Canada-wide Standards for Dioxins and Furans

Iron Sintering Pollution Prevention Strategy

Context

The Canadian Council of Ministers of the Environment (CCME) signed the Canada-wide Standards (CWS) for emissions of Dioxins and Furans from Iron Sintering Plants in March 2003. An important provision of the CWS is a commitment to develop pollution prevention strategies, consistent with the principles outlined in the Canada-wide Environmental Standards Sub-Agreement, that is:

*Pollution prevention is the preferred approach to environmental protection. Governments will place emphasis on a pollution prevention approach when implementing standards under this Sub-Agreement.*

CCME’s definition of pollution prevention is as follows:

“The use of processes, practices, materials and energy that avoid or minimize the creation of pollutants and wastes at source.”

The following is the text of the commitment incorporated in the Iron Sintering Plants CWS for Dioxins and Furans:

*Pollution Prevention Strategy:*

*Ministers recognize the contribution iron sintering makes as a recycling activity, making use of mill secondary materials to recover useful iron content and thus avoiding the landfill disposal of hundreds of thousands of tonnes of such materials every year, along with the environmental impacts such disposal would impose on surrounding communities. At the same time, Ministers note the need to ensure that a reasonable balance is struck between avoiding landfill disposal impacts and mitigating emissions to other media, particularly when addressing releases of substances subject to virtual elimination under CEPA [the Canadian Environmental Protection Act] or the CCME PMTS [Policy for the Management of Toxic Substances].

In addition to the continuing efforts of iron sintering plant operators to destroy or capture emissions of dioxins and furans, emphasis will be placed on identifying and implementing opportunities to prevent the creation of dioxins and furans as well as discharges of pollutants, especially emissions of particulate matter. For air pollutants, this will entail addressing both discharges through the main stack and from process fugitive emissions. The fate of dioxins and furans collected in the air pollution control system is also to be examined in terms of potential cross-media transfer concerns. As an initial action with shared responsibility by Ontario and Canada, strategies identifying opportunities to minimize iron sintering plant multimedia discharges of pollutants including particulate matter and dioxins and furans will be developed through a
multistakeholder process by October 31, 2003 to provide a framework for continual progress towards the virtual elimination of dioxins and furans. It is expected that the preliminary process sampling work carried out by the existing plant and Ontario will serve as the basis for identification of additional pollutant minimization activities.

The range of issues to be addressed in developing the strategy could include:

- measures to capture and control fugitive emissions of particulate matter and other contaminants from the process equipment in order to further reduce the total loadings from the plant to the atmosphere;
- additional consideration of materials currently included in the feed mixture which may have the effect of causing elevated dioxin and furan levels in the exhaust gases from the plant;
- consideration of materials included in the feed mixtures which may have the effect of causing elevated mercury levels in the exhaust gases from iron-sintering plants, i.e., levels exceeding the detection limit as 1998 results were “non-detect”;
- consideration of alternative processes for the treatment of mill secondary materials to create materials suitable for use as blast furnace feed or other beneficial uses;
- discussion of additional and ongoing monitoring requirements for materials collected from the gas cleaning system and the east lagoon sludge; and
- consideration of the best management practices mandated when collecting, treating and/or disposing of materials recovered from the gas cleaning system.

The Dioxins and Furans CWS Development Committee charged the Iron Sintering Multi-stakeholder Advisory Group (IS-MAG) to provide advice on potential strategies to prevent and/or minimize emissions from iron sintering, including, but not limited to, dioxins and furans. This group was comprised of representatives of environmental non-government organizations, the only Canadian iron sintering plant, the Ontario Ministry of the Environment and Environment Canada.

As described above, the CWS pollution prevention strategy is to identify opportunities to minimize emissions of air pollutants from iron sintering plants and provide a framework for continual progress toward the goal of virtual elimination of dioxins and furans. The Dioxins and Furans CWS Development Committee advised IS-MAG that a pollution prevention strategy is considered as a tool or advice for jurisdictions to consider and use in whole or in part.

Members of IS-MAG met regularly by teleconference and at a face-to-face meeting to discuss the range of issues. An extensive background paper entitled “Research on Technical Pollution Prevention Options for Iron Sintering” was commissioned to address potential approaches and technological options. The report is a thorough collection and examination of the currently available information on dioxin and furan formation and dioxins/furans prevention and control technologies for iron sintering operations. It also includes a detailed analysis of the dioxin, furan and particulate emission source tests...
The consultant’s report considered all of the pollution prevention issues in the above list.

The first recommendation of the consultant’s comprehensive pollution prevention report is:

“Develop and implement a pollution prevention plan with objectives to prevent or minimize the formation of dioxins/furans in the sintering process, to prevent or minimize the release of dioxins/furans to the atmosphere, and to provide good environmental management of the handling, storage, and disposal of material containing dioxins/furans.” The report goes on to outline a number of specific actions that could be included in the pollution prevention plan. Further research and development is required to establish effective pollution prevention actions to assist the existing iron sintering plant in meeting the CWS limits.

The members of IS-MAG achieved consensus on the following:

- options for a CWS pollution prevention strategy were captured effectively in the consultant’s report;
- a recommendation be made to the Dioxins and Furans CWS Development Committee that the consultant’s report should form the CWS pollution prevention strategy;
- the remaining iron sintering plant should develop and implement a detailed pollution prevention plan, as recommended in the consultant’s report;
- a summary of the consultant’s report should be posted on the CCME website in both official languages, along with this context note and the text of the original report or a link to the original report;
- IS-MAG should continue meeting as it is an ideal forum to support progress towards virtual elimination of dioxins and furans from iron sintering operations by sharing new information between members. It should be noted that dioxin/furan formation is currently not completely understood nor agreed upon and new emission source testing and research data becomes available on a regular basis.

The existing iron sintering plant agreed that they would develop a pollution prevention plan and members agreed that IS-MAG was a suitable venue to meet on a regular basis to review the progress on the development of the pollution prevention plan and provide input on the plan’s development and implementation. IS-MAG members are unanimous in making the above observations and recommendations to the Development Committee.
SUMMARY REPORT

Research on Technical Pollution Prevention Options for Iron Sintering

Prepared for:
The Canadian Council of Ministers of the Environment (CCME)

Prepared by:
William Lemmon and Associates Ltd.
Peachland, BC

and

Cheminfo Services Inc.
Markham, ON

Final: November 27, 2003
CCME Contract No. 283-2003
Disclaimer

This report was prepared by William Lemmon & Associates Ltd. for the Canadian Council of Ministers of the Environment (CCME).

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Abstract

This report provides a review of technical information on the formation, prevention, and reduction of dioxins/furans emissions from iron sintering. The contents include an overview of the iron sintering process, review of the theory and research for dioxins/furans formation, emission control and pollution prevention techniques, alternative production processes, assessment of the relationship between particulate material and dioxins/furans emissions, other environmental issues associated with iron sintering, and recommendations for further action.
Summary

S.1 Introduction

In 1998 the Canadian Council of Ministers of the Environment (CCME) established dioxins and furans as a priority substance for Canada-Wide Standards (CWS) development. The objective of the CWS process is to make significant strides in reducing anthropogenic releases of dioxins and furans.

A Multi-stakeholder Advisory Group (MAG) led by Ontario Ministry of the Environment (OMOE) submitted recommendations to the Development Committee (DC) during the development of the CWS for dioxins and furans. Environment Canada contributed to the development process with background technical work, based largely on its earlier work during the Strategic Options Process (SOP) consultations with the steel sector. Recommendations for the standard were submitted to the DC by OMOE on behalf of the Iron Sintering (IS) MAG in June 2001. The proposed CWS was received by the CCME Ministers in September 2001 and was endorsed by the Ministers of all jurisdictions in March 2003 with the exception of Québec.

The CWS sets out numerical emission limits for dioxins and furans and timelines for achievement as shown in Table T.1. Development of CWS for dioxins and furans has taken into consideration environmental benefits, available technologies, socio-economic impacts, opportunities for pollution prevention, and collateral benefits from reductions in other pollutants. The actions specified in the CWS represent significant steps towards the goal of virtual elimination as expressed by attaining concentrations less than the Level of Quantification (LOQ) of 32 pg ITEQ/Nm$^3$.

Table T.1: CWS Dioxins/Furans Emission Limits and Schedules for Iron Sintering

<table>
<thead>
<tr>
<th>Facility</th>
<th>Dioxins/furans emission limit (pg ITEQ/ Rm$^3$)</th>
<th>Scheduled date</th>
<th>Anticipated particulate emissions (mg/ Rm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron sintering plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing</td>
<td>1350</td>
<td>2002</td>
<td>&lt;50</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>2005</td>
<td>&lt;50</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>2010</td>
<td>&lt;20</td>
</tr>
<tr>
<td>New or expanding</td>
<td>200</td>
<td>CWS effective date</td>
<td>&lt;20</td>
</tr>
</tbody>
</table>

In addition the CWS make it clear that the ultimate goal of virtual elimination be kept in mind. Accordingly CCME Ministers asked that pollution prevention strategies be developed under the CWS for iron sintering. In setting out the goals for these substances, CCME Ministers also emphasized the importance of a multi-pollutant approach and to consider reduction measures having multiple benefits.

The current study was commissioned to help develop a Pollution Prevention Strategy. This report provides background technical information on the formation and reduction of dioxins/furans emissions from iron sintering, identifies pollution prevention techniques for dioxins/furans, and discusses associated environmental issues in support of the development of the Pollution Prevention Strategy. CCME requested that as an initial action strategies identifying opportunities
to minimize emissions of air pollutants from the steel manufacturing iron sintering process be developed through a multi-stakeholder process and that these strategies be submitted by October 31, 2003.

The CWS identified the following factors that could be considered in developing the Strategy:

- **Measures to capture and control fugitive emissions of particulate matter and other contaminants from the process equipment in order to further reduce the total loadings from the plant to the atmosphere;**

- **Additional consideration of materials currently included in the feed mixture which may have the effect of causing elevated dioxin and furan levels in the exhaust gases from the plant;**

- **Consideration of materials included in the feed mixtures which may have the effect of causing elevated mercury levels in the exhaust gases from iron-sintering plants, i.e., levels exceeding the detection limit as 1998 results were “non-detect”;**

- **Consideration of alternative processes for the treatment of mill secondary materials to create materials suitable for use as blast furnace feed or other beneficial uses;**

- **Discussion of additional and ongoing monitoring requirements for materials collected from the gas cleaning equipment and the east lagoon sludge;**

- **Consideration of the best management practices mandated when collecting, treating and/or disposing of materials recovered from the gas cleaning system; and**

- **Further assessment of the relationship between removal of particulate matter and dioxins and furans in the air pollution control system.**

The DC asked that the full scope of technical options be considered. In broad terms the options include pollution prevention measures (e.g., process modifications) that would avoid the formation of dioxins/furans and control measures that mitigate the environmental releases of these substances. The introduction of alternative production processes to replace the conventional iron sintering process would be an example of a preventative measure.

The objective of this research is to assemble information that will provide the DC with an understanding of the technical options available for preventing emissions of air pollutants from iron sintering as described above.

### S.1.1 Environmental Releases from Iron Sintering

Three emission tests have been carried out on the Stelco Hamilton iron sinter plant. The results are summarized in Table T.1.

A significant part of the TPM emissions from sinter plants is composed of fine or sub-micron particulate material. This is true of the Stelco Hamilton sinter plant as 98 percent of the TPM was less than 2.5 um in size and 93 percent was less than 1.0 um in size in the 1998 emission test.
Table T.2: Summary of Emission Test Results for the Stelco Hamilton Sinter Plant

<table>
<thead>
<tr>
<th>Factor</th>
<th>1998</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scrubber system inlet</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dioxins/furans (pg ITEQ/Nm$^3$)</td>
<td>3,849 (1)</td>
<td>1,066</td>
<td>4,100</td>
</tr>
<tr>
<td>TPM (mg/Nm$^3$)</td>
<td>616</td>
<td>652</td>
<td>962</td>
</tr>
<tr>
<td>Temperature ($^\circ$C)</td>
<td>78</td>
<td>75.5</td>
<td>60.3</td>
</tr>
<tr>
<td><strong>Stack</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dioxins/furans (pg ITEQ/Nm$^3$)</td>
<td>2,444 (1)</td>
<td>510</td>
<td>1,036</td>
</tr>
<tr>
<td>TPM (mg/Nm$^3$)</td>
<td>90.1</td>
<td>49.8</td>
<td>67.7</td>
</tr>
<tr>
<td>Temperature ($^\circ$C)</td>
<td>31</td>
<td>41.7</td>
<td>47</td>
</tr>
<tr>
<td><strong>Emission reduction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dioxins/furans (%)</td>
<td>36.5</td>
<td>55.8</td>
<td>74.5</td>
</tr>
<tr>
<td>Particulate (%)</td>
<td>85.4</td>
<td>92.4</td>
<td>93.0</td>
</tr>
</tbody>
</table>

Notes: (1) Run 1 – dioxins/furans emissions increased for stack compared to scrubber inlet in the report, therefore the results for run 1 are reversed.

S.2 Review of the Theory of Dioxin and Furan Formation for Iron Sintering

A recent (2003) United Nations Environment Programme (UNEP) document, *Formation of PCDD/PCDF – An Overview*, provides an overview of the formation of dioxins/furans. The findings from this document that are pertinent to iron sintering are as follows:

- The processes by which dioxins/furans are formed are not completely understood nor agreed upon. Most information about formation of dioxins/furans during combustion processes has been obtained from laboratory experiments, pilot-scale systems, and municipal waste incinerators.
- Dioxins/furans appear to be formed in the iron sintering process via the *de novo* synthesis. Note that recent French and Japanese research indicate that *de novo* synthesis is the primary formation mechanism for the iron sintering process.
- Furans dominate in the waste gas from sinter plants, suggesting that precursors with a phenyl ring structure are less important than the formation of furans from solid carbon structures and inorganic chloride.
- Some metals act as catalysts in the formation of dioxins/furans. Copper is a strong catalyst and iron a weaker one.
- Condensation starts in the 125-60 °C range with the higher chlorinated dioxins and increases very rapidly as the temperature drops. The lower chlorinated furans are the last to condense, which explains why the tetra- and penta-furans constitute the majority of the dioxins/furans congeners observed in iron sintering emission tests.
S.2.1 Iron Sintering Operational Research

Most of the research on dioxins/furans formation and control has been carried out for iron sintering in Europe and Japan. The early published research was carried out by Voest-Alpine Industrieanlagenbau GmbH and Voest-Alpine Stal Linz GmbH on the Voest Stahl iron sintering plant in Linz, Austria, with the objectives of understanding dioxins/furans formation mechanisms and of developing emission control technology for dioxins/furans. British Steel set up a research program at their Swinden Technology Centre in Rotherham, UK, to research the formation of dioxins/furans in the sintering process and to determine methods of dioxins/furans emission prevention and control. In France starting in 1996, Usinor’s IRSID research center carried out research of ways to understand dioxin pathways, to assess the influence of raw materials on dioxin emissions, and to evaluate abatement solutions such as adsorption. In Japan a collaborative research project was formed in 1997 by the integrated steelmakers and universities to investigate the behaviours of dioxins and related substances in the sintering process and to search for pollution prevention technological principles.

Environment Canada commissioned technical studies to review research on dioxins/furans formation mechanisms and emission control for iron sintering in the late 1990s following the identification of dioxins/furans emissions as an environmental issue by the Strategic Options Process.

A summary of the iron sintering operational findings follows:

- The dioxins/furans formation mechanism appears to start in the upper regions of the sinter bed shortly after ignition. The dioxins/furans and other compounds condense on cooler burden beneath as the sinter layer advances along the sinter strand towards the burn-through point. The process of volatilization and condensation continues until the temperature of the cooler burden beneath rises sufficiently to prevent condensation and the dioxins/furans exit with the flue gas. Consequently, dioxins/furans emissions increase rapidly and peak just before burn-through and then decrease rapidly to a minimum. This result is supported in several studies on the dioxins/furans profile compared to the temperature profile along the sinter strand.
- Recent French and Japanese research indicate that de novo synthesis is the primary formation mechanism for the iron sintering process.
- Most of the studies concluded that there was little or weak correlation between the VOC content in the sinter feed materials and the dioxins/furans emissions. The postulated furan formation mechanism and the large proportion of furans compared to dioxins may explain the lack of a strong correlation.
- Some dioxins/furans will be recycled to the sinter strand from the dust collected in the emission control system.
- The composition of the feed mixture appears to have an impact on the formation of dioxins/furans.
- Three furan congenors, 2378-T4CDF, 23478-T5CDF, and 123478-T6CDF, consistently accounted for 77 to 83 percent of the dioxins/furans I-TEQ concentration in the Canadian iron sintering emission tests. Similar results have been reported in European emission tests of iron sintering plants. These results are comparable to the theoretical condensation calculations for dioxins/furans since these congenors would be among the last to condense as the gas temperature decreases.
S.3 Pollution Control Techniques

Iron sintering is a high temperature agglomeration process that was developed for the processing of finely ground iron to produce a product suitable for blast furnace feedstock. The Stelco iron sintering process recycles fine materials containing iron oxides from iron and steelmaking environmental control systems and production processes.

Dioxins/furans emissions from iron sintering were first raised as an environmental concern in Europe in the early 1990s. Therefore the early iron sintering dioxins/furans emission control technologies were developed in Europe and retrofitted to European iron sintering steelmaking plants.

Brief reviews of current dioxins/furans pollution control techniques follow:

Emission Optimized Sintering:
This technology recycles approximately half of the flue gas as combustion air, thus increasing energy efficiency and reducing dioxins/furans emissions by about 50 percent since the flue gas volume exhausted is reduced by half while the dioxins/furans concentration remains constant. This technology has been retrofitted to several European sinter plants.

Voest Alpine Wet Scrubbing (Airfine®) System:
This system uses a counter-current water quench followed by co-current injection of fine water droplets produced by compressed air atomization. This technology reduces dioxins/furans concentration to a range of 200 to 300 pg ITEQ/Nm$^3$ and TPM to approximately 30 mg/Nm$^3$. The Airfine system has been retrofitted to four sinter strands in Europe and an iron pellet plant in Australia.

Regenerative Activated Carbon Technology:
This technology, developed by Sumitomo Metal Industries, uses a moving bed of activated carbon char particles to remove dioxins/furans from several sinter plants in Japan. A retrofit installation on a sinter plant in Australia is in the startup phase with a design limit of 100 pg ITEQ/Nm$^3$ for dioxins/furans and 20 mg/Nm$^3$ for TPM. An ESP is used to remove dust emissions prior to the sinter waste gas entering the activated carbon moving bed.

High Efficiency Wet Scrubber (NELS):
At the Stelco sinter plant Nels Consulting Services carried out tests of an in-duct water spray system using steam to atomize the spray water. Following the test program, a full-scale system was installed upstream of the venturi scrubber. Emission test results were as low as 510 pg ITEQ/Nm$^3$ for dioxins/furans and 50 mg/Nm$^3$ for TPM.

Selective Catalytic Reduction (SCR):
SCR systems were retrofitted to two sinter plants in Japan in the late 1970s to remove NO$_x$ emissions. Electrostatic precipitators and a sulphur dioxide removal system were installed in front of the SCR systems. Recent dioxins/furans emission test results at one of the sinter plants were as low as 40 pg ITEQ/Nm$^3$. 
S.4 Pollution Prevention Techniques and Practices

Raw Materials:
Pollution prevention practices include reduction of oil in raw materials and avoidance of dioxins/furans and mercury in raw materials.

Preparation of Raw Materials:
Pollution prevention practices include storage and handling of dusty materials in an enclosed space to prevent fugitive emissions, blending of raw materials to provide a homogenous sinter feed, and agglomeration of fine materials to minimize fugitive emissions in handling, feeding to the sinter strand, and on the sinter strand.

Sinter Strand Operations:
Pollution prevention practices include hooding with emission controls of the sinter strand including the feed and discharge ends to minimize fugitive emissions, the application of best operating and maintenance practices to prevent or minimize dioxins/furans emissions and minimize TPM emissions, and possibly the addition of materials that would suppress or prevent dioxins/furans formation.

Emission Control System:
Pollution prevention practices include development and implementation of best operating and maintenance practices and the installation and operation of a continuous parameter monitoring system.

Collection, Handling, Storage, and Disposal of Collected Dust and Sludge:
Pollution prevention practices include development and implementation of best environmental management practices for collection, handling, storage, and disposal of collected dust and sludge and hooding of transfer points.

S.5 Assessment of Relationship Between Removal of Particulate Material and Dioxins and Furans

Analysis of the results of the three emission tests of the Stelco sinter plant was carried out and the findings are summarized:

- A limited relationship exists between TPM emissions and dioxins/furans emissions from the sinter strand. This is evident from the results of the 2001 and 2002 emission tests where the sinter strand dioxins/furans scrubber inlet concentration increased 400 percent while the TPM scrubber inlet concentration increased by 50 percent.
- A limited relationship exists between the reduction efficiency of TPM and dioxins/furans through the scrubber and spray system. The TPM stack concentrations were reduced in the range of 92 to 93 percent from scrubber inlet concentrations in both the 2001 and 2002 emission tests; however the reduction of dioxins/furans concentrations from the scrubber inlet to the stack increased from 52 percent in 2001 to 75 percent in 2002. This increased reduction efficiency is likely due both to the significantly larger scrubber inlet dioxins/furans concentration in 2002 and to increased adsorption on the particulate material because of the higher dioxins/furans and particulate material concentrations but the proportion due to each is unknown. Note that both the “policeman” dust collector and
scrubber inlet temperatures were lower in the 2002 emission test than in the 2001 emission test, which may have resulted in more condensation of the dioxins/furans in 2002.

- The 400 percent increase in the scrubber inlet dioxins/furans concentrations in the 2002 emission test compared to the 2001 emission test was likely due to operating factors which had a significantly smaller impact on the TPM concentrations. These factors included reduced ignition hood temperature, increased strand speed, and increased gas flow. It is likely that other operating factors, some of which may be addressed through a pollution prevention program, were also involved.

- It appears that a portion of the dioxins/furans emissions is probably in a gaseous state. Since gaseous emissions do not behave like particulate material, a different emission control approach is necessary to remove/reduce this portion of the total dioxins/furans emissions effectively.

- The analysis of the operating data identified that there were significant differences in some operating parameters. It is important to develop and implement standard operating procedures based on best operating practices and procedures to minimize such occurrences (e.g., increased gas flow and lower ignition hood temperature).

- It is evident from the analysis of the relationship of TPM and dioxins/furans emissions that the NELS scrubbing system has increased the scrubbing efficiency for the dioxins/furans adsorbed on fine particulate material or acting as fine particulate.

S.6 Modification or Alternate Feed Process Materials

Dioxins/furans present in the sinter plant scrubber sludge and collected dust may revert to sinter strand emissions if these materials are included in the sinter strand feed. Identification and avoidance or reduction of chlorides in the feed process materials have been identified as a pollution prevention measure. The European Union IPPC recommends the reduction of hydrocarbons, such as oils, in the sinter feed to minimize the reduction of VOC emissions, which may also reduce dioxins/furans emissions. Japanese research and Corus (British Steel) experiments with addition of nitrogen compounds indicate a potential for reduction of the formation of dioxins/furans in the sinter strand.

S.7 Conclusions and Recommendations

S.7.1 Conclusions

The following conclusions are based on the data and information presented in the main body of this report.
Formation of Dioxins/Furans in the Sintering Process

- The dioxins/furans formation mechanism appears to be evaporation of aromatic hydrocarbon compounds in the upper regions of the sinter bed and de novo synthesis involving carbon and chloride and then condensation of the dioxins/furans on cooler burden beneath as the sinter layer moves along the sinter strand towards the burn-through point. The base layer of sinter may act as a filter trapping soot particles, thus providing suitable conditions in the base layer for de novo synthesis. The process of volatilization and condensation continues until the temperature of the cooler burden beneath rises sufficiently to prevent condensation, and the dioxins/furans exit with the flue gas.

- The results of recent Japanese research indicate that the composition of the raw material affects the formation and quantity of dioxins/furans emissions and that de novo synthesis is the primary dioxins/furans formation mechanism.

- Furans, especially the lower chlorinated congeners, dominate in the waste gas from sinter plants, including the Stelco sinter plant.

- Dioxins/furans condense in the 125 to 60°C temperature range starting with the higher chlorinated dioxins and later with the higher chlorinated furans. Some or most of the lower chlorinated furans may be in gaseous form at the off-gas temperature prior to the wet scrubbing system.

- Japanese laboratory research indicates that dioxins/furans emissions may be significantly reduced by the addition of some forms of nitrogen such as urea. It isn’t known whether or not nitrogen addition results in other emission changes such as an increase in NOx.

Pollution Control Technologies and Techniques

- Moving bed activated carbon was identified as a potential pollution control technology for retrofit to the Stelco sinter plant. This technology was retrofit to a Broken Hill Propriety sinter plant in Australia and is scheduled to start up shortly. The design specification was less than 20 mg/Nm$^3$ for TPM and less than 100 pg ITEQ/Nm$^3$ for dioxins/furans.

- Selective catalytic reduction (SCR) emission control technology may be considered for retrofit to the Stelco sinter plant. Kawasaki Steel Corporation and Nippon Kokan installed SCR emission control technology on their sinter plants in the late 1970s for NOx emission control. Reported dioxins/furans emissions for one of the sinter plants, not identified, were 40 pg ITEQ/Nm$^3$.

Pollution Prevention Techniques

Best environmental practices identified that would assist in achieving pollution prevention are summarized below:

Raw Material Preparation: Best operating practices.

Sinter Strand Operations: Hooding of sinter strand to prevent fugitive emissions, best operating practices, and feasibility of furan emission suppression by nitrogen compound addition.

Emission Control System: Best operating practices and design, installation, and operation of a continuous parameter monitoring system.

Collection, Handling, and Disposal of Collected Dust and Sludge: Best operating practices.

Process Change

The Fastmet process was identified as a potential candidate production process to replace the traditional sintering process. Two Fastmet plants are in commercial production in Japan processing steel plant iron oxide materials. The DRI product is suitable as a feed material for the blast furnace and steelmaking basic oxygen furnaces (BOFs) and electric arc furnaces (EAFs).

Relationship Between Removal of Particulate Matter and Dioxins/Furans

The dioxins/furans condensation range is between 125 and 60°C with the higher chlorinated dioxins condensing first, followed by the higher chlorinated furans, and ending with the lower chlorinated furans. Since some of the dioxins/furans will be adsorbed on fine particulate and some will condense to form fine particulate, the dioxins/furans will increasingly be adsorbed on or behave as fine particulate as the off-gas temperature decreases through the dioxins/furans condensation temperature range. Note that the lower chlorinated furans are the predominant congeners in sinter plant emission testing results.

The NELS scrubbing system has increased the scrubbing efficiency for the dioxins/furans adsorbed on fine particulate material or acting as fine particulate

Modification or Alternate Feed Process Materials

According to the available data, the scrubber wastewater filter sludge is the only material that had significant dioxins/furans content. Japanese laboratory scale research data indicate that dioxins/furans emissions are reduced when other carbon fuel sources such as anthracite coal are used in place of coke breeze. Note that the European Union IPPC recommends the replacement of anthracite with coke breeze to reduce hydrocarbon release. Japanese laboratory scale research data also indicate that dioxins/furans formation is suppressed when a source of nitrogen such as urea is added to the sinter feed. It isn’t known whether nitrogen addition results in other emission changes such as an increase in NOx.

Information and Data Deficiencies

- There were limited capital and operating cost data and information available for emission control technologies and the Fastmet production process; therefore only limited capital and operating costs could be developed for application to the Stelco sinter plant.

- Capital and operating cost data could not be estimated for most of the identified pollution prevention techniques due to the lack of site-specific and cost information data.
S.7.2 Recommendations

The following pollution prevention elements are based on the findings and pollution prevention practices identified in this study and are presented as considerations for the development of the pollution prevention strategy:

- Develop and implement a pollution prevention plan with objectives to prevent or minimize the formation of dioxins/furans in the sintering process, to prevent or minimize the release of dioxins/furans to the atmosphere, and to provide good environmental management of the handling, storage, and disposal of material containing dioxins/furans. The pollution prevention plan could include the following:
  - identify and avoid or minimize substances in the sinter feed mix that contribute to the formation of dioxins/furans in the sintering process;
  - identify and implement best operating practices that prevent or minimize the formation of dioxins/furans in the sintering process;
  - identify and implement best maintenance practices that optimize the sinter strand and emission control system operation and that prevent or minimize the formation of dioxins/furans in the sintering process;
  - identify sinter strand operating parameters that contribute to the formation and release of dioxins/furans from the sinter strand, identify the optimum parameter operating values, and develop and implement a continuous parameter monitoring system to minimize dioxins/furans formation and release;
  - identify the optimum emission control system operating parameters and develop and implement a continuous parameter monitoring system to minimize dioxins/furans releases to the environment;
  - identify and implement actions to prevent or minimize the release of fugitive dioxins/furans emissions from the sinter plant operations including hooding of sinter strand; and
  - identify and implement best environmental practices for the storage, handling, and disposal of material containing dioxins/furans.

- Investigate the addition of materials such as nitrogen compounds that may prevent or minimize the formation and release of dioxins/furans in the sintering process.

- Identify and assess the feasibility of alternate commercial or emerging production processes to recycle the steel plant iron oxide materials.

- It would be prudent to carry out further analysis of the relationship between TPM emissions and dioxins/furans as more emission test data become available.