

# 77 Vanadium

Vanadium is a scarce element. It occurs in association with titaniferous magnetite and recovered as a by-product during iron & steel manufacture. Vanadium is also concentrated in many end-products of organic material including coal and oil. In addition, vanadium present in bauxite can also be recovered as vanadium sludge from red mud during the production of alumina.

## RESOURCES

In India, vanadium is associated with titaniferous magnetite which contains 0.8 to 3%

$V_2O_5$ . It also occurs in significant amounts in association with chromite, laterite, bauxite and ferro-magnesium-rich rocks, such as pyroxenite, anorthosite and gabbro.

As per UNFC system, the total estimated resources of vanadium ore as on 1.4.2010 are placed at 24.72 million tonnes with an estimated  $V_2O_5$  content of 64,887 tonnes. Out of the total resources, the reserves are 0.41 million tonnes having 1,603 tonnes of  $V_2O_5$  content while the remaining resources are 24.31 million tonnes having 63,284 tonnes of  $V_2O_5$  content (Table-1).

**Table – 1 : Reserves/Resources of Vanadium as on 1.4.2010(P)  
(By Grades/States)**

(In tonnes)

Total	Reserves			Remaining resources					Total resources (A+B)
	Proved STD111	Probable STD122	Total (A)	Prefeasibility		Indicated STD332	Inferred STD333	Total (B)	
				STD221	STD222				
<b>All India : Total</b>									
<b>By Grades</b>									
<b>Ore</b>	<b>293539</b>	<b>117416</b>	<b>410955</b>	<b>1720000</b>	<b>4000000</b>	<b>232000</b>	<b>18355933</b>	<b>24307933</b>	<b>24718888</b>
<b>Contained <math>V_2O_5</math></b>	<b>1144.8</b>	<b>457.92</b>	<b>1602.72</b>	<b>2835</b>	<b>5600</b>	<b>487.2</b>	<b>54362.25</b>	<b>63284.45</b>	<b>64887.17</b>
<b>By States</b>									
<b>Karnataka</b>									
Ore	–	–	–	500000	4000000	–	14884430	19384430	19384430
Contained $V_2O_5$	–	–	–	700	5600	–	43197.55	49497.55	49497.55
<b>Maharashtra</b>									
Ore	293539	117416	410955	–	–	–	58708	58708	469663
Contained $V_2O_5$	1144.8	457.92	1602.72	–	–	–	229	229	1831.72
<b>Odisha</b>									
Ore	–	–	–	1220000	–	232000	3412795	4864795	4864795
Contained $V_2O_5$	–	–	–	2135	–	487.2	10935.74	13557.94	13557.94

Figures rounded off.

## VANADIUM

### PRODUCTION

Vanadium sludge is separated as a by-product during the Bayer process for production of alumina hydrate. The vanadium sludge obtained at BALCO's Korba plant contains 6 to 10% V<sub>2</sub>O<sub>5</sub>, Hindalco's Renukoot plant 18.2% V<sub>2</sub>O<sub>5</sub> and Muri and Belgaum plants 6 to 20% V<sub>2</sub>O<sub>5</sub>.

Production of ferro-vanadium during 2005-06 to 2009-10 is given in Table-2.

**Table – 2 : Production of Ferro-Vanadium  
2005-06 to 2009-10**

(In tonnes)	
Year	Production
2005-06	877
2006-07	1139
2007-08	1585
2008-09	1501
2009-10	1389

*Source: Indian Ferro-alloys Producers' Association.*

### USES

It is used primarily as an alloying element in iron & steel industry and to some extent as a stabiliser in titanium and aluminium alloys which are used in aerospace applications. It imparts toughness and strength to steel, alloys and also acts as scavenger for oxygen. Vanadium is consumed in the steel industry in a wide range of products, from low carbon flat rolled steels, high strength plates and structural steels to pipes, reinforcing bars, forging steels, rail steels and tool steels. Most of the vanadium (about 80%) is used in the form of ferro-vanadium as a means of introducing vanadium into steel. The content of vanadium in ferro-vanadium varies from 45 to 50% and sometimes it is up to 80%, depending upon the demand. The 45 to 50% grade is produced from slag and other vanadium containing material by silicothermic reduction of vanadium pentoxide in presence of steel scrap or by direct reduction in an electric arc furnace. The resultant vanadium steels can be divided into micro-alloy or low-alloy steels with less than 0.15% vanadium and high-

alloy steels up to 5% vanadium. Non-metallurgical applications include as catalyst and in ceramic, chemical, pigments, health preparations and electronic industries. New uses include vanadium secondary batteries for power plants and vanadium redox rechargeable battery for commercial applications. It is also used to produce a super conductive magnet with a field of 175,000 gauss.

### SUBSTITUTES

Substitution of vanadium in steel by niobium, chromium, titanium, manganese, molybdenum and tungsten is possible although at higher cost or with lower performance. Heat-treated carbon steels can replace vanadium steels in some applications. Platinum and nickel can be used in some catalytic processes but at higher cost. Presently, there is no acceptable substitute for vanadium in aerospace titanium alloys.

### CONSUMPTION

Ferro-vanadium producing units in India consume either imported V<sub>2</sub>O<sub>5</sub> concentrates or indigenous vanadium sludge. The domestic availability of vanadium sludge from aluminium industry is limited for ferro-vanadium production and gap is met by imports. The reported consumption of ferro-vanadium during 2007-08 to 2009-10 by various units in the organised sector is given in Table-3.

**Table – 3 : Reported Consumption of  
Ferro-Vanadium, 2007-08 to 2009-10  
(By Industries)**

(In tonnes)			
Industry	2007-08(R)	2008-09(R)	2009-10(P)
<b>All Industries</b>	<b>688</b>	<b>651</b>	<b>770</b>
Foundry	8 (4)	7 (4)	7 (4)
Alloy steel	119 (7)	105 (8)	121 (8)
Iron & steel	561 (9)	539(10)	642(10)

*Data collected on non-statutory basis.*

*Figures in parentheses denote the number of units reporting\* consumption in organised sector.*

*(\*includes actual reported consumption and/or estimates made, wherever required).*

## WORLD REVIEW

The world reserves of vanadium in 2009 were about 13 million tonnes of metal located mainly in China, Russia, South Africa and the USA and are expected to last till next century at the current rate of consumption (Table-4). Most of the reserves are of titaniferous magnetite from which vanadium could be extracted as a by-product of iron. The resources are also available in crude oil, tar sands, phosphate rock, uraniumiferous sandstone and siltstone. In all these cases, extraction depends on economic recovery of the product.

**Table – 4 : World Reserves of Vanadium  
(By Principal Countries)**

(In '000 tonnes of vanadium content)

Country	Reserves
<b>World : Total (rounded)</b>	<b>13000</b>
China	5000
Russia	5000
South Africa	3000
USA	45
Other countries	NA

*Source: Mineral Commodity Summaries, 2010.*

The world production of vanadium in 2009 was estimated at about 58 thousand tonnes excluding vanadium recovered as a by-product of refining and burning of heavy oils. Major producing countries were Russia, China and South Africa (Table-5).

Nearly all the world's vanadium supply originates from primary sources. Five countries recovered vanadium from ores, concentrates, slag or petroleum residues. Four countries out of these mine and process magnetite-bearing ores as an important source of vanadium. Japan and the United States are probably the only countries to recover significant quantities of vanadium from petroleum residues.

### Brazil

Largo Resources Ltd has acquired a 20-year lease located in Campo Alegre de Lourdes in the state of Bahia. It is likely to be the world's largest known vanadium deposit outside China.

### China

China's Panzhihua New Steel and Vanadium Co. Ltd (a subsidiary of Panzhihua Iron and Steel Group) is the major producer that operates from Panzhihua in Sichuan Province, the largest vanadium producing region of China. The second leading vanadium producer in China is the Chengde Xinxin Vanadium & Titanium Co. Ltd, associated with the steel and vanadiferous slag production in Hebei Province. The company completed extensive expansion in 2008 and is now a significant supplier in world market.

**Table – 5 : World Mine Production of Vanadium  
(By Principal Countries)**

(In tonnes of metal content)

Country	2007	2008	2009
<b>World:Total (rounded)</b>	<b>65000</b>	<b>63000</b>	<b>58000</b>
China <sup>e</sup>	18000	18500	20800
Kazakhstan <sup>e</sup>	1000	1000	1000
Russia <sup>e</sup>	23000	23000	22000
South Africa	23486	20295	14353

*Source : World Mineral production, 2005-2009.*

*Note : Include vanadium in slag product but exclude vanadium recovered as a by-product of refining and burning of heavy oil.*

## FOREIGN TRADE

No exports and imports of vanadium & scrap were reported in 2009-10. Exports of vanadium ores and concentrates during 2009-10 were 124 tonnes valued at about Rs 18.5 million to Vietnam (Table-6). Imports of vanadium ores and concentrates increased to 60 tonnes in 2009-10 from 39 tonnes in the previous year. Imports were mainly from Germany (Table-7).

**Table – 6 : Exports of Vanadium Ores & Conc.  
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
<b>All Countries</b>	–	–	<b>124</b>	<b>18554</b>
Vietnam	–	–	124	18554

## VANADIUM

**Table – 7 : Imports of Vanadium Ores & Conc.  
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs.'000)	Qty (t)	Value (Rs.'000)
<b>All Countries</b>	<b>39</b>	<b>22500</b>	<b>60</b>	<b>7762</b>
Germany	16	5147	59	6936
South Africa	–	–	1	826
Chile	23	17353	–	–

### FUTURE OUTLOOK

The worldwide demand for vanadium is directly related to the demand for steel. In vanadium batteries, the consumption may increase in future.

The future Indian alumina plants, being mostly based on East Coast bauxite having a very low content of vanadium, will not be able to generate adequate quantity of vanadium sludge to meet the internal demand. On the other hand, with growth of automobile and casting sectors, demand for ferro-vanadium is expected to increase and this has to be met by imports. The high growth registered in automobile sector led to increased use of vanadium in steels. The accelerated growth in the forging industry and increased demand for die steels and tool steel paved the way for increased vanadium consumption. Steps are also necessary to utilise huge vanadium-bearing titaniferous ores available in Indian states; viz, Karnataka, Maharashtra and Odisha through R&D efforts to meet the domestic demand of vanadium pentoxide and ferro-vanadium.