Government of Canada's Action Plan 2000 on Climate Change and Specific SF_6 Reduction Strategies for the Magnesium Sector

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Abstract

The Government of Canada's "Action Plan 2000 on Climate Change" targets key sectors and is expected when fully implemented, to reduce greenhouse gas (GHG) emissions by 65 Mt per annum by 2010. Although focused on greenhouse gas mitigation, this program also advances knowledge on climate science, impacts and adaptation, and technological innovation. The Government of Canada's Action Plan 2000 involves seven federal departments and is being horizontally managed by Environment Canada and Natural Resources Canada.

The minerals and metals sector was identified as one of the key sectors capable of significant greenhouse gas reductions and four projects were identified under the Action Plan. The four projects are (a) increasing awareness of the advantages of concrete roads for improving vehicle fuel efficiency; (b) increasing the use of supplementary cementing materials to replace Portland cement; (c) enhancing metals recycling processes and practices; and (d) assessing alternate process and production approaches in high GHG emitting activities. All activities in these areas are ongoing. The websites listed at the end of this paper give specifics on progress to-date.

The reduction and/or replacement of sulphur hexafluoride (SF_6) use as a cover gas for molten magnesium alloys by the magnesium production sector falls under project (d), of the Minerals and Metals program under Action Plan 2000. This paper provides an overview of Action Plan 2000 activities and describes the actions underway in Canada to replace SF_6 as a cover gas for molten magnesium alloys.

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Introduction

The Government of Canada's Action Plan 2000 on Climate Change targets key sectors and is expected, when fully implemented, to achieve an estimated annual reduction of 65 Mt in greenhouse gas (GHG) emissions by 2010. Although focused on greenhouse gas mitigation, this program also advances knowledge on climate science, impacts and adaptation, and technological innovation. While this initiative is being horizontally managed by Environment Canada and Natural Resources Canada, the Government of Canada's Action Plan 2000 involves many federal departments.

The minerals and metals sector was identified as one of the key sectors in Canada capable of significant greenhouse gas reductions.

This paper provides an overview of the main initiatives under the Government of Canada's Action Plan 2000 on Climate Change and describes, in particular, the initiatives underway in Canada to replace SF_6 as a cover gas in the production of magnesium alloys. This paper consists of two main sections. The first is an overview of Canada's actions and programs on climate change. The second section focuses on the Canadian SF_6 emissions inventory, current research and development initiatives to replace SF_6 as a cover gas in molten magnesium processing and voluntary efforts by the magnesium industry to reduce the quantity being used, and to disseminate the research findings to the magnesium industry.

Canada's Actions on Climate Change

Canada signed the United Nations Framework Convention on Climate Change (FCCC) at the "Earth Summit" in Rio de Janeiro in 1992. An important outcome of the Rio meeting was the agreement by industrialized countries to implement policies and measures with the aim of stabilizing greenhouse gas (GHG) emissions.

In December 1997, Canada was among over 160 countries that met in Kyoto, Japan to develop the Kyoto Protocol. The Protocol set legally binding targets for reducing GHG emissions for industrialized nations. Canada's target is to lower emissions so that the yearly average between 2008 and 2012 will be a six-percent reduction from levels in

1990. The Protocol was formally signed by Canada in April 1998 as a signal of its intent to ratify the protocol, which was done by the Parliament in December 2002.

With the formal signing of the Kyoto Protocol in April 1998, the Government of Canada established a three-year, $150 million Climate Change Action Fund (CCAF) to support early and meaningful actions to reduce GHG emissions, as well as policy development and initiatives to understand climate change and to adapt to it. Over that period, a significant portion of the funding was invested in the Technology Early Actions Measures (TEAM) initiative that supported technology projects to reduce GHG emissions while sustaining economic and social development.

The Action Plan 2000 on Climate Change reflected the government's intention to invest up to $500 million on specific actions to reduce GHG emissions. This was in addition to the $625 million investment over five years in the Federal budget of 2000. A portion of the funding ($100 million) was earmarked for establishment of the Sustainable Development Technology Fund to stimulate the development and demonstration of environmental technologies, particularly those aimed at reducing GHG emissions.

At the United Nations World Summit on Sustainable Development in Johannesburg, August, September 2002, the Prime Minister declared his intention to ask Parliament to ratify the Kyoto Protocol on climate change before the end of this year (2002). A draft plan for implementing the Protocol was recently released in late October 2002 and a released a Climate Change Plan for Canada on November 21, 2002. The Parliament finally ratified the Kyoto Protocol in December 2002.

Canada's Action Plan 2000 on Climate Change

The Government of Canada's Action Plan 2000 on Climate Change, announced in October 2000, is intended to be a cornerstone to Canada's action on climate change. The Plan is a five-year, $500 million commitment, and targets key sectors. When it is fully implemented, it is expected to achieve an estimated annual reduction of 65 million tonnes in greenhouse gas (GHG) emissions by 2010. While focused primarily on GHG mitigation, the initiative also advances knowledge and foundation building in climate

science, impacts and adaptation, northern and Aboriginal communities, and technical innovation.

The Action Plan is a horizontally managed initiative led by Environment Canada and Natural Resources Canada, which will see seven federal departments work on 45 specific measures in distinct, but interrelated sectors. As such, it will require a coordinated, sustained, and informed action by governments, industry, interest groups and individual Canadians to ensure that issues related to global warming are given top priority. The early initiatives are intended to build long-term active partnerships and establish the infrastructure necessary to achieve significant GHG emission reductions by 2010, and to continue advancements in knowledge and foundation building.

Minerals and Metals Program under Climate Change

The minerals and metals program forms a key part of Action Plan 2000. The program targets GHG reductions and mitigation actions from aluminum production, iron and steel manufacturing, mining, cement and concrete, semi-fabricating metals industry and industrial metals industry. The actions under the minerals and metals program consist of measures aimed at promoting the increased use of alternative and recycled materials, and at identifying opportunities to further minimize greenhouse gas emissions through the adoption of new technologies and process modification.

One of the actions under the Minerals and Metals Program is to promote monitoring and studies to increase knowledge and understanding of ways to reduce greenhouse gas emissions in the minerals and metals sector. It is under this action that the research being conducted on the replacement of sulphur hexafluoride (SF_6) use as a cover gas is being done.

There are three programs promoting alternative materials and recycling. The first is promoting use of supplementary cementing materials (SCM) to replace cement in the manufacture of concrete, thereby reducing GHG emissions associated with the highly energy intensive production of cement. The second is promoting the use of concrete in the construction of roads carrying significant volumes of heavy vehicles, since the

reduced rolling resistance associated with a rigid pavement decreases fuel consumption. And third, is promoting Enhanced Recycling programs, which aim to improve the Canadian recycling infrastructure, leading to, increased recycling of metals and minerals with consequent reductions in greenhouse gas emissions.

The Minerals and Metals Program under Canada's Action Plan 2000 is being managed by a steering committee for the sector with an advisory committee administering each of the measures. The steering committee is chaired by Natural Resources Canada (NRCan) with participation from Environment Canada (EC) and Industry Canada (IC). The advisory committees consist of experts in the fields and representatives from interested industry and government groups. Ten million dollars have been made available over a five-year period (2001-2006) for projects in each area.

REVIEW OF CANADIAN SF_6 EMISSIONS INVENTORY [(1)]

SF_6 Use, Emissions and Projections in Magnesium Industry

Sulphur hexafluoride (SF_6) is used as a protective cover gas in operations that involve the processing of molten magnesium and its alloys such as primary production, ingot casting, die casting, sand casting, recycling, etc. During magnesium alloy production, SF_6 is emitted in relatively small quantities (2.3 Mt CO_2 equivalent). SF_6 constitutes a small component of the cover gas, typically in concentrations less than 0.5 % in dry air, nitrogen, CO_2, or blends of these gases. Despite its relatively low level in the gas mixtures, the global warming potential (GWP) factor is 23,900 times that of CO_2 that makes its use in the manufacture of magnesium alloys a significant source of greenhouse gas (GHG) emissions. Further reduction in its use can probably be achieved by experimenting with lower concentrations and/or the development of a better gas delivery system or improved containment.

Estimated SF_6 emissions in Canada from 1990 to 2000 are based on SF_6 sales data collected from gas suppliers and end users in various sectors. These estimates were published in a recent report [(1)], and are given in Table 1 and shown in Fig. 1. It is apparent from Table 1 and Fig. 1 that primary magnesium ingot production, magnesium casting, and electrical equipment (as an insulating gas for high-voltage electrical

equipment) use are the major SF_6 emission sources. It was also reported that all SF_6 used in Canada is imported and therefore there are no production-related emissions in Canada. SF_6 emissions declined from 1990 to 1996 with a steady increase from 1996 to 2000 (Fig. 1). It is noted that the data shown in Table 1 has been prepared based on estimated Canadian SF_6 demand by market segment shown in Table 2 and presented in Fig. 2. It is apparent from Table 2 that the major end uses of SF_6 in Canada are as a cover gas in primary magnesium production (melting furnace and ingot casting), as an insulating gas for high-voltage electrical equipment, and as a cover gas during magnesium casting (sand casting, high pressure die casting and recycling) operations. It is noted that there is some difference between the estimated SF_6 emissions (Table 1) and demand (Table 2) in the electrical equipment use sector.

Table 1 Canadian SF_6 Emission Inventory (1990-2000) [(1)]

	Estimated SF_6 Emission (year/year)										
Applications	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Primary Magnesium Production	120	136	91	84	85	79	57	58	64	70	97
Magnesium Product Casting	7	8	8	9	9	10	11	12	14	21	20
Electrical Equipment	62	64	60	68	62	53	38	45	50	50	51
Semi-conductor Manufacturing	1	1	1	1	1	1	1	1	1	1	1
Laboratory Use	2	2	2	2	2	2	3	2	2	2	2
Miscellaneous	2	2	2	2	2	1	0	2	3	3	4
Total SF_6	**195**	**215**	**165**	**167**	**163**	**146**	**110**	**120**	**135**	**146**	**175**
Total (Mt CO2 e)	**4.7**	**5.1**	**3.9**	**4**	**3.9**	**3.5**	**2.6**	**2.9**	**3.2**	**3.5**	**4.2**

Table 2: SF_6 Demand by Market Segment (1990-2000) [1]

Applications	Estimated SF_6 Demand (tonnes/year)										
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Primary Magnesium Production	120	136	91	84	85	79	57	58	64	70	97
Magnesium Product Casting	7	8	8	9	9	10	11	12	14	21	20
Electrical Equipment	75	78	73	82	76	64	46	55	61	60	61
Semi-conductor Manufacturing	1	1	1	1	1	1	1	1	1	1	1
Aluminum Degassing	3	3	3	4	4	4	4	1	2	3	1
Laboratory Use	2	2	2	2	2	2	3	2	2	2	2
Miscellaneous	2	2	2	2	2	1	0	2	3	3	4
Total Demand	**211**	**231**	**181**	**185**	**180**	**161**	**122**	**130**	**147**	**159**	**186**

Source: Primary Magnesium- Environment Canada; Others – Cheminfo estimates based on company data submissions and supplier sales data.

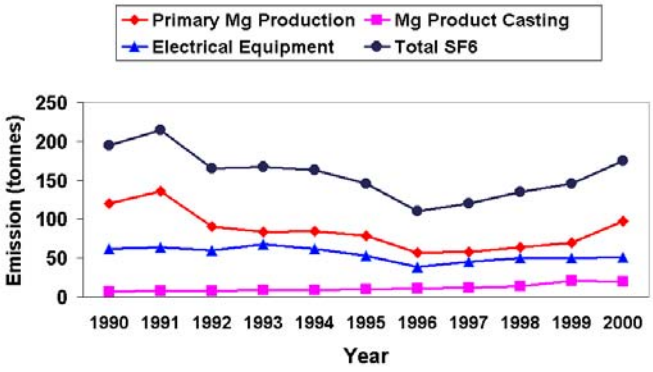

Figure 1: Canadian SF_6 emission inventory in 1990-2000

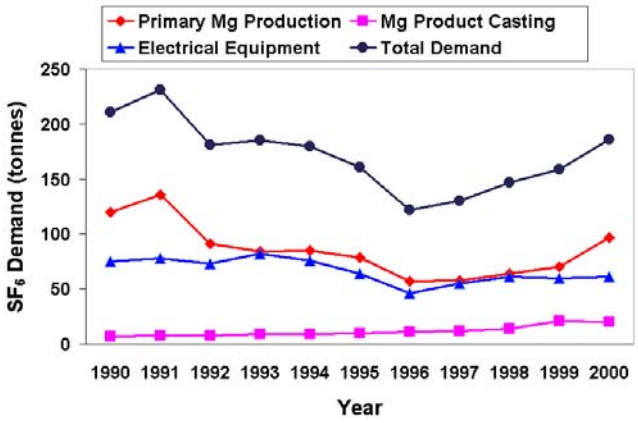

Figure 2: SF_6 demands by market segment in 1990-2000.

The International and Domestic Policy Division of Natural Resources Canada (NRCan) reported three major magnesium primary producers in Canada [2]. The new Noranda Magnola's facility in Danville, Quebec, which started operation in 2000, is expected to reach full commercial production of 58,000 tonnes per year (t/y) in early 2003. The Magnesium Division of Norsk Hydro in Becancour, Quebec is expected to increase its plant capacity to 48,000 t/y this year (2002). The third facility is Timminco Ltd's smaller (~6000 t/y) integrated magnesium facility in Haley Station, Ontario that produces high purity metal for specialized market applications and magnesium alloys.

An independent estimate of total Canadian SF_6 imports from 1990 to 2001 from supply analysis is shown in Table 3, and presented in Fig. 3. It is apparent from Fig. 3 that United States is a major SF_6 supplier to the Canadian market. Table 3 shows that total Canadian imports of SF_6 have declined from 364 tonnes in 1990 to 106 tonnes in 1999. Modest improvement in the supply of SF_6 is expected as primary magnesium production and magnesium casting expands over the next few years until an alternate cover gas is found. As shown in Table 3, there are no documented exports of SF_6 from Canada, so net Canadian supply equals imports.

The estimated SF_6 emissions for 1990, 1995 and 2000 based on interviews with magnesium casters (Table 4) are 7, 10 and 20 tonnes respectively [(1)]. This data is also presented in Fig 4. The SF_6 emission estimates from Canadian casting operations in 2000 were approximately 20 tonnes. The 1990 and 1995 estimates are considerably lower. It should be noted that the accuracy of this data is suspect. However, it is considered a good start, laying foundation for a more reliable data collection in future surveys. This estimate is based on the assumption that all SF_6 consumption by magnesium casters was entirely emitted. The 1999 Issue Table's projection assumes that SF_6 use will be virtually eliminated from all magnesium operations by 2010 with the substitution of an alternate gas or technology [(1)]. However, as more magnesium alloys are substituted for aluminum through such initiatives as the United States Automotive Materials Partnership (USAMP), resulting in new structural cast magnesium castings in automotive components, an increased use of SF_6 may be inevitable unless a new cover gas is developed very soon.

Table 3: Canadian SF_6 Net supply (1990-2001) [(1)]

Source of Supply	Net supply / year (tonnes)											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
U.S.	342	303	221	247	215	127	139	154	149	106	104	134
Germany	7	0	12	9	23	3	38	12	0	0	29	47
Other	15	7	0	0	0	0	0	0	1	0	1	6
Total Imports	**364**	**310**	**233**	**256**	**238**	**130**	**177**	**166**	**150**	**106**	**134**	**187**
Net Supply	**364**	**310**	**233**	**256**	**238**	**130**	**177**	**166**	**150**	**106**	**134**	**187**

Source: Statistics Canada, CANSIM

Table 4: SF_6 Emissions from Magnesium Product Casting [1]

Year	Mg Product Casting (t Mg)	SF_6 Emissions (t SF_6)
1990	5.849	7
1995	12.488	10
2000	31, 000*	20

Source: Interview with magnesium casters.
*Data not available, value shown is Cheminfo estimates based on approximate Mg casting capacity and interviews with Magnesium casters.

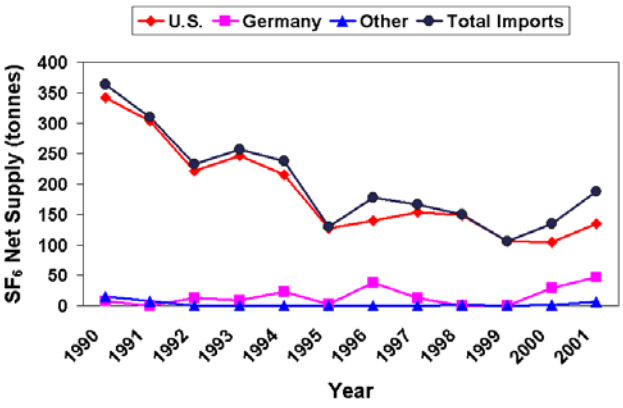

Figure 3: Canadian SF_6 net supply 1990-2001.

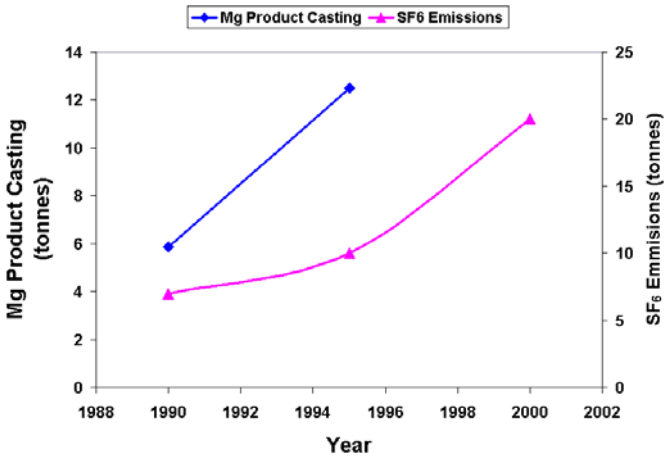

Figure 4: Canadian SF_6 emissions from magnesium casting.

Apart from the three Canadian primary magnesium ingot producers, there are ten magnesium casting facilities reported in a recent publication [1]. These companies are listed in Table 5. Eight of the ten are using SF_6 as a cover gas in their operations. One of the eight recently introduced the use of SO_2 as cover gas in some operations. These results clearly show that significant effort is needed to come up with an alternate cover gas for these magnesium foundries. SF_6 users not included in the list are universities and other research and development centers that are working on the development of magnesium casting technology.

Table 5: Current Magnesium Casting Facilities in Canada [(1)]

Company	Location	Type	SF_6 Use Status
Meridian Technologies	Stathroy, ON	Diecaster	Yes
Trimag Diecasting	Haley, ON	Diecaster	No
Trimag Diecasting*	Boisbriand, QC	Diecaster	Yes
Simalex Manufacturing	Langley, BC	Diecaster	Yes
Fisher Gauge	Peterborough, ON	Diecaster	Yes
Performag	Pointe Claire, QC	Diecaster	Yes
Haley Industries	Haley Station, ON	Gravity caster	Yes
Intermag	Quebec City, QC	Gravity caster	Yes
Robert Mitchell Inc.	Montreal, QC	Gravity caster	Yes
Thixotech Inc.	Calgary, AB	Thixotropic caster	No

Replacement of SF_6 As A Cover Gas In Molten Magnesium Processing

IMA/SINTEF Study On SF_6

The International Magnesium Association (IMA) Committee on SF_6 Alternatives met in Aalen, Germany, Sept. 26th, 2001 and in Montreal, Canada, May 19, 2002 to discuss the status of the IMA project at the Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF), an independent research organization based in Norway. Dr. Gabriella Tranell, principal project manager at SINTEF gave a summary of the major results of the ongoing project. The seven cover gases evaluated were: SF6 (benchmark), BF3, Brochot mixture, HFC 134a, HFE 7100, HFE 7200, and L15566 (3M F-ketone). Based on technical performance, HFE 7100 was found to be the most effective both in melt protection and in fire extinguishing activity. HFE 7200, HFC 134a, L15566 and BF3 also work well, but due to their lower thermal stability they appear to require more uniform distribution for optimum performance. While these initial findings are encouraging, issues relating to toxicity, GWP, availability and cost will be critical in the final assessment.

With the SINTEF planning full-scale industrial trials in August 2002 at the Porsgrunn facility in Norway, the magnesium industry is closer to finding a possible replacement gas for both SF_6 and SO_2. The large number of presentations at these conferences, there is significant interest in replacing SF_6 as a cover gas by the magnesium industry.

These efforts are beginning to pay off, as many ingot makers and die casters are reducing their use of SF_6 by lowering the concentration of SF_6 in their gas mixtures and supporting R&D initiatives for an alternate gas that is equally as effective as/or better than SF_6.

Current Trends to Reduce SF6 Use in Mg Industry

Primary magnesium ingot producers, die casters and foundries that use SF_6 are aware of its high GWP and are voluntarily reducing the amounts of SF_6 used in their operations or switching to SO_2 as a cover gas. For example, the SF_6 concentration in the cover gas of some die casters had dropped from 0.7 % to 0.3 % in CO_2. This initiative produced a 50 % reduction in SF_6 use. In addition, many recyclers converted from SF_6 to SO_2. Another die caster was successfully using even lower SF_6 concentrations (0.22 %SF_6) in N_2. In some cases, 98.5%N_2 mixed with 1.5 %SO_2 can also be used. Other die casters have successfully used a mixture of CO_2 and air with only 0.2% SF_6. Other initiatives include the proper control of gas flow rates during the casting operations to reduce use, improve effectiveness and improve containment of SF_6.

Dissemination of R&D Results

Natural Resources Canada's (NRCan) project "SF_6-Alternatives in Magnesium Casting " conducted at CANMET's Materials Technology Laboratory (MTL) focuses on the dissemination of the results of the ongoing IMA and NRCan-funded R&D at SINTEF on "SF_6/SO_2 Alternatives for Protection of Molten Magnesium" to the Canadian primary magnesium ingot producers, die casters and foundries.

The Canadian Government expects that Action Plan 2000's funding of research and co-sponsoring conferences such as this will give it access to the latest developments in the quest for SF_6 replacement gas.

SUMMARY

1. With the ongoing R&D initiatives to replace the use of SF_6 in the magnesium industry, a significant reduction in SF_6 use is expected once a replacement gas is found.

2. The recently completed SF_6 emission's inventory by Environment Canada is a good start and should lead to a more accurate database on SF_6 imports and usage by the magnesium industry.

3. The voluntary reductions in SF_6 usage by several die casters and other magnesium producers are a welcomed development that is consistent with an industry that is looking for a solution.

4. The use of lower SF_6 concentrations in different gas mixtures is expected to continue until a replacement gas is found.

5. It is imperative that continued and ongoing dialogue between R&D performers, industrial gas suppliers, new gases developers, and the magnesium producers are necessary for the eventual elimination of SF_6 from the magnesium industry.

6. As more magnesium alloys are substituted for aluminum, through such initiative as the United States Automotive Materials Partnership (USAMP) new structural cast magnesium castings in automotive components, increased use of SF_6 may be inevitable unless a new cover gas is developed during the ongoing R&D initiatives.

Acknowledgements

The authors greatly appreciate the contribution of Ken Olsen, for providing the report "Review of Canadian SF_6 Emissions Inventory" prepared by Cheminfo Services Inc., for Environment Canada, Pollution Data Branch, Greenhouse Gas Division, Hull Quebec.

National Climate Change Websites:

Government of Canada Climate Change Site: http://www.climatechange.gc.ca

National Climate Change Secretariat: http://www.nccp.ca

Environment Canada's Green Lane: http://www.ec.gc.ca

Natural Resources Canada - Climate Change Site: http://www.climatechange.nrcan.gc.ca

Agriculture and Agri-Food Canada: http://www.agr.gc.ca/environ_e.phtml

Fisheries and Oceans: http://www.dfo-mpo.gc.ca

Canadian International Development Agency: http://www.acdi-cida.gc.ca/index.htm

Clean Development Mechanism and Joint Implementation Office: http://dfait-maeci.gc.ca/cdm-ji

Health Canada: http://www.hc-sc.gc.ca/hecs-sesc/hecs/climate/

Industry Canada - Technology Partnerships Canada: http://tpc.ic.gc.ca

Transport Canada: http://www.tc.gc.ca/programs/environment/climatechange/menu.htm

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1. Review of Canadian SF_6 Emissions Inventory" prepared by Cheminfo Services Inc., for Environment Canada, Pollution Data Branch, Green House Gas Division, Hull Quebec, September 2002.

2. Wagner, Wayne, Magnesium, Canadian Minerals Yearbook, 2000, prepared by the International and Domestic Market Policy Division of Natural Resources Canada.