentoxide, anhydride | 62 | 90 | 201 | 356 | 180 |
| Oxides and hydroxides, other | 305 | 427 | 350 | 100 | 160 |
| Aluminum-vanadium master alloys (gross weight) | 432 | 347 | 443 | 229 | 140 |
| Vanadium metal ¹ (gross weight) | 26 | 58 | 32 | 5 | 5 |
| Consumption: | | | | | |
| Apparent | 8,530 | 10,100 | 12,300 | 14,100 | 11,400 |
| Reported | 3,960 | 3,980 | 4,070 | 3,930 | 4,000 |
| Price, average, dollars per pound vanadium pentoxide | 6.49 | 6.04 | 5.61 | 4.16 | 3.10 |
| Stocks, consumer, yearend ² | 219 | 220 | 225 | W | W |
| Net import reliance ³ as a percentage of apparent consumption | 99 | 94 | 100 | 100 | 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. Some tool steel scrap was recycled primarily for its vanadium content, but this only accounted for a small percentage of total vanadium used.

Import Sources (2012–15): Ferrovanadium: Czech Republic, 41%; Canada, 21%; Republic of Korea, 19%; Austria, 14%; and other, 5%. Vanadium pentoxide: South Africa, 51%; Russia, 29%; China, 12%; and other, 8%.

Tariff:

| Item | Number | Normal Trade Relations <u>12–31–16</u> |
|--|--------------|---|
| Vanadium bearing ash and residues | 2620.40.0030 | Free. |
| Vanadium bearing ash and residues, other | 2620.99.1000 | Free. |
| Chemical compounds: | | |
| Vanadium sulfates | 2833.29.3000 | Free. |
| Vanadium vanadates | 2841.90.1000 | Free. |
| Vanadium pentoxide anhydride | 2825.30.0010 | 5.5% ad val. |
| Vanadium oxides and hydroxides, other | 2825.30.0050 | 5.5% ad val. |
| Vanadates | 2841.90.1000 | 5.5% ad val. |
| Ferrovanadium | 7202.92.0000 | 4.2% ad val. |
| Vanadium and articles thereof ⁴ | 8112.99.2000 | 2.0% ad val. |

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

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Events, Trends, and Issues: U.S. reported consumption of vanadium in 2016 decreased slightly from that of 2015. Among the major uses for vanadium, production of carbon, full-alloy, and high-strength low-alloy steels accounted for 16%, 44%, and 36%, respectively, of domestic reported consumption. U.S. imports for consumption of vanadium in 2016 decreased by 16% from those of the previous year. The main decrease was in imports of vanadium-bearing ash and residues, a 24% decrease from those of 2015. U.S. exports increased by 28% from those of the previous year. The main increase was in exports of ferrovandium.

An iron and vanadium mine in South Africa closed in 2015, forcing the suspension of production by a major vanadium product producer because it was no longer receiving raw material from the closed mine. This has left South Africa with only two major producers of vanadium. A company in Austria, which also received raw material from the mine in South Africa, was also expected to decrease its vanadium product output in 2016. These vanadium products included aluminum-vanadium, ferrovandium, vanadium chemicals, and vanadium oxides.

Few new operations have been commissioned in recent years, with the exception of a producer in Brazil. The producer continued to optimize operations as part of its rampup to full production levels, creating new material for the market.

Vanadium pentoxide and ferrovandium prices slowly began to increase throughout 2016. However, prices were not expected to come anywhere near the high prices experienced in 2004 through 2008. In August 2016, vanadium pentoxide prices were \$3.26 per pound compared with \$15.40 per pound in August 2008.

World Mine Production and Reserves: The reserves estimate for China was revised based on new information from the National Bureau of Statistics of China.

| | Mine production | | Reserves ⁵ (thousand metric tons) |
|-----------------------|-----------------|-------------------------|---|
| | <u>2015</u> | <u>2016^e</u> | |
| United States | — | — | 45 |
| Australia | — | — | 1,800 |
| Brazil | 5,800 | 6,000 | NA |
| China | 42,000 | 42,000 | 9,000 |
| Russia | 16,000 | 16,000 | 5,000 |
| South Africa | <u>14,000</u> | <u>12,000</u> | <u>3,500</u> |
| World total (rounded) | <u>77,800</u> | <u>76,000</u> | <u>19,000</u> |

World Resources: 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. Although domestic resources and secondary recovery are adequate to supply a large portion of domestic needs, 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.

^eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.

¹Vanadium metal includes waste and scrap.

²Does not include vanadium pentoxide.

³Defined as imports – exports + adjustments for industry stock changes.

⁴Aluminum-vanadium master alloy consisting of 35% aluminum and 64.5% vanadium.

⁵See [Appendix C](#) for resource and reserve definitions and information concerning data sources.