VANADIUM

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Summary

Vanadium pentoxide (V_2O_5) is extracted from natural ores, vanadiferous slags and vanadium-containing petroleum residues. The basic feedstock, V_2O_5, used for the industrial production of vanadium master alloys and other vanadium products is not currently produced in Canada. Ferrovanadium, a master alloy used in steels, is produced in Canada by Masterloy Products Ltd. (Masterloy) from imported V_2O_5. Consumption of ferrovanadium in Canada in 1993, the latest year for which data are compiled, was 618 t of contained vanadium, 22% higher than in 1992.

Total world production of vanadium in 1994, about 44 000 t (metal content), is estimated to have decreased by 5.6% compared to 1993. In contrast, the world's vanadium consumption in 1994 is estimated to have increased by 15.4%. Prices for vanadium pentoxide and intermediate products in 1994 gradually increased on the strength of increased demand from the steel industry, a reduction in supplies from Russia and China, and increased production costs.

The market is expected to remain tight in the short term, which will lead to further price increases in the first half of 1995. Prices should then stabilize at the higher level when additional production is brought on stream. Consumption is expected to increase in the short term following increased demand from the steel industries of economies like Japan's, which are emerging from a long recession.

Uses

Vanadium's main industrial use, 85% of consumption, is in the production of high-strength, low-alloy steels (HSLA) and tool and die steels. Another 10% is used in the manufacture of titanium-aluminum alloys for the aerospace industry, while about 5% is used in the chemical industry.

Vanadium is used in the steel industry for its property as an active grain refiner and as a strong deoxidant, and can impart strength, hardness and wear resistance to steels.

Additions to steel are made primarily in the form of ferrovanadium, which is produced mostly by using the aluminothermic process or an electric furnace. With the aluminothermic process, a mixture of vanadium pentoxide, aluminum, ferrous scrap and a flux is charged to a refractory-lined open steel crucible. The reaction is initiated by using a fuse of barium pentoxide mixed with aluminum or magnesium powder to ignite the charge. If an electric furnace is used, less aluminum is needed and less vanadium is lost to the slag, but the process is more energy-intensive.

In the steel industry, HSLA steels have gradually replaced carbon steels in many instances where the higher intrinsic strength of the steel permits a lower design weight that can offset the somewhat higher per-unit weight cost. The lighter weight also results in savings in transportation costs and improved weldability. The major uses of HSLA steels are in pipelines, concrete reinforcing bars, structural shapes, tool steels, and automobile components. In these applications, niobium and vanadium are largely interchangeable.

The superalloy industry uses vanadium mainly for aircraft applications, such as for turbine blades and jet engines where high-temperature strength is essential.

In the nonferrous sector, vanadium's main use is as a stabilizer in titanium-aluminum alloys used in the aerospace industry. In this application there is essentially no substitute for vanadium as a strengthening element.

In the chemical industry, vanadium compounds are used in oxidation catalysts for the production of sulphuric acids and the cracking of petroleum products. It is also used as a glass and ceramic pigment, in permanent magnets, in driers in paints and varnishes, in the processing of colour films, as a strengthening element in aluminum alloys, in small rechargeable batteries, and in catalysts for the control of exhaust fumes in diesel engines.

Canadian Developments

Vanadium occurrences are widespread throughout Canada. The most common type of occurrence is vanadium contained in titaniferous magnetite. The grade of the best deposits, at 0.6%, is comparable to the grades of some deposits now being worked in other countries, but it is only about one third the grade of deposits being mined in the Republic of South Africa.

Vanadium was last produced in Canada in 1990/91 by Carbovan Inc., who recovered the material from fly ash generated at the Fort McMurray oil refinery of Suncor Inc. in Saskatchewan. The vanadium produced initially consisted of redcake, HVO_3, an intermediate higher-grade product, while production of vanadium pentoxide was expected to start later on. The plant closed as a result of declining prices.

Canada's sole ferrovanadium converter, Masterloy, a wholly owned subsidiary of Applied Industrial Materials Corp. (Aimcor) of the United States, produces 80% ferrovanadium. Canada imports all of its

vanadium pentoxide requirements, which in 1994 were sourced mostly from South Africa and the United States.

Masterloy's Ottawa, Ontario plant, which uses the aluminothermic process, has a combined ferrovanadium-ferromolybdenum capacity of over 1500 t/y. It supplies most of the ferrovanadium consumed in Canada, with the remainder being imported mainly from the United States and Russia. Up to 50% of the company's output of ferrovanadium is exported to the United States.

Canada's principal consumers of ferrovanadium are: Sydney Steel Corp., Sidbec Dosco Inc., Atlas Specialty Steels, Stelco Inc., Stelco McMaster Ltée, Les Forges de Sorel Inc., Slater Steels Industries Ltd., The Algoma Steel Corp. Ltd., CO-STEEL LASCO, Manitoba Rolling Mills, Ipsco Inc., and Atlas Steel Ltd.

Since Aimcor's announcement in September 1993 of its intention to sell its ferrovanadium plant in Ottawa and its ferrosilicon facility in Bridgeport, Alabama, prospective buyers have been reported, but no favourable offer has yet been made.

Future potential sources of vanadium pentoxide in Canada include a recent vanadium-rich mineral discovery by joint-venture partners Gossan Resources Ltd. (51%) and Cross Lake Explorations Inc. (49%). Located about 600 km north of Winnipeg, Manitoba, the Pipestone Lake deposit has titaniferous-magnetite-rich zones located in an anorthosite complex. Four zones have been discovered up to now with the Main Central and South zones showing the best potential for vanadium.

Results of a 1994 diamond drilling program enabled the outline in the Main Central Zone of inferred resources of 21.5 Mt grading 42.7% Fe_2O_3, 8.72% TiO_2, and 0.58% V_2O_5, down to a depth of 330 m. Pyrometallurgical testwork has shown recoveries of over 85% for TiO_2 and 90% for vanadium. The main effort in 1995 will be to establish sufficient reserves for an open-pit operation. Diamond drilling resumed in early January 1995.

Canada's reported consumption of ferrovanadium was up 22% at 618 t (vanadium content) in 1993, compared to 3371 t for the United States. In 1994, imports consisting of vanadium pentoxide and ferrovanadium were valued at C$13.4 million, an increase of 37% over 1993, while exports, consisting mostly of ferrovanadium, were worth C$7.4 million, up 59% over 1993.

World Developments

World vanadium production statistics are not officially compiled; however, one published estimate puts total production of vanadium in 1994 at 44 100 t vanadium content, a decrease of 5.6% compared to 1993. Quoting the same source, the world's vanadium consumption is estimated at 43 465 t vanadium content, up 15.4% from 1993.

Practically all of the increase is attributed to a hike in demand for ferrovanadium.

Production of vanadium pentoxide in the world is restricted to a small number of countries. Based on annual vanadium pentoxide production capacity from all sources, the world's production can be split as follows: South Africa, 43%; the United States, 17%; Russia, 15%; China, 13%; Venezuela, 4%; Chile, 4%; and others, 4%.

South Africa

South Africa's production of vanadium in 1994 is estimated at 19 965 t vanadium content, down 20% from 1993. The South African production comes mostly from four companies: Highveld Steel and Vanadium Corporation (Highveld), Vametco Minerals Corporation, Transvaal Alloys Pty Ltd., and Vanadium Technologies (Vantech).

Highveld, the largest producer of vanadium in the Western World, significantly reduced production at its facilities in recent years in response to market overcapacity. In February 1994, Highveld re-started its mothballed Vantra plant in response to an improvement in the market. Closed since August 1993, the 8170-t/y (contained vanadium) capacity plant was said to be operating as the market dictates. Its production unit from vanadiferous slag was kept at 1993 production levels.

Strategic Minerals Corp. (Stratcor) stopped its vanadium mining and concentrating activities indefinitely at its South African subsidiary, Vametco Minerals Corp., because of poor prices. As soon as plant modifications were completed, it started using, as feedstock, vanadium-bearing slags from South African steel producers. Production capacity was expected to stay at more than 4500 t/y vanadium content.

Following the purchase of Transvaal Alloys Pty Ltd. (Transvaal) by Highveld on January 1, 1994, the latter company closed Transvaal's mining operations and pentoxide production, but continued to produce vanadium chemicals, catalysts and vanadium powder using Highveld slag as raw material. Transvaal is thought to account for as much as 30% of the world's vanadium chemicals market.

In the third quarter of 1994, Rhombus Vanadium Holdings Ltd.'s Rhovan project started shipments of vanadium pentoxide and was expected to reach full-scale production of about 5200 Mt/y of contained vanadium by the end of the year. The mining operation, located near Brits in Bophuthatswana, has proven and probable ore reserves of 90.6 Mt grading 1.97% V_2O_5 in magnetite, down to a depth of 60 m. Although no decision has been taken yet, the

company is mulling over the possibility of converting the V_2O_5 into ferrovanadium on site.

United States

On May 31, 1994, Shieldalloy Metallurgical Corp., a major U.S. producer of ferrovanadium and a subsidiary of Metallurg Inc., filed an anti-dumping suit against ferrovanadium and nitride vanadium imports from Russia. Imports from Russia to the United States gradually increased from negligible amounts in 1991 to 680 t of contained vanadium in 1993, and were still increasing in early 1994.

Despite allegations that the surge in exports resulted from sales from Russia's strategic stockpile, and that Russian producers Tulatchermet and Chusovskoy Metallurgical Works had rationalized production, the U.S. Department of Commerce announced on December 28, 1994, the introduction of preliminary anti-dumping duties on imports from Russia. Duties ranging from 28.25% to 108% will be applied on imports of ferrovanadium and nitride vanadium from Russia until a final determination is issued in May 1995 by the U.S. Department of Commerce.

During 1994, Shieldalloy Metallurgical Corp. remained protected from its creditors under Chapter 11 of the U.S. Bankruptcy Code. However, the upturn in demand for ferrovanadium during the year helped the company redress itself and, by the end of the year, it was on its way to resolving the situation with its creditors.

In October 1994, Congress authorized the Defense Logistics Agency (DLA) to sell 651 t of contained vanadium held in the U.S. strategic stockpile as part of the fiscal year 1995 Annual Materials Plan. However, by the end of 1994, the DLA had still not made a public offer for the sale of the material, which is to be sold on a negotiated sealed bid basis.

Russia

Russia was reportedly producing at about 60% of its installed capacity of around 17 000 t/y vanadium content in early 1994. Production of V_2O_5 in Russia is mainly from titanomagnetite and ilmenite deposits located in the Ural mountains. Vanadium-rich slags are produced, with some being converted into technical-grade V_2O_5 and ferrovanadium at two main plants, Tulatchermet and Chusovskoy Metallurgical Works. The rest is exported through traders such as Odermet of London, England, or to converters such as NIKOM, the Czech Republic-based ferrovanadium producer.

Other Developments

In Australia, Precious Metals Australia (PMA) confirmed that its Windimurra project located in the Murchison District of Western Australia was on hold. However, Perth-based Clough Resources announced in January 1994 that it was pursuing its evaluation to re-start its Coates Ridge vanadium project near Wundowie in Western Australia. The vanadiferous-magnetite deposit was mined between 1980 and 1982, but was closed after having delivered just over 300 t of V_2O_5. Now plans are for the facility to produce aluminum hydroxide and ferrotitanium products, in addition to 1500 t/y of V_2O_5. If the project is approved, initial production could start near the end of 1995.

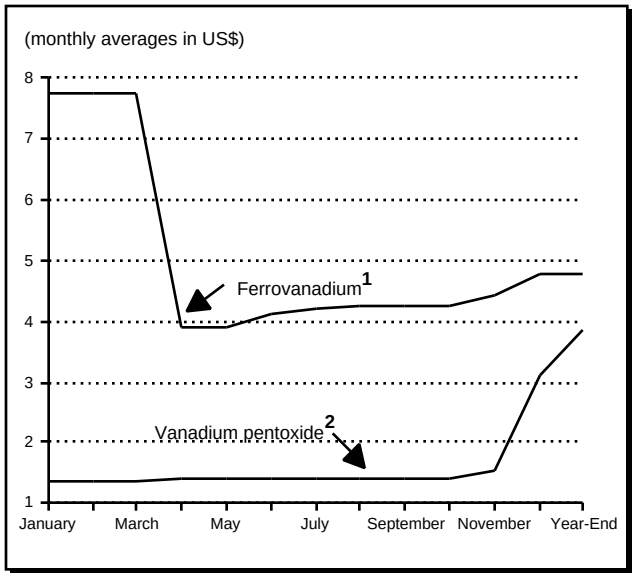
Meanwhile, the Czech Republic-based NIKOM joint venture between the Japanese trading house Nissho Iwai and the ferrovanadium producer Mnisek Ferozliatinárske Zavody, S. P. was reportedly operating, in early 1994, at 80-90% of its 1700-t/y vanadium contained capacity.

Prices

Historically, vanadium pentoxide prices have remained fairly stable except for a price surge between the last quarter of 1988 and the third quarter of 1990. That surge resulted from a major increase in demand for ferrovanadium by the steel industry. Prices in 1994 appear to have mirrored that last price surge inasmuch as an increase in demand from the steel industry caused a tightening in the supply of vanadium products.

Prices for U.S. free market vanadium pentoxide started the year in the range of US$1.30-$1.40/lb of V_2O_5 and inched up to US$1.35-$1.45/lb by early

Figure 1
Vanadium Price Variations, 1994



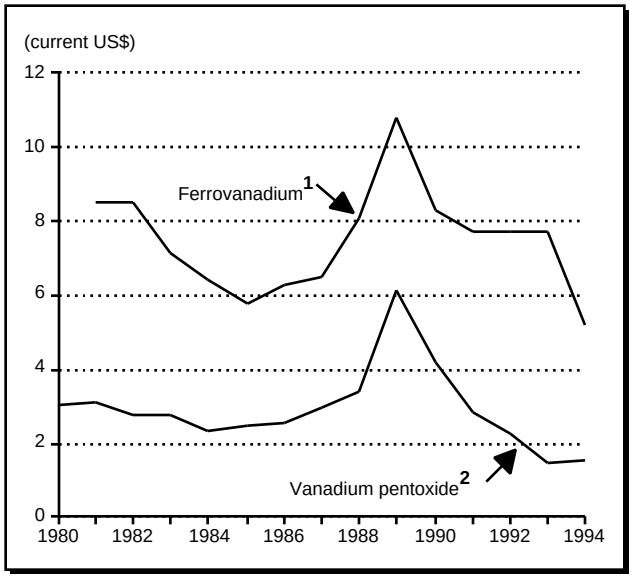
Source: *Metals Week.*

[1] Price per pound of contained vanadium, U.S. producer, 80% vanadium.
[2] Price per pound V_2O_5, free market.

April. They stayed at that level until mid-November, at which time prices increased rapidly to close the year in the range of US$3.70-$4.00/lb.

Ferrovanadium prices increased in a similar fashion, but reacted faster to market supply conditions. As of mid-April 1994, the U.S. vanadium producer Stratcor started publishing its own price for ferrovanadium. The quoted price of US$3.90/lb vanadium content for 80% ferrovanadium started increasing gradually in June 1994 to finish the year at US$4.75/lb. On December 8, 1994, Stratcor suspended its published price to sell on the basis of prices at the time of shipment. The basis for higher prices was the increase in demand from the steel and alloy industries, a perceived slowdown in exports from Russia, and rising production costs, especially higher prices for aluminum reducing agents.

Figure 2
Vanadium Price Variations in the Past Fifteen Years, 1980-94



Sources: *Metals Week*; U.S. Bureau of Mines.

1 Average annual price per pound of contained vanadium (lower end range), U.S. producer, 80% vanadium.

2 Average annual price per pound V_2O_5, free market.

Outlook

In 1995, Masterloy is expected to produce at the plant's rated capacity. The introduction of preliminary anti-dumping duties on imports from Russia into the United States and the increase in consumption in North America will help the company's sales.

On the world supply side, although vanadium is still in long-term oversupply, a short-term supply/demand imbalance developed in 1994. This situation is expected to last about six months before additional production is brought on line to stabilize the market. Accordingly, prices are expected to increase in the first half of 1995 and to stabilize once the supply deficit is resolved. Highveld, for example, has indicated that it will set prices as high as US$3.00/lb for vanadium pentoxide for the first quarter of 1995.

In the short and medium terms, consumption of vanadium products is expected to increase further as a result of greater industrial activity in the recovering world economies, and because of re-stocking by Japanese steel-makers. Growth should centre around the steadily expanding steel industry, especially for structural shapes, tool steels, and automobile components. However, the substitution of ferrovanadium for ferroniobium will start to take place in some applications if prices increase too much.

Note: Information in this review was current as of January 25, 1995.

TARIFFS

Item No.	Description	Canada			United States	E.U.	Japan[1]
		MFN	GPT	USA	Canada	MFN	MFN
2825.30	Vanadium oxides and hydroxides	Free	Free	Free	Free	5.5%	Free
7202.92	Ferrovanadium	9.5%	6.5%	Free	Free	4.9%	3.7%

Sources: Customs Tariff, effective January 1995, Revenue Canada; Harmonized Tariff Schedule of the United States, 1995; the "Bulletin International des Douanes," Journal Number 14 (16th Edition), European Economic Commity, 1992-1993, "Conventional" column; 1st Supplement to Journal Number 14 (16th Edition), European Economic Community, 1993-1994, "Conventional" column; Customs Tariff Schedules of Japan, 1994.
[1] GATT rate is shown; lower tariff rates may apply circumstantially.

TABLE 1. CANADA, VANADIUM IMPORTS AND EXPORTS, 1992-94

Item No.		1992		1993		1994[p]	
		(kilograms)	($000)	(kilograms)	($000)	(kilograms)	($000)
Exports							
2825.30	Vanadium oxides and hydroxides						
	United States	4	2	1 876	26	608	9
	Total	4	2	1 876	26	608	9
7202.92	Ferrovanadium						
	United States	446 884	5 336	478 834	4 599	790 944	7 207
	Netherlands	–	–	–	–	15 451	193
	United Kingdom	–	–	–	–	20	...
	Philippines	–	–	2 061	32	–	–
	Total	446 884	5 336	480 895	4 632	806 415	7 401
Imports							
2825.30	Vanadium oxides and hydroxides						
	United States	90 291	903	645 955	3 644	680 727	4 299
	South Africa	1 196 725	6 512	679 383	2 838	815 925	3 512
	People's Republic of China	17 000	90	–	–	32 800	125
	France	–	–	–	–	1 408	30
	Other countries	1 197	90	64	1	1 620	22
	Total	1 305 213	7 596	1 325 402	6 484	1 532 480	7 990
7202.92	Ferrovanadium						
	United States	293 193	3 832	226 448	2 314	462 909	4 677
	Russia[1]	17	...	11 015	109	153 821	616
	Germany	–	–	54 684	458	14 537	159
	Austria	46 439	539	35 143	363	–	–
	Other countries	22 542	296	9 618	105	–	–
	Total	362 191	4 670	336 908	3 352	631 267	5 452

Source: Statistics Canada.
[1] Former U.S.S.R. for 1992.
– Nil; ... Amount too small to be expressed; [p] Preliminary.
Note: Numbers may not add to totals due to rounding.