ENVIRONMENTAL CODE OF PRACTICE

Canadian Environmental Protection Act, 1999

First Edition

Base Metals Smelters and Refineries

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ABSTRACT

The Environmental Code of Practice for Base Metals Smelters and Refineries describes operational activities and associated environmental concerns of this industrial sector. Recommendations for the environmental performance of these facilities are presented to mitigate these concerns. The recommended practices in the Code include the development and implementation of environmental management systems and the prevention and control of atmospheric emissions, wastewater effluents, and wastes. These recommended practices may be used as requirements for new facilities and as goals for continual improvements for existing facilities.

RÉSUMÉ

Le Code de pratiques écologiques pour les fonderies et affineries de métaux communs décrit les activités opérationnelles de ce secteur industriel et les préoccupations environnementales qu'elles soulèvent. En répondre à ces préoccupations, on présente des recommandations relatives à la performance environnementale pour ces établissements. Les pratiques recommandées dans le Code sont notamment l'élaboration et la mise en œuvre de systèmes de gestion de l'environnement, ainsi que la prévention et la réduction des émissions atmosphériques, des effluents d'eaux usées et des déchets. On propose aux nouveaux établissements d'utiliser ces pratiques recommandées à titre d'exigences, et aux établissements existants, de les utiliser à titre d'objectifs d'amélioration permanente.

TABLE OF CONTENTS

TABLES

FIGURES

SUMMARY

S.1 CONTEXT

Various environmental initiatives and legislation provide context for the development of an Environmental Code of Practice for the base metals smelting and refining sector.

Under the *Canadian Environmental Protection Act*, 1999 (CEPA 1999), there are provisions for developing regulations, objectives, guidelines, and codes of practice and for requiring pollution prevention plans. The *Fisheries Act* includes provisions for developing regulations to manage the release of deleterious substances to Canadian fishery waters.

The Canadian Council of Ministers of the Environment sets nationwide standards for various toxic substances and also agreed on the development of comprehensive Multi-pollutant Emission Reduction Strategies for various industrial sectors as a means for achieving the standards.

Canada is committed to reducing emissions under international agreements such as the 2000 Ozone Annex under the 1991 Canada–United States Air Quality Agreement and the United Nations Economic Commission for Europe Convention on Long-range Transboundary Air Pollution.

Base metals smelters and refineries release various substances found on the List of Toxic Substances in Schedule 1 to CEPA 1999. A multistakeholder consultation, called the Strategic Options Process, was conducted in 1996–1997 and resulted in several recommendations for the management of toxic substances from the sector. These recommendations included the development of environmental performance standards.

These provisions are taken into account in the development of this Environmental Code of Practice for Base Metals Smelters and Refineries.

S.2 CODE OBJECTIVES

The overall objectives of the Environmental Code of Practice are to identify and promote recommended practices as requirements for new facilities and as goals for continual improvements for existing facilities.

S.3 CODE SCOPE, DEVELOPMENT, AND IMPLEMENTATION

The Environmental Code of Practice for Base Metals Smelters and Refineries includes descriptions of processes used in the sector and associated environmental concerns, as well as recommended environmental performance standards for mitigating these concerns.

The recommended practices in the Code include guidance for environmental management systems and guidelines for environmental releases to air, water, and land, based on best available techniques for pollution prevention and control.

The Code has been developed by Environment Canada in consultation with a Base metals Environmental Multistakeholder Advisory Group.

Potential options for the implementation of the Code include:

- voluntary adoption by a corporation and/or a facility;
- use as performance standards for environmental audits;
- use as a benchmark for public corporate commitments and performance reporting;
- inclusion as a commitment in an environmental performance agreement between a corporation and/or a facility and environmental protection agencies;
- inclusion of some or all of the Code recommendations as requirements by financial lending institutions and/or insurance companies or underwriters; and

- use of some of the Code recommendations as the basis for provincial/territorial regulations or permits or federal regulations.

S.4 SMELTER AND REFINERY OPERATIONS AND ENVIRONMENTAL CONCERNS

In smelters and refineries, ores and concentrates are supplied from mines and mills, and recycled material is supplied for further recovery and purification of metals. This Code of Practice applies to both smelters and refineries of primary copper, primary and secondary lead, primary zinc, primary nickel, and primary cobalt.

Operations in this sector can include:

- pre-treatment of the ores, concentrates and recycled material;
- roasting;
- smelting;
- converting;
- fire refining;
- electrorefining;
- carbonyl refining;
- leaching;
- electrowinning;
- casting; and
- process off-gas conditioning.

Pollutant releases of concern associated with these operations include:

- process air emissions from stacks;
- process air emissions from unenclosed process equipment and buildings;
- fugitive air emissions from outdoor storage piles and during transfers of materials;
- releases of pollutants accidentally or in environmental emergency;
- water effluents from processes;
- water effluents from site runoff; and
- slags, sludges, slimes, and other residues and wastes.

Pollutant releases of concern in facility air emissions include:

- sulphur dioxide;
- particulate matter, including particulate matter less than or equal to 10 microns in size (PM_{10}) and particulate matter less than or equal to 2.5 microns in size ($PM_{2.5}$);
- certain heavy metal compounds; and
- certain organic compounds.

In addition to effluent acidic or alkaline pH, the following substances in water effluents and contaminated surface water and groundwater are of concern:

- suspended and dissolved solids and metals; and
- oil and grease.

S.5 RECOMMENDED ENVIRONMENTAL PROTECTION PRACTICES

To reduce or eliminate the adverse environmental impacts associated with smelters and refineries, the environmental practices summarized in Tables S.1–S.4 are recommended.

TABLE S.1: RECOMMENDATIONS FOR ENVIRONMENTAL MANAGEMENT SYSTEMS

Number	Subject	Summary of Recommendations: Environmental Management Systems
R 101	Environmental Policy Statement	Each company should develop and implement an environmental policy statement.
R 102	Environmental Management Systems	Each facility should develop, implement, and maintain an environmental management system in accordance with ISO 14001[1] or an equivalent standard or system.
R 103	Environmental Management Plans	Each facility should develop and implement a site-specific environmental management plan, consistent with the *Environmental Management Plan Guidance Document for the Base Metals Smelting Sector.*[2] The plan should include, as a minimum, the following: (i) company and site information; (ii) environmental policy statement; (iii) environmental performance requirements; (iv) air quality management systems; (v) water quality management systems; (vi) solids management systems; (vii) land management systems; (viii) pollution prevention planning; (ix) emissions reduction options, targets, and schedules; (x) environmental management systems and auditing; (xi) community relationships; (xii) communication procedures; and (xiii) periodic environmental management plan review for effectiveness and continual improvement.
R 104	Environmental Assessment	Environmental assessment principles should be followed by companies for new and significantly modified or expanded facilities, consistent with the Canadian Environmental Assessment Agency Reference Guide,[3] Table 1.
R 105	Pollution Prevention Planning	Each facility should develop and implement a pollution prevention plan, consistent with Environment Canada's *Pollution Prevention Planning Handbook*[4] or in compliance with any Pollution Prevention Plan Notification issued under the *Canadian Environmental Protection Act, 1999*.
R 106	Emergency Planning	Each facility should develop and make publicly available an environmental emergency plan, consistent with Environment Canada's *Implementation Guidelines for Part 8 of the Canadian Environmental Protection Act, 1999 — Environmental Emergency Plans.*[5]
R 107	Decommissioning Planning	A facility should begin planning for decommissioning in the design stage of the project life cycle for new facilities and as early as possible in the operating stage for existing facilities. Site closures and associated decommissioning activities should be undertaken by the facility, consistent with the *National Guidelines for Decommissioning Industrial Sites.*[6]
R 108	Environmental Training	Each facility should establish and maintain procedures to identify its environmental training needs and ensure that all personnel who work in areas that may create a significant adverse impact upon the environment have received training.
R 109	Environmental Facility Inspection	Each facility should develop and implement an environmental inspection plan.
R 110	Environmental Auditing	Each facility should conduct periodic environmental audits by internal, corporate, or third-party auditors.

1 Canadian Standards Association, *Environmental Management Systems — Specification with Guidance for Use*, CAN/CSA-ISO 14001-96, 1996.

2 Hatch Associates Ltd., *Environmental Management Plan Guidance Document for the Base Metals Smelting Sector*, prepared for Environment Canada, March 14, 2001.

3 Canadian Environmental Assessment Agency, Reference Guide: *Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects* (www.ceaa-acee.gc.ca/013/0001/0008/guide3_e.htm#Reference%20Guide).

4 Environment Canada, *Pollution Prevention Planning Handbook*, 2001 (www.ec.gc.ca/CEPARegistry/plans/p2).

5 Environment Canada, *Implementation Guidelines for Part 8 of the Canadian Environmental Protection Act, 1999, Environmental Emergency Plans*, September 2003, ISBN 0-662-33797-2 (www.ec.gc.ca/CEPARegistry/guidelines/impl_guid/toc.cfm).

6 Canadian Council of Ministers of the Environment, *National Guidelines for Decommissioning Industrial Sites*, Report No. CCME-TS/WM-TRE013E, March 1991, ISBN 0-662-18705-9.

Number	Subject	Summary of Recommendations: Environmental Management Systems
R 111	Environmental Performance Indicators	Each facility should develop a set of environmental performance indicators that can provide an overall measure of the facility's environmental performance.
R 112	Product Stewardship	Each company should develop and implement a product stewardship program aimed at minimizing the environmental impacts associated with the products used and produced by the facility and under the control of the company.
R 113	Public Reporting	Documented procedures for the monitoring and reporting of environmental performance to the public should be developed and implemented by the facility, consistent with the *Guidance Document for Reporting Releases from the Base Metals Smelting Sector*[7] and taking into account the Global Reporting Initiative's *Sustainability Reporting Guidelines*[8] for the mining and metals sector.
R 114	Community Advisory Panel	Each facility should establish a Community Advisory Panel with representatives from the surrounding community, in order to provide a forum for the review and discussion of facility operations and associated environmental and other concerns.

TABLE S.2: RECOMMENDATIONS FOR ATMOSPHERIC RELEASES MANAGEMENT

Number	Subject	Summary of Recommendations: Atmospheric Releases Management
R 201	Prevention and Control of Fugitive Air Emissions	Each facility should identify potential sources of fugitive emissions and should prevent or control those emissions through the use of appropriate mitigative measures. These sources may include unpaved roads, storage piles, material conveyance systems, waste disposal piles, and leaks from processes and buildings.
R 202	Collection and Control of Process Air Emissions	Each facility should ensure that air pollution control equipment is adequately sized, designed, constructed, operated, and maintained to contain and control pollutant releases to ambient air from all plant processes.
R 203	Total Particulate Matter Emissions Guidelines	Each facility should be designed and operated to achieve the following recommended release concentrations for total particulate matter after the emission control device of less than 50 mg/Nm^3.
R 204	Sulphur Fixation Guidelines	1. Each facility should consider use of low sulphur feed and recycled materials to reduce emissions of sulphur dioxide. 2. Each existing facility should be designed and operated to achieve a minimum sulphur fixation rate of 90% by a committed timetable. 3. Each new copper, lead and zinc smelter should be designed and operated to achieve a minimum sulphur fixation rate of 99%. 4. Each new nickel smelter should be designed and operated to achieve a minimum sulphur fixation rate of 96%.
R 205	Mercury Emissions Guidelines[9]	1. Each existing facility should be designed and operated to limit air release loadings to less than 2 grams of mercury per tonne of finished product. 2. Each new or expanded facility should be designed and operated to limit air release loadings in accordance with the following: (a) less than 0.2 grams of mercury per tonne production of finished zinc, nickel, and lead; and (b) less than 1 gram of mercury per tonne production of finished copper.
R 206	Dioxins and Furans Emissions Guidelines[10]	1. Each existing facility should be designed and operated to limit release concentrations of dioxins and furans to less than 100 pg ITEQ*/Rm^3. 2. Each new facility should be designed and operated to limit release concentrations of dioxins and furans to less than 32 pg ITEQ*/Rm^3. ** ITEQ = International Toxicity Equivalency Quotient.*

7 Hatch Associates Ltd., *Guidance Document for Reporting Releases from the Base Metals Smelting Sector*, prepared for Environment Canada, October 2001.

8 Global Reporting Initiative, *Sustainability Reporting Guidelines*, 2002, GRI Mining and Metals Sector Supplement, Pilot Version 1.0, February 2005 (www.globalreporting.org/guidelines/sectors/mining.asp).

9 In accordance with the *Canada-wide Standards for Mercury* (see Appendix A of the Code).

10 Canadian Council of Ministers of the Environment, *Canada-wide Standards for Dioxins/Furans*, March 2003, developed for other sources such as steel manufacturing electric arc furnaces.

Number	Subject	Summary of Recommendations: Atmospheric Releases Management
R 207	Metals Emissions Limit Targets	Each facility should develop facility emission reduction targets for and timetables to achieve reductions in releases of arsenic, cadmium, lead, nickel, mercury, and other metals of concern, taking into account facility emission reduction targets for sulphur dioxide and particulate matter, pollution prevention and control options, and performances for various feeds, smelting processes, and emission control systems.
R 208	Air Releases Reporting	Each facility should measure or estimate and report releases, consistent with the *Guidance Document for Reporting Releases from the Base Metals Smelting Sector*[11] and in accordance with the notice requiring submission of data for the National Pollutant Release Inventory.[12]
R 209	Ambient Air Quality Objectives	In addition to the source performance recommendations of R 203 and R 204, each facility should design and operate air emission prevention and control systems, taking into account local conditions and the following ambient air quality objectives, standards, criteria and guidelines:

Pollutant		Averaging time: 1 hour	8 hours	24 hours	Annual	Notes
Sulphur dioxide (SO_2) ($\mu g/m^3$)	Desirable	450		150	30	1
	Acceptable	900		300	60	1
	Tolerable			800		1
WHO Guideline (SO_2) ($\mu g/m^3$)				125	50	6
Total suspended particulate (TSP) ($\mu g/m^3$)	Desirable	–		–	60	1
	Acceptable	–		120	70	1
	Tolerable	–		400	–	1
Particulate matter ($PM_{2.5}$) ($\mu g/m^3$)	Reference level*			15		2
Ozone (O_3) (ppb)			65			2
Metals ($\mu g/m^3$)						
- Arsenic				0.3		3
- Cadmium				2		4
- Lead				2		4
- Nickel		5.0				5

Notes:

1. Canadian Council of Ministers of the Environment, *Canadian Environmental Quality Objectives, Canadian National Ambient Air Quality Objectives: Appendix 1*, 1999.
2. Canadian Council of Ministers of the Environment, *Canada-wide Standards for Particulate Matter and Ozone*, June 5–6, 2000.
3. Ontario Ministry of the Environment's Ambient Air Quality Criteria for Arsenic and Its Compounds.
4. Ontario Regulation 337.
5. Ontario Regulation 346 Point of Impingement (POI) 30-minute average.
6. World Health Organization, *Air Quality Guidelines* (www.euro.who.int/document/aiq/7_4sulfurdioxide.pdf).

* *Reference level is the level above which there are demonstrated effects on human health and/or the environment.*

Number	Subject	Summary of Recommendations: Atmospheric Releases Management
R 210	Ambient Air Quality Monitoring	Each facility should develop and implement an ambient air quality monitoring program in consultation with the regulatory bodies having authority over the facility. This program should include the sampling and analysis of metals, particulate matter (total, PM_{10}, and $PM_{2.5}$), sulphur dioxide, and other pollutants of concern, taking into account: (i) the location of release sources under the control of the facility operator and other sources affecting air quality; and (ii) local meteorological conditions and probable maximum pollutant deposition areas.

11 Hatch Associates Ltd., *Guidance Document for Reporting Releases from the Base Metals Smelting Sector*, prepared for Environment Canada, October 2001.

12 Environment Canada, National Pollutant Release Inventory (www.ec.gc.ca/pdb/npri/npri_home_e.cfm).

TABLE S.3: RECOMMENDATIONS FOR WATER AND WASTEWATER MANAGEMENT

Number	Subject	Summary of Recommendations: Water and Wastewater Management
R 301	Water Use/Reuse	Water use should be minimized, to the maximum extent practicable, possibly through the recycling or reuse of water and the cascading of cooling water and wastewater between production processes using lower-quality water.
R 302	Wastewater Collection	All wastewater streams that may exceed the effluent criteria of R 304 should be directed to a treatment facility prior to discharge to the environment.
R 303	Wastewater Containment Sizing	Wastewater collection and containment systems should be designed to contain the maximum volume of liquid that could reasonably be expected to be in storage for the following conditions: (i) the maximum volume of wastewater that would be accumulated during the time required to shut down wastewater generating processes, plus 50%; (ii) 110% of the volume that could enter the containment system in the event of a leak, spill, or other like incident; or (iii) the accumulated precipitation from a 24-hour, 50-year storm (return period) for outdoor containments.
R 304	Water Effluent Guidelines	Wastewater treatment facilities should be designed, constructed, operated, and maintained to achieve the following effluent quality prior to release: **On a continuous basis:** pH 6.0–9.5 **Maximum monthly mean concentration:** Total suspended solids 15.0 mg/L Arsenic 0.5 mg/L Copper 0.3 mg/L Cyanide* 1.0 mg/L Lead 0.2 mg/L Nickel 0.5 mg/L Zinc 0.5 mg/L * *If cyanide is used in the process.* **Non-acutely lethal effluent:** No more than 50% mortality of *Daphnia magna* and rainbow trout test species in 100% effluent when tested in accordance with Environment Canada Reference Methods 1/RM/13[13] and 1/RM/14.[14]
R 305	Water Effluent Reporting	Effluents should be monitored, tested, estimated and reported, consistent with Environment Canada's *Guidance Document for the Sampling and Analysis of Metal Mining Effluents*[15] and *Guidance Document for Flow Measurement of Metal Mining Effluents*[16] and in accordance with the notice requiring submission of data for the National Pollutant Release Inventory.[17]

13 Environment Canada, *Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout*, Report EPS 1/RM/13, Second Edition, December 2000.

14 Environment Canada, *Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to* Daphnia magna, Report EPS 1/RM/14, Second Edition, December 2000.

15 Environment Canada, *Guidance Document for the Sampling and Analysis of Metal Mining Effluents*, EPS 2/MM/5, April 2001.

16 Environment Canada, *Guidance Document for Flow Measurement of Metal Mining Effluents*, EPS 2/MM/4, April 2001.

17 Environment Canada, National Pollutant Release Inventory (www.ec.gc.ca/pdb/npri/npri_home_e.cfm).

<table>
<tr><th>Number</th><th>Subject</th><th colspan="2">Summary of Recommendations: Water and Wastewater Management</th></tr>
<tr><td rowspan="22">R 306</td><td rowspan="22">Ambient Water Quality Guidelines</td><td colspan="2">In addition to the source performance recommendations of R 304 and R 305, each facility should design and operate effluent discharge systems, taking into account local conditions and the following ambient water quality objectives:</td></tr>
<tr><th>Substance</th><th>Guideline* (µg/L)</th></tr>
<tr><td>Aluminum</td><td>5–100</td></tr>
<tr><td>Ammonia (total)**</td><td>(see table in Section 4.3.6 of the Code)</td></tr>
<tr><td>Ammonia (un-ionized)***</td><td>19</td></tr>
<tr><td>Arsenic (total)</td><td>5.0</td></tr>
<tr><td>Benzene</td><td>370</td></tr>
<tr><td>Cadmium</td><td>0.017</td></tr>
<tr><td>Chromium
- Trivalent chromium (Cr(III))
- Hexavalent chromium (Cr(VI))</td><td>
8.9
1.0</td></tr>
<tr><td>Copper (total)</td><td>2–4</td></tr>
<tr><td>Cyanide (free)</td><td>5</td></tr>
<tr><td>Iron (total)</td><td>300</td></tr>
<tr><td>Lead (total)</td><td>1–7</td></tr>
<tr><td>Mercury
- Inorganic mercury
- Methylmercury</td><td>
0.026
0.004</td></tr>
<tr><td>Molybdenum</td><td>73</td></tr>
<tr><td>Nickel (total)</td><td>25–150</td></tr>
<tr><td>pH</td><td>6.5–9.0****</td></tr>
<tr><td>Selenium (total)</td><td>1.0</td></tr>
<tr><td>Silver (total)</td><td>0.1</td></tr>
<tr><td>Thallium</td><td>0.8</td></tr>
<tr><td>Zinc</td><td>30</td></tr>
<tr><td colspan="2">Notes:
* Canadian Council of Ministers of the Environment, Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life (Summary Table update December 2003).
** Ammonia (total) is used to describe the sum of ammonia (NH_3) and ammonium (NH_4^+).
*** Ionized ammonia refers to the ammonium ion (NH_4^+).
**** No units for pH.</td></tr>
<tr><td>R 307</td><td>Aquatic Environmental Effects Monitoring</td><td colspan="2">Each facility that discharges to a receiving water, should develop and implement an aquatic environmental effects monitoring program, consistent with Environment Canada's Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring.[18]</td></tr>
</table>

18 Environment Canada, *Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring*, 2002 (www.ec.gc.ca/eem/english/MetalMining/Guidance/default.cfm).

TABLE S.4: RECOMMENDATIONS FOR WASTE MANAGEMENT

Number	Subject	Summary of Recommendations: Waste Management
R 401	Reduction, Reuse, and Recycling	Each facility should develop, implement, and maintain a waste reduction, reuse, and recycling program. The program should be one that: (i) identifies opportunities for in-plant reduction, reuse, and recycling of wastes; (ii) develops and implements plans for the evaluation and implementation of reduction, reuse, and recycling opportunities; (iii) identifies and evaluates market opportunities for wastes with a view to maximizing waste material reduction, reuse, and recycling (this includes the sale of by-products that would otherwise be considered wastes); and (iv) develops and implements a research and development program for reducing, reusing, and recycling residual wastes.
R 402	Location and Construction of Waste Disposal Sites	Expansions to existing waste disposal sites and the design and construction of new sites should be undertaken so as to ensure that: (i) the site plan is updated to clearly show the location and dimensions of the new or expanded waste disposal site; (ii) the perimeter of the disposal area is far enough away from all watercourses to prevent contamination by runoff, seepage, or fugitive emissions; (iii) the surface drainage from off-site areas is diverted around the disposal area; (iv) the expanded area is hidden from view by fences, berms, or buffer zones; and (v) future beneficial uses of the waste disposal site after its closure have been considered.
R 403	Development of Solid Waste Disposal Sites	Solid waste disposal sites should be developed in accordance with the following practices: (i) the disposal area should be developed in modules or cells; (ii) all wastes should be placed such that they have physical and chemical stability suitable for land reuse, if the disposal area is reclaimed; (iii) contouring, capping, and reclamation of cells should be undertaken throughout the operating life of the site; and (iv) all disposal sites should be reclaimed for beneficial uses before final closure or restricted from public access if they cannot be reclaimed.
R 404	Management of Waste Disposal Sites	All waste disposal sites should be managed in accordance with documented, site-specific waste management plans approved by the appropriate regulatory bodies having authority over the facility so that: (i) solid, liquid, and hazardous wastes are transferred only to facilities specifically designed, approved, and operated for that purpose; (ii) access to the site is controlled and disposal activities are supervised by trained personnel; and (iii) records are maintained of the types, approximate quantities, and point of origin of the wastes.
R 405	Monitoring of Waste Disposal Sites	A groundwater monitoring program should be developed for all waste disposal sites in accordance with the following guidelines: (i) a permanent system of appropriately located piezometers and wells should be provided; (ii) a program of pre-operational monitoring of groundwater regimes should be initiated; (iii) groundwater samples should be collected at least quarterly; and (iv) each groundwater sample should be analyzed for pH, total dissolved solids, and other appropriate site-specific parameters.
R 406	Waste Reporting	Wastes disposed of and transferred should be reported, in accordance with the notice requiring submission of data for the National Pollutant Release Inventory.[19]
R 407	Waste Management	Wastes should be managed consistent with the *Guidance Document for Management of Wastes from the Base Metals Smelting Sector*.[20]

19 Environment Canada, National Pollutant Release Inventory (www.ec.gc.ca/pdb/npri/npri_home_e.cfm).

20 Hatch Consulting, *Guidance Document for Management of Wastes from the Base Metals Smelting Sector,* prepared for Environment Canada, March 31, 2004.

1 INTRODUCTION

Under the *Canadian Environmental Protection Act, 1999* (CEPA 1999), Environment Canada and Health Canada are accountable for the assessment and management of toxic substances. Responsibilities under CEPA 1999 include identifying substances that may be toxic and assessing them to determine whether they are toxic as defined under section 64. If assessed to be toxic, they are recommended for addition to the List of Toxic Substances (Schedule 1 of CEPA 1999).[21]

CEPA 1999 contains provisions for developing regulations or instruments respecting preventive or control actions and for requiring pollution prevention plans, virtual elimination plans, and environmental emergency plans.

CEPA 1999 also provides for the development of environmental quality objectives, environmental quality guidelines, release guidelines and codes of practice. Under CEPA 1999, subsection 54(1), paragraph (d), the Minister shall issue:

> … codes of practice respecting pollution prevention or specifying procedures, practices or release limits for environmental control relating to works, undertakings and activities during any phase of their development and operation, including the location, design, construction, start-up, closure, dismantling and clean-up phases and any subsequent monitoring activities.

Under the *Fisheries Act*, there are prohibitions against the deposit of deleterious substances into waters frequented by fish and against any works or undertakings that result in the harmful alteration, disruption, or destruction of fish habitat.

Under the Canadian Council of Ministers of the Environment's Canada-wide Accord on Environmental Harmonization, Canada-wide Standards and Multi-pollutant Emission Reduction Strategies have been developed for various industrial sectors, including base metals smelting.

Under the 2000 Ozone Annex to the 1991 Canada–United States Air Quality Agreement, there are commitments to reduce the releases of substances that contribute to ground-level ozone, such as nitrogen oxides and volatile organic compounds.

Under the United Nations Economic Commission for Europe's Convention on Long-range Transboundary Air Pollution, there are protocols that commit Canada to reductions of specified releases.

In response to concerns about the globalization of trade, there is an emerging trend towards the globalization of environmental performance standards.

All of these factors affect the base metals smelting and refining sector.

Various substances on the List of Toxic Substances in Schedule 1 to CEPA 1999 are released by base metals smelters and refineries. Following the assessment of these substances as toxic, a multistakeholder consultation, called the Strategic Options Process, was conducted and resulted in various recommendations for the management of toxic substances from the sector. These recommendations included the development of environmental performance standards.

The Strategic Options Process was launched in May 1996 to assess potential options for the management of substances declared toxic under the *Canadian Environmental Protection Act* of 1988, the predecessor of CEPA 1999. The toxic substances examined during the Strategic Options Process were known to be released by the base metals smelting sector. Under the Strategic Options Process, a multistakeholder Issue Table was convened to identify and evaluate options and provide advice to the Ministers of the Environment and Health. The Base Metals Smelting Sector Issue Table held 10 meetings between May 1996 and February 1997.[22] Environment Canada's objective in this exercise was to consider options to reduce releases and the adverse environmental impacts of the toxic substances in question.

21 Environment Canada, *Canadian Environmental Protection Act, 1999, List of Toxic Substances* (www.ec.gc.ca/CEPARegistry/subs_list/toxiclist.cfm).

22 Environment Canada, *Strategic Options for the Management of Toxic Substances from the Base Metals Smelting Sector, Report of Stakeholder Consultations*, June 23, 1997.

Similarly, the goal of Health Canada in this undertaking was to minimize health risks by examining means to reduce human exposure to these substances.

The Strategic Options Process culminated in the development of a Strategic Options Report that reported on stakeholder consultations. The Strategic Options Report for the base metals smelting sector advanced recommendations for the following:[23]

- the reduction of toxic substances, with specific targets and timelines for achievement;
- the development of environmental standards;
- the development of site-specific environmental management plans;
- consistent data and reporting, with independent verification, by base metals smelting facilities;
- federal–provincial/territorial cooperation to avoid duplication;
- enhancing opportunities for recycling and for increasing the recyclability of products produced by the base metals smelting sector;
- testing of releases for dioxins and furans;
- research and development to characterize releases and to identify and develop pollution prevention opportunities and technologies;
- establishing ongoing public education and community programs; and
- a public review, conducted by the Ministers of the Environment and Health, to assess the implementation and effectiveness of the Strategic Options Report.

1.1 SECTOR DESCRIPTION

The base metals smelting and refining sector includes producers of primary copper, primary and secondary lead, primary zinc, primary nickel, and primary cobalt. "Producers" of primary base metals and secondary lead include both smelting and/or refining facilities. Secondary production of metals other than lead is not included in this sector for the purposes of this Environmental Code of Practice.

Table 1 indicates the amounts of refined metals that were produced in Canada in 2002.[24]

The non-ferrous smelting and refining portion of the Canadian mining industry employed 26 894 people in 1999 and, together with ferrous metals production, contributed some $4.648 billion to Canada's national Gross Domestic Product.[25] In 1998, Canada was the second largest producer of refined nickel and slab zinc in the world. Canada was also the third largest producer of cobalt metal and the seventh largest producer of both refined copper and refined lead.[26]

Production processes can include roasting, leaching, and electrolytic techniques. Figure 1 shows a simplified overview of the extraction and processing of base metals.

General descriptions of the major processes used in the production of copper, lead, zinc, nickel, and cobalt are provided in Section 2.0.

TABLE 1: REFINED METALS PRODUCTION IN CANADA (2002)

Metal	Production (tonnes)
Refined copper	495 140
Refined lead (primary and secondary)	251 820
Slab zinc	793 475
Refined nickel	144 476
Cobalt metal	4 303

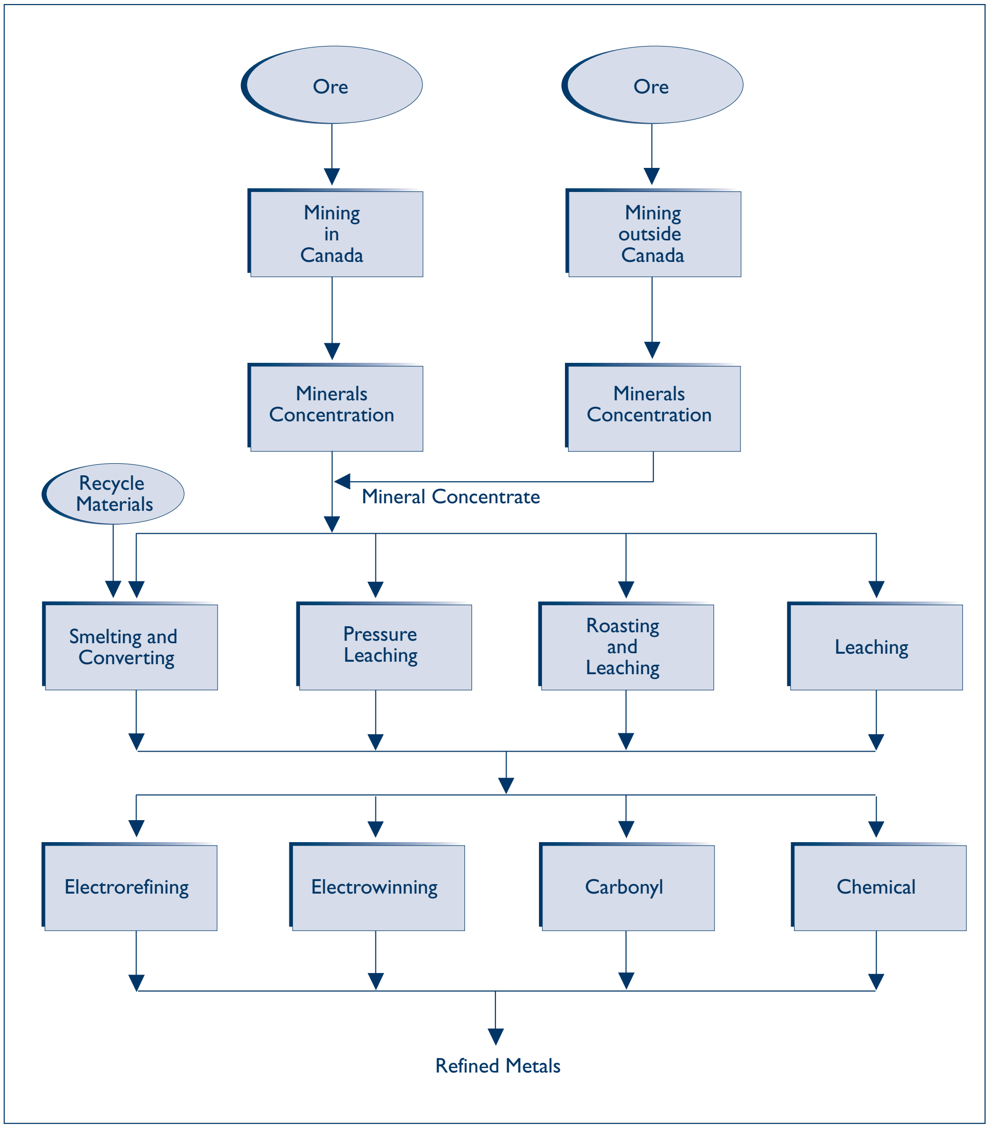
23 Ibid. pp. 9

24 Natural Resources Canada, Minerals and Metals Sector (http://mmsd1.mms.nrcan.gc.ca/mmsd/production/Table_4x.htm).

25 Mining Association of Canada, *It's a Fact: 1999 Facts and Figures*, Ottawa, 2000 (www.mining.ca).

26 Natural Resources Canada, Minerals and Metals Sector, *World Non-Ferrous Statistics 1989–1998*, Ottawa, October 1999.

FIGURE 1: PROCESS OVERVIEW FOR THE EXTRACTION AND PROCESSING OF BASE METALS[27]



1.2 CODE OBJECTIVES

The overall objectives of the Environmental Code of Practice are to identify and promote recommended practices as requirements for new facilities and as goals for continual improvements for existing facilities.

1.3 CODE STRUCTURE

The Code describes operational activities (Section 2.0) and related environmental concerns, such as atmospheric releases, wastewater discharges, and waste management, from each of the manufacturing activities described (Section 3.0). This is followed by a section on recommended environmental protection practices and mitigative measures for activities of potential adverse environmental effect (Section 4.0).

27 Reproduced from Hatch Associates Ltd., *Environmental Management Plan Guidance Document for the Base Metals Smelting Sector,* prepared for Environment Canada, March 14, 2001.

1.4 CODE SCOPE

The Environmental Code of Practice for Base Metals Smelters and Refineries outlines environmental concerns associated with the operational activities typical to the sector. To mitigate these concerns, recommendations for environmental performance are presented. The Code also contains recommended measures to prevent or mitigate adverse effects on the environment that could result from the activities of the sector.

The recommended practices in the Code include guidance for environmental management systems and guidelines for environmental releases to air, water, and land, based on best available techniques for pollution prevention and control.

Although the recommendations are intended to be clear and specific to the intended results, they are not intended to discourage the use of alternative technologies and practices that can achieve an equivalent or better level of environmental protection.

The Code does not have the force of law, and, therefore, it is not a substitute for existing regulatory requirements of the municipal, provincial/territorial, and federal authorities. Commitment by companies to conform to the Code recommendations does not remove obligations to comply with all applicable statutory and regulatory requirements.

1.5 CODE DEVELOPMENT

The Code was developed in consultation with a Base metals Environmental Multistakeholder Advisory Group (BEMAG).

Federal, provincial/territorial, and international environmental criteria of relevance to the operation of smelters and refineries were considered in the development of the recommendations in the Code. Environmental management practices recommended by various national and international organizations were also incorporated. Sources of standards-related information include environmental agencies in the European Union and Japan, the World Bank Group, and the United Nations Economic Commission for Europe. Information on best management practices was drawn from various reports and literature produced by provinces/territories, Environment Canada, the Canadian Council of Ministers of the Environment, the United States Environmental Protection Agency, the United Nations Environment Programme, the World Bank Group, and the Mining Association of Canada, as well as from individual smelters and refineries and technical journals.

1.6 CODE IMPLEMENTATION

Options for the recommended use and implementation of the Code include:

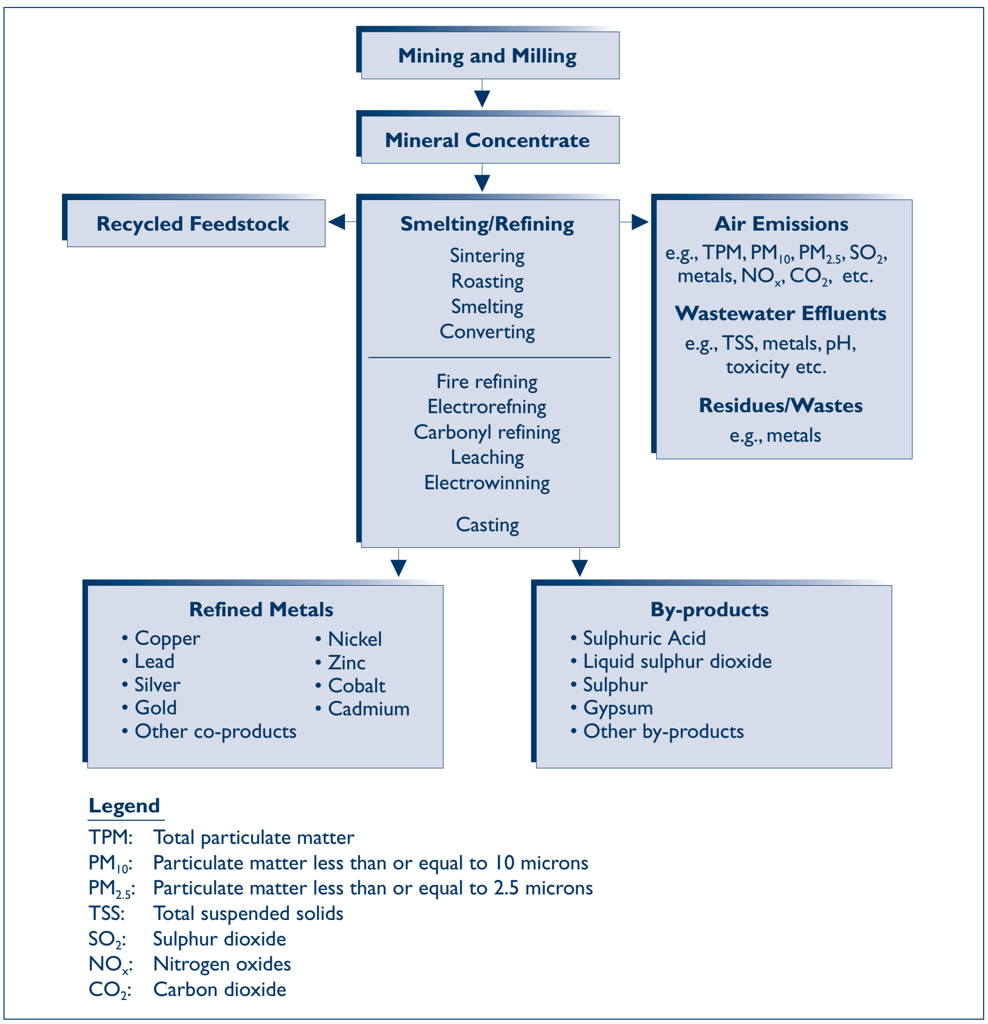
- voluntary adoption by a corporation and/or facility;
- use as performance benchmarks for environmental audits;
- use as a benchmark for public corporate commitments and performance reporting;
- inclusion as a commitment in an environmental performance agreement between a corporation and/or facility and government bodies responsible for environmental protection or pollution prevention;
- inclusion of some or all of the Code recommendations as requirements by financial lending institutions and/or insurance companies or underwriters;
- inclusion of some or all of the Code recommendations as regulatory requirements at the federal, provincial, territorial, municipal or aboriginal government level.

2 OPERATIONAL ACTIVITIES

This section describes the major activities involved in the operation of base metals smelters and refineries. It is not intended to be an all-inclusive list of operational activities of potential environmental significance, nor are all activities and techniques necessarily applicable to all base metals smelters and refineries. Rather, the intent is to identify the nature and scope of activities addressed in the Code with emphasis on those activities that relate to the possible adverse environmental impacts and to the mitigative measures that are discussed in Sections 3.0 and 4.0.

The main processes and common techniques involved in the extraction and refining of base metals generally proceed as shown in Figure 2.

FIGURE 2: PROCESSES INVOLVED IN THE EXTRACTION AND REFINING OF BASE METALS[28]



28 Adapted from Environment Canada, *Strategic Options for the Management of Toxic Substances from the Base Metals Smelting Sector, Report of Stakeholder Consultations*, June 23, 1997.

The key metal recovery technologies that are used to produce refined metals are:

(i) *Pyrometallurgical* technologies, which separate desired metals from other less desirable or undesirable materials in the molten state at very high temperatures. These processes capitalize on the differences between constituent oxidation potential, melting point, vapour pressure, density, and/or miscibility when melted.

(ii) *Hydrometallurgical* technologies, which differ from pyrometallurgical processes in that the desired metals are separated from undesirables using techniques that capitalize on differences between constituent solubilities and/or electrochemical properties in acid or basic solutions at temperatures generally below 300°C.

(iii) *Vapo-metallurgical* technologies, which apply to the Inco Carbonyl Process, whereby nickel alloys are treated with carbon monoxide gas to form nickel carbonyl.

Sulphur dioxide can be captured during pyrometallurgical processing and recovered as sulphuric acid.

Primary smelting and refining processes produce metals directly from ores, while secondary smelting and refining processes produce metals from scrap and process wastes. Most primary smelters have the technical capability to supplement primary feed with recyclable materials. Several have done so. Examples of scrap feedstock include post-consumer goods, such as telephone and computer components, metal parts, bars, turnings, sheets, and wire that is off-specification or worn out. Lead has the largest and most developed recycling component, resulting primarily from the relatively short product life of lead acid batteries and the relative ease with which batteries can be segregated at source for collection and recycling.

Base metals include copper, lead, nickel and zinc. Depending upon the origin of the ore or scrap metal and its residual metals content, various metals, such as gold, silver, indium, germanium, cadmium, bismuth, and selenium, may be recovered as co-products. A general overview of the major processes currently employed by the base metals smelting sector is given in this section. Canadian site-specific flow sheets and process descriptions for existing facilities can be found in the report *Review of Environmental Releases for the Base Metals Smelting Sector*, prepared for Environment Canada by Hatch Associates Ltd. and dated November 3, 2000.

2.1 PRETREATMENT

Pretreatment of feed materials includes drying of slurry concentrates, milling, sorting and separation of scrap material, and feed proportioning. Pretreatment is conducted to ensure that feeds are in appropriate condition and proportions for initial processing.

2.2 ROASTING

Roasting is the conventional technique used in the pyrometallurgical processing of copper, nickel, and zinc sulphide concentrates. During roasting, the sulphur is removed by adding air and simultaneously heating and drying the concentrate to achieve sulphur content favourable for smelting. The sulphur is released as sulphur dioxide. Roasting to completion eliminates the sulphur and produces the metal oxide for reduction by carbon or carbon monoxide or for leaching in a sulphuric acid solution followed by electrowinning. Incomplete roasting is used to remove excess sulphur in copper and nickel sulphides in preparation for the matte smelting process. The sulphur dioxide in the process off-gas is usually recovered as sulphuric acid or, sometimes, liquefied sulphur dioxide.

2.3 SMELTING

Smelting serves two functions: first, to melt the concentrates to a molten state, and second, to separate the metal of value from other less desirable metals, impurities, and gangue materials.

Concentrates are fed to the furnace along with fluxing agents, fuel (oil, natural gas), and oxygen (in the form of air, pure oxygen, or oxygen-enriched air). High temperatures from combustion and oxidation in the smelting furnace cause the feed materials to melt. Separation of the metal of value from other impurities and gangue materials occurs through fluxing, where the siliceous fluxing agent forms a silica–iron–sulphur slag. Some impurities (e.g., sulphur, some metal compounds) are also separated from the metal of value through oxidation and volatilization.

The resulting product from a smelter is a molten matte or bullion containing a high concentration of the metal of value.

Layers of matte or bullion and slag are tapped from the furnace, or, in the case of continuous processes (e.g., Mitsubishi process), the materials travel through covered gravity-flow launders to the next processing stage. Primary and secondary releases of process off-gases are captured through direct ductwork from the furnace and/or overhead canopies. The collected off-gases are treated by a gas conditioning system, which may include removal of sulphur dioxide, particulate matter, fume, etc. Smelter slags are treated or "cleaned" to recover any remaining metal of value.[29]

2.4 CONVERTING

Converting is used primarily for copper and nickel matte processing and serves to remove residual sulphur and iron in the matte from the smelter. Converters also have the capability of processing high-grade scrap materials. Both continuous and batch converting processes are used in Canada. Air or oxygen-enriched air is blown through the matte, generating off-gases containing sulphur dioxide and volatile metals such as lead and zinc. Continuous converting allows for better capture of process off-gases and a consistent and/or higher concentration of sulphur dioxide, enabling capture of the sulphur dioxide through the production of sulphuric acid. Converting produces blister copper, named for the blisters of air/oxygen trapped in the molten material. Slag from the converter typically has a high copper concentration and can be returned to the smelting furnace for recovery of the copper.

2.5 FIRE REFINING (ANODE REFINING)

Prior to final casting or electrorefining, impurities must be further removed from metals. This process is sometimes used in the production of copper in Canada. Fire refining lowers the sulphur and oxygen levels in blister copper and removes the impurities as slag or volatile products. Reverberatory or rotary furnaces are used. First, air is blown through the molten mixture to oxidize the copper and volatilize the sulphur impurities, producing a small amount of slag. Sodium carbonate flux may be added to remove arsenic and antimony. Then the copper is reduced by a process known as "poling" with green wood poles or by feeding ammonia or natural gas to remove the oxygen, forming the purer copper to be cast as anodes.

2.6 ELECTROREFINING

Electrorefining produces a purified metal from a less pure metal. This process is used to refine copper, nickel, and lead in Canada. The metal to be purified is cast as an anode and placed in an electrolytic cell. A current is applied, and the metal is dissolved into an acidic aqueous electrolyte or molten salt. The pure metal is electroplated or deposited on the starter plates, which act as the cathodes. Metallic impurities either dissolve in the electrolyte or precipitate out and form a sludge. These anode slimes contain precious metals such as silver, gold, and tellurium and are recovered. The cathode deposits are washed, then cast into bars, ingots, or slabs for sale.

2.7 CARBONYL REFINING

The carbonyl process is used for refining crude nickel oxide. Carbon monoxide and the crude nickel react to form nickel carbonyl at high pressure. The volatile and highly toxic nickel carbonyl is refined by separation of solid impurities. With further heating, the carbon monoxide separates, and high-purity nickel powder or pellets are formed. The solid impurities contain copper and precious metals, which are recovered. The generated carbon monoxide off-gases are recycled back to the process.

2.8 LEACHING

Leaching requires the use of an acid or other solvent to dissolve the metal content of ores and concentrates before refining and electrowinning. Leaching is usually conducted using material in the form of an oxide, either an oxidic ore or an oxide produced by roasting. Sulphidic ores can also be leached, but require conditions that promote oxidation of the ore or concentrate, such as high pressure, presence of bacteria, and/or the addition of oxygen, chlorine, or ferric chloride. The pregnant leach solution is processed by solvent extraction and is purified. The purified solution is then used for electrowinning and refining of the metal.

2.9 ELECTROWINNING

Electrowinning is used to capture metal dissolved in the pregnant solution produced during leaching (purified electrolyte). Electrowinning is used for refining zinc, copper, nickel, and cobalt in Canada. The process

29 European Integrated Pollution Prevention and Control Bureau, *Reference Document on Best Available Techniques in the Non Ferrous Metals Industries*, Seville, Spain, May 2000 (http://eippcb.jrc.es).

is conducted in tank houses, with electrolytic cells containing the purified electrolyte, inert anodes, and starter cathodes of the pure metal (for copper refining) or permanent cathodes of stainless steel or aluminum. Electric current is passed through the cell, and the dissolved metal ions (metal of value) are deposited onto the cathode. Oxygen gas, acid mist, and spent electrolyte (acid) are generated through the electrowinning process. The spent electrolyte is returned to the leaching process. After a sufficient time lapse, the cathodes are removed. Either the cathodes are sold directly or the metal is stripped from the cathode, melted, and cast.

2.10 CASTING

The casting process involves melting the metal and passing it through a holding furnace and into the caster, where billets, blocks, slabs or cakes, and rods are produced. Casting can be done continuously or in batches. Stationary casting uses a casting wheel with a series of moulds, which can be on the circumference of a rotating table that passes through a series of cooling water jets. Continuous casting involves the production of a continuous bar or rod for reduction to wire. The bar or rod is cut into shape using shears or by casting in special side dam blocks spaced in defined intervals in the caster. The billets can be heated, then extruded and drawn into tubes. Slabs or cakes are preheated and rolled into sheets and strips. Ingots are produced using a fixed mould casting process.

2.11 PROCESS OFF-GAS CONDITIONING

Off-gases from smelting facilities typically contain sulphur dioxide, particulate matter, fume (e.g., volatile metals), and other pollutants of concern, such as carbon dioxide, nitrogen oxides, and organics. Off-gases are treated to remove sulphur dioxide, particulate matter, and/or other pollutants before being released to ambient air.

For removal of particulate matter and dust, cyclones are used to remove medium- to large-sized particles. Cyclones are not considered sufficient control devices on their own to remove particulate matter. Other control devices with greater dust removal efficiencies include electrostatic precipitators, either hot or wet, and fabric filter baghouses. Hot electrostatic precipitators can withstand higher off-gas temperatures than fabric filter baghouses. However, baghouses can achieve greater dust collection efficiencies than hot electrostatic precipitators.[30] Scrubbers are also used to remove both dust and soluble or acidic gases from the off-gas stream.

Process off-gases with a minimum sulphur dioxide concentration of 5–7% can be used for the manufacture of sulphuric acid and thus can remove the sulphur dioxide from the off-gas stream. Double-contact acid plants are able to achieve a higher rate of conversion of sulphur dioxide in the process off-gas to sulphuric acid compared with single-contact acid plants.

30 Ibid. pp. 15 (http://eippcb.jrc.es).

3 ENVIRONMENTAL CONCERNS

This section presents an overview of environmental concerns related to the major activities and processes used in the smelting and refining of base metals. Typical preventative and control measures taken in modern systems are indicated.

3.1 ROASTING

Sulphur dioxide and particulate matter are the principal air contaminants generated during roasting of the concentrates. The sulphur dioxide can be recovered at on-site sulphuric acid plants if the type of roaster used generates a high enough concentration of sulphur dioxide in the off-gas. Otherwise, the roaster off-gases are cleaned in electrostatic precipitators and then released to the atmosphere via a stack. Fluid bed roasters, waste heat boilers, cyclones, and scrubbers may also be used to treat off-gases. Metals that may be present in the particulate matter include copper and iron oxides, arsenic, cadmium, lead, mercury, and zinc.

3.2 SMELTING

The major environmental concerns associated with smelting are energy consumption, releases of sulphur dioxide and particulate matter to air, and the generation of residues, such as slag and captured dust.

Bath smelting consumes more energy than alternative processes such as flash smelting. Flash smelting makes use of the autogenous reaction between sulphur and oxygen to fuel the smelting process, thus requiring less fuel and energy than bath smelting. Taking primary copper production as an example, bath smelting has energy requirements ranging from 35 to 47 gigajoules per tonne (GJ/tonne) of cathode copper produced.[31] Flash smelting has been reported to have energy requirements of approximately 23 GJ/tonne of cathode copper produced, which is about half of the energy required for bath smelting.[32]

Releases of sulphur oxides, including sulphur dioxide, are a significant environmental concern for primary smelters. Sulphur in the concentrate feed that does not remain in the slag, matte, or bullion is oxidized to form sulphur dioxide. Smelter off-gases containing a sulphur dioxide concentration of 5–7% or higher can be used for the manufacture of sulphuric acid. Flash smelting generates higher percentages of sulphur dioxide in the off-gases compared with bath smelting, and both flash smelting and continuous processes allow for better collection of the off-gases, producing a consistent concentration of sulphur dioxide in the off-gas, which is ideal for the production of sulphuric acid.

Smelter off-gases also contain particulate matter, organics, and volatile metals, such as mercury.

Slag from the smelting process is also an environmental concern. In general, smelter slags may not contain a high enough concentration of the metal of value to be returned to the smelter. Slags are typically cleaned to recover the remaining metal of value and are then disposed of in landfills or tailings ponds. Cleaned slags have been used as aggregate in the construction industry or as an abrasive for sandblasting.

3.3 CONVERTING

Off-gases from the converter require treatment to remove sulphur dioxide, dust or particulate matter, and fume prior to discharge to ambient air. Off-gases from batch converters are high in volume and low in sulphur dioxide. With these characteristics, the off-gas may be unsuitable as a feed for acid plants. Therefore, it is often conditioned to remove particulate matter and then vented to ambient air. However, continuous converting produces a more consistent and higher concentration of sulphur dioxide in the off-gases than batch converting, and the off-gases are suitable for acid production/sulphur fixation.[33]

Slag generated during the converting process is often returned to the smelter to recover metals.

31 World Bank Group, *Pollution Prevention and Abatement Handbook 1998: Toward Cleaner Production*, July 1998 (http://lnweb18.worldbank.org/ESSD/envext.nsf/51ByDocName/PollutionPreventionandAbatementHandbook).

32 Ibid.

33 European Integrated Pollution Prevention and Control Bureau, *Reference Document on Best Available Techniques in the Non Ferrous Metals Industries*, Seville, Spain, May 2000 (http://eippcb.jrc.es).

3.4 FIRE REFINING

Air releases of nitrogen oxides, particulate matter, and metals arise from the fire-refining process.

Fugitive emissions are generated during the charging and discharging of the anode furnaces. These may be collected with a secondary hood or an enclosure around the furnace with a small opening.

Slag produced from the anode furnace is minor in amount and can be recycled within the plant.

3.5 ELECTROREFINING

Electrolytic refining does not produce releases to the atmosphere unless the associated sulphuric acid tanks are open to the atmosphere. However, spent electrolyte and wash water contain significant quantities of metal compounds in solution and are treated before discharge to water. The metal compounds that are deposited at the bottom of the electrolytic cell during the electrorefining process (i.e. the impurities) form what is known as anode slime. The slimes are collected and processed to extract precious metals, such as silver, gold, and tellurium.

3.6 CARBONYL REFINING

Carbonyl refining produces gas bleed streams that contain waste nickel carbonyl, a highly toxic substance. Incinerators should be used to convert the nickel carbonyl to nickel oxide and carbon dioxide. Particulate matter may be released from the transfer of nickel oxide concentrate, from the drying of solids recovered from the aqueous effluent, and from local exhaust ventilation gases. Electrostatic precipitators are typically used for dust abatement, since inlet temperatures are too high for fabric filters. The collected dust may be sluiced with water on discharge and may be dried and recovered for recycling.

3.7 LEACHING

A significant environmental issue arising from the leaching process is the generation of ferrite residues. These iron-based residues contain various concentrations of heavy metals and present a risk to the environment by the gradual leaching of heavy metals from the residue material. Residues generated during the leaching process may be landfilled or stored in a secure site, stabilized to immobilize the metals, or sent to another process for recovery of remaining metals of value.

3.8 ELECTROWINNING

As electrowinning takes place in tank houses open to the atmosphere, oxygen or other gases generated during the electrowinning process can entrain the acid or other solvent into the air.

3.9 CASTING

Air releases of particulate matter and metals arise from the transfer of molten metal to the mould and from the cutting to length of the product with torches. Wastewater effluents are generated during the cooling and cleaning of the hot metal and can contain scale particles and oil. Wastewater is typically treated and reused or recycled. Solid waste is generated from the cutting of the metal but is minor in amount and is recycled within the plant.

3.10 PROCESS OFF-GAS CONDITIONING

Process off-gas conditioning generates collected dusts and sludges, which are either returned to production processes for recovery of metals or disposed of. The type of off-gas conditioning technology may also be of environmental concern. In some cases, there is a potential that the use of wet electrostatic precipitators and wet scrubbers could result in the cross-media transfer of pollutants.

4 RECOMMENDED ENVIRONMENTAL PROTECTION PRACTICES

This section presents recommended mitigative measures for activities of potential environmental concern. These recommendations were derived from regulatory and non-regulatory standards, in particular on environmental practices, published by various agencies and organizations.

The overall objectives of the Code are to identify and promote recommended practices as requirements for new facilities and as goals for continual improvements for existing facilities.

Application of the recommendations to individual facilities may involve practices that are not mentioned in this Code but that may achieve an equivalent or better level of environmental protection.

Site-specific municipal, provincial/territorial, federal, and legal requirements must be taken into account where they exist. Recommendations that are not legally binding or conditions set down by insurance companies or financial, lending institutions, may also be applicable.

For some of the recommendations presented, following explanatory text is provided.

4.1 ENVIRONMENTAL MANAGEMENT SYSTEMS

In the context of this Code of Practice, the term 'environmental management systems' is used to capture an organized set of activities, actions, processes, and procedures that go beyond legal requirements in helping to ensure that facilities have minimal adverse impact on the environment in which they operate. The effective development and implementation of environmental management systems should also facilitate efforts to achieve continual improvement in the overall environmental performance of base metals smelters and refineries.

The recommendations presented in this section take into account policies, principles, and commitments advanced by Environment Canada, the Canadian Council of Ministers of the Environment, provinces/territories, the Mining Association of Canada, and other organizations.

4.1.1 Environmental Policy Statement

***RECOMMENDATION* R 101**

Each company should develop and implement an environmental policy statement.

The policy should relay that protection of the environment is a top organizational priority and that commitment to continual improvement of environmental performance and compliance with laws and regulations are the guiding principles of the organization.

4.1.2 Environmental Management Systems

***RECOMMENDATION* R 102**

Each facility should develop, implement, and maintain an environmental management system in accordance with ISO 14001[34] or an equivalent standard or system.

The management system should, among other things, ensure a process of continual improvement as well as compliance with environmental regulations and voluntary commitments.

34 Canadian Standards Association, *Environmental Management Systems — Specification with Guidance for Use*, CAN/CSA-ISO 14001-96, 1996.

4.1.3 Environmental Management Plans

RECOMMENDATION R 103

Each facility should develop and implement a site-specific environmental management plan, consistent with the *Environmental Management Plan Guidance Document for the Base Metals Smelting Sector*.[35] The plan should include, as a minimum, the following:

(i) company and site information;

(ii) environmental policy statement;

(iii) environmental performance requirements;

(iv) air quality management systems;

(v) water quality management systems;

(vi) solids management systems;

(vii) land management systems;

(viii) pollution prevention planning;

(ix) emissions reduction options, targets, and schedules;

(x) environmental management systems and auditing;

(xi) community relationships;

(xii) communication procedures; and

(xiii) periodic environmental management plan review for effectiveness and continual improvement.

4.1.4 Environmental Assessment

RECOMMENDATION R 104

Environmental assessment principles should be followed by companies for new and significantly modified or expanded facilities, consistent with the Canadian Environmental Assessment Agency Reference Guide,[36] Table 1.

The development of new facilities and changes to existing facilities that could significantly increase releases to the environment should be subjected to an environmental assessment process, with the aim of identifying potential problems and formulating solutions that address them.

Companies should follow assessment principles consistent with Table 1 in the Reference Guide of the Canadian Environmental Assessment Agency when conducting the assessment. The environmental assessment process should also comply with all other applicable provincial/territorial and municipal requirements, should be initiated during the early stages of pre-project planning, and should continue as an iterative process through the project design, construction, and operations phases. Consideration should be given to potential impacts on air quality, water quality, water supply and use, land use, flora and fauna, and local infrastructure.

4.1.5 Pollution Prevention Planning

RECOMMENDATION R 105

Each facility should develop and implement a pollution prevention plan, consistent with Environment Canada's *Pollution Prevention Planning Handbook*[37] or in compliance with any Pollution Prevention Plan Notification issued under the *Canadian Environmental Protection Act, 1999*.

The intention of prevention is to eliminate the root cause of pollution, rather than treating the symptoms. For example, pollution prevention relies on source reduction to address inefficiencies in the production of goods and services at their source, resulting in reduced waste and releases. Thus, pollution prevention planning is a systematic comprehensive method of identifying options to minimize or avoid the creation of pollutants and waste.

35 Hatch Associates Ltd., *Environmental Management Plan Guidance Document for the Base Metals Smelting Sector*, prepared for Environment Canada, March 14, 2001.

36 Canadian Environmental Assessment Agency, *Reference Guide: Determining Whether a Project is Likely to Cause Significant Adverse Environmental Effects* (www.ceaa-acee.gc.ca/013/0001/0008/guide3_e.htm#Reference%20Guide).

37 Environment Canada, *Pollution Prevention Planning Handbook*, 2001 (www.ec.gc.ca/CEPARegistry/plans/p2).

4.1.6 Emergency Planning

RECOMMENDATION R 106

Each facility should develop and make publicly available an environmental emergency plan, consistent with Environment Canada's *Implementation Guidelines for Part 8 of the Canadian Environmental Protection Act, 1999* — Environmental Emergency Plans.[38]

Existing emergency response plans can be modified or used as is, if they are consistent with the recommendations spelled out in the above guideline. An effective plan would address, among other things, aspects of prevention, preparedness, response, and recovery for an uncontrolled, unplanned, or accidental release of a toxic substance or hazardous substance in the facility. Companies should review their hazardous chemicals and storage facilities and develop an environmental emergency plan. They should also verify if the Environmental Emergency Regulations under CEPA 1999 apply to any of the substances on their premises and if the laws of other jurisdictions (such as provinces and municipalities) may also apply.

4.1.7 Decommissioning Planning

RECOMMENDATION R 107

A facility should begin planning for decommissioning in the design stage of the project life cycle for new facilities and as early as possible in the operating stage for existing facilities. Site closures and associated decommissioning activities should be undertaken by the facility, consistent with the *National Guidelines for Decommissioning Industrial Sites*.[39]

This could help to identify areas of the facility whose closure or decommissioning may cause an environmental problem. This could also help to implement operational procedures and management practices that could prevent or reduce site contamination. Decommissioning should be carried out in a way that ensures that no or limited adverse risk to the environment or human health remains after closure.

4.1.8 Environmental Training

RECOMMENDATION R 108

Each facility should establish and maintain procedures to identify its environmental training needs and ensure that all personnel who work in areas that may create a significant adverse impact upon the environment have received training.

The facility should also require that contractors working on its behalf are able to demonstrate that their employees have appropriate training so that they can avoid adverse impacts on the environment as a result of their activities. The environmental training program should include:

(i) a list by job title or classification of all personnel who require training; and

(ii) an outline of the topics to be covered, the training methods to be used, and the required frequency of refresher training for each group of personnel.

4.1.9 Environmental Facility Inspection

RECOMMENDATION R 109

Each facility should develop and implement an environmental inspection plan.

The plan could include:

(i) documented procedures for the inspection of each environmental facility, including air emission control equipment; wastewater treatment facilities; liquid handling, storage, and containment facilities; waste handling, storage, and containment facilities; and air emission and wastewater monitoring and control instrumentation;

(ii) visual observations of, or procedures for detecting air release excursions and liquid leaks;

(iii) a documented schedule for inspections, including timing of inspections and identification of a responsibility centre for carrying out the inspection and for correcting any deficiencies identified during the inspection;

38 Environment Canada, *Implementation Guidelines for Part 8 of the Canadian Environmental Protection Act, 1999, Environmental Emergency Plans*, September 2003, ISBN 0-662-33797-2 (www.ec.gc.ca/CEPARegistry/guidelines/impl_guid/toc.cfm).

39 Canadian Council of Ministers of the Environment, *National Guidelines for Decommissioning Industrial Sites*, Report No. CCME-TS/WM-TRE013E, March 1991, ISBN 0-662-18705-9.

(iv) documented procedures for the reporting of inspection results to both internal management and external agencies; and

(v) documented procedures for follow-up to inspection reports.

Facilities should train staff to undertake the environmental inspections.

4.1.10 Environmental Auditing

RECOMMENDATION R 110

Each facility should conduct periodic environmental audits by internal, corporate, or third-party auditors.

The audit should be conducted throughout the operating life of the facility as a means of assessing environmental risk, ensuring conformance with regulatory, appropriate non-regulatory, and corporate requirements, and identifying opportunities for improving environmental performance. The audit could be conducted internally or by corporate or third-party auditors. The recommendations advanced in this Code of Practice should be included in the audit criteria.

4.1.11 Environmental Performance Indicators

RECOMMENDATION R 111

Each facility should develop a set of environmental performance indicators that can provide an overall measure of the facility's environmental performance.

These indicators would include a broad and practical set of ecological and economic elements that offer significant opportunities to link environmental performance to financial performance. An example of an environmental performance indicator is expressing pollutant emissions in kilograms per tonne of product manufactured, such as kilograms of sulphur dioxide per tonne of copper.

4.1.12 Product Stewardship

RECOMMENDATION R 112

Each company should develop and implement a product stewardship program aimed at minimizing the environmental impacts associated with the products used and produced by the facility and under the control of the company.

Under this program, the company takes full responsibility for the environmental impacts associated with the operational, use, and handling aspects of the products used and produced by its facilities, at every stage of each product's life cycle that is under the direct control of the company.

The management program may include consideration of:

(i) types of materials used;

(ii) sources of supply of materials;

(iii) sources of energy used;

(iv) type and amount of packaging; and

(v) management of manufacturing by-products and wastes.

4.1.13 Public Reporting

RECOMMENDATION R 113

Documented procedures for the monitoring and reporting of environmental performance to the public should be developed and implemented by the facility, consistent with the *Guidance Document for Reporting Releases from the Base Metals Smelting Sector*[40] and taking into account the Global Reporting Initiative's *Sustainability Reporting Guidelines*[41] for the mining and metals sector.

40 Hatch Associates Ltd., *Guidance Document for Reporting Releases from the Base Metals Smelting Sector,* prepared for Environment Canada, October 2001.

41 Global Reporting Initiative, *Sustainability Reporting Guidelines*, 2002, GRI Mining and Metals Sector Supplement, Pilot Version 1.0, February 2005 (www.globalreporting.org/guidelines/sectors/mining.asp).

4.1.14 Community Advisory Panel

RECOMMENDATION R 114

Each facility should establish a Community Advisory Panel with representatives from the surrounding community, in order to provide a forum for the review and discussion of facility operations and associated environmental and other concerns.

The objective of the forum should be to address community concerns related to the potential adverse environmental, health, and safety impacts that may arise as a result of the operational activities of the facility. The forum should be used, among other things, to provide opportunity to the community to raise issues of concern, if any, to discuss topics important to them, to obtain information and/or clarification on issues of concern, and also to offer input or advice to the company on those issues. Issues of concern could be site-specific or general concerns regarding, for example, emergency planning, release levels, risk assessment, etc.

The Panel would typically be an advisory group and not a decision-making body.

4.2 ATMOSPHERIC RELEASES MANAGEMENT

4.2.1 Prevention and Control of Fugitive Air Emissions

RECOMMENDATION R 201

Each facility should identify potential sources of fugitive emissions and should prevent or control those emissions through the use of appropriate mitigative measures. These sources may include unpaved roads, storage piles, material conveyance systems, waste disposal piles, and leaks from processes and buildings.

To prevent fugitive emissions and minimize losses, it is essential to implement good housekeeping and best environmental practices. These would, for example, include enclosure of process equipment, use of covered or enclosed conveyors and transfer points, implementation of Leak Detection and Repair programs, covering of major stockpiles, spray coating of smaller and temporary stockpiles, and paving of yards.

4.2.2 Collection and Control of Process Air Emissions

RECOMMENDATION R 202

Each facility should ensure that air pollution control equipment is adequately sized, designed, constructed, operated, and maintained to contain and control pollutant releases to ambient air from all plant processes.

Air pollution control equipment designed on the basis of sound engineering considerations should be able to maintain control of releases to the ambient air from all operational sources and at different operational conditions, including in the event of operational upsets.

4.2.3 Total Particulate Matter Emissions Guidelines

RECOMMENDATION R 203

Each facility should be designed and operated to achieve the following recommended release concentrations for total particulate matter after the emission control device of less than 50 mg/Nm^3.

Emission testing should be carried out in a manner that is consistent with Environment Canada's *Guidance Document for Reporting Releases from the Base Metals Smelting Sector*[42] or with *Reference Methods for Source Testing: Measurement of Releases of Particulate from Stationary Sources*,[43] as amended from time to time.

In cases where a fabric filter emission control system does not have a stack, emission testing should be carried out in a manner that is consistent with the U.S. Environmental

42 Hatch Associates Ltd., *Guidance Document for Reporting Releases from the Base Metals Smelting Sector*, prepared for Environment Canada, October 2001.

43 Environment Canada, *Reference Methods for Source Testing: Measurement of Releases of Particulate from Stationary Sources*, Report EPS 1/RM/8, December 1993.

Protection Agency's *Method 5D: Determination of Particulate Matter Emissions from Positive Pressure Fabric Filters*.[44] It is recognized that particulate release estimates for facilities without stacks are typically less accurate than release estimates for facilities equipped with stacks and that relative accuracy must be taken into account in assessing the results of tests conducted in accordance with Method 5D.

4.2.4 Sulphur Fixation Guidelines

***RECOMMENDATION* R 204**

1. Each facility should consider use of low sulphur feed and recycled materials to reduce emissions of sulphur dioxide.
2. Each existing facility should be designed and operated to achieve a minimum sulphur fixation rate of 90% by a committed timetable.
3. Each new copper, lead and zinc smelter should be designed and operated to achieve a minimum sulphur fixation rate of 99%.
4. Each new nickel smelter should be designed and operated to achieve a minimum sulphur fixation rate of 96%.

Sulphur can be fixed in metallurgical processes by at least one of the following four processes:[45]

(i) sulphuric acid production;

(ii) gas scrubbing and gypsum production;

(iii) liquid sulphur dioxide manufacture; and

(iv) elemental sulphur production.

All of the processes benefit from high sulphur dioxide concentrations in the gas stream; however, the production of liquid sulphur dioxide and the production of elemental sulphur both require high sulphur dioxide concentrations. This can be achieved by using oxygen-enriched air in the process. The production of sulphuric acid is the most widely used, because it is the easiest and least expensive sulphur fixation method, and the market for sulphuric acid is generally much larger than that for the other products.[46]

The sulphur fixation values can be calculated in accordance with the methodology applied by Hatch Associates Ltd.[47]

4.2.5 Mercury Emissions Guidelines

***RECOMMENDATION* R 205**

1. Each existing facility should be designed and operated to limit air release loadings to less than 2 grams of mercury per tonne of finished product.
2. Each new or expanded facility should be designed and operated to limit air release loadings in accordance with the following:
   (a) less than 0.2 grams of mercury per tonne production of finished zinc, nickel, and lead; and
   (b) less than 1 gram of mercury per tonne production of finished copper.

Numerical targets set for the release of mercury from base metals smelters, under the Canada-wide Standards (see Appendix A), are as follows:

(i) For existing facilities: application by all primary zinc, lead, and copper smelters of best available pollution prevention and control techniques economically achievable to achieve an environmental source performance (atmospheric emission) guideline of 2 grams of mercury per tonne total production of finished metals.

(ii) For new and expanding facilities: application of best available pollution prevention and control techniques to minimize mercury emissions throughout the life cycle of the minerals in question to achieve an environmental source performance (atmospheric emission) guideline of 0.2 gram of mercury per tonne production of finished zinc, nickel, and lead and 1 gram of mercury per tonne production of finished copper, and consideration of a mercury offset program to ensure that no "net" emission increases occur.

(iii) Existing facilities will be expected to make a determined effort to meet this standard by 2008, coincident with implementation of the federal Strategic Options Report, while any new facility will be required to design for and achieve compliance immediately upon full-scale operation.[48]

44 U.S. Environmental Protection Agency, *Method 5D: Determination of Releases of Particulate from Positive Pressure Fabric Filters*, Federal Register, CFR 40 Part 60, Appendix A, pp. 647–651, January 7, 1996.

45 Riekkola-Vanhanen, M., *Finnish Expert Report on Best Available Techniques in Nickel Production*, Finnish Environment Institute, Helsinki, 1999, ISBN 952-11-0507-0.

46 Ibid.

47 Hatch Associates Ltd., *Implementation Scenario for Proposed Emission Standards for Particulate Matter and Sulphur Dioxide for the Base Metal Smelting Sector*, December 2001.

48 Canadian Council of Ministers of the Environment, *Canada-wide Standards for Mercury Emissions*, pp. 4–5 (www.ccme.ca/assets/pdf/mercury_emis_std_e1.pdf).

4.2.6 Dioxins and Furans Emissions Guidelines

RECOMMENDATION R 206

1. Each existing facility should be designed and operated to limit release concentrations of dioxins and furans to less than 100 pg ITEQ*/Rm^3.
2. Each new facility should be designed and operated to limit release concentrations of dioxins and furans to less than 32 pg ITEQ*/Rm^3.

** ITEQ = International Toxicity Equivalency Quotient.*

Dioxins and furans are persistent, bioaccumulative and toxic substances. The federal *Toxics Substances Management Policy* and the Canadian Council of Ministers of Environment Policy on Management of Toxic Substances calls for the virtual elimination of such substances. An ultimate objective is to reduce the concentration of dioxins and furans in air emissions from base metal smelters to below the “level of quantification” which has been determined to be 32 pg/Rm^3.

4.2.7 Metals Emissions Limit Targets

RECOMMENDATION R 207

Each facility should develop facility emission reduction targets for and timetables to achieve reductions in releases of arsenic, cadmium, lead, nickel, mercury, and other metals of concern, taking into account facility emission reduction targets for sulphur dioxide and particulate matter, pollution prevention and control options, and performances for various feeds, smelting processes, and emission control systems.

4.2.8 Air Releases Reporting

RECOMMENDATION R 208

Each facility should measure or estimate and report releases, consistent with the *Guidance Document for Reporting Releases from the Base Metals Smelting Sector*[49] and in accordance with the notice requiring submission of data for the National Pollutant Release Inventory.[50]

4.2.9 Ambient Air Quality Objectives

RECOMMENDATION R 209

In addition to the source performance recommendations of R 203 and R 204, each facility should design and operate air emission prevention and control systems, taking into account local conditions and the following ambient air quality objectives, standards, criteria and guidelines:

National ambient air quality objectives are benchmarks to assess the impact of human activities on air quality and ensure that emission control policies are successfully protecting human health and the environment.

49 Hatch Associates Ltd., *Guidance Document for Reporting Releases from the Base Metals Smelting Sector*, prepared for Environment Canada, October 2001.

50 Environment Canada, National Pollutant Release Inventory (www.ec.gc.ca/pdb/npri/npri_home_e.cfm).

TABLE 2: AMBIENT AIR QUALITY OBJECTIVES

Pollutant		Averaging time				Notes
		1 hour	8 hours	24 hours	Annual	
Sulphur dioxide (SO_2) (µg/m³)	Desirable	450		150	30	1
	Acceptable	900		300	60	1
	Tolerable			800		1
WHO Guideline (SO_2) (µg/m³)				125	50	6
Total suspended particulate matter (TSP) (µg/m³)	Desirable	–		–	60	1
	Acceptable	–		120	70	1
	Tolerable	–		400	–	1
Particulate matter ($PM_{2.5}$) (µg/m³)	Reference level*			15		2
Ozone (O_3) (ppb)			65			2
Metals (µg/m³)						
- Arsenic				0.3		3
- Cadmium				2		4
- Lead				2		4
- Nickel		5.0				5

Notes:

1. Canadian Council of Ministers of the Environment, *Canadian Environmental Quality Objectives, Canadian National Ambient Air Quality Objectives: Appendix 1*, 1999.
2. Canadian Council of Ministers of the Environment, *Canada-wide Standards for Particulate Matter and Ozone*, June 5–6, 2000.
3. Ontario Ministry of the Environment's Ambient Air Quality Criteria for Arsenic and Its Compounds.
4. Ontario Regulation 337.
5. Ontario Regulation 346 Point of Impingement (POI) 30-minute average.
6. World Health Organization, *Air Quality Guidelines* (www.euro.who.int/document/aiq/7_4sulfurdioxide.pdf).

** Reference level is the level above which there are demonstrated effects on human health and/or the environment.*

Another management tool for establishing and estimating the magnitude of risk is the application of effects-based critical loads. A critical load may be defined as the amount of deposition required for contaminant levels to reach threshold effect values in receiving media when a "steady state" has been achieved.[51]

The critical load concept is used in developing emission control policies, as illustrated by the following applications:

(i) The Government of Canada has used it to evaluate the effectiveness of its acid rain strategy.

(ii) Environment Canada used it to evaluate the impacts of metal emissions from copper and zinc smelters.

(iii) The European Union is using the concept to develop strategies for the control of acidification and ozone. European policy-makers have proposed that critical loads for acid deposition should not be exceeded anywhere in Europe by the year 2015.[52]

(iv) The United Nations Economic Commission for Europe applied an effects-based approach such as the critical load concept in preparation for the 1994 Oslo Protocol on Further Reductions of Sulphur Emissions.[53]

51 Doyle, P.J., D.W. Gutzman, M.I. Sheppard, S.C. Sheppard, G.A. Bird, and D. Hrebenyk, An ecological risk assessment of air emissions of trace metals from copper and zinc production facilities, *Human and Ecological Risk Assessment*, 9(2): 607–636, 2003.

52 Skeffington, R., The use of critical loads in environmental policy making: a critical appraisal, *Environmental Science and Technology*, 33(11): 245 A–252 A, 1999 (http://pubs.acs.org/hotartcl/est/99/jun/skeff.html).

53 United Nations Economic Commission for Europe, *The 1994 Oslo Protocol on Further Reductions of Sulphur Emissions* (www.unece.org/env/lrtap/fsulf_h1.htm).

Environment Canada has developed generic aquatic and terrestrial critical loads for six metals based on reasonable worst-case conditions of the Canadian Shield (i.e., soft, circumneutral to acidic lake waters and acidic, sandy soils). These critical loads are applicable to facilities located on the Shield or having similar conditions in their vicinity.[54] In particular, sandy soils are ubiquitous throughout most of Canada. The probabilistic approach utilized yielded 25th- and 10th-percentile critical loads, representing levels protective of the endpoint organisms under 75% and 90% of receiving environment conditions, respectively.

Estimated critical loads can be compared with actual deposition rates monitored near a releasing facility and thereby act as one of the environmental quality objective indicators for evaluating the effectiveness of utilized pollution controls by the facility. It can take decades (or more) for contaminant concentrations in receiving media to reach steady state. Critical loads have the advantage of providing an early indication of whether the current monitored deposition rate could cause contaminant levels to exceed threshold effect values once steady state is established.

Detailed descriptions of methodology for modelling and critical load calculations can be found in the Bibliography section.

4.2.10 Ambient Air Quality Monitoring

***RECOMMENDATION* R 210**

Each facility should develop and implement an ambient air quality monitoring program in consultation with the regulatory bodies having authority over the facility. This program should include the sampling and analysis of metals, particulate matter (total, PM_{10}, and $PM_{2.5}$), sulphur dioxide, and other pollutants of concern, taking into account:

(i) the location of release sources under the control of the facility operator; and

(ii) local meteorological conditions and probable maximum pollutant deposition areas.

4.3 WATER AND WASTEWATER MANAGEMENT

4.3.1 Water Use/Reuse

***RECOMMENDATION* R 301**

Water use should be minimized, to the maximum extent practicable, possibly through the recycling or reuse of water and the cascading of cooling water and wastewater between production processes using lower-quality water.

4.3.2 Wastewater Collection

***RECOMMENDATION* R 302**

All wastewater streams that may exceed the effluent criteria of R 304 should be directed to a treatment facility prior to discharge to the environment.

To the extent practicable, system designs should provide for the segregation and collection of similar wastewaters (e.g., oily, acid, cleaning, and sanitary wastes).

4.3.3 Wastewater Containment Sizing

***RECOMMENDATION* R 303**

Wastewater collection and containment systems should be designed to contain the maximum volume of liquid that could reasonably be expected to be in storage for the following conditions:

(i) the maximum volume of wastewater that would be accumulated during the time required to shut down wastewater generating processes, plus 50%;

(ii) 110% of the volume that could enter the containment system in the event of a leak, spill, or other like incident; or

(iii) the accumulated precipitation from a 24-hour, 50-year storm (return period) for outdoor containments.

54 Environment Canada and Health Canada, *Canadian Environmental Protection Act, 1999, Priority Substances List Assessment Report: Releases from Primary and Secondary Copper Smelters and Copper Refineries; Releases from Primary and Secondary Zinc Smelters and Zinc Refineries*, 2001, ISBN 0-662-29871-3.

4.3.4 Water Effluent Guidelines

RECOMMENDATION R 304

Wastewater treatment facilities should be designed, constructed, operated, and maintained to achieve the following effluent quality prior to release:

On a continuous basis:

pH	6.0–9.5

Maximum monthly mean concentration:

Total suspended solids	15.0 mg/L
Arsenic	0.5 mg/L
Copper	0.3 mg/L
Cyanide*	1.0 mg/L
Lead	0.2 mg/L
Nickel	0.5 mg/L
Zinc	0.5 mg/L

* *If cyanide is used in the process.*

Non-acutely lethal effluent:
No more than 50% mortality of *Daphnia magna* and rainbow trout test species in 100% effluent when tested in accordance with Environment Canada Reference Methods 1/RM/13[55] and 1/RM/14.[56]

4.3.5 Water Effluent Reporting

RECOMMENDATION R 305

Effluents should be monitored, tested, estimated and reported, consistent with Environment Canada's *Guidance Document for the Sampling and Analysis of Metal Mining Effluents*[57] and *Guidance Document for Flow Measurement of Metal Mining Effluents*[58] and in accordance with the notice requiring submission of data for the National Pollutant Release Inventory.[59]

4.3.6 Ambient Water Quality Guidelines

RECOMMENDATION R 306

In addition to the source performance recommendations of R 304 and R 305, each facility should design and operate effluent discharge systems, taking into account local conditions and the following ambient water quality objectives:

TABLE 3: AMBIENT WATER QUALITY GUIDELINES

Substance	Guideline (µg/L)*
Aluminum	5–100
Ammonia (total)**	See table 4
Ammonia (un-ionized)***	19
Arsenic (total)	5.0
Benzene	370
Cadmium	0.017
Chromium - Trivalent chromium (Cr(III)) - Hexavalent chromium (Cr(VI))	 8.9 1.0
Copper (total)	2–4
Cyanide (free)	5
Iron (total)	300
Lead (total)	1–7
Mercury - Inorganic mercury - Methylmercury	 0.026 0.004
Molybdenum	73
Nickel (total)	25–150
pH	6.5–9.0****
Selenium (total)	1.0
Silver (total)	0.1
Thallium	0.8
Zinc	30

Notes:

* Canadian Council of Ministers of the Environment, *Canadian Environmental Quality Guidelines for the Protection of Freshwater Aquatic Life* (Summary Table update December 2003).

** Ammonia (total) is used to describe the sum of ammonia (NH_3) and ammonium (NH_4^+).

*** Ionized ammonia refers to the ammonium ion (NH_4^+).

**** No units for pH.

55 Environment Canada, *Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout*, Report EPS 1/RM/13, Second Edition, December 2000.

56 Environment Canada, *Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to* Daphnia magna, Report EPS 1/RM/14, Second Edition, December 2000.

57 Environment Canada, *Guidance Document for the Sampling and Analysis of Metal Mining Effluents*, EPS 2/MM/5, April 2001.

58 Environment Canada, *Guidance Document for Flow Measurement of Metal Mining Effluents*, EPS 2/MM/4, April 2001.

59 Environment Canada, National Pollutant Release Inventory (www.ec.gc.ca/pdb/npri/npri_home_e.cfm).

Critical loads can be used to indicate whether deposition of sulphates, metals, and metal compounds to surface waters is above or below a level that would lead to environmental impacts.

Critical loads may be defined as the amount of deposition required for contaminant levels to reach threshold effect values in receiving media. For surface waters, the critical load is the rate of deposition to the water body or to areas draining to it that would lead (accounting for the fraction retained in the soil) to minimal effects on sensitive aquatic organisms.[60]

The estimated critical loads can be compared with actual deposition rates near a releasing facility and thereby act as one of the environmental quality objective indicators for evaluating the effectiveness of utilized pollution controls by the facility (see also Section 4.2.9 for more details on critical loads).

The total ammonia guideline is not a specific value, but rather a range of values over various pHs and temperatures. That is because ammonia toxicity is affected by various factors, among which are pH, the most important, and temperature.

Table 4 provides total ammonia guidelines over a range of pHs (6.0–9.5) and temperatures (0–30°C) based upon the un-ionized ammonia guideline of 0.019 mg/L and the following two equations:[61]

Equation 1:

$pK_a = 0901821.0 + 92.2729 / T$

where:
T = temperature in K (= T in °C + 273.15)

Equation 2:

$f = 1 / [10^{(pK_a - pH) + 1}]$

where:
f = fraction of total ammonia that is un-ionized
pK_a = dissociation constant from equation 1

TABLE 4: WATER QUALITY GUIDELINES FOR TOTAL AMMONIA FOR THE PROTECTION OF AQUATIC LIFE[62]

Temperature (°C)	Guideline (mg NH_3/L) at the following pHs:							
	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5
0	231	73.0	23.1	7.32	2.33	0.749	0.250	0.042
5	153	48.3	15.3	4.84	1.54	0.502	0.172	0.034
10	102	32.4	10.3	3.26	1.04	0.343	0.121	0.029
15	69.7	22.0	6.98	2.22	0.715	0.239	0.089	0.026
20	48.0	15.2	4.82	1.54	0.499	0.171	0.067	0.024
25	33.5	10.6	3.37	1.08	0.354	0.125	0.053	0.022
30	23.7	7.50	2.39	0.767	0.256	0.094	0.043	0.021

Notes:

- The guideline values and all reported total ammonia concentrations in the table above are reported in mg NH_3/L; measurements of total ammonia in the aquatic environment are often also expressed as mg total ammonia-N/L.
- The present guideline values (mg NH_3/L) can be converted to mg total ammonia-N/L by multiplying the corresponding guideline value by 0.8.
- Values falling outside of the shaded area should be used with caution.
- There is no recommended guideline for marine waters.

60 Ibid. pp. 28 (www.ec.gc.ca/pdb/npri/npri_home_e.cfm).
61 Canadian Council of Ministers of the Environment, *Canadian Water Quality Guidelines for Aquatic Life: Ammonia Fact Sheet*, 2000, ISBN 1-89699-34-1.
62 Ibid.

4.3.7 Aquatic Environmental Effects Monitoring

RECOMMENDATION R 307

Each facility that discharges to a receiving water should develop and implement an aquatic environmental effects monitoring program, consistent with Environment Canada's *Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring.*[63]

4.4 WASTE MANAGEMENT

4.4.1 Reduction, Reuse, and Recycling

RECOMMENDATION R 401

Each facility should develop, implement, and maintain a waste reduction, reuse, and recycling program. The program should be one that:

(i) identifies opportunities for in-plant reduction, reuse, and recycling of wastes;

(ii) develops and implements plans for the evaluation and implementation of reduction, reuse, and recycling opportunities;

(iii) identifies and evaluates market opportunities for wastes with a view to maximizing waste material reduction, reuse, and recycling (this includes the sale of by-products that would otherwise be considered wastes); and

(iv) develops and implements a research and development program for reducing, reusing, and recycling residual wastes.

4.4.2 Location and Construction of Waste Disposal Sites

RECOMMENDATION R 402

Expansions to existing waste disposal sites and the design and construction of new sites should be undertaken so as to ensure that:

(i) the site plan is updated to clearly show the location and dimensions of the new or expanded waste disposal site;

(ii) the perimeter of the disposal area is far enough away from all watercourses to prevent contamination by runoff, seepage, or fugitive emissions;

(iii) the surface drainage from off-site areas is diverted around the disposal area;

(iv) the expanded area is hidden from view by fences, berms, or buffer zones; and

(v) future beneficial uses of the waste disposal site after its closure have been considered.

4.4.3 Development of Solid Waste Disposal Sites

RECOMMENDATION R 403

Solid waste disposal sites should be developed in accordance with the following practices:

(i) the disposal area should be developed in modules or cells;

(ii) all wastes should be placed such that they have physical and chemical stability suitable for land reuse, if the disposal area is reclaimed;

(iii) contouring, capping, and reclamation of cells should be undertaken throughout the operating life of the site; and

(iv) all disposal sites should be reclaimed for beneficial uses before final closure or restricted from public access if they cannot be reclaimed.

63 Environment Canada, *Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring,* 2002 (www.ec.gc.ca/eem/english/MetalMining/Guidance/default.cfm).

4.4.4 Management of Waste Disposal Sites

RECOMMENDATION R 404

All waste disposal sites should be managed in accordance with documented, site-specific waste management plans approved by the appropriate regulatory bodies having authority over the facility so that:

(i) solid, liquid, and hazardous wastes are transferred only to facilities specifically designed, approved, and operated for that purpose;

(ii) access to the site is controlled and disposal activities are supervised by trained personnel; and

(iii) records are maintained of the types, approximate quantities, and point of origin of the wastes.

4.4.5 Monitoring of Waste Disposal Sites

RECOMMENDATION R 405

A groundwater monitoring program should be developed for all waste disposal sites in accordance with the following guidelines:

(i) a permanent system of appropriately located piezometers and wells should be provided;

(ii) a program of pre-operational monitoring of groundwater regimes should be initiated;

(iii) groundwater samples should be collected at least quarterly; and

(iv) each groundwater sample should be analyzed for pH, total dissolved solids, and other appropriate site-specific parameters.

4.4.6 Waste Reporting

RECOMMENDATION R 406

Wastes disposed of and transferred should be reported, in accordance with the notice requiring submission of data for the National Pollutant Release Inventory.[64]

4.4.7 Waste Management

RECOMMENDATION R 407

Waste should be managed consistent with the *Guidance Document for Management of Wastes from the Base Metals Smelting Sector.*[65]

64 Environment Canada, National Pollutant Release Inventory (www.ec.gc.ca/pdb/npri/npri_home_e.cfm).

65 Hatch Associates Ltd., *Guidance Document for Management of Wastes from the Base Metals Smelting Sector*, prepared for Environment Canada, July 2004.

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More references on critical loads, mapping, and calculations can be found in a compilation of articles on the following website: www.environmental-center.com/magazine/kluwer/wafo/

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APPENDIX A: CANADA-WIDE STANDARDS (CWS) FOR MERCURY EMISSIONS

Endorsed by the Canadian Council of Ministers of the Environment (CCME) June 5–6, 2000

PART 1: BASE METAL SMELTING[66]

Rationale for standard:

The base metal smelting sector has historically been responsible for much of the mercury emitted in Canada. However the voluntary application of a number of process changes and stack treatments/scrubbers have combined to reduce mercury emissions from this sector by more than 90% since 1988. Due to reductions from this sector, Canada has complied with its obligations under the United Nations Economic Commission for Europe Heavy Metals Protocol. Despite this substantial progress additional reductions are possible. As of 2000, the mercury emissions from base metal smelting remain the single largest emission sector in Canada at 2.8 T/yr. Under the federal Strategic Options Process (SOP), industry and government recommended development by CCME of "environmental source performance guidelines" that reflect application of best available techniques. By following this approach, Canada's domestic program will be consistent with international objectives for this industry.

Nature and application:

Based upon the performance of various technologies and practices as demonstrated at existing facilities in Canada, and in consideration of the recommendations made in the federal SOP for this sector, a two-part standard is recommended. This standard reflects the application of "best available techniques" on a facility-specific basis, and a uniform reporting mechanism based upon environmental source performance (atmospheric emission) guidelines.

Standards are suggested for both existing facilities, to reflect actions taken to reduce emissions of mercury, and for new facilities, to ensure that smelters utilize the best available techniques to avoid or reduce metals emissions generally and mercury emissions specifically.

Numeric targets:

For existing facilities: application by all primary zinc, lead and copper smelters of best available pollution prevention and control techniques economically achievable to achieve an environmental source performance (atmospheric emission) guideline of 2 g Hg/tonne total production of finished metals.

For new and expanding facilities: application of best available pollution prevention and control techniques to minimize mercury emissions throughout the life-cycle of the minerals in question to achieve an environmental source performance (atmospheric emission) guideline of 0.2 g Hg/tonne production of finished zinc, nickel and lead, and 1 g Hg/tonne of finished copper, and consideration of a mercury offset[67] program to ensure no "net" emission increases occur.

Timeframe for achieving the targets:

Existing facilities will be expected to make a determined effort[68] to meet this standard by 2008, coincident with implementation of the federal Strategic Options Report, while any new facility will be required to design for and achieve compliance immediately upon full scale operation. Jurisdictions will evaluate changes and upgrades to existing facilities to ensure they constitute determined efforts.

66 Canadian Council of Ministers of the Environment, *Canada-wide Standards for Mercury Emissions*, June 5–6, 2000 (www.ccme.ca/assets/pdf/mercury_emis_std_e1.pdf).

67 A new facility will recover and retire an amount of mercury equivalent to their annual emissions.

68 Determined efforts include the ongoing review of opportunities for reductions and implementation of in plant changes and/or emissions control upgrades that are technically and economically feasible and which confer on-going reductions in emissions.

APPENDIX B: STATUS REPORT FORM ON CONFORMANCE WITH THE ENVIRONMENTAL CODE OF PRACTICE

ENVIRONMENTAL PERFORMANCE DATA SHEET (EPDS) BASE METALS SMELTING SECTOR (BMSS)

FACILITY INFORMATION

NPRI Identification No.: __________

Manufacturer

Company: ______________________________

Address: ______________________________

____

Website: ______________________________

Contact person: ______________________________

Tel: ______________________________

Fax: ______________________________

E-mail: ______________________________

ENVIRONMENTAL MANAGEMENT SYSTEMS

Note: Information on references and sources cited in this table can be found in the main body of the document.

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 101 Environmental Policy Statement Each company should develop and implement an environmental policy statement.					Include date approved by senior management. Is policy publicly available? If so, how can it be accessed?
R 102 Environmental Management Systems Each facility should develop, implement, and maintain an environmental management system in accordance with ISO 14001 or an equivalent standard or system.					Has the facility implemented or is it planning to implement an environmental management system in accordance with ISO 14001 or an equivalent standard or system? Is the facility planning on receiving ISO 14001 registrations? If yes, indicate anticipated year of registration.
R 103 Environmental Management Plans Each facility should develop and implement a site-specific environmental management plan, consistent with the *Environmental Management Plan Guidance Document for the Base Metals Smelting Sector*. The plan should include, as a minimum, the following (see list of the elements in Table S.1, Section S.5, R 103, or Section 4.1.3 of the Code).					Indicate what percentage of the 13 elements listed in the Code are in place.
R 104 Environmental Assessment Environmental assessment principles should be followed by companies for new and significantly modified or expanded facilities, consistent with the Canadian Environmental Assessment Agency Reference Guide, Table 1.					Has the process been applied to the planning phase of new or modified facilities? If so, for which projects?

ENVIRONMENTAL MANAGEMENT SYSTEMS — POLICY PLANS, PARTICIPATION

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 105 Pollution Prevention Planning Each facility should develop and implement a pollution prevention plan, consistent with Environment Canada's *Pollution Prevention Planning Handbook* or in compliance with any Pollution Prevention Plan Notification issued under the *Canadian Environmental Protection Act, 1999*.					Has the facility developed a pollution prevention (P2) plan? What is the timeframe for implementation? Is the P2 plan consistent with the specified guideline?
R 106 Emergency Planning Each facility should develop and make publicly available an environmental emergency plan, consistent with Environment Canada's *Implementation Guidelines for Part 8 of the Canadian Environmental Protection Act, 1999 — Environmental Emergency Plans*.					Were community and interest groups and local and provincial/territorial emergency authorities included in the development and preparation of the plan? Has the plan been shared with these persons? Does it address the elements elaborated in the guideline? Is it publicly available? If so, how can it be accessed?
R 107 Decommissioning Planning Planning for decommissioning should begin in the design stage of the project life cycle for new facilities and as early as possible in the operating stage for existing facilities. Site closures and associated decommissioning activities should be undertaken, by the facility, consistent with the *National Guidelines for Decommissioning Industrial Sites*.					Has decommissioning planning begun for this facility? When will the plan be completed? Is it in accordance with Canadian Council of Ministers of the Environment guidelines? What provisions have been made for funding the decommissioning phase?

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 108 Environmental Training Each facility should establish and maintain procedures to identify its environmental training needs and ensure that all personnel who work in areas that may create a significant adverse impact upon the environment have received training.					Has the facility conducted environmental training needs analysis and the identified training? Do the procedures address the need to train new employees? How frequently is the program reviewed? Is there a program in place to ensure that contractors demonstrate that their employees have the required environmental training?
R 109 Environmental Facility Inspection Each facility should develop and implement an environmental inspection plan.					Does the plan include inspection procedures for each operation, a schedule, and procedures for reporting and follow-up?
R 110 Environmental Auditing Each facility should conduct periodic environmental audits by internal, corporate, or third-party auditors.					How frequently are audits conducted? Is company staff or external personnel used? Date of last audit.
R 111 Environmental Performance Indicators Each facility should develop a set of environmental performance indicators that can provide an overall measure of the facility's environmental performance.					Please provide a copy of your set of environmental performance indicators.
R 112 Product Stewardship Each company should develop and implement a product stewardship program aimed at minimizing the environmental impacts associated with the products used and produced by the facility and under the control of the company.					Does the product stewardship program include consideration of: - types of materials used; - sources of supply of materials; - sources of energy used; - type and amount of packaging; and - management of manufacturing by-products and wastes?

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 113 Public Reporting Documented procedures for the monitoring and reporting of environmental performance to the public should be developed and implemented by the facility, consistent with the *Guidance Document for Reporting Releases from the Base Metals Smelting Sector* and taking into account the Global Reporting Initiative's *Sustainability Reporting Guidelines* for the mining and metals sector.					Are facility-specific environmental performance data made publicly available? If so, how can the data be accessed? Does your facility use the *Sustainability Reporting Guidelines* developed by the Global Reporting Initiative in preparing its reports? How are data made available (e.g., reports, Internet, reporting programs)? Year public reporting began.
R 114 Community Advisory Panel Each facility should establish a Community Advisory Panel with representatives from the surrounding community, in order to provide a forum for the review and discussion of facility operations and associated environmental and other concerns.					Name of advisory panel, date established, frequency of meetings, date of last meeting. Are minutes publicly available? If so, how can they be accessed?

ATMOSPHERIC RELEASES MANAGEMENT

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 201 Prevention and Control of Fugitive Air Emissions Each facility should identify potential sources of fugitive emissions and should prevent or control those emissions through the use of appropriate mitigative measures. These sources may include unpaved roads, storage piles, material conveyance systems, waste disposal piles, and leaks from processes and buildings.					Identify key sources of fugitive emissions at your facility. Describe how fugitive emissions are prevented and/or controlled.
R 202 Collection and Control of Process Air Emissions Each facility should ensure that air pollution control equipment is adequately sized, designed, constructed, and maintained to contain and control pollutant releases to ambient air from all plant processes.					Are all process releases collected and treated? Describe which process emission streams are not collected and treated. Are Standard Operating Procedures in place for the key equipment and/or activities?
R 203 Total Particulate Matter Emissions Guidelines Each facility should be designed and operated to achieve the following recommended release concentrations for total particulate matter after the emission control device of less than 50 mg/Nm^3.					Indicate the number of stacks where the guideline is achieved. Indicate the number of stacks where the guideline is not achieved. Provide additional information, such as total loading or flow rate for stacks.

<table>
<tr><th>Recommendation Number and Subject
Summary of Recommendation</th><th>Developed & Implemented</th><th>Under Development</th><th>Not Yet Developed</th><th>Comments</th><th>Notes on what to include under "Comments"</th></tr>
<tr><td colspan="6">If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.</td></tr>
<tr><td>R 204 Sulphur Fixation Guidelines
1. Each facility should consider use of low sulphur feed and recycled materials to reduce emissions of sulphur dioxide.
2. Each existing facility should be designed and operated to achieve a minimum sulphur fixation rate of 90% by a committed timetable.
3. Each new copper, lead and zinc smelter should be designed and operated to achieve a minimum sulphur fixation rate of 99%.
4. Each new nickel smelter should be designed and operated to achieve a minimum sulphur fixation rate of 96%.</td><td></td><td></td><td></td><td></td><td>Indicate the current sulphur fixation percentage. Please provide details of the calculation, including the ratio of sulphur in the feed to the product.

Indicate any projects planned to increase the sulphur fixation percentage, including projected start-up date.</td></tr>
<tr><td>R 205 Mercury Emissions Guidelines
1. Each existing facility should be designed and operated to limit air release loadings to less than 2 grams of mercury per tonne of finished product.
2. Each new or expanded facility should be designed and operated to limit air release loadings in accordance with the following:
(a) less than 0.2 grams of mercury per tonne production of finished zinc, nickel, and lead; and
(b) less than 1 gram of mercury per tonne production of finished copper.</td><td></td><td></td><td></td><td></td><td>Indicate the release of mercury per tonne production of finished zinc, nickel, lead, or copper.

What year are the above data for?</td></tr>
</table>

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 206 Dioxins and Furans Emissions Guidelines 1. Each existing facility should be designed and operated to limit release concentrations of dioxins and furans to less than 100 pg ITEQ/Rm^3 2. Each new facility should be designed and operated to limit release concentrations of dioxins and furans to less than 32 pg ITEQ/Rm^3					Indicate release of dioxins/furans per tonne production of finished zinc, nickel, lead, or copper. What year are the above data for?
R 207 Metals Emissions Limit Targets Each facility should develop facility emission reduction targets for and timetables to achieve reductions in releases of arsenic, cadmium, lead, nickel, mercury, and other metals of concern, taking into account facility emission reduction targets for sulphur dioxide and particulate matter, pollution prevention and control options, and performances for various feeds, smelting processes, and emission control systems.					Does your facility have emission reduction targets and a schedule for reducing releases of arsenic, cadmium, lead, nickel, and mercury? Has your facility achieved, or is it on course to achieve, the reduction targets?
R 208 Air Releases Reporting Each facility should measure or estimate and report releases, consistent with the *Guidance Document for Reporting Releases from the Base Metals Smelting Sector* and in accordance with the notice requiring submission of data for the National Pollutant Release Inventory.					How frequently are stacks tested? What parameters are tested for? Does your facility have any continuous emission monitors? Describe their location and parameters monitored. What methodology is used to calculate emissions (e.g., stack test, mass balance)? Indicate if these reports are sent to Head Office, the National Pollutant Release Inventory, provincial/territorial regulatory agency, the public, other? With what frequency is information reported to each of the above — annually, quarterly, other?

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 209 Ambient Air Quality Objectives In addition to the source performance recommendations of R 203 and R 204, each facility should design and operate air emission prevention and control systems, taking into account local conditions and the following ambient air quality objectives, standards, criteria and guidelines (substances and objectives as shown in detail in Table S.2, Section S.5, and Section 4.2.9 of the Code of Practice).					Are ambient air quality objectives being met at air monitoring stations affected by the facility? Indicate the number and type of exceedances. Indicate the percentage of time air quality meets objectives at each station.
R 210 Ambient Air Quality Monitoring Each facility should develop and implement an ambient air quality monitoring program in consultation with the regulatory bodies having authority over the facility. This program should include the sampling and analysis of metals, particulate matter (total, $PM_{10,}$ and $PM_{2.5}$), sulphur dioxide, and other pollutants of concern, taking into account: (i) the location of release sources under the control of the facility operator; and (ii) local meteorological conditions and probable maximum pollutant deposition areas.					Which of the following parameters does the program include: metals, particulate (total, PM_{10}, $PM_{2.5}$), sulphur dioxide? Does the program take into account the location of emissions sources and local meteorological conditions and probable maximum deposition area?

WATER AND WASTEWATER MANAGEMENT

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 301 Water Use/Reuse Water use should be minimized, to the maximum extent practicable, possibly through the recycling or reuse of water and the cascading of cooling water and wastewater between production processes using lower-quality water.					Are flow measurements carried out in accordance with documented, performance-based standards approved by the appropriate regulatory authorities? Is any reduction achieved, and if so, how?
R 302 Wastewater Collection All wastewater streams that may exceed the effluent criteria of R 304 should be directed to a treatment facility prior to discharge to the environment.					Are all wastewater streams that may exceed the effluent criteria directed to a treatment facility prior to discharge?
R 303 Wastewater Containment Sizing Wastewater collection and containment systems should be designed to contain the maximum volume of liquid that could reasonably be expected to be in storage for the following conditions: (i) the maximum volume of wastewater that would be accumulated during the time required to shut down wastewater generation processes, plus 50%; (ii) 110% of the volume that could enter the containment system in the event of a leak, spill, or other like incident; or (iii) the accumulated precipitation from a 24-hour, 50-year storm (return period) for outdoor containments.					Are design parameters for the maximum volume of liquid storage as described in the recommendation being met? If not, please explain why not and provide details on storage capacity.

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
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R 304 Water Effluent Guidelines Wastewater treatment facilities should be designed, constructed, operated, and maintained to achieve the following effluent quality prior to release: **On a continuous basis:** pH 6.0–9.5 **Maximum monthly mean concentration:** Total suspended solids 15.0 mg/L Arsenic 0.5 mg/L Copper 0.3 mg/L Cyanide* 1.0 mg/L Lead 0.2 mg/L Nickel 0.5 mg/L Zinc 0.5 mg/L * *If cyanide is used in the process.* **Non-acutely lethal effluent:** No more than 50% mortality of *Daphnia magna* and rainbow trout test species in 100% effluent when tested in accordance with Environment Canada Reference Methods 1/RM/13 and 1/RM/14.					Do all final effluent streams meet these criteria? If not, indicate which criteria are not being met and the frequency of non-conformance.
R 305 Water Effluent Reporting Effluents should be monitored, tested, estimated and reported, consistent with Environment Canada's *Guidance Document for the Sampling and Analysis of Metal Mining Effluents* and *Guidance Document for Flow Measurement of Metal Mining Effluents* and in accordance with the notice requiring submission of data for the National Pollutant Release Inventory.					Are sampling and analysis methods and quality control procedures consistent with the guidance documents? Are selection, design, and installation of flow measurement systems consistent with the guidance documents? Indicate if these reports are sent to Head Office, the National Pollutant Release Inventory, provincial/territorial regulatory agency, the public, other? With what frequency is information reported to each of the above — annually, quarterly, other?

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 306 Ambient Water Quality Guidelines In addition to the source performance recommendations of R 304 and R 305, each facility should design and operate effluent discharge systems , taking into account local conditions and the ambient water quality objectives as shown in Table S.3, Section S.5, and Section 4.3.6 of the Code of Practice.					Are ambient water quality guidelines being met? If not, indicate the number and type of exceedances.
R 307 Aquatic Environmental Effects Monitoring Each facility that discharges to a receiving water should develop and implement an aquatic environmental effects monitoring program, consistent with Environment Canada's *Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring*.					Is an aquatic environmental effects monitoring program being conducted? If not, when do you plan to initiate one?

WASTE MANAGEMENT

For the purposes of this section, waste refers to both non-hazardous and hazardous wastes.

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 401 Reduction, Reuse, and Recycling Each facility should develop, implement, and maintain a waste reduction, reuse, and recycling program. The program should be one that: (i) identifies opportunities for in-plant reduction, reuse, and recycling of wastes; (ii) develops and implements plans for the evaluation and implementation of reduction, reuse, and recycling opportunities; (iii) identifies and evaluates market opportunities for wastes with a view to maximizing waste material reduction, reuse, and recycling (this includes the sale of by-products that would otherwise be considered wastes); and (iv) develops and implements a research and development program for reducing, reusing, and recycling residual wastes.					Does the program: - identify opportunities for in-plant reduction, reuse, and recycling of wastes; - evaluate and implement these opportunities; - identify and evaluate market opportunities for wastes to maximize waste material reduction, reuse, and recycling; and - include a research and development program for reducing, reusing, and recycling residual wastes?
R 402 Location and Construction of Waste Disposal Sites Expansions to existing waste disposal sites and the design and construction of new sites should be undertaken so as to ensure that: (i) the site plan is updated to clearly show the location and dimensions of the new or expanded waste disposal site; (ii) the perimeter of the disposal area is far enough away from all watercourses to prevent contamination by runoff, seepage, or fugitive emissions; (iii) the surface drainage from off-site areas is diverted around the disposal area; (iv) the expanded area is hidden from view by fences, berms, or buffer zones; and (v) future beneficial uses of the waste disposal site after its closure have been considered.					Indicate whether any new or expansions to the waste disposal sites have been undertaken since 2001. Indicate whether location and construction meet the criteria in the recommendation.

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 403 Development of Solid Waste Disposal Sites Solid waste disposal sites should be developed in accordance with the following practices: (i) the disposal area should be developed in modules or cells; (ii) all wastes should be placed such that they have physical and chemical stability suitable for land reuse, if the disposal area is reclaimed; (iii) contouring, capping, and reclamation of cells should be undertaken throughout the operating life of the site; and (iv) all disposal sites should be reclaimed for beneficial uses before final closure or restricted from public access if they cannot be reclaimed.					Does the waste disposal site meet all the practices in the recommendation? If the waste disposal site does not meet one or more of the practices, please explain the reason for deviation and how the facility will be addressing this Code recommendation.
R 404 Management of Waste Disposal Sites All waste disposal sites should be managed in accordance with documented, site-specific waste management plans approved by the appropriate regulatory bodies having authority over the facility so that: (i) solid, liquid, and hazardous wastes are transferred only to facilities specifically designed, approved, and operated for that purpose; (ii) access to the site is controlled and disposal activities are supervised by trained personnel; and (iii) records are maintained of the types, approximate quantities, and point of origin of the wastes.					Does the waste disposal site meet all criteria of the recommendation? If not, please indicate which criteria are not met and the reasons. Have management plans been approved by the appropriate regulatory authority?

Recommendation Number and Subject Summary of Recommendation	Developed & Implemented	Under Development	Not Yet Developed	Comments	Notes on what to include under "Comments"
If you respond "Under Development," please indicate what aspects have been completed and what aspects are still to be implemented or completed. If you respond "Not Yet Developed," please indicate when you expect to develop this element; if your company has no plans to develop a particular element, please explain why not.					
R 405 Monitoring of Waste Disposal Sites A groundwater monitoring program should be developed for all waste disposal sites in accordance with the following guidelines: (i) a permanent system of appropriately located piezometers and wells should be provided; (ii) a program of pre-operational monitoring of groundwater regimes should be initiated; (iii) groundwater samples should be collected at least quarterly; and (iv) each groundwater sample should be analyzed for pH, total dissolved solids, and other appropriate site-specific parameters.					Is there a groundwater monitoring program in place? Does the groundwater monitoring program follow all criteria of the recommendation? Provide information on the frequency of monitoring for each parameter. Have monitoring results indicated any potential problems?
R 406 Waste Reporting Wastes disposed of and transferred should be reported, in accordance with the notice requiring submission of data for the National Pollutant Release Inventory.					Does your facility report on wastes disposed of and transferred? Indicate if these reports are sent to Head Office, the National Pollutant Release Inventory, provincial/territorial regulatory agency, the public, other? With what frequency is information reported to each of the above — annually, quarterly, other? As a referenced guidance document has not been developed, please indicate if wastes disposed of and transferred are reported consistent with the *Guide for Reporting to the National Pollutant Release Inventory 2001*.
R 407 Waste Management Waste should be managed consistent with the *Guidance Document for Management of Wastes from the Base Metals Smelting Sector.*					Are efforts made to recycle residues? Are reuse options identified? Is disposal considered only when there are no options for recycling or reuse?

LIST OF CHEMICAL NAME SYMBOLS/ACRONYMS

As	Arsenic
Cd	Cadmium
Cr	Chromium
Cu	Copper
Hg	Mercury
Ni	Nickel
Pb	Lead
Zn	Zinc

CH_4	Methane
N_2O	Nitrous Oxide
HFCs	Hydrofluorocarbons
PFCs	Perfluorocarbons
SF_6	Sulphur hexafluoride

GLOSSARY OF TERMS

Acid plant	A process that converts sulphur dioxide into sulphuric acid. At a base metals smelter, sulphur dioxide is produced by oxidation of sulphide mineral concentrates and other minerals contained in smelter feed materials. The acid plant converter oxidizes sulphur dioxide to sulphur trioxide in the presence of a catalyst. Single or double absorption stages may be used to absorb sulphur trioxide.
Baghouse	An air pollution control device used to trap particulates by filtering gas streams through large fabric bags, usually made of glass fibres.
Base metal	Any of the following metals: cobalt, copper, lead, nickel, zinc.
Bath smelting	A smelting process where the concentrate feed is charged into and reacted in a bath of molten matte.
Converting	Process of removing impurities or metallic compounds from molten metal by blowing air through the liquid matte. The impurities or metallic compounds are changed either to gaseous compounds, which are removed by volatilization, or to liquids, which are removed as slags.
Critical load	A quantitative estimate of an exposure to one or more pollutants, below which significant harmful effects on specified sensitive elements of the environment do not occur, according to present knowledge.
Decommissioning	A closure of an industrial facility followed by the removal of process equipment, buildings, and structures (on a site-specific basis). Decommissioning may include all or part of a facility and "mothballing." Cleanup may be required to remove chemical substances or hazardous materials from the environment or to render the industrial site safe and aesthetically acceptable. Decommissioning may result in a change of land use.
Dry scrubber	Any device that separates gas-borne particles from the gas stream by such methods as gravitational deposition, flow-line interception, diffusional deposition, and electrostatic deposition. Most forms of dust collection systems use more than one of these collection mechanisms.
Effluent	A release of an aqueous flow.
Electric furnace	A furnace using electricity to supply heat/thermal energy. The chief types of such furnaces are direct arc, in which the electric current passes through the charge; indirect arc, in which the arc is struck between the electrodes only; and induction furnace, in which the metal charge is heated by magnetic susceptibility.
Electrostatic precipitator	An air pollution control device that removes particulate matter by imparting an electrical charge to particles in a gas stream for mechanical collection on an electrode.

Electrowinning	Production of high-purity metal from a metal-bearing solution. The process takes place in cells containing a number of closely spaced rectangular metal plates acting as anodes and as cathodes. A series of reactions occurs in the electrolysis cells that result in the deposition of the desired metal at the cathode and the regeneration of sulphuric acid in the electrolyte at the anode. This differs from electrorefining, in that the source metal is already in solution.
Emission	A release of pollutants into the air.
Emission factor	The average amount of a pollutant emitted from each type of polluting source in relation to a specific amount of material processed.
Endpoint	Response of a natural resource or service to a contaminant (e.g., adverse reproductive effects on sensitive fish species in a community).
Environmental effects monitoring (EEM)	A science-based tool that can detect and measure changes in atmospheric and aquatic ecosystems (receiving environments) potentially affected by human activity (i.e., air and effluent discharges). EEM is an iterative system of monitoring and interpretation phases that can be used to help assess the effectiveness of environmental management measures.
EPI	Environmental performance indicator, expressed by a unit of emission per unit of produced material.
Fabric filters	A device for removing dust and particulate matter from industrial emissions, much like a home vacuum cleaner bag. Fabric filters are generally located in a baghouse.
Facility	A stand-alone production unit or part of a continuous production complex where raw material or product is processed, upgraded, or stored before the point of transfer to another unit for further processing, upgrading, or transformation. A stand-alone production unit may be part of a larger production complex.
Flash converting	Very fast smelting of copper can be accomplished in a converter by feeding the matte and supplying oxygen. The oxygen efficiency is high, no fuel is required, and the off-gas is very high in sulphur dioxide.
Flash smelting	It combines the operations of roasting and smelting to produce a high-grade matte. Dried ore concentrates and finely ground fluxes are injected together with oxygen, preheated air, or a mixture of both into a furnace of special design, where the temperature is maintained.
Fluid bed roasting	Oxidation of the finely ground pyritic minerals by means of upward currents of air, blown through a reaction vessel with sufficient force to cause the bed materials to fluidize.
Fugitive emissions	These emissions usually result from process leakage and spills of short duration that are associated with storage, material handling, charging, and other secondary process operations. Fugitive emissions are usually uncontrolled.
International Toxicity Equivalency Quotient	The method of relating the toxicity of various dioxin/furan congeners to the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin.
ISO 14000	The International Organization for Standardization (ISO) is an international federation of over 100 national standards bodies that, since 1993, has been developing a series of integrated environmental management system standards, known as the ISO 14000 series.
Matte	A molten solution of metal sulphides produced during smelting.
Matte separation	Separation of copper and nickel sulphides by crushing, grinding, magnetic separation, and flotation following the controlled cooling of the copper–nickel matte.

Mitsubishi continuous smelting	Injects dried concentrate through a lance into the smelting furnace. Oxygen-rich air conveys the concentrate and oxidizes the bath.
New facility	A facility that started operation in Canada after the publication of first edition of the Environmental Code of Practice for Base Metals Smelters and Refineries.
Nm^3	Refers to the volume of gas at normal conditions of 1 atm and 0°C.
Noranda process reactor and converters	Produces copper matte by feeding fuel, flux, and coal while oxygen-enriched air is blown into the liquid matte. A long settling zone in the reactor allows for separation of slag and matte. The matte proceeds on to a converter while the slag is cooled; a sulphide-rich fraction is concentrated and sent to the reactor for recycling.
NO_x	Refers collectively to nitric oxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide equivalent.
NPRI Identification Number	The specific identification number assigned to facilities under the National Pollutant Release Inventory (NPRI).
Particulates	Any finely divided solid or liquid particles in the air or in an emission. Particulates include dust, smoke, fumes, and mist.
Pierce-Smith converters	The most common type of converters is refractory lined cylindrical steel shells mounted on trunions on either end and rotated about the major axis for charging and pouring. Air or oxygen-rich air is blown through the molten matte, where iron and sulphur are oxidized.
Piezometer	A type of monitoring well used to measure the elevation of the water table, i.e., how far below the surface groundwater is located.
Primary smelting	A process where mine concentrate or calcite is smelted.
Pressure leaching	In chemical extraction of valuable ore constituents, use of an autoclave to accelerate attack by means of increased temperatures and pressures.
Product stewardship	Making health, safety, and environmental protection an integral part of a product's life cycle, from design, manufacture, marketing, sale, and distribution to use, recycling, and disposal.
Release	Includes discharge, spray, inject, inoculate, abandon, deposit, spill, leak, seep, pour, emit, empty, throw, dump, place, and exhaust.
Reverberatory furnace	A type of furnace used in base metal smelters for melting the metal concentrates.
Rm^3	Reference conditions defined as volumes at 25°C (298.15°K) and 101.3 kPa, dry gas basis and operating oxygen levels.
Roasting	The charge material of metal sulphides (ore concentrates) is heated in air, partially eliminating the sulphur as sulphur dioxide in order to facilitate smelting.
Roast leach	Roasting of sulphide concentrates followed by acid leaching and electrowinning for recovery of metals.
Scrubber	An air pollution control device that uses a liquid spray to remove pollutants from a gas stream by absorption or chemical reaction. Scrubbers also reduce the temperature of the gas stream.
Secondary smelting	Reclaiming/recycling of a metal into a usable form.

Slag	A molten layer formed on top of a bath of liquid metal or matte when iron and other impurities in the charge oxidize and mix with flux.
Slag cleaning	Slag containing a significant amount of the desired metal is treated in a slag cleaning furnace to extract the desired metal and reduce the amount of magnetite. Usually slag from flash furnaces and converter furnaces requires cleaning. The slags are charged to a slag cleaning furnace (usually electric furnace), where the metals and metal sulphides are allowed to settle under reducing conditions with the addition of coke or iron sulphide.
SO_2	Sulphur dioxide, formed primarily by the combustion of sulphur-containing fuels.
Storm water	Any water from a precipitation event that is not considered to have been contaminated as defined by the appropriate regulatory agency.
Top blown rotary converter smelting	Converter that allows rapid and independent temperature and atmosphere control by the introduction of oxygen, an oxygen–fuel mixture, or other gases above the furnace bath, which is stirred by the rotation of the vessel.
U.S. Environmental Protection Agency	The environmental protection agency in the United States that is the U.S. equivalent to Environment Canada.
VOCs	Also known as reactive organic gases or non-methane volatile organic compounds. Volatile organic compounds refer only to photochemically reactive hydrocarbons and therefore exclude compounds such as methane, ethane, and several chlorinated organics.
Waste	Residues and by-products that are not recovered, reused, or recycled and are discarded.
Wastewater	Any water that is known to contain a deleterious substance that originates in and is discharged from the plant. This includes the discharge of water used for direct cooling or cleaning, blow-down from water treatment systems, and water that has been contaminated by process leaks. This does not include water used for indirect cooling or storm water.
Wet scrubbers	Removal of particles from the gas stream by capturing the particles in liquid (usually water) droplets and separating the droplets from the gas stream. The droplets act as conveyors of the particulate out of the gas stream.
Zinc plant	A zinc smelter or refinery.

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