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I N D U S T R Y  
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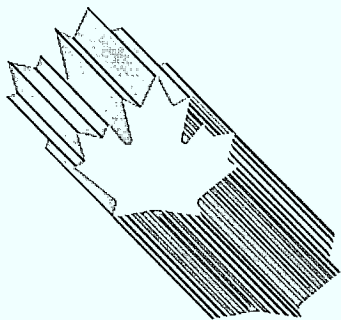


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**Nickel Smelting  
and Refining**

Canada



# I N D U S T R Y

## P R O F I L E

### NICKEL SMELTING AND REFINING

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#### FOREWORD

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In a rapidly changing global trade environment, the international competitiveness of Canadian industry is the key to survival and growth. This Industry Profile is one of a series of papers which assess, in a summary form, the current competitiveness of Canada's industrial sectors, taking into account technological and other key factors, and changes anticipated under the Canada-U.S. Free Trade Agreement. Industry participants were consulted in the preparation of the papers.

The series is being published as steps are being taken to create the new Department of Industry, Science and Technology from the consolidation of the Department of Regional Industrial Expansion and the Ministry of State for Science and Technology. It is my intention that the series will be updated on a regular basis and continue to be a product of the new department. I sincerely hope that these profiles will be informative to those interested in Canadian industrial development and serve as a basis for discussion of industrial trends, prospects and strategic directions.

Minister

## 1. Structure and Performance

### Structure

The Canadian nickel smelting and refining industry consists of three companies which smelt and/or refine nickel. The nickel smelting operation transforms nickel concentrates into crude metal, while the refining operation upgrades metal purity.

Nickel is principally recovered from two types of ore: sulphide and laterite. Sulphide ores have historically been recovered by labour-intensive underground methods, as compared to the large-scale, open-cut operations for laterite ores. A high degree of mechanization and improved techniques in sulphide mining have reduced the mining costs. In addition, lower downstream processing costs and greater by-product credits from copper, cobalt and precious metals (not shared by laterite ores) have resulted in sulphide nickel production costs being lower than laterite.

About 60 percent of current refined nickel production in non-Communist countries is derived from sulphide ores. Of this refined production, approximately 55 percent is in the pure, metallic state, such as cathodes and pellets, and the remainder is in the ferronickel or oxide forms.

Primary nickel products are classified by the industry into two groups.

*Class I* products are essentially pure, with a nickel content of more than 99 percent: they are sold as cathodes, pellets, powder and briquets. In Canada, these products are made from the processing of sulphide ores.

*Class II* products consist mainly of ferronickel and nickel oxide. Ferronickel is produced mainly from lateritic ores found in tropical countries and contains 20 to 50 percent nickel. Nickel oxide is produced from both sulphide and lateritic ores and contains 76 percent nickel.

Nickel is used principally in alloys, mainly for its ability to impart corrosion resistance, strength, toughness and other physical properties. Fifty percent of this metal is used in the production of stainless steel. Other alloyed steel and iron and steel castings account for ten percent and eight percent, respectively, of total consumption. Another 20 percent goes into the nickel-based and copper-based alloys used in chemical, petrochemical, power, nuclear and aircraft industries. Other important markets for nickel are in plating, used mainly as a base for chrome-plating and for the production of batteries, catalysts, ceramics and pigments.

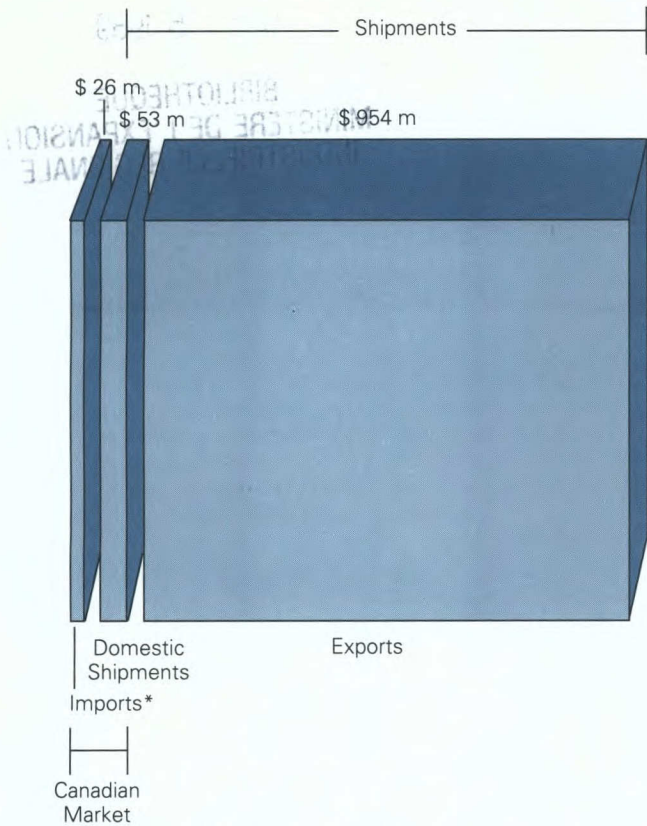
Two of the three Canadian nickel producers have mining and milling, as well as smelting and/or refining operations. Inco Ltd., the largest producer in the world, is fully integrated in its Canadian operations, processing its ores from some 17 mines in Ontario and Manitoba through two smelter-refinery facilities at Sudbury, Ontario, and Thompson, Manitoba. Falconbridge Ltd., the second-largest nickel producer in Canada, smelts concentrates in Sudbury. Sherritt Gordon Ltd., which has no nickel mining operations, purchases nickel-bearing concentrates from Inco's Thompson mill, as well as foreign sources, and processes these into nickel powder and briquettes at Fort Saskatchewan, Alberta. The company will also purchase some feedstock from the Namew Lake nickel mine being developed in Manitoba, but over the long term it expects to experience difficulty in sourcing feedstock.

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**Imports, Exports and Domestic Shipments 1986**

\* Imports have little effect on the domestic market since the Canadian producers do the bulk of the importing.

It is estimated that Canada and the Soviet Union each provide 22 percent of current world nickel mine production. The other important producers are Australia with about 10 percent, Indonesia with nine percent, New Caledonia with five percent and Cuba with just under five percent of world production. A total of 23 countries mine nickel.

In terms of western world market share, Inco and Falconbridge hold about 34 and 13 percent, respectively. Other major suppliers are Australia's Western Mining Corp. Ltd., 10 percent; France's Société Métallurgique Le Nickel, 10 percent; and Japanese producers, 10 percent. The remainder is shared among the Soviet Union, Cuba and other producing nations.

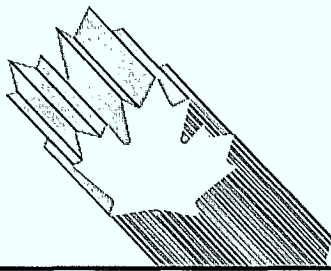
Canadian nickel shipments for 1986 are estimated at \$1007 million, of which \$954 million (95 percent) were exported. Canadian nickel is exported as refined metal, nickel-copper matte and nickel oxide sinter. Of total exports, 55 percent is refined nickel, shipped primarily to the United States and the European Community (E.C.). Nickel-copper matte, a partially smelted material which represents about 30 percent of exports, is shipped to Norway and the United Kingdom. Nickel oxide sinter, accounting for about 10 percent, is shipped to both the United States and the United Kingdom. Imports in 1986 amounted to \$26 million, mostly ferronickel, representing more than 32 percent of the Canadian market.

All three companies are Canadian-owned, with shares held by a wide spectrum of investors. The combined employment of their Canadian nickel facilities, which include the mining, milling, smelting and refining operations, is approximately 13 200.

### Performance

The three major nickel-consuming geographic areas — western Europe, Japan and the United States — account for approximately 90 percent of western world consumption. Between 1946 and 1973, nickel consumption in the non-Communist world grew at an annual rate of more than six percent. The growth rate declined after the oil shock in 1973, reflecting the decline in the overall performance of the world economy. Nickel demand picked up in 1976 to peak in 1979, when total non-communist world consumption was 536 000 tonnes. Demand fell off subsequently and picked up in 1984 to 530 000 tonnes. Since then, western world nickel consumption has risen sharply because of greater demand for stainless steel. Preliminary results for 1987 indicate a record western world consumption of 617 000 tonnes.

Canada has been the dominant world nickel producer since the turn of the century. In the 1950s, Canada accounted for more than 95 percent of the western world's nickel mine production. Canada's role, however, has changed from dominant supplier and price-setter, to swing supplier. This change can be explained by the emergence of the newly industrialized countries (NICs) in the world nickel market and the increase in state ownership and control of production during the 1970s. More than 40 percent of world production capacity is now either directly or indirectly state-controlled. These operations were not responsive to the usual price-cost relationships during the 1960s and 1970s because the primary goals of their government owners were to raise foreign currency and maintain employment.



The value of Canadian exports of primary nickel fell by about 35 percent during the 1982-83 period: from \$1106 million in 1980 to less than \$750 million. Recovery has been slow as nickel prices remained depressed until the second half of 1987. Since then, prices have risen sharply to record levels. Exports reached \$954 million in 1986 and are estimated to exceed \$1100 million in 1987.

Inco and Falconbridge suffered large losses between 1981 and 1983. Depressed metal prices and high debt-servicing charges have affected the profitability of both companies adversely. Falconbridge returned to profitability in 1984; Inco has been profitable since the fourth quarter of 1984, after sustaining losses for 13 consecutive quarters.

This downturn had a profound impact on employment. Falconbridge reduced its workforce by 38 percent; Inco, by 41 percent. While production cutbacks accounted for some of the layoffs, the major reductions were due to productivity improvements and rationalization of operations. Most noticeable has been the increase in the amount of ore being mined by bulk-mining methods, which will have a significant impact in raising productivity given that mining accounts for about 50 percent of current operating costs.

Poor nickel market conditions persisted throughout 1985-1986, depressing nickel prices. Whereas Canadian companies had adjusted to market situations earlier, many producers had not. As a consequence, high-cost producers began to close operations. In terms of international cost-competitiveness, the recent closures represent about 80 percent of the highest-cost producers. Nickel operations in Australia, the United States and the Philippines have reduced capacity by about 40 000 tonnes. An additional 100 000 tonnes of production have been curtailed, involving operations in Canada, Australia, France and Japan. The long-awaited restructuring appears to have occurred, lowering effective nickel production-capacity from non-Comecon countries to 610 000 tonnes, down from 750 000 tonnes a few years ago. This development augurs well for the industry: a better balance in supply and demand should strengthen nickel prices in the long run.

## 2. Strengths and Weaknesses

### Structural Factors

It is generally acknowledged that sulphide nickel producers (such as those in Canada) have lower costs than the lateritic nickel producers (those in tropical countries). Some estimates place laterite production costs at 1.2 to 1.5 times higher, with oil at US\$20 per barrel. The large difference in production costs is due in part to the amount of energy required to smelt nickel. Energy constitutes about 15 percent and 60 percent of the production cost of sulphide and lateritic nickel, respectively. Another advantage enjoyed by Canadian producers is attributed to the by-product credits they receive from the sale of copper, cobalt, platinum-group metals and other precious metals.

Labour costs are still a substantial portion of the Canadian operating costs, representing now about 40 percent, down from 50 percent a few years ago. While Canadian wage rates are significantly higher than those in laterite-producing countries, a well-trained workforce, improved underground mining methods and modern processing facilities help the Canadian industry achieve its lower unit operating cost.

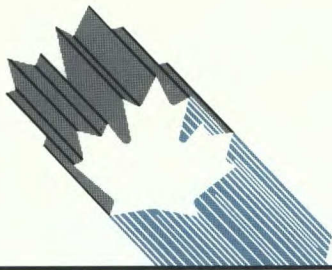
Canadian environmental regulations represent an additional cost which some foreign producers do not have. New sulphur dioxide (SO<sub>2</sub>) control orders will require substantial capital expenditures and raise operating costs at domestic smelting operations. The stricter emission control limits on non-ferrous smelters will require the conversion of sulphur dioxide into sulphuric acid, increasing the production of smelter acid by about 800 000 tonnes per year by 1994.

### Trade-related Factors

In almost all industrial countries, imports of nickel ores and concentrates are admitted duty-free. Refined nickel enters the E.C. and the United States duty-free; however, Japan levies a duty of 81 yen/kg.

As far as non-tariff barriers are concerned, no significant measures preventing the entry of refined nickel exist in major importing markets.

Under the Canada-U.S. Free Trade Agreement (FTA), most remaining tariffs will be eliminated over a period of 10 years. In the case of refined nickel, trade between Canada and the United States is already duty-free. Some tariffs do apply on fabricated products containing nickel and its derivatives, and these will be gradually eliminated under the agreement.



### Technological Factors

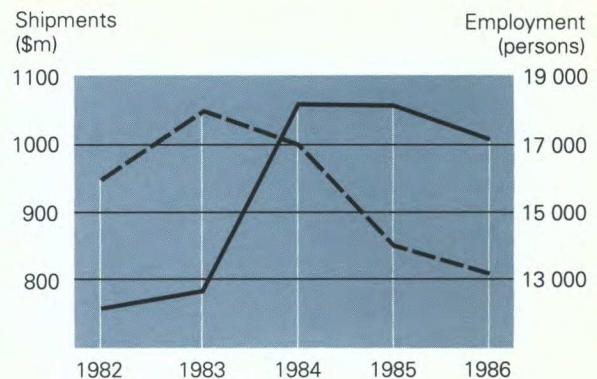
Inco has traditionally been the world leader in the development of both new production processes and new applications for nickel uses. In recent years, however, the company has been concentrating its research and development (R&D) efforts on new technologies in mining, milling and smelting, and only recently has it resumed efforts in product development. Sherritt Gordon has been the world leader in developing hydrometallurgical and powder metallurgy processes. Falconbridge has focused its R&D on improving its productivity and reducing its sulphur dioxide emissions.

The technological challenge facing Inco and Falconbridge in the near future is to develop affordable processes that will permit the reduction of sulphur dioxide emissions to the levels stipulated in the new Ontario regulations. To meet this challenge, research and development is being pursued vigorously by both companies.

### Other Factors

Under the *Ontario Mining Act*, the Ontario government has the legislative power to require companies to increase further-processing of ores in Canada; it has, however, allowed a number of specific exemptions to reflect special circumstances. For instance, Falconbridge has been permitted to export nickel-copper matte to its refinery in Norway, because of its long-standing relationship in that country. Inco has been given an exemption, which has been extended to December 1995, to ship nickel oxide sinter and nickel sulphide to its plant in Clydach, Wales, for processing, another long-established relationship. It is also allowed to ship nickel sulphide under long-term contract to two Japanese refineries in which it has an equity interest.

In 1982, Canada undertook a major commitment, as part of a Trans-boundary Air Pollution Agreement with the United States, to reduce sulphate disposition to 20 kilograms per hectare per year in order to protect moderately sensitive lakes and streams. To achieve this objective, the federal Minister of the Environment and some provincial ministers agreed in 1985 to a program of environmental control which included major reductions of sulphur dioxide emissions by 1994. As the non-ferrous smelters were identified as major emitters of sulphur dioxide, the Ontario government issued new control orders to Inco and Falconbridge. Under the new regulations, the two companies will be obliged to cut SO<sub>2</sub> emissions at their Sudbury smelters to a combined total of 365 000 tonnes per year by 1994 from the previous permissible level of 882 000.



Shipments\* —————

Employment\*\* - - - - -

### Total Shipments and Employment

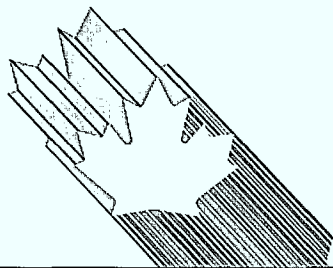
\* Actual total shipment figures are not published. The figures used were obtained by adding exports and domestic shipments.

\*\* Estimates combine mining, milling, smelting and refining employment.

## 3. Evolving Environment

The demand for nickel in the western world is expected to grow at 1.5 to 2.5 percent per annum to the end of this decade. Causing this slow growth are the maturing of the nickel market and the moderate growth forecast for the western economy. There are few substitutes for nickel today; however, rapid developments in ceramics and plastics could affect nickel markets over the longer term. The key to the future of the industry, therefore, will depend on the continual development of new applications, and hence new markets, for new nickel alloys. For this reason, western world producers have established the Nickel Development Institute which will ensure a continuation of the product development carried on by Inco for decades.

The absence of well-established and properly classified statistical data hampers the analysis and projections of trade on a worldwide basis. In an effort to overcome this obstacle, Canada and other interested countries have been promoting the establishment of an international study group on nickel, similar in structure to the International Lead-Zinc Study Group.



Currently, there is a worldwide shortage of nickel which has given rise to high nickel prices. A boom in capital investment has created a sharp rise in the demand for stainless steel, which traditionally accounts for 50 percent of annual nickel consumption. On the supply side, world capacity has decreased significantly, inventories of nickel and scrap stainless steel have diminished, and Soviet shipments of nickel to the West have moderated.

Marginal smelter operations are being kept in production by some NICs' governments, as social rather than commercial factors tend to dictate production decisions. The unpredictability of Soviet Union shipments to western Europe is another destabilizing factor; exports from the U.S.S.R. rose from 25 000 tonnes in 1985 to 55 000 tonnes in 1986. Soviet Union shipments in 1987, however, were estimated at 43 000 tonnes.

By 1992, the total nickel consumption of the western world could approach 658 000 tonnes. Current non-Comecon world nickel supply capacity is only 610 000 tonnes, after the closure of some 140 000 tonnes in production facilities over the past few years. Some of this capacity can be reactivated. Overall capacity could also increase if Cuba, New Caledonia, Brazil and the Soviet Union follow through on announced expansion plans. Given the high cost of establishing new facilities, return on investment is not likely to be high enough to encourage their establishment unless high nickel prices are sustained.

With improved market conditions beginning in 1987 and reduced world capacity, the companies are optimistic that profits will return to acceptable levels. Concerns remain with respect to the increased capital and operating costs needed to comply with the 1994 deadline on sulphur dioxide reduction. The costs required to meet these government regulations remain undefined until more R&D is completed.

The question of nickel's role as a carcinogen will also undoubtedly receive increased attention. While the International Agency for Research on Cancer recently reclassified nickel as a carcinogen, Canadian and some other health authorities disagree. Developments in this area could have far-reaching effects on the industry, including demand for regulations, a potential increase in product liability cases and consumer resistance in the longer term.

The Canada-U.S. Free Trade Agreement is expected to have a limited direct impact on this industry, as the United States has no restrictions on imports of primary nickel. The impact on the nickel-using industries will have some effect on this industry.

## **4. Competitiveness Assessment**

Canadian nickel companies are expected to remain the lowest-cost producers in the western world. The long-awaited restructuring and rationalization of the nickel industry has reduced worldwide capacity by about 10 percent, bringing supply and demand essentially into balance. The bulk of this shutdown in capacity is not likely to be reactivated unless nickel prices remain at a high level for a sustained period of time.

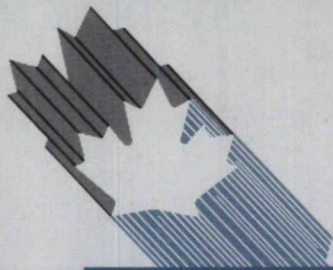
At this juncture, both Inco and Falconbridge have rationalized their operations to the extent that net production costs are about C\$5.50 per kilogram. This new low point, along with lower debt obligations, places Canadian producers in a strong position to generate levels of profitability not experienced in this decade. The dramatic improvement in metal prices over the past few months, and the improved long-term outlook for demand, should secure Canada's share of the western world nickel market.

The FTA is expected to have only a limited direct impact on the Canadian nickel industry.

For further information concerning the subject matter contained in this profile, contact:

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**PRINCIPAL STATISTICS**

**SIC: 2959**

	1973	1982	1983	1984	1985	1986
Establishments*	7	7	7	7	7	7
Employment**	N/A	16 000	18 000	17 000	14 000	13 200
Shipments (\$ millions)*** (volume, '000 tonnes)	546 190	759 109	784 123	1 069 168	1 067 170	1 007 168
Gross domestic product**** (constant 1981 \$ millions)	1 390	488	541	606.5	622.2	647
Investment (\$ millions)****	258	807	745	1 114	1 031	N/A
Profit (loss) after taxes (\$ millions)	N/A	(329.4)	(303.0)	(20.3)	(110.0)	(15.2)

**TRADE STATISTICS**

	1973	1982	1983	1984	1985	1986
Exports (\$ millions)	515	715	741	1 013	1 031	954
Domestic shipments (\$ millions)	31	44	43	56	36	53
Imports (\$ millions)*****	53	17	15	6	21	26
Canadian market (\$ millions)	84	61	58	62	57	79
Exports as % of shipments	94	94	95	95	97	95
Imports as % of domestic market	63	28	26	11	37	32
Canadian share of international market as % of mine production	39	15	19	23	22	22

\* The nickel refinery at Port Colborne was closed permanently on December 17, 1984; utility nickel production has continued.

\*\* Estimates combine mining, milling, smelting and refining employment.

\*\*\* Actual total shipment figures are not published. The figures used were obtained by adding exports and domestic shipments.

\*\*\*\* Total value for SIC 295, which includes smelting and refining of all non-ferrous metals except aluminum; nickel is not separated out.

\*\*\*\*\* Imports have little effect on the domestic market since the Canadian producers do the bulk of the importing.

**(continued)**



**TRADE STATISTICS (cont.)**

	1973	1982	1983	1984	1985	1986
Source of imports (% of total value)			U.S.	E.C.	Asia	Other
		1982	31	3	—	66
		1983	28	28	—	44
		1984	27	3	—	70
		1985	32	3	—	64
		1986	37	4	—	59
Destination of exports (% of total value)			U.S.	E.C.	Asia	Other
		1982	25	34	4	37
		1983	30	33	17	20
		1984	26	36	14	24
		1985	33	33	13	21
		1986	37	32	0	31

**REGIONAL DISTRIBUTION — Average over the last 3 years**

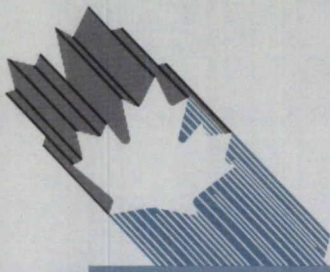
	Atlantic	Quebec	Ontario	Prairies	B.C.
Establishments - % of total	—	—	57	43	—
Employment - % of total	—	—	86	14	—
Shipments - % of total	—	—	61	39	—

**MAJOR FIRMS**

Name	Ownership	Location of Major Plants
Inco Ltd.	Canadian	Smelters and refineries at Sudbury, Ontario and Thompson, Manitoba Refinery at Port Colborne, Ontario
Falconbridge Ltd.	Canadian	Smelter at Sudbury, Ontario
Sherritt Gordon	Canadian	Hydrometallurgical plant at Fort Saskatchewan, Alberta

**(continued)**





**PRODUCTION STATISTICS (tonnes)**

	Production	Matte exports	Oxide exports	Refined metal exports	Total exports	Refined imports	Consumption
1973	274 527	100 385	65 818	132 949	299 153	16 141	11 862
1980	184 802	42 647	16 989	88 125	147 761	4 344	9 676
1981	160 247	53 841	14 390	79 935	148 166	2 335	8 603
1982	88 581	27 037	13 127	62 314	102 478	2 588	6 723
1983	125 022	40 087	11 167	66 949	118 203	2 357	5 010
1984	173 725	59 305	20 080	153 935	233 320	3 479	7 290
1985	169 971	63 305	17 972	81 687	162 964	2 764	5 932
1986	163 639	57 780	13 923	86 004	157 707	2 963	6 606
1987	194 507						

Source: Energy, Mines and Resources Canada

**CANADIAN PROCESSING CAPACITY, 1987 (tpy of contained nickel)**

	Inco			Falconbridge	Sherritt Gordon
	Port Colborne	Sudbury	Thompson	Sudbury	Fort Saskatchewan
Smelter	N/A	127 000 <sup>1</sup>	81 600	45 000	N/A
Refinery	30 000	56 700	55 000	N/A	24 000

Source: Energy, Mines and Resources Canada

1. Reduced from 154 200 tonnes due to a 1980 government regulation on SO<sub>2</sub> emissions. Due to current nickel market conditions, effective capacity is closer to 110 000 tonnes.

N/A Not applicable.

**Note:** Statistics Canada data have been used, to the greatest extent possible, in preparing this profile.

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