

Code of Practice for Small Incinerators

September 2005

made under the Environmental Protection and Enhancement Act

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ALBERTA ENVIRONMENT

**CODE OF PRACTICE FOR SMALL INCINERATORS (made under the
Environmental Protection and Enhancement Act, RSA 2000, c.E-12, as
amended and *Waste Control Regulation* (AR 192/96), as amended)**

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Schedule 1 Registration Information for Small Incinerators

Section 1: Definitions

- 1.1 All definitions in the *Act* and the regulations under the *Act* apply except where expressly defined in this Code of Practice.
- 1.2 In this Code of Practice:
- (a) **“Act”** means the *Environmental Protection and Enhancement Act*, RSA 2000, c.E-12, as amended;
 - (b) **“auxiliary burner”** means a burner that fires auxiliary fuel in a small incinerator for the purpose of:
 - (i) preheating,
 - (ii) drying and igniting solid waste, or
 - (iii) maintaining adequate operating temperatures;
 - (c) **“ISO 17025”** means the international standard, developed and published by International Organization for Standardization (ISO), specifying the management and technical requirements for laboratories to demonstrate their technical competence to perform defined tests and produce valid data and results;
 - (d) **“kPa”** means kilopascal;
 - (e) **“mg/kg”** means milligrams per kilogram;
 - (f) **“mg/L”** means milligrams per litre;
 - (g) **“mobile incinerator”** means an incinerator that:
 - (i) is not fixed to any location, and
 - (ii) is operated at any one (1) location for a total of not more than 365 days in two (2) consecutive calendar years;
 - (h) **“primary chamber”** means the chamber of a small incinerator into which waste is added;
 - (i) **“Professional Engineer”** means a professional engineer or registered professional technologist (engineering) under the *Engineering, Geological and Geophysical Professions Act* or an equivalent professional designation from other jurisdiction;

- (j) **“registration holder”** means a person who has been issued a registration under the *Act* for the construction, operation, or reclamation of a small incinerator;
- (k) **“regulations”** mean the regulations under the *Act*;
- (l) **“Rm³”** means cubic metre of air at the reference conditions of twenty-five (25) degrees Celsius and 101.325 kPa;
- (m) **“secondary combustion chamber”** also known as afterburner, means the chamber of a small incinerator where the flue gas from the primary chamber is heated to a temperature that will destroy the waste;
- (n) **“small incinerator”** means:
 - (i) a mobile incinerator that, by means of burning under control conditions, treats waste that contains:
 - (A) halogenated organic compounds in an amount of not more than one thousand (1000) milligrams per kilogram of waste,
 - (B) polychlorinated biphenyls in an amount of not more than fifty (50) milligrams per kilogram of waste,
 - (C) lead in an amount of not more than one hundred (100) milligrams per kilogram of waste, or
 - (D) mercury in an amount of not more than two (2) milligrams per kilogram of waste; and
 - (ii) an incinerator that, by means of burning under controlled conditions, treats not more than ten (10) tonnes of waste per month, and:
 - (A) is fixed to one location, or
 - (B) is operated at any one (1) location for a total of more than 365 days in two (2) consecutive calendar years,

but does not include an incinerator that:

- (iii) is used by one single-family detached dwelling to burn household waste generated only by that household,

- (iv) is used for burning kitchen camp wastes at a mining, construction, demolition, drilling or exploration site,
 - (v) is used for burning human bodies at a crematory that is licensed under the *Cemeteries Act*, or
 - (vi) is governed by an authorization issued under the *Oil and Gas Conservation Act*.
- (o) **"TEQ"** means dioxin toxic equivalent with respect to the following toxicity equivalency factors:

Congeners	Toxicity Equivalency Factor
2,3,7,8-tetrachloro-dibenzo-p-dioxin	1.000
1,2,3,7,8-pentachloro-dibenzo-p-dioxin	0.500
1,2,3,4,7,8-hexachloro-dibenzo-p-dioxin	0.100
1,2,3,6,7,8-hexachloro-dibenzo-p-dioxin	0.100
1,2,3,7,8,9-hexachloro-dibenzo-p-dioxin	0.100
2,3,7,8-tetrachloro-dibenzofuran	0.100
1,2,3,7,8-pentachloro-dibenzofuran	0.050
2,3,4,7,8-pentachloro-dibenzofuran	0.500
1,2,3,4,7,8-hexachloro-dibenzofuran	0.100
1,2,3,6,7,8-hexachloro-dibenzofuran	0.100
1,2,3,7,8,9-hexachloro-dibenzofuran	0.100
2,3,4,6,7,8-hexachloro-dibenzofuran	0.100

- (p) **"thermal desorber"** means a small incinerator that:
- (i) uses indirect heat to separate volatile organic compounds from a waste, and
 - (ii) destroys these volatile organic compounds in a combustion chamber; and
- (q) **"this Code of Practice"** means the *Code of Practice for Small Incinerators*, published by the Department, as amended.

Section 2: General Requirements

- 2.1 Any registration holder who operates a small incinerator, must do so in accordance with this Code of Practice.
- 2.2 Any conflict between the registration application and the terms and conditions of this Code of Practice shall be resolved in favour of this Code of Practice.

- 2.3 The terms and conditions of this Code of Practice do not affect any rights or obligations created under any other authorization issued by Alberta Environment.
- 2.4 The terms and conditions of this Code of Practice are severable. If any term or condition of this Code of Practice or the application of any term or condition is held invalid, the application of such term or condition to other circumstances and to the remainder of this Code of Practice shall not be affected by that invalidity.
- 2.5 Subject to 2.6, if the registration holder monitors for any substances or parameters which are the subject of limits in this Code of Practice more frequently than is required, using procedures authorized in this Code of Practice, then the registration holder shall provide the results of such monitoring as an addendum to the next reports required by this Code of Practice.
- 2.6 Section 2.5 does not apply to short term testing or monitoring of operational changes, new processes, or technologies that do not cause an adverse effect.
- 2.7 The registration holder shall immediately notify the Director in writing if any of the following events occur:
- (a) the registration holder is served with a petition into bankruptcy;
 - (b) the registration holder files an assignment in bankruptcy or Notice of Intent to make a proposal;
 - (c) a receiver or receiver-manager is appointed;
 - (d) an application for protection from creditors is filed for the benefit of the registration holder under any creditor protection legislation; or
 - (e) any of the assets, which are the subject matter of this Code of Practice, are seized for any reason.

Section 3: Analytical Requirements

- 3.1 Any sample required pursuant to this Code of Practice shall be:
- (a) collected;
 - (b) preserved;
 - (c) stored;
 - (d) handled; and

(e) analysed

in accordance with:

- (i) the *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, published by the United States Environmental Protection Agency, 1998, as amended,
 - (ii) the *Alberta Stack Sampling Code*, published by Alberta Environment, 1995, as amended,
 - (iii) the *Methods Manual for Chemical Analysis of Atmospheric Pollutants*, AEC V93-M1, Alberta Environmental Centre, 1993, as amended,
 - (iv) the *Air Monitoring Directive*, Alberta Environment, 1989, as amended,
 - (v) the *Standard Methods for the Examination of Water and Waste Water*, 20th edition, 1998, published by the American Public Health Association, American Water Works Association, and Water Environment Federation, as amended, or
 - (vi) any other equivalent method authorized in advance in writing by the Director.
- 3.2 The registration holder shall analyse all samples that are required to be obtained by this Code of Practice in a laboratory accredited pursuant to ISO 17025 standard, as amended, for the specific parameter(s) to be analysed, unless otherwise authorized in writing by the Director.
- 3.3 The registration holder shall comply with the terms and conditions of any written authorization issued by the Director under 3.2.

Section 4: Registration Application / Administration Requirements

- 4.1 An application for a registration of a small incinerator shall contain, at a minimum, the information specified in Schedule 1.
- 4.2 The technical assessment of the small incinerator referred to in clause (f) of Schedule 1 shall be signed and stamped by a Professional Engineer, the manufacturer, or the supplier of the equipment.
- 4.3 Where a registration has been issued regarding a particular small incinerator, that registration applies only to that small incinerator, and shall not be applied to any other small incinerator.

- 4.4 A registration holder shall provide written notice to the Director within fourteen (14) calendar days of any change in the information provided in the application for the registration, regarding:
- (a) the maximum volume of wastes to be treated on a monthly basis;
 - (b) change in the chemical characteristics of the wastes that affects the classification of the waste;
 - (c) the name, address, and phone number of the registration holder; and
 - (d) the name, address, and phone number of the person who has charge, management, or control of the small incinerator.

Section 5: Design Requirements

- 5.1 No person shall operate a small incinerator that has no secondary chamber unless the small incinerator is equipped with:
- (a) an auxiliary burner;
 - (b) a spark arrestor;
 - (c) a temperature recording system, which:
 - (i) measures, and
 - (ii) continuously recordsthe temperature of the flue gas in the primary chamber, subject to 5.5; and
 - (d) a flue gas stack with a top that is at an elevation of at least:
 - (i) four (4) metres above the ground, and
 - (ii) two (2) metres above any natural or man-made structure located within ten (10) metres of the small incinerator.
- 5.2 No person shall operate a small incinerator that has both a primary combustion chamber and a secondary combustion chamber unless the small incinerator is equipped with:
- (a) an auxiliary burner;
 - (b) a temperature recording system, which:

- (i) measures, and
 - (ii) continuously records

the temperature of the flue gas in the primary combustion chamber, subject to 5.5;
 - (c) a temperature recording system which:
 - (i) measures, and
 - (ii) continuously records

the temperature of the flue gas in the secondary chamber, subject to 5.5; and
 - (d) a flue gas stack with a top that is at an elevation of at least:
 - (i) four (4) metres above the ground, and
 - (ii) two (2) metres above any natural or man-made structure located within ten (10) metres of the small incinerator.
- 5.3 Subsections 5.1(d) and 5.2(d) do not apply where the small incinerator is operated at a location that is 1.5 kilometres or more from:
- (a) the boundary of a city, town, village, hamlet, or summer village; or
 - (b) a residence or business.
- 5.4 The temperature of:
- (a) the flue gas in the primary combustion chamber; and
 - (b) the flue gas in the secondary combustion chamber
- shall be recorded continuously, subject to 5.5.
- 5.5 The temperature recording system referred to in 5.1(c)(ii), 5.2(b)(ii), and 5.2(c)(ii) is not required to be continuous in the combustion chambers of:
- (a) batch small incinerators that burn less than ninety (90) kilograms of non-hazardous waste per hour; or
 - (b) thermal desorbers used for the removal of non-halogenated organic compounds from waste or contaminated soil.

5.6 The temperature recording system for the small incinerators referred to in 5.5(a) and (b) shall:

- (a) measure; and
- (b) record

the temperature of the flue gas in the combustion chamber or in the treated waste or soil, as applicable, while the waste is being burned.

Section 6: Operational and Emission Requirements

6.1 The registration holder operating a small incinerator that has no secondary combustion chamber shall not burn waste that contains any of the following:

- (a) halogenated organic compounds in a total amount greater than fifty (50) mg/kg of waste;
- (b) lead in an amount greater than one hundred (100) mg/kg of waste; or
- (c) mercury in an amount greater than two (2) mg/kg of waste.

6.2 Subject to 6.3, emissions from a small incinerator shall not exceed any of the following limits:

- (a) a maximum one (1) hour average concentration of fifty (50) milligrams of particulate matter per Rm^3 ;
- (b) a maximum one hour average concentration of seventy five (75) milligrams of hydrogen chloride per Rm^3 ;
- (c) a maximum one hour average concentration of fifty seven (57) milligrams of carbon monoxide per Rm^3 ;
- (d) visible emissions of twenty (20) percent opacity averaged over a period of six (6) consecutive minutes, determined in accordance with Part 1 of the *Substance Release Regulation* (AR 124/93);
- (e) a maximum one hour average concentration of eighty (80) pg TEQ of dioxins and furans per Rm^3 ; and
- (f) a maximum one hour average concentration of twenty (20) μg of mercury per Rm^3 .

- 6.3 The emission limits in 6.2(e) and (f) apply only to a small incinerator that has both a primary combustion chamber and a secondary combustion chamber if the following criteria are met:
- (a) the registration holder burns waste with:
 - (i) halogenated organic compounds at levels which exceed a total amount greater than fifty (50) mg/kg of waste, or
 - (ii) mercury in an amount greater than two (2) mg/kg of waste; and
 - (b) the burning is done on or after January 1, 2006.
- 6.4 Subject to 6.6, no person shall operate a small incinerator that has no secondary combustion chamber unless the operating temperature is at least five hundred (500) degrees Celsius.
- 6.5 Subject to 6.6, no person shall operate a small incinerator that is equipped with both a primary combustion chamber and a secondary combustion chamber unless the operating temperatures are at least:
- (a) Five-hundred (500) degrees Celsius in the primary combustion chamber; and
 - (b) Eight hundred seventy (870) degrees Celsius in the secondary combustion chamber.
- 6.6 No person shall operate a thermal desorber unless:
- (a) the temperature in the combustion chamber is greater than the boiling point of the least volatile chemical constituent in the waste or contaminated soil being treated; and
 - (b) the operation complies with the design, operation, and control systems of the small incinerator, as specified by the manufacturer.
- 6.7 All wastes and wastewater resulting from the small incinerator shall be:
- (a) handled in compliance with the *Waste Control Regulation*; and
 - (b) disposed of or recycled in a manner authorized under the *Act*.

Section 7: Monitoring Requirements

- 7.1 The monitoring referred to in 5.6 for the temperature of the flue gas in the combustion chamber or in the treated waste or soil, as applicable,

shall be conducted at least once per day or once for each different batch of wastes being processed, whichever represents a shorter period.

- 7.2 Prior to, or during operation of the small incinerator, and as often as there is a change in the nature of the waste burned, the registration holder shall collect data on:
- (a) the waste characteristics, including the parameters specified in 6.1; and
 - (b) the expected or actual emissions as specified in 6.2.
- 7.3 Subject to 7.4, a person responsible for a small incinerator shall complete a manual stack survey:
- (a) within six (6) months of commencement of burning waste that contains:
 - (i) halogenated organic compounds in a total amount greater than fifty (50) mg/kg of waste,
 - (ii) lead in an amount greater than one-hundred (100) mg/kg of waste,
 - (iii) mercury in an amount greater than two (2) mg/kg of waste; or
 - (b) as requested in writing by the Director.
- 7.4 Upon application and submission by the person responsible for the small incinerator the Director may exempt the person from the test under 7.3. by notice in writing.
- 7.5 At least two (2) weeks prior to conducting a manual stack survey required in 7.3, the registration holder shall notify the Director in writing that the manual stack survey will be undertaken.
- 7.6 The manual stack survey required under section 7.3 shall meet the following requirements:
- (a) the stack gas must be analysed for the parameters set out in section 6.2, as applicable;
 - (b) the operating temperatures of all combustion chambers must be recorded; and
 - (c) the manual stack survey must comply with the sampling procedures in the *Alberta Stack Sampling Code*, 1995, published by Alberta Environment, as amended.

7.7 In addition to the collection and analysis of samples under this *Code of Practice*, the registration holder shall:

- (a) collect;
- (b) analyse; and
- (c) provide the Director with results of

any additional samples that are required in writing by the Director.

Section 8: Closure Requirements

8.1 Where a small incinerator:

- (a) has ceased operations permanently; or
- (b) has not been operated for a period of twelve (12) consecutive months;

the registration holder shall notify the Director in writing within thirty (30) calendar days after the respective event.

Section 9: Reporting Requirements

9.1 In addition to any other reporting required pursuant to this Code of Practice, the *Act*, or the regulations, the registration holder shall immediately report any contravention of this Code of Practice to the Director, either:

- (a) by telephone at (780) 422-4505; or
- (b) by a method:
 - (i) in compliance with the release reporting provisions in the *Act* and the regulations, or
 - (ii) authorized in writing by the Director.

9.2 In addition to the immediate report in 9.1, the registration holder shall provide a report to the Director:

- (a) in writing; or
- (b) by a method:
 - (i) in compliance with the release reporting provisions in the *Act* and the regulations, or

- (ii) authorized in writing by the Director

within seven (7) calendar days of the discovery of the contravention, or within a time period specified in writing by the Director, unless the Director waives the requirement for a report.

9.3 The report required under 9.2 shall contain, at a minimum, the following information:

- (a) a description of the contravention;
- (b) the date, time, and duration of the contravention;
- (c) the address or legal land description (LLD) of the location of the contravention;
- (d) the name of the registered owner or owners of the land on which the contravention occurred;
- (e) the name, address, phone number, and responsibilities of all persons operating the small incinerator at the time the contravention occurred;
- (f) an explanation as to why the contravention occurred including, but not limited to, a comparison of operating conditions at the time the contravention to normal operating conditions;
- (g) a summary of all measures and actions that were taken to mitigate any effects of the contravention;
- (h) a summary of all measures that will be taken to address the remaining effects and potential effects related to the contravention;
- (i) the name, address, phone number, and responsibilities of all persons who had charge, management, or control of the small incinerator at the time the contravention occurred;
- (j) a summary of proposed measures that will prevent future contraventions, including a schedule of implementation for these measures;
- (k) any information that was maintained or recorded under this Code of Practice, as a result of the incident; and
- (l) any other information required by the Director in writing.

9.4 A registration holder, who is required to complete a manual stack survey under 7.3 shall, within sixty (60) days of completion of the manual stack

survey, provide to the Director a copy of the manual stack survey results.

Section 10: Record Keeping Requirements

10.1 The registration holder shall:

- (a) record the following information;
- (b) maintain the following information; and
- (c) keep the following information available for five (5) years after the creation of the record:
 - (i) all records that are required under this Code of Practice,
 - (ii) the results of any recording, monitoring, analysis, and any stack testing that are carried on pursuant to this Code of Practice, including the method of testing used,
 - (iii) the source, quantity, and characteristics of waste incinerated on a per monthly basis,
 - (iv) the quantity, type, and disposal location of all wastes resulting from operation of the small incinerator, on a monthly basis,
 - (v) a description of all maintenance and repairs made to the small incinerator including:
 - (A) the date of the maintenance;
 - (B) a description of the maintenance conducted; and
 - (C) the name of person conducting the maintenance,
 - (vi) a copy of all applications submitted to the Department for a registration,
 - (vii) design drawings and specifications for the small incinerator,
 - (viii) all reports of inspections conducted by the Department,

- (ix) the registration issued under the *Act* for the activity, and
- (x) all correspondence with the Department regarding the small incinerator.

10.2 The results and records in 10.1(a) and 10.1(c) shall contain, at a minimum, all of the following information:

- (a) the date, place, and time of monitoring, and the name of the person collecting the sample;
- (b) the date of analysis;
- (c) the laboratory name and person responsible for performing analysis;
- (d) the analytical method used; and
- (e) the results of the analysis.

10.3 Prior to commencing operation of a mobile incinerator at a new location, the person responsible shall prepare an information sheet, which shall include, but is not limited to, the following information with respect to the small incinerator:

- (a) the registration;
- (b) the name, address, and phone number of the person who holds the registration;
- (c) the name of the company and/or persons who will have control of the mobile incinerator on behalf of the registration holder;
- (d) the name, address, and phone number of the person responsible for the small incinerator;
- (e) the name and mailing address of the waste generator from whom the waste was received;
- (f) the name and address of the registered owner of the land on which the mobile incinerator will operate;
- (g) a site plan showing the proposed operating location;
- (h) a map showing water bodies, residences, institutions, and commercial and industrial developments within a 1.5 kilometre radius of the site at which the small incinerator will operate; and

- (i) the planned duration of the operation.
- 10.4 The requirements in 10.3 do not apply to a mobile incinerator that:
 - (a) operates for less than seven (7) days in two (2) consecutive months at the same location; and
 - (b) burns less than ten (10) tonnes of waste per month.
- 10.5 A registration holder shall, upon request by an inspector or Director, provide to the inspector or Director, a copy of the registration issued under the *Act*, any accompanying correspondence, and any records or data regarding the small incinerator.

Section 11: Code of Practice Administration

- 11.1 This Code of Practice will be reviewed as changes in technological and other standards warrant.

SCHEDULE 1

REGISTRATION INFORMATION FOR SMALL INCINERATORS

Pursuant to 4.1 of this Code of Practice, all of the following information shall be provided to the Director:

- (a) The name of the intended registration holder, their address, phone number, facsimile number, and e-mail address;
- (b) The company name (if any) and the name, job title, address, phone number, facsimile number, e-mail address, and signature of the person who submitted the registration application on behalf of the intended registration holder;
- (c) If a person other than the intended registration holder submitted the registration application, written authorization is required from the intended registration holder, stating that the person who submitted the registration application was authorized to do so on behalf of the intended registration holder;
- (d) The name, job title, address, phone number, facsimile number, and e-mail address of the person designated by the intended registration holder as the primary contact for the small incinerator;
- (e) The municipal address (if one exists), or legal land description (LLD) on which the small incinerator is or will be located;
- (f) A technical assessment of the small incinerator, which includes but is not limited to:
 - (i) the make, model, and serial number of the incinerator,
 - (ii) type of incinerator,
 - (iii) the design and number of combustion chambers,
 - (iv) the operating temperature(s) of the combustion chambers,
 - (v) the operating temperatures of the desorption and combustion chambers of a thermal desorber,
 - (vi) any modifications to the small incinerator,
 - (vii) equipment to be used in conjunction with the small incinerator,
 - (viii) the actual and rated capacity, as specified by the manufacturer, in kilograms per hour,

- (ix) the source, quantity, and chemical characteristics of wastes or contaminated soils expected to be processed,
- (x) the proposed disposal location of any wastes resulting from the operation, and
- (xi) monitoring to be conducted.

In consideration of the information required above, and the information required in an Activities Plan, the Director waives the requirements of subsection 3(1)(a) through (o) of the *Approvals and Registrations Procedure Regulation*, A.R. 113/93, as amended from time to time, for a registration application under this Code of Practice.

CONTINUOUS EMISSION MONITORING SYSTEM (CEMS) CODE

1998

**Alberta Environmental Protection
Environmental Service**

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(CEMS) CODE

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1.0 INTRODUCTION

1.1 General

This code establishes requirements for the installation, operation, maintenance, and certification of continuous emission monitoring systems. These requirements will ensure effective measurement, recording, and standardized reporting of specified emissions and other parameters. In addition, the code establishes requirements for alternative monitoring systems and for the quality assurance and quality control of continuous emission monitoring data.

1.2 Purpose and Intent

Approvals issued under the Environmental Protection and Enhancement Act (EPEA) may require continuous emissions monitoring on an effluent source. The Alberta Continuous Emission Monitoring System (CEMS) Code, hereafter referred to as the "CEMS Code," identifies acceptable methods and specifications for the installation and operation of such monitoring systems.

The Alberta CEMS Code is largely based on methodology developed and used by both the U.S. Environmental Protection Agency and Environment Canada.

The CEMS Code contains performance specifications for the majority of CEM system requirements that are referenced in facility approvals. For those CEM systems for which specifications are not included in this code, new methods will be incorporated into the CEMS Code as they are developed.

The final decision on any matter dealing with the CEMS Code rests with the Director of Air and Water Approvals, hereafter referred to as the "Director," in Alberta Environmental Protection.

1.3 CEMS Data Use

All data generated by a CEMS (where the use of that CEMS is linked to the EPEA approval for its associated facility) can be used as a basis for enforcement. Exceptions include in-stack opacity data except as noted otherwise or data specified in the approval as not useable for compliance. These other CEMS data would be used only to fulfil performance assessment requirements. For the purposes of this Code, opacity and in-stack opacity are defined differently and are not equivalent.

Within the thermal electric power generating industry, in-stack opacity limits for start-up and shutdown have been established and CEMS generated data for this industry can be used as a basis for compliance.

For opacity, the "visible emissions reader" will continue to be the only official compliance method for determining opacity levels as currently referenced in the Substance Release Regulation. In the event that this compliance requirement changes, the "Director," will provide a minimum advance notice of at least two years of the intent to implement in-stack opacity CEMS as compliance monitors (except as already noted above). This transition period would allow sufficient lead time for implementation of any required equipment changes to in-stack opacity monitors.

1.4 Implementation

The CEMS Code applies to all facilities where continuous emission monitoring is a condition of an EPEA approval.

The requirements in the CEMS Code come into effect on January 1, 1999.

1.5 Application of CEMS Code to Existing and New CEMS Installations

1.5.1 Code Requirements for Existing Installations

A number of facilities, approved prior to the issuance of this CEMS Code, may have CEMS that do not fully comply with the CEMS Code with respect to either of the following, namely: (a) installation requirements; or (b) equipment required to conduct various quality control procedures (for example, calibration gas may not be introducible at the proper location in some of the older designs, etc.).

Each facility shall assess (within 6 months of this code coming into effect or alternatively according to a schedule agreed to by the Director), on the basis of technical merit, whether CEMS operational and performance specification requirements (as specified in Section 4) can be achieved with the existing configuration. This assessment is to ensure that the facility's CEMS can meet CEMS Code performance specification requirements. If the CEMS can meet these requirements, then no further action would be required; if not, then the facility shall establish a program, acceptable to Alberta Environmental Protection, to upgrade the CEMS installation so it meets performance specification requirements.

Replacement of the existing data handling system associated with a CEMS will not require that initial performance specification testing requirements be conducted; however, the Quality Assurance Plan (QAP) for the facility should detail the appropriate quality control procedures to ensure data quality of the new data acquisition system.

Facilities for which installation received approval prior to the effective date of the CEMS Code are still required to meet ongoing Quality Assurance/Quality Control (QA/QC) requirements as specified in the code.

1.5.2 Code Requirements for New Installations

All new CEMS required after the issuance of this Code must comply with all design, installation, performance, and quality control requirements of this Code. All new CEMS will be required to conduct the initial performance specification testing as contained in this CEMS Code and be certified in accordance with Section 4.0 of this code.

1.6 CEMS Technology

In general, monitoring techniques are based on the direct measurement of both physical and chemical properties of the component of interest. The method selected for the gas analysis depends primarily upon the characteristics of the subject gas, but it can also be affected by other parameters such as regulatory requirements and stack conditions. Commonly used analytical techniques include those of spectroscopic absorption, luminescence, electroanalysis, electro-chemical analysis and paramagnetism.

The specifications of this Code address the use of independent, certified gases for calibration and audit for CEMS that accept calibration gases. The Director reserves the right to review

CEMS that do not accept independent, certified gases for calibration or audit. Alternative methods of calibration will be authorized if equivalent performance to gas calibrated systems can be demonstrated.

The Director also reserves the right to review proposed indirect monitoring systems that use operating parameters correlated to emissions. Such "parameter" or "predictive" emission monitoring systems must be validated initially for the range of operating and control conditions likely to occur at the facility. Parameter and predictive emission monitoring systems must also provide for a method of daily validation that results in continuous performance equivalent to that of gas calibrated CEMS.

1.7 Endorsement

Alberta Environmental Protection does not endorse specific CEMS equipment, alternative methods, or equipment suppliers. No list of approved equipment will be maintained by Alberta Environmental Protection.

1.8 CEMS Data Retention Requirements

Each facility shall maintain "raw" data for a period of at least 3 years and "summary" data for a period of at least 10 years. "Raw" data must be consistent with the definition of continuous as defined in Appendix A and should provide for "satisfactory demonstration" of quality control activities as defined in the CEMS Code and the facility Quality Assurance Plan (QAP). The media for storage of "raw" data shall be designated by the facility and documented in the facility QAP. Raw data shall be made available for inspection if requested by Alberta Environmental Protection.

1.9 Monitoring Plan

For new installations, the following information regarding the CEM system must be submitted to the Director at least sixty (60) days prior to system installation : ¹

- A. Describe in general terms the process(es) and pollution control equipment, along with all factors that may affect the operation of the monitoring system.
- B. Describe the location of the monitoring system/sample acquisition point(s) or path(s) in relation to flow disturbances (fans, elbows, inlets, outlets), pollution control equipment, flue walls, and emission point of the monitored effluent streams to the atmosphere. Explain any deviations from the location criteria that are specified in Section 3.0.
- C. List the following system information:
 - pollutant(s) or parameters to be monitored,
 - the operating principles of the analyzer(s),
 - the number of analyzers, and the number of acquisition point(s) or path(s) for a analyzer, or bank of analysers sharing multiple ducts (time sharing systems),
 - the equipment manufacturer and model number(s),
 - a copy of the checklist to be used by the instrument technician for periodic checking of the analyzer(s), and
 - the expected normal and maximum analyzer or flow rate readings.
- D. Describe the process and pollution control equipment operating parameters that affect the emission levels of the pollutants being monitored or the parameters being monitored, and also explain the method to be used to record these parameters.

¹ The listed information requirements may be included as part of the QAP. It is not necessary to duplicate this information elsewhere.

- E. Describe calibration, operational and maintenance procedures, along with recommended schedules.
- F. Explain procedures to be used to satisfy the requirements for record keeping as defined by the Director.

2.0 DESIGN SPECIFICATIONS

Continuous Emission Monitoring Systems for monitoring gases consists of the following four subsystems:

- Sample Interface/Conditioning;
- Gas Analyzers;
- Data Acquisition;
- Flow monitor (where applicable).

The acceptability of emission monitoring systems is in general, performance based; however minimal design specifications are specified for gas analyzers, in-stack opacity monitors, and flow monitoring systems. These specifications have been established either to ensure the overall stability of the CEMS once the analyzers are incorporated into the system, or to ensure that accurate readings will be obtained for the parameter being measured. Procedures for the verification of design specifications are given in Section 4.0.

Unless otherwise authorized by the Director, the chosen range of each monitor is specified in Tables 1 to 4. If the average monthly parameter of any analyzer should fall outside these limits, the analyzer span should be adjusted so that the average is brought back within these limits. If emission values vary widely, the use of multi-range analyzers is encouraged. Data that fall outside the range of an analyzer are considered to be missing.

2.1 Design Specifications for Gas Analyzers

Design specifications for gas analyzers for monitoring sulphur dioxide, oxides of nitrogen, and carbon monoxide are given in Table 1.

Table 1 Design Specifications for CEM system gas analyzers

Design Specifications	Sulphur Dioxide Analyzers	Oxides of Nitrogen Analyzers	Carbon Monoxide Analyzers
Lower detection limit	$\leq 2\%$ of span	$\leq 2\%$ of span	$\leq 2\%$ of span
Interference rejection (sum total)	$\leq \pm 4\%$ of span	$\leq \pm 4\%$ of span	$\leq \pm 4\%$ of span
Response time (95%)	200 s (Max.)	200 s (Max.)	200 s (Max.)
Analyzer range	1.5 times approval limit		
Temperature-responsive zero drift ^a	$\leq \pm 2\%$ of span	$\leq \pm 2\%$ of span	$\leq \pm 2\%$ of span
Temperature-responsive span drift ^a	$\leq \pm 3\%$ of span	$\leq \pm 4\%$ of span	$\leq \pm 3\%$ of span

^a for every 10°C change in analyzer operating temperature.

Table 2 Design Specifications for Total Reduced Sulfur analyzers

Design Specification	TRS Analyzer
Lower detection limit	$\leq 2\%$ of span
Interference rejection (sum total)	$\leq \pm 4\%$ of span
Response time (95%) and cycle time	15 minutes (Max.)
Analyzer range	1.5 times approval limit or 30 ppm whichever is the greater

Design specifications for oxygen and carbon dioxide (diluent) monitors are given in Table 3.

Table 3 Design Specifications for diluent monitors

Design Specification	O ₂ Analyzers	CO ₂ Analyzers
Lower detection limit	$\leq 0.5\% \text{ O}_2$	$\leq 0.5\% \text{ CO}_2$
Interference rejection	$\leq \pm 1.0\% \text{ O}_2$	$\leq \pm 1.0\% \text{ CO}_2$
Response time (95%)	200s (Max.)	200s (Max.)
Analyzer range	0 - 21%	0 - 25%
Temperature-responsive zero drift ^a	$\leq \pm 0.5\% \text{ O}_2$	$\leq \pm 0.5\% \text{ O}_2$
Temperature-responsive span drift ^a	$\leq \pm 0.5\% \text{ O}_2$	$\leq \pm 0.5\% \text{ O}_2$

^a for every 10°C change in analyzer operating temperature.

2.1.1 Interference Rejection

Each analyzer shall exhibit a response of less than that specified in Tables 1 to 3 for the sum of all interferences due to other gas constituents as measured by the procedures given in Section 4.0.

2.1.2 Temperature-Responsive Drifts

Each pollutant or diluent gas analyzer used in the system must exhibit a zero drift less than 2% of the full-scale setting for any 10°C change over the temperature range of 5° to 35°C.

Additionally, each analyzer must exhibit a span drift of less than 3 or 4% of the full-scale setting for any 10°C change in temperature from 5° to 35°C. Both the zero and span drift tests are to be carried out within the acceptable temperature operating range of the analyzer, as specified by the manufacturer. Follow the procedures outlined in Section 4.4.2 or alternatively confirm that Section 4.4.3 has been complied with to determine the temperature-responsive drift.

2.1.3 Cycle-time/Response Time

The cycle-time/response-time specification applies to systems, as opposed to analyzers. One complete measurement or cycle of measurements of all effluent streams must be completed in 15 minutes or less.

2.2 Design Specifications for In-Stack Opacity Monitors

Design Specifications for in-stack opacity monitors are given in Table 4. These specifications establish specific design criteria for the in-stack opacity monitoring system.

Table 4 In-Stack Opacity Monitor Design specifications

Design Specification		In-Stack Opacity Monitors
Spectral response		Photopic
Angle to view		$\leq 5^\circ$
Angle of projection		$\leq 5^\circ$
Response time		10 sec (Max.)
Range		0 - 100%
Temperature-Responsive zero drift ^a		2% opacity
Temperature-Responsive span drift ^a		2% opacity
Physical design	a. Simulated zero and upscale calibration system b. Access to external optics c. Automatic zero compensation d. External calibration filter access e. Optical alignment sight	

^a for every 10°C change in analyzer operating temperature

Alternatively, a certificate of conformance stating that the in-stack opacity monitor meets the design specifications of the U.S. EPA given in 40 CFR 60 Appendix B - Performance Specification 1, obtained from the manufacturer would be acceptable to the Director.

Then, the in-stack opacity monitor is calibrated, installed, and operated for a specified length of time. During this specified time period, the system is evaluated to determine conformance with the established performance specifications given in Section 4.0 of this Code.

2.2.1 Peak and Mean Spectral Responses

The peak and mean spectral responses must occur between 500 nm and 600 nm. The response at any wavelength below 400 nm or above 700 nm shall be less than 10% of the peak spectral response.

2.2.2 Angle of View

The total angle of view shall be no greater than 5 degrees.

2.2.3 Angle of Projection

The total angle of projection shall be no greater than 5 degrees.

2.2.4 Simulated zero and upscale calibration system

Each analyzer must include a calibration system for simulating a zero in-stack opacity and an upscale in-stack opacity value for the purpose of performing periodic checks of the monitor calibration while on an operating stack or duct. This calibration system will provide, as a minimum, a system check of the analyzer internal optics and all electronic circuitry including the lamp and photodetector assembly.

2.2.5 Access to external optics

Each analyzer must provide a means of access to the optical surfaces exposed to the effluent stream in order to permit the surfaces to be cleaned without requiring removal of the unit from the source mounting or without requiring optical realignment of the unit.

2.2.6 Automatic zero compensation

If the system has a feature that provides automatic zero compensation for dust accumulation on exposed optical surfaces, the system must also provide some means of indicating when a compensation of 4% in-stack opacity has been exceeded.

2.2.7 External calibration filter access

The monitor must provide a design that accommodates the use of an external calibration filter to assess monitor operation.

2.2.8 Optical Alignment sight

Each analyzer must provide some method for visually determining that the instrument is optically aligned. The method provided must be capable of indicating that the unit is misaligned when an error of ± 2 percent in-stack opacity occurs due to misalignment at a monitor pathlength of 8 metres.

2.3 Design Specifications for Flow Monitors

Design specifications for flow monitors are given in Table 5.

Table 5 Flow Monitor Design specifications

Design Specification	Flow Monitors
Lower detection limit	1.0 m/sec
Range	1.5 times expected max. value
Response time (95%)	10 sec (Max.)
Physical design	a. Means of cleaning flow element b. No interference from moisture

2.3.1 Cleaning

If necessary, differential pressure flow monitors shall provide an automatic, timed period of backpurging or equivalent method of sufficient force and frequency to keep the sample port and probe and lines free of obstructions. Differential pressure flow monitors shall provide a method (either manual or automated) for detecting leaks or plugging throughout the system. Thermal flow monitors and ultrasonic monitors shall provide a method for detecting probe fouling and a means of cleaning the transducer surface in situ or by removal and cleaning.

2.3.2 Calibration

The entire flow monitoring system including the flow probe or equivalent and including the data acquisition and handling system shall be calibrated as per the requirements contained in Table 16.

2.4 Design Specifications for Temperature Sensors

Table 6. Temperature sensor design specifications.

Design Specification	Temperature Sensors
Response time (95%)	60 sec (Max.)
Range	1.5 times approval limit

2.5 Specifications for the Data Acquisition System

2.5.1 General

The CEMS shall include a data acquisition system that accepts the output of the analyzers and flow monitors (where applicable) and converts these to emission rates of the gaseous pollutants in appropriate units as specified in the facility approval. These systems shall be capable of interpreting and converting the individual output signals from each monitor to produce a continuous readout in appropriate units as specified in the facility approval. Where diluent emissions are measured with a CEMS, the data acquisition system shall also be capable of producing a readout in appropriate units as specified in the facility approval.

The system shall maintain a permanent record of all parameters in a format acceptable to the Director.

The system must also record and compute daily zero and span drifts (as specified in Table 16), and provide for backfilling and substitution for missing data, if required by an approval.

Automated data acquisition and handling systems shall:

1. read and record the full range of pollutant concentrations from zero through to span, and
2. provide a continuous, permanent record.

Data shall be reduced to valid one-hour averages and shall be computed from four (4) or more values equally spaced or averaged over each one-hour period and in accordance with the definition of a "valid hour" as defined in Appendix A.

During each 24 hour period, one, one-hour average may consist of a minimum of two (2) data points (representing 30 minutes of data) to allow for calibration, quality assurance activities, maintenance, or repairs. If this minimum data accumulation is not achieved, the hour will be counted as missing data for the purposes of calculating availability.

2.5.2 Data Recorder Resolution

Data recorder hard copy resolution for system response shall be $\pm 0.5\%$ of full scale or better. Data recorder hard copy time resolution shall be 1 minute or less.

2.5.3 Availability

The percentage availability for the system and each analyzer shall be calculated monthly either by the data acquisition system or manually, using the following equation:

$$\% \text{ Availability (System or Analyzer)} = \frac{T_a}{T} \times 100$$

where:

T_a = the time in hours during which the system or analyzer was generating quality assured data (as defined in Appendix A) during the time the source operated during the month.

T = the total time in hours the source operated during the month and is defined as those hours during which the fuel is burned* (for combustion-related processes) or those hours during which effluent is being discharged from an effluent source as described in an approval (for noncombustion-related sources).

* for combustion sources, the operational time also includes any time period(s) attributable to "cool down" or "purge" modes.

Time periods necessary for CEMS calibration, quality control checks or backpurging, shall not be considered as downtime when calculating T_a .

2.5.4 Backfilling and Substitution for Missing Data

Upon the authorization of the Director, emissions data that are missing due to a malfunction of the CEMS may be substituted for a period of up to 120 hours for any single episode using data derived from operational parameter correlation or predictive modelling techniques. Reference Method test data or data obtained from a monitor previously certified for the application may also be used for substituting data. The technique used to obtain substitute data must be fully described in the QAP developed for each CEMS, and must be authorized in writing by the Director prior to implementation.

For sources authorized to backfill or substitute data, when a CEMS malfunction extends beyond 120 hours for any single episode, data must be generated by another authorized CEMS or valid Reference Method.

Other CEMS used for this purpose must meet all design and performance specifications given in this Code. When using another system, the effluent stream sample shall be extracted from the sample port used for the Reference method during certification of the installed CEMS.

Data that are substituted using the correlation technique cannot be credited towards meeting the CEMS availability criteria. Data generated by an acceptable alternate CEMS may be credited to the availability requirement.

Data substitution shall be limited to a maximum of 120 hours per calendar month for each CEMS, unless specified otherwise by the Director.

3.0 INSTALLATION SPECIFICATIONS

This Section contains guidelines for selecting a suitable sampling site on the flue, duct, or stack and determining the representativeness of the desired location with respect to the homogeneity of the effluent stream.

3.1 Location of the Sampling Site

The frequency and quality of maintenance on the CEMS have been shown to be directly related to the accessibility of the stack-mounted portion of the CEMS.

The stack-mounted analyzing equipment generally must be installed in a location that is accessible at all times and during any normal weather conditions. Overshadowing this criterion is the over-riding concern for personal safety; it is not expected that individuals place themselves at risk to service the CEMS equipment under conditions of severe thunderstorms, or during high wind or heavy icing/snow/rain events.

To achieve the required up-time, the CEMS equipment must be able to operate in any environmental condition under which the plant will be operating. For example: a thermal power plant will require stack-mounted equipment to operate and be maintainable over the full range of ambient temperatures experienced (at least -40° to +40°C). Such performance may be accomplished by enclosing the instruments in heated/air conditioned shelters, enclosed stack annulus, etc., and ensuring that provisions are in place for conducting adequate maintenance procedures on schedule as per the QAP.

Gaseous pollutant monitors, in-stack opacity monitors, volumetric flow monitors and temperature sensors shall be sited in accordance with the requirements specified in Method 1 of the Alberta Stack Sampling Code as amended from time to time.

3.1.1 Measurement Locations

The measurement location shall be (1) at least two equivalent diameters downstream from the nearest control device, the point of pollutant generation, or other point at which a change in the pollutant concentration or emission rate may occur, and (2) at least a half equivalent diameter upstream from the effluent exhaust or control device.

3.1.2 Point CEM Systems

The measurement point shall be (1) no less than 1.0 m from the stack or duct wall, or (2) within or centrally located over the centroidal area of the stack or duct cross section.

3.1.3 Flow Monitors

The installation of a flow monitor is acceptable if the location satisfies the siting criteria of Method 1 of the Alberta Stack Sampling Code. Check for non-cyclonic or non-swirling flow conditions shall be made to ensure the suitability of the sampling site.

3.2 Representativeness

The sampling probe or in-situ analyzer must be installed in a location where effluent gases are completely mixed or at a location authorized by the Director. Flowing gases are generally well mixed, but stratification can occur when there are differing temperatures or when dissimilar gas streams intersect or where the duct/flue geometry changes. The degree of stratification in a duct or stack can be quantified. One method of quantification has been proposed (U.S. EPA 1979) that involves traversing the stack or duct and obtaining gas concentrations and comparing those concentrations to the target gas at a fixed concentration. To verify that the effluent stream is not stratified, the procedure outlined in Section 3.2.1 of this code is recommended or an alternative method as authorized by the Director, may be used.

3.2.1 Stratification Test Procedure

A minimum of nine (9) traverse points are required for this test. Locate the points in a balanced matrix of equal area on the stack or duct, using the procedures of Method 1 of the Alberta Stack Sampling Code. Using two automated systems with similar response characteristics, the concentration of a target gas is measured at each of the sampling points in the matrix with one system (traversing system), while simultaneously measuring the target gas concentration at a fixed location, usually at the centre of the flue, duct or stack.

For determining flow stratification, a pitot tube may be used (instead of automated gas monitoring systems) following the procedures of Method 2 of the Alberta Stack Sampling Code.

If the concentration of the gas measured or the velocity of the effluent stream at the fixed location varies by more than $\pm 10\%$ of the average concentration for longer than one minute during this test, retest for stratification when more stable conditions prevail.

Alternately, if the stability of the emission source has been demonstrated at a chosen load, using the output of a chosen automated analyzer withdrawing a sample from a fixed point, the single automated analyzer may be used to measure the degree of stratification.

The concentration of a target gas or the velocity of the effluent stream shall be measured at each of the sampling points in the matrix. At the conclusion of the traverses, repeat the measurement of the concentration at the initial measurement point. If the concentrations differ by more than 10% for the pre- and post-test values at this point, retest for stratification when more stable conditions prevail.

The degree of stratification at each sampling point can be calculated as:

$$\% \text{ of stratification at point } i = \frac{(c_i - c_{ave})}{c_{ave}} \times 100$$

where:

c_i = concentration of target gas at point i

c_{ave} = average of target gas concentration

The sampling plane across the stack or duct is considered stratified if any of the calculated values are greater than $\pm 10\%$.

4.0 PERFORMANCE SPECIFICATIONS and TEST PROCEDURES

4.1 General

This section addresses how to evaluate the acceptability of a CEMS at the time of installation and whenever specified in the CEMS Code. The specifications are not designed to evaluate CEMS performance over an extended period of time, nor do they identify detailed calibration procedures to assess CEMS performance. It is the responsibility of the source owner or operator to properly calibrate, maintain, and operate the CEMS.

Performance specifications and test procedure requirements for each specific CEMS are detailed in this section.

4.1.1 Initial Certification Requirements and Test Procedures

Subject to Section 1.5.1, the owner or operator of the facility shall demonstrate that the CEMS meets all the applicable system performance specifications within six (6) months of the installation of a new CEMS, upon recertification, or as specified otherwise by the Director. The satisfactory demonstration by the approval holder of meeting all of these performance specifications, along with notice of such to the Director, shall constitute certification of the CEMS.

4.2 Performance Specifications

Performance specifications for continuous emission monitoring systems are given in Tables 7 to 12.

4.2.1 Performance Specifications for Sulphur Dioxide, Oxides of Nitrogen, and Carbon Monoxide Emission Monitoring Systems.

Any owner or operator, subject to the provisions of an applicable approval, shall install, calibrate, maintain, and operate sulphur dioxide, oxides of nitrogen, and/or carbon monoxide monitoring systems and record the output of the systems.

Table 7 provides a summary of the general performance specifications of sulphur dioxide, oxides of nitrogen, and carbon monoxide emission monitoring systems. These specifications are not meant to limit the types of technologies that can be used or prevent the use of equivalent methods. Both technologies and methods can be varied upon authorization of the Director.

Table 7. Performance specifications for sulphur dioxide, oxides of nitrogen, and carbon monoxide emission monitoring systems.

Performance Specifications	Sulphur Dioxide Systems	Oxides of Nitrogen Systems	Carbon Monoxide Systems
Analyzer linearity	$\leq \pm 2\%$ of span from cal. curve	$\leq \pm 2\%$ of span from cal. curve	$\leq \pm 2\%$ of span from cal. curve
Relative accuracy ^a	$\leq \pm 10\%$ of RM	$\leq \pm 10\%$ of RM	$\leq \pm 10\%$ of RM
Zero drift - 24 hr	$\leq \pm 2\%$ of span	$\leq \pm 2\%$ of span	$\leq \pm 2\%$ of span
Span drift - 24 hr	$\leq \pm 4\%$ of span	$\leq \pm 4\%$ of span	$\leq \pm 4\%$ of span

a If the reference method value is less than 50% of the analyzer full scale, then use 10% of full scale for relative accuracy for SO₂, NO_x, and CO.

4.2.2 Performance Specifications for Oxygen and Carbon Dioxide Monitors

Any owner or operator, subject to the provisions of an applicable approval, shall install, calibrate, maintain, and operate oxygen and/or carbon dioxide monitoring systems and record the output of the systems.

Table 8 provides a summary of the general performance specifications for oxygen and carbon dioxide monitors. These specifications are not meant to limit the types of technologies that can be used or prevent the use of equivalent methods. Both technologies and methods can be varied upon the written authorization of the Director.

Table 8. Performance Specifications for oxygen and carbon dioxide monitors.

Performance Specifications	Oxygen Monitors	Carbon Dioxide Monitors
Relative accuracy	$\leq \pm 10\%$ of RM or within 1% of O ₂ (whichever is greater)	$\leq \pm 10\%$ of RM or within 1% CO ₂ (whichever is greater)
Analyzer linearity	$\leq \pm 0.5\%$ O ₂	$\leq \pm 0.5\%$ CO ₂
Zero drift - 24 hr	$\leq \pm 0.5\%$ O ₂	$\leq \pm 0.5\%$ CO ₂
Span drift - 24 hr	$\leq \pm 0.5\%$ O ₂	$\leq \pm 0.5\%$ CO ₂

4.2.3 Performance Specifications for Total Reduced Sulphur Monitoring Systems

Any owner or operator, subject to the provisions of an applicable approval, shall install, calibrate, maintain, and operate a Total Reduced Sulphur (TRS) monitoring system and a data acquisition system for the continuous measurement and recording of the TRS emissions from the affected facility.

A summary of the performance specifications for operation of TRS Monitors are provided in Table 9. These specifications are not meant to limit the use of alternative technology and may be varied upon the written authorization of the Director to accommodate the use of alternative technology.

Table 9. Performance specifications for Total Reduced Sulphur monitoring systems.

Performance Specifications	Total Reduced Sulphur Systems
Analyzer linearity	$\leq 5\%$ of span
Relative accuracy	$\leq \pm 20\%$ of RM or within ± 2 ppm (whichever is greater)
Zero drift - 24 hr	$\leq \pm 5.0\%$ of span
Span drift - 24 hr	$\leq \pm 5.0\%$ of span

4.2.4 Performance Specifications for In-Stack Opacity Monitoring Systems.

The specifications given in Table 10 shall be adhered to until final requirements for in-stack opacity monitors are specified at a later date. As required in the approval, the approval holder shall install, operate, and maintain each continuous in-stack opacity monitoring system in accordance with the specifications and procedures as contained in Table 10.

Certain design requirements and test procedures established in this specification may not apply to all instrument designs. In such instances, equivalent design requirements and test procedures may be used with prior written authorization of the Director.

Laboratory and field verification procedures have been established for in-stack opacity monitors by the U.S. Environmental Protection Agency and are found in the reference USEPA 1996c. These specifications are to be used to evaluate the acceptability of continuous in-stack opacity monitoring systems.

Table 10. Performance Specifications for In-Stack Opacity Monitors

Performance Specifications	In-Stack Opacity Monitors
Zero drift - 24 hr	$\leq \pm 2\%$ In-Stack Opacity
Span drift - 24 hr	$\leq \pm 2\%$ In-Stack Opacity

4.2.5 Performance Specifications for Volumetric Flow/Velocity Monitoring Systems.

Table 11 provides a summary of the general performance specifications of flow monitors. These specifications are not meant to limit the types of technologies to be used or prevent the use of equivalent methods (such as the use of F-factors). Both technologies and methods can be varied upon written authorization of the Director.

Table 11. Performance specifications for volumetric flow/velocity monitors.

Performance Specifications	Volumetric Flow/Velocity Monitors
System Relative Accuracy for velocity ≥ 3 m/sec	$\leq \pm 15\%$ of Reference Method
System Relative Accuracy for velocity < 3 m/sec	within 0.5 m/sec of Reference Method
Orientation Sensitivity	$\leq \pm 4\%$ of span
Zero drift - 24 hr	$\leq \pm 3\%$ of span
Span drift - 24 hr	$\leq \pm 3\%$ of span

4.2.6 Performance Specifications for Temperature Sensors

The approval holder shall install, operate, and maintain a continuous temperature sensing system on each stack or source, and record the output of the system, for effluent streams released to the atmosphere, as specified in an EPEA approval.

Table 12 provides a summary of the general performance specifications of temperature sensors. These specifications are not meant to limit the types of technologies to be used or prevent the use of equivalent methods. Both technologies and methods can be varied upon the written authorization of the Director.

Table 12. Performance specifications for temperature sensors.

Performance Specification	Temperature Sensors
System Accuracy	$\pm 10^{\circ}\text{C}$ of the reference method

The response time should also be verified in "small" step changes in the process, as the opportunity presents itself (i.e., internal audits).

4.2.7 Performance Specifications for other Pollutant Monitoring Systems

The following requirements shall be adhered to until final requirements for other categories of pollutant monitors are specified.

Design requirements and test procedures established in these specifications may not apply to all emission monitoring system designs. Approval holders, who are required to continuously monitor other pollutant parameters that are not specified in the CEMS Code, shall install, operate, and maintain those CEMS in a manner satisfactory to the Director.

Each owner or operator shall develop and implement a Quality Assurance Plan (QAP) for the overall CEMS (See Section 5.0). As a minimum, each QAP must include a written plan that describes in detail complete, step-by-step procedures and operations for each of the activities. Quality control procedures for the calibration of the CEMS may require some variance from the procedures in Section 4.5.3 (e.g., how gases are injected, adjustments of flow rates and pressure). These variances must be documented in the QAP.

The details of what is required for the QAP are outlined in Section 5.0 as quality assurance and quality control. This section provides a description of the procedures required for a QAP.

Sixty (60) days before the CEMS is installed and begins operation, the approval holder must submit a Monitoring Plan that provides the information specified in Section 1.9.

4.3 Test Procedures - Administrative

The test procedures needed to demonstrate compliance with the relevant performance specifications are given here for each CEMS. Test procedures for determining compliance with the applicable performance specifications include the following:

- Conditioning and Performance Evaluation Periods
- Relative Accuracy Test Audit and Bias Calculation
- Zero Drift (24 hour)
- Span Drift (24 hour)
- Linearity
- Response Time
- Interference Rejection

The Director must be advised in writing (or facsimile) of the intent to test (complete with tentative test schedule[s]) at least two weeks before the performance testing is to occur. This notice enables the Director or his/her designate to have the opportunity to observe any or all testing.

The owner or operator of the facility shall retain on file at the facility, and make available for inspection or audit, the performance test results on which the certification was based.

Recertification is required following any major change in the CEMS (e.g., addition of components or replacement of components with different makes/models, change in gas cells, path length, probe or system optics, relocation) that could impair the system from meeting the applicable performance specifications for that system. Recertification should be conducted at the earliest possible opportunity or as agreed to in writing by the Director.

The comparison of CEMS measurements to the reference method values during certification or recertification shall be based only on the output as recorded by the data acquisition system.

4.4 Test Procedures for Verifying Design Specifications

4.4.1 Analyzer Interference Rejection

This test may be carried out after the analyzers have been installed in the CEMS or in a laboratory or other suitable location before the analyzers are installed. Sufficient time must be allowed for the analyzer under test to warm up, then the analyzer must be calibrated by introducing appropriate low- and high-range gases directly to the analyzer sample inlet. After the initial calibration, test gases shall be introduced, each containing a single interfering gas at a concentration representative of that species in the gas flow to be monitored. The magnitude of the interference of each potential interfering species on the target gas shall then be determined.

The analyzer is acceptable if the summed response of all interfering gases is less than 4% of the full-scale value.

4.4.2 Analyzer Temperature-Responsive Zero and Calibration Drifts

Place the analyzer in a climate chamber in which the temperature can be varied from 5 to 35°C. Allow sufficient time to warm up, then calibrate the analyzer at 25°C using appropriate zero and span gases. Adjust the temperature of the chamber to 35, 15, and 5°C, respectively. Ensure that the analyzer temperature has stabilized. Do not turn off the power to the analyzer over the duration of this test.

When the analyzer has stabilized at each climate chamber temperature, introduce the calibration gases at the same flow or pressure conditions, and note the response of the analyzer. Calculate the temperature-responsive zero drift from the difference in the indicated zero reading and the next higher or lower temperature. The analyzer is acceptable if the difference between all adjacent (i.e. 5/15, 15/25, and 25/35°C) zero responses is less than 2% of the full-scale setting.

Calculate the temperature-responsive span drift from the differences between adjacent span responses. An analyzer is acceptable if the difference between all adjacent span responses is less than 4% of the full-scale setting.

4.4.3 Manufacturer's Certificate of Conformance

It may be considered that specifications for both interference rejection and temperature-responsive drift have been met if the analyzer manufacturer certifies that an identical, randomly selected analyzer, manufactured in the same quarter as the delivered unit, was tested according to the procedures given above in Subsections 4.4.1 and 4.4.2, and the parameters were found to meet or exceed the specifications.

4.5 Performance Specification Test Procedures

4.5.1 Conditioning Test Period

After the CEMS has been installed according to the manufacturer's written instructions, the entire CEMS shall be operated for a period of not less than 168 hours, during which the emission source must be operating. During this period, the entire CEMS must operate normally, which means all processes of the entire system must work, including the analyzing of both the concentrations of the pollutant and diluent gases, and the effluent stream flow rate (where applicable). The only exceptions are for periods during which calibration procedures are being carried out, or other procedures as indicated in the QAP. Note that the data acquisition system forms an integral part of the overall system and must be fully operational during this period.

The system must output emission rates of the pollutants in units as specified in the facility approval.

System modifications may be carried out, along with fine-tuning of the overall system, in preparation for the Operational Test Period.

Daily calibration checks shall be conducted, and when the accumulated drift exceeds the daily control limits, the analyzers shall be adjusted using the procedures defined in the CEMS QAP. The data acquisition system must reflect any calibration adjustments. Any automatic adjustments made in response to the daily zero and span checks must also be indicated in the data acquisition system. If the Conditioning Test Period is interrupted as a result of a process shutdown, the times and dates of the shutdown period shall be recorded and the 168-hour test period shall be continued, after the emission source has resumed operation.

4.5.2 Operational Test Period

When the Conditioning Test Period has been successfully completed, the CEMS must be operated for an additional 168-hour period during which the emission source is operating under typical conditions. The Operational Test Period need not immediately follow the Conditioning Test Period.

During the Operational Test Period, the CEMS must continue to analyze the gases without interruption and produce a permanent record, using the data acquisition system, of the emission data. Sampling may be interrupted during this test period only to carry out system calibration checks and specified procedures as contained in the QAP.

During this period, no unscheduled maintenance, repairs, or adjustments should be carried out. Calibration adjustments may be performed at 24-hour intervals or more frequently, if specified by the manufacturer and stated in the QAP. Automatic zero and calibration adjustments made without operator intervention may be carried out at any time, but these adjustments must be documented by the data acquisition system.

If the test period is interrupted because of process shutdown, the times and dates of this period should be recorded, and the test period continued when the process continues operation. If the test period is interrupted as a result of CEMS failure, the entire test period must be restarted after the problem has been rectified.

The Performance Specifications tests outlined in Section 4.5 are carried out during the Operational Test Period, with the exception of the relative accuracy tests, which may be conducted during the Operational Test Period or during the 168-hour period immediately following the Operational Test Period. These tests are to be carried under conditions that typify the day-to-day operation of the CEMS and should be described in the QAP.

4.5.3 Calibration Drift Test Protocol for Gas and Flow Monitoring Systems

(a) General - For those systems that are not designed (and authorized as such by the Director) for the dynamic use of calibration gases, alternative protocols (as authorized by the Director) may be used in place of the following. These alternative procedures shall be included and detailed in the facility QAP.

Measure the zero and span drift of the CEMS once each day at 24-hour intervals (to the extent possible) for 7 consecutive operating days according to the following procedures. Units using dual span monitors must perform the calibration drift test on both high- and low-end scales of the pollutant concentration monitor.

(b) Calibration Adjustments - Automatic or manual calibration adjustments may be carried out each day. The Calibration Drift Test must be conducted immediately before these adjustments, or in such a manner that the magnitude of the drifts can be determined. A zero drift adjustment may be made prior to the span drift determinations.

(c) Test Procedures - At approximately 24-hour intervals for seven (7) consecutive days, perform the calibration drift tests at two concentration ranges:

low-level range (0-20% of full scale)

high-level range (80-100% of full scale)

Operate each monitor in its normal sampling mode. For extractive and dilution type monitors, pass the audit gas through all filters, scrubbers, conditioners and other monitor components used during normal sampling and through as much of the sampling probe as is practical. For in situ-type monitors, perform calibration by checking all active electronic and optical components, including the transmitter, receiver, and analyzer. Challenge the CEMS once with each gas. Record the monitor response from the data acquisition system.

(d) Calculations - Determine the calibration drift, at each concentration, once each day (at 24-hour intervals) for 7 consecutive days according to the following calculation:

$$\text{Calibration Drift (\%)} = \frac{(R - A)}{FS} \times 100$$

where:

R = the true value of the reference standard (ppm or % for gas analyzers, kPa for pressure transducers, °C for temperature transducers, m³/d or tonnes/d for flow elements).

A = the CEM component value (in same units as R).

FS = the full scale reading of the CEM system component (in the same units as R).

With dual span CEMS, the above procedure must be conducted on both concentration ranges. Use only NIST (National Institute of Standards and Technology) -traceable reference material, standard reference material, Protocol 1 calibration gases (certified by the vendor to be within 2% of the label value, or where applicable, zero air material).

Calibration drift test results are acceptable for CEMS certification, if none of these daily calibration system test results exceed the applicable CEMS specifications in Section 4.2.

4.5.4 Linearity

Perform a linearity test using the following test gases and procedures:

(a) General - For those systems that are not designed (and authorized as such by the Director) for the dynamic use of calibration gases, alternative protocols (as authorized by the Director) may be used in place of the following. These alternative procedures shall be included and detailed in the facility QAP.

(b) Test Gases - Use Protocol 1 gases at low (0 to 20% FS (full scale)), mid-(40 to 60% FS), and high-level (80 to 100% FS) for each pollutant and diluent gas analyzer. Dynamic or static dilution of a test gas to generate lower concentration standards is acceptable provided that the corresponding QA/QC plan/procedures are established and followed for the use of dynamic or static dilution systems.

(c) Calibration Gas Injection Port -Test gases may be injected immediately before each analyzer.

(d) Procedures - The system must operate normally during the test, with all pressures, temperatures, and flows at nominal values. Introduce each test gas and allow the system response to stabilize, then record the concentration of the pollutant or diluent gas indicated by the data acquisition system output. Challenge the system three (3) times with each gas, but not in succession. To do this, alternate the gases presented to the system.

Calculate the average response of the system as indicated by the data acquisition system to the three (3) challenges of each gas for each pollutant or diluent gas analyzer at low-, mid-, and high-level.

(e) Calculations and Acceptable Results - Determine the linearity, at each concentration, according to the following calculation:

$$\text{Linearity (\%)} = \frac{(R - A)}{FS} \times 100$$

R = the true value of the test gas (% or ppm).

A = the average of the three system response to the low-, mid-, or high-range calibration gas, (% or ppm).

FS = the full scale value of the monitoring system (% or ppm).

With dual span CEMS, the above procedure must be conducted on both concentration ranges. Use only NIST-traceable reference material, standard reference material, Protocol 1 calibration gases (certified by the vendor to be within ± 2 % of the label value, or where applicable, zero ambient air material).

The system is acceptable if each of the three values of the linearity do not exceed the value for linearity, specified in Table 7, 8, or 9, as applicable.

4.5.5 Flow Monitor Calibration Drift

Use the zero and span reference signals generated by the system for this test, following the procedures given in 4.5.3 above (where, instead of calibration gas, read reference signal).

Once a day over the 168-hour Operational Test Period, introduce the flow monitors reference signals to the sensor, corresponding to low (0 to 20% FS) and high (80 - 100%) flow rates, and record the response of the monitor to each signal, as reported by the data acquisition system.

The unit is acceptable if the drift does not exceed 3% of the corresponding input signal for any day during the 168-hour test period.

4.5.6 Flow Monitor Orientation Sensitivity

This test is intended as a test for flow rate monitors that are sensitive to the orientation of the sensor in the gas flow, such as differential pressure flow sensors. Where possible, it is recommended that this test is carried out at three loads (rates):

- a) minimum safe and stable operating load (rate);
- b) approximately mid-load (rate) (40 to 60%); and
- c) full load (rate) (90 -100%).

During a period of steady flow conditions at each load (rate), rotate the sensor in the gas flow a total of 10 degrees on each side of the zero degree position (directly into the gas flow, with no cyclonic flow patterns) in increments of 5 degrees, noting the response of the sensor at each angle. A total of five (5) flows will be generated for each load (rate) condition, at -10, -5, 0, +5, +10 degrees relative to the zero-degree position.

The sensor is acceptable if the flow measurements do not exceed a difference of 4% from the zero-degree orientation.

4.5.7 System Cycle Time/Response Time Test

Perform a response time test for each CEMS according to the following procedures.

Use a low-level and a high-level calibration gas as used in the calibration drift assessment alternately. While the CEMS is measuring and recording the concentration, inject either a low-level or a high-level concentration calibration gas into the injection port. Continue injecting the gas until a stable response is reached. Record the amount of time required for the monitor or monitoring system to complete 95.0% of the concentration step change using the data acquisition system output. Then repeat the procedure with the other gas. For CEMS that perform a series of operations (such as purge, sample, and analyze), time the injections of the calibration gases so they will produce the longest possible response time. (Note: for some CEMS, such as TRS/H₂S and CO₂/O₂ CEMS, it will be necessary to simultaneously inject calibration gases into the pollutant and diluent monitors, in order to measure the step change in the emission rate.)

Cycle time/response time test results are acceptable for monitoring or monitoring system certification, if none of the response times exceeds the applicable specifications in Section 4.2.

4.5.8 Relative Accuracy and Bias Tests for Gas Monitoring Systems

Perform a Relative Accuracy Test audit (RATA) for each CEMS. Record the CEMS output from the data acquisition system. For each CEMS, calculate bias as well as relative accuracy for each test.

(a) Plant Operating Conditions - For new CEMS installations, complete the RATA test during the operational test period or within 168 hours after the completed operational test period has been completed or when the unit is combusting its primary fuel or producing its primary product (as applicable). Perform the test for each CEMS at a normal rate for the unit.

For existing CEMS installations, RATA tests shall be conducted at a frequency as specified in Table 16.

When the test is performed on a CEMS or component(s) installed on bypass stacks/ducts or combined units exhausting into a common stack, perform the test for each CEMS installed to monitor the individual units when the units are operating. Use the fuels normally combusted by the units or operate the unit in a normal manner (as the case may be for combustion related or non combustion sources).

(b) CEMS Operating Conditions - Do not perform corrective maintenance, repairs, replacements or adjustments on the CEMS during the RATA other than as required in the operation and maintenance portion of the QAP.

(c) Reference Method Sampling Points - When the absence of stratified flow has not been verified, or if the gas flow has been found to be stratified, the Reference Method samples must be collected at a number of points in the effluent stream. Establish a "measurement line" that passes through the centroidal area of the flue or duct. This line should be located within 30 cm of the CEM sampling system cross section. Locate three (3) sampling points at 16.7, 50, and 83.3% along the length of the measurement line. Other sample points may be selected if it can be demonstrated that they will provide a representative sample of the effluent flow over the period of the test. A tip of the Reference Method probe must be within 3 cm of each indicated traverse point, but no closer than 7.5 cm to the wall of the stack or duct.

Where two or more probes are in the same proximity, care should be taken to prevent probes from interfering with each other's sampling.

(d) Reference Method Sampling Conditions - Conduct the Reference Method tests in accordance with the Alberta Stack Sampling Code, and in such a manner that they will yield results representative of the pollutant concentration, emission rate, moisture content, temperature, and effluent flow rate from the unit and can be correlated with the CEMS measurements. Conduct the diluent (O_2 or CO_2) measurements and any moisture measurements that may be needed simultaneously with the pollutant concentration measurements. To properly correlate individual CEMS data, with the Reference Method data, mark the beginning and end of each Reference Method test run (including the exact time of day) on the data acquisition system, individual chart recorder(s) or other permanent recording device(s).

(e) Consistency - Confirm that the CEMS and Reference Method test results are based on consistent moisture, pressure, temperature, and diluent concentration and in the same units. In addition, consider the response times of the CEMS to ensure comparison of simultaneous measurements.

For each RATA conducted, compare the measurements obtained from the monitor via the data acquisition system (in ppm, % CO₂, lb./M Btu, or other units as appropriate) against the corresponding Reference Method values. Display the paired data in a table.

(f) Sampling Strategy - Perform a minimum of nine sets of paired monitor (or monitoring system) and Reference Method test data for every required (i.e., certification, semiannual, or annual) relative accuracy or Bias Test audit. Each test shall take a minimum duration of thirty (30) minutes, sampling for equal periods at the three (3) sampling points for stratified flow testing, or at the single point for nonstratified flow.

NOTE: the tester may choose to perform more than nine sets of Reference Method tests up to a total of 12 tests. If this option is chosen, the tester may reject a maximum of three sets of the test results, if an appropriate statistical test applied to the data demonstrates that these results are outliers, and as long as the total number of test results used to determine the relative accuracy or bias is greater than or equal to nine. All data must be reported, including the outliers, along with all calculations.

(g) Calculations - Analyze the test data from the Reference Method and CEMS tests for the applicable CEMS.

Summarize the results on a data sheet. Calculate the mean of the monitor or monitoring system measurement values. Calculate the mean of the Reference Method values. Using data from the automated data acquisition system, calculate the arithmetic differences between the Reference Method and monitor measurement data sets. Then calculate the arithmetic mean of the difference, the standard deviation, the % confidence coefficient, and the monitor or monitoring system relative accuracy using the following procedures and equations.

The absolute value of the average difference, $|\bar{d}|$, is calculated using the equation:

$$|\bar{d}| = \frac{1}{n} \sum_{i=1}^n (X_i - Y_i)$$

Where: n = number of data points

X_i = concentration from the Reference Method

Y_i = concentration from the CEMS

The standard deviation, S_d , is calculated using the equation:

$$S_d = \sqrt{\frac{\sum_{i=1}^n d_i^2 - \frac{1}{n} \left(\sum_{i=1}^n d_i \right)^2}{n - 1}}$$

Where: d_i = difference between individual pairs

The 2.5% error confidence coefficient, $|cc|$, is calculated using the equation:

$$|cc| = t_{0.025} \frac{S_d}{\sqrt{n}}$$

Where: $t_{0.025}$ = t - table value from Table 13.

Table 13. Range of t-values applicable for calculating confidence coefficients in Relative Accuracy Tests of CEMS.

<u>t-VALUES</u>			
n	t _{0.025}	n	t _{0.025}
2	12.706	10	2.262
3	4.303	11	2.228
4	3.182	12	2.201
5	2.776	13	2.179
6	2.571	14	2.160
7	2.447	15	2.145
8	2.365	16	2.131
9	2.306		

The Relative Accuracy (RA) is calculated using the equation:

$$RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} \times 100$$

Where:

$|\bar{d}|$ = Absolute value of the mean difference

$|cc|$ = Absolute value of the confidence coefficient

RM = Average Reference Method value

(h) The Bias Test

A bias, or systematic error is considered to be present if:

$$|d| \geq |cc|$$

(i) Acceptance Criteria for Analyzer Bias-

For each pollutant and diluent gas analyzer in the CEMS, calculate $|d|$ and $|cc|$, in the units of the analyzer. If

$$|d| - |cc| \geq 4\% \text{ of FS}$$

the analyzer has significant bias. The cause of the bias must be determined and rectified. After corrections have been made, the Relative Accuracy Tests must be repeated to determine if the systematic error has been eliminated or reduced to an acceptable level.

4.5.9 Relative Accuracy Test for Flow Monitors

For new systems, carry out this test during the Operational Test Period, or during the week immediately following. It is recommended, if possible, that the testing be carried out at the three (3) loads (rates) as per section 4.5.6. For existing systems, conduct this test in accordance with the frequency specified in Table 16.

Carry out a minimum of nine (9) manual velocity traverse measurements at each load condition. Calculate the Relative Accuracy for each load (rate) condition as shown in 4.5.8.

The flow monitor is satisfactory if it meets the performance specifications given in Table 11.

4.5.10 Relative Accuracy Test for Temperature Sensors

Temperature sensors shall be verified using a certified reference thermometer or certified resistance temperature device (RTD)/readout or thermocouple/readout combination when conducting the RATA test.

5.0 QUALITY ASSURANCE AND QUALITY CONTROL

The Quality Assurance (QA) procedures consist of two distinct and equally important functions. One function is the assessment of the quality of the CEMS data by estimating accuracy. The other function is the control and improvement of the quality of the CEMS data by implementing Quality Control (QC) policies and corrective actions. These two functions form a control loop. When the assessment function indicates that the data quality is inadequate, the control effort must be increased until the data quality is acceptable.

To provide high-quality data on a continuing basis a good QA program is necessary. The approval holder shall develop a QAP for each installed CEMS to ensure the quality of the CEMS measurements.

A "Quality Assurance" program is defined as a management program to ensure that the necessary quality control activities are being adequately performed, whereas "Quality Control" activities are those that detail the day-to-day operation of the system. The program shall be fully described in a Quality Assurance Plan (QAP) that is specific to the CEMS.

5.1 Quality Assurance Plan (QAP) for CEMS

The QAP must include and describe a complete program of activities to be implemented to ensure that the data generated by the CEMS will be complete, accurate, and precise. As a minimum, the manual must include QA/QC procedures specified in this code. The recommended Table of Contents for a QAP is shown in Table 14.

5.1.1 Section 1 - Quality Assurance Activities

This section of the manual describes the CEM system QAP, and describes how the QA program is managed, provide personnel qualifications, and describe the QA reporting system. It must describe the CEMS, how it operates, and the procedures for calibration and inspection. It must also include preventative maintenance and performance evaluation procedures.

5.1.2 Section 2 - Quality Control Activities

This section of the manual provides the detailed descriptions of the step-by-step procedures, the standard operating procedures required to operate and evaluate the system, including details about daily calibration procedures, CGAs, Relative Accuracy Tests, and tests for system bias. Minimum criteria and procedures for these activities are provided in Section 4.2, Section 4.4, and Section 4.5.

Table 14. Example Table of Contents for facility CEMS QAP.

SECTION	SUBSECTION	CONTENTS
I		The Quality Assurance Plan
	1	Assurance Policy and Objectives
	2	Document Control System
	3	CEMS Description
	4	Organization and Responsibilities
	5	Facilities, Equipment and Spare Parts Inventory
	6	Methods and Procedures
	7	Calibration and Quality Control Checks
	8	Preventative Maintenance Schedule
	9	Systems Evaluations
	10	Performance Evaluations
	11	Corrective Action Program
	12	Reports
	13	Data Backfilling Procedures (where authorized)
	14	References
II		Quality Control Procedures
	1	Start-up and Operation
	2	Daily CEMS Operation
	3	Calibration Procedures
	4	Preventative Maintenance Procedures
	5	Corrective Maintenance Procedures
	6	Evaluation Procedures - Cylinder Gas Audits
	7	Evaluation Procedures - Relative Accuracy Tests
	8	System and Subsystem Evaluation Procedures
	9	Data Backup Procedures
	10	Training
	11	CEMS Security
	12	Data Reporting Procedures
III		Appendices
	1	Facility Approval
	2	CEMS Specifications
	3	Reference Method Procedures
	4	Blank Forms

5.1.3 Inspection, Verification, and Calibration

Inspection, verification and calibration (when required) of the CEMS performance are among the most important aspects of the QA/QC program. The following summarizes the requirements for inspection, verification and calibration, all of which must appear in the QAP.

The method of verifying the accuracy of a CEMS component is to compare the value of the reference standard (e.g., reference gas or dead weight tester output) to the value displayed by the data acquisition system.

(a) Frequency - All CEMS components shall be inspected periodically (approval holder shall identify frequency in the QAP) to verify that individual components have not failed and are operating within prescribed guidelines (e.g., sample system flow rates are appropriate). The use of system components with integral fault detection diagnostics is highly desirable.

The minimum verification frequency for individual CEMS components (e.g., analyzers and temperature transmitters) performance shall be as specified in Table 16. The minimum frequency may be reduced (upon the written authorization of the Director) provided the operator can demonstrate (using historical data) that a lower verification frequency will not affect system performance at the 95% confidence level.

(b) Accuracy of Verification/Calibration Equipment and Materials - The minimum accuracy requirement for verification/calibration equipment and materials shall be a factor of two or better than the performance requirement specified for that system component in Section 4.2. (For example, if a performance specification requires an accuracy of $\pm 2\%$ then the verification/calibration equipment shall be accurate to within $\pm 1\%$.)

For analyzers, the use of certified reference gases is acceptable for routine analyzer system performance verifications. Protocol 1 gases are required for a CGA. All other calibration equipment such as test pressure gauges, dead weight testers and multi-meters must be calibrated at least every 2 years in a manner that is traceable either through the Canadian Standards Association (CSA) or the U.S. National Institute of Standards and Technology (NIST).

For parameters for which cylinder gases are not available at reasonable cost, are unstable, or are unavailable, alternative calibration techniques are acceptable, if the Director has given prior written authorization.

(c) Calibration Adjustment - A CEMS component must be calibrated (i.e., output adjusted) whenever the observed inaccuracy exceeds the limits for that system component accuracy as specified in the Performance Specifications. A CEMS component need not be calibrated after each verification, only when it exceeds the specified tolerance.

(d) Out-of-Control Conditions - Only quality assured data may be used to determine CEMS availability. When an analyzer or system is out-of-control, the data generated by the specific analyzer or system are considered missing and does not qualify for meeting the requirement for system availability.

An out-of-control period occurs if either the low level (zero) or high level calibration results exceed twice the applicable Performance Specification. The criteria that pertain to out-of-control periods for specific CEMS are illustrated in Table 15.

Table 15. Criteria for out-of-control periods^e.

Instrument	Acceptable		2X ^(a,b)		4X ^(c)	
	Zero drift	Span drift	Zero drift	Span drift	Zero drift	Span drift
SO ₂ ^g	±2%	±4%	±4%	±8%	±8%	±16%
NO _x ^g	±2%	±4%	±4%	±8%	±8%	±16%
TRS ^g	±5%	±5%	±10%	±10%	±20%	±20%
O ₂ ^{d,f}	±0.5%	±0.5%	±1%	±1%	±2%	±2%
CO ₂ ^{d,f}	±0.5%	±0.5%	±1%	±1%	±2%	±2%
In-Stack Opacity ^g	±2%	±2%	±4%	±4%	±8%	±8%
CO ^g	±3%	±4%	±6%	±8%	±12%	±16%

- ^a Corrective action must be taken, at a minimum, whenever the daily zero calibration drift or daily span calibration drift exceeds two times the limits stated above.
- ^b If either the zero or span calibration drift results exceeds twice the above stated calibration drift for five consecutive daily periods, the CEMS is out-of-control beginning on the fifth day of error.
- ^c If either the zero or span calibration drift results exceeds four times the applicable calibration drift, the CEMS is out-of-control back to the previous calibration drift found to be within tolerance unless a decisive point error occurrence can be defined.
- ^d If the CO₂/O₂ CEMS is defined as being out-of-control, the TRS/SO₂/NO_x will also be out-of-control, until the CO₂/O₂ CEMS is defined as being within acceptable limits.
- ^e If the CEMS is out-of-control, assess and identify the cause of the excessive drift and correct accordingly. Once the appropriate corrective action has been implemented, repeat the calibration drift test in order to demonstrate the CEMS is back within acceptable limits.
- ^f Values are given as a % of gas concentration.
- ^g Values are given as a % of full scale reading.

In addition, an out-of-control period also occurs if any of the quarterly, semiannual, or annual performance evaluations exceed the applicable performance specification criteria (i.e., Relative Accuracy, Bias, etc.). In this case, the out-of-control period begins with the hour when this condition occurred and ends with the hour after this condition ends.

(e) Verification/Calibration—Data Logging, and Tabulation - The "as found" values for each verification point shall be recorded before any calibration occurs. The "as left" values for each verification point shall also be recorded after any component is calibrated (i.e., adjustment). For systems capable of automated calibrations, the data system shall record the "as found" and "as left" values including a time stamp (date and time). If strip chart recorder data are reported, any automatic calibration adjustments must be noted on the strip chart recorder.

All verification data must be time-stamped and tabulated on a daily (where applicable) and monthly basis. The use of quality control charts is recommended.

The approval holder must retain the results of all performance evaluations including raw test data as well as all maintenance logs, corrective action logs and the QAP (including sample calculations) for a period of at least 3 years for inspection by Alberta Environmental Protection.

(f) Gas Analyzer/ System Verification - For all CEMS, the system is calibrated rather than the analyzer.

System performance shall be verified in accordance with the procedures specified in the facility QAP. For multi-range analyzers, all applicable operating ranges must be verified.

For systems amenable to verification through the use of standard reference gases, the standard reference gas must be introduced at the probe inlet or in the vicinity of the probe inlet. A calibration filter may be used for daily system zero and span verification for path in-situ CEMS only.

Ensure enough time passes to allow the system to attain a steady output, as shown by the data acquisition system, before recording.

For CGAs, the process and analyzer system must be operating at normal conditions (e.g., pressure, temperature, flow rate, pollutant concentration). The analyzer system must be challenged three times with each gas, but not in succession. To do this, alternate the gases presented to the system. Calculate the average response of the system as indicated by the data acquisition system or chart recorder to the three challenges of each concentration of reference gas.

For analyzers not amenable to verification/calibration through the use of reference gases, the operator shall detail verification/calibration procedures in the facility's QAP.

(g) In-Stack Opacity Analyzer Verification - Procedures for verification of in-stack opacity monitors are shown in US EPA 40 CFR 60, Appendix B.

(h) Temperature Measurement Subsystem Verification - The temperature measurement shall be verified using a certified reference thermometer or certified resistance temperature device (RTD)/readout or thermocouple/ readout combination when conducting the RATA test.

(i) Pressure Measurement Subsystem Verification - The static pressure and differential measurement devices shall be verified using a certified manometer, dead weight tester or test gauge when conducting the RATA test.

(j) Flow Element Subsystem Verification - For pitot tube or similar systems visual inspection at turnaround (or at least once per year) and as opportunities present themselves for visible signs of plugging or damage. Wind tunnel calibration of flow-measuring devices should be carried out before initial installation, when visible damage has occurred, or when flow system inaccuracy exceeds acceptable tolerances and inaccuracy cannot be attributed to any component other than the flow element. For pitot tube systems, if, when compared to the stack survey data, $|d| > \pm 15\%$, then pitot tubes must be pulled and recalibrated unless the source of the error is found to be in the transmitter. ($|d|$ refers to absolute difference.)

Backpurging (as necessary) of the primary flow measuring elements at an appropriate frequency is acceptable to ensure accurate data (and remove any build up of materials) but should be done when analyzer is being calibrated (or zeroed) so that actual complete sampling time of both flow and pollutant concentration is maximized.

For other flow methods such as ultrasonic meters, anemometers, etc., the QA/QC procedures and frequency shall be specified in the facility QAP and be followed accordingly.

Table 16. Minimum frequency for CEM system component Quality Assurance/Quality Control (QA/QC) requirements.

CEMS COMPONENT	Frequency of Performance Verification Parameter				
	Inspection	Zero Drift	Span Drift	Cylinder Gas Audit ^a	Relative Accuracy Test Audit ^a
Analyzers					
Sulphur Dioxide	Daily	Daily	Daily	2/yr.	2/yr.
Oxides of Nitrogen	Daily	Daily	Daily	2/yr.	2/yr.
Carbon Monoxide	Daily	Daily	Daily	2/yr.	2/yr.
Total Reduced Sulphur	Daily	Daily	Daily	2/yr.	2/yr.
In-Stack Opacity	Daily	Daily	Daily	na	na
Oxygen	Daily	Daily	Daily	2/yr.	2/yr.
Carbon Dioxide	Daily	Daily	Daily	2/yr.	2/yr.
Other Monitors	as specified in QAP	as specified in QAP	as specified in QAP	as specified in QAP	as specified in QAP
Rate Measurement Components					
Temperature	Daily	NA	semi-annual	NA	
Diff. Pressure	Daily	semi-annual	semi-annual	NA	
Static Pressure	Daily	semi-annual	semi-annual	NA	
Flow Element	1/yr.	NA	at RATA	NA	
Data Acquisition Components					
Recorder	Daily	See Note b	See Note b		
PLC/DCS	Daily	See Note b	See Note b		

^a Frequency is subject to requirements in Section 5.2.

^b The inputs to a PLC/SCADA or DCS must be checked as part of the trouble shooting procedures, only if the analyzer or flow system is found to be out-of-control.

(k) Data Receiver Subsystem Verification

The inputs to the digital data acquisition system (e.g., PLC, DCS, Scada) or chart recorder must be verified at the frequency specified in Table 16 using an appropriate calibrator as identified in the QAP.

5.2 Relative Accuracy Test Audits and Cylinder Gas Audits

5.2.1 General Requirements (applicability)

The approval holder shall conduct Relative Accuracy Tests and Cylinder Gas Audits on each CEMS. For the 1st year of CEMS operation a minimum of two Relative Accuracy Tests and a minimum of two CGAs must be conducted on each CEMS. A RATA may be substituted in place of a CGA; however, a CGA cannot be substituted in place of a Relative Accuracy Test. For the second and succeeding years, the minimum frequency of Relative Accuracy Tests may be decreased to once per year upon the Director being satisfied that the QAP demonstrates compliance with ongoing CEMS performance requirements (as detailed in Section 4.2). In lieu of the decreased RATA frequency, the minimum CGA frequency would be increased to three times per year.

The data obtained during a Relative Accuracy Test may also be used toward fulfilling associated stack survey requirements as provided for in an approval issued under EPEA.

5.2.2 Relative Accuracy Test Procedures

The procedure for carrying out the relative accuracy and bias tests is given in Subsections 4.5.9 of this Code.

5.2.3 Cylinder Gas Audits

The Cylinder Gas Audit procedure and acceptance criteria are the same as the Linearity Procedure of 4.5.4.

For those systems that are not designed for the dynamic use of calibration gases, alternative protocols (as authorized by the Director) may be used in place of the cylinder gas audit. These alternative procedures shall be included and detailed in the facility QAP.

5.2.4 Test Procedure Requirements

The associated QA/QC test procedures applicable to each CEMS and a description of the actual test procedures shall be contained in the facility QAP and adhered to by the facility operator.

During periods of scheduled CEMS quality control procedures, such as Relative Accuracy Test, the facility should be operated at a rate of at least 90 % of "normal" production. Normal production is defined as the average production or throughput for the facility over the previous month. Any exceptions to this would need to be authorized in writing by the Director.

At least one month must elapse between conducting either a CGA or a RATA, unless otherwise authorized by the Director.

5.3 Annual Evaluation

The CEMS and QAP must be evaluated every twelve (12) months.

An auditor, knowledgeable in auditing procedures and in CEMS operations, and independent of the CEMS operation, must review the QAP, the CEMS operation, reports, and other associated records to determine if the procedures in the QAP are being followed. The auditor shall also note any changes in the system or the procedures since the last yearly evaluation and ensure that these have been included in the QAP.

The auditor shall report the findings and observations to the facility management. This report may include recommendations for improvements in the CEMS or its operation.

5.4 Minimum System Availability Requirements

The operational time or "availability" for both the CEMS and each individual monitor shall be greater than or equal to 90% based on the calendar month.

For CEMS applications requiring CO₂, O₂, mass or volumetric measurements, whenever these CEM subsystems are out-of-control, the data generated by the entire CEMS are considered missing and do not qualify for meeting the requirement for system availability. For other applications (e.g., in-stack opacity, concentration limit on a specific pollutant), only when that monitoring system is found to be out-of-control (See Table 15) are the data generated by that system considered missing and not qualified for meeting the requirement for system availability.

6.0 REPORTING REQUIREMENTS

6.1 General

All reporting requirements regarding continuous source emission data generated by the CEMS will be specified in the Air Monitoring Directive issued by Alberta Environmental Protection and as amended from time to time.

The approval holder shall make the QAP (and related QC information generated as a result of the QAP) available for inspection and audit to Alberta Environmental Protection upon request.

Detailed reporting requirements for the CEMS will be incorporated through the Air Monitoring Directive. In the interim, Section 6.2 shall apply until such time it can be formally incorporated into the Air Monitoring Directive, at which time Section 6.2 will cease to apply.

6.2 Quality Assurance Reporting Requirements

Within 1 month following the end of each quarter, the CEMS operator must report a summary of the following performance evaluations carried out within the quarter; these include: a) initial certification performance tests, b) Relative Accuracy Test Audits, and c) Cylinder Gas Audits. All other data records for the facility's QAP shall be retained at the facility site and be made available for inspection and audit by Alberta Environmental Protection upon request.

In addition, the CEMS availability for each month must be calculated in a manner as specified in Section 2.5.3 of the CEMS Code and reported in accordance with the reporting frequency as specified in the facility's approval. Section 6.2 ceases to apply upon the amendment of the Air Monitoring Directive to incorporate applicable CEMS reporting requirements.

The annual report shall contain confirmation of whether the annual evaluation (as required in Section 5.3) has been conducted and the date of completion of the evaluation.

APPENDIX A - DEFINITIONS

APPENDIX A - DEFINITIONS

Accuracy means the closeness of the measurement made by a CEMS, a pollutant concentration monitor or a flow monitor, to the true value of the emissions or volumetric flow. It is expressed as the difference between the measurement and a Reference Method value, which is assumed to be equivalent to the true value. Variation among these differences represents the variation in accuracy that could be caused by random or systematic error.

Alberta Stack Sampling Code means Publication No. REF. 89, published by Alberta Environmental Protection and as amended from time to time.

Alternative monitoring system means a system designed to provide direct or indirect determinations of mass per unit time emissions, pollutant concentrations, and/or volumetric flow data that does not use analyzers that accept independent, certified calibration gases. For the purposes of this Code, acceptable alternative monitoring systems are those that meet the same criteria of performance with respect to accuracy, precision, and availability, as CEMS that accept calibration gases.

As found or unadjusted value means the output value of the measurement device that corresponds to the reference value input before a calibration check or adjustment.

As left or adjusted value means the output value of the measurement device corresponding to the reference value input after calibration adjustment.

Available means that the CEMS or continuous in-stack opacity monitoring system is functional and operating within the calibration drift limits and other applicable performance specifications.

Bias means systematic error. The result of bias is that measurements will be either consistently low or high, relative to the true value.

Bypass means any flue, duct, stack, or conduit through which emissions from an unit may or do pass to the atmosphere, which either augments or substitutes for the principal ductwork and stack exhaust system during any portion of the unit's operation.

Calibration adjustment means the procedure to adjust the output of a device to bring it to a desired value (within a specified tolerance) for a particular value of input (typically the value of the reference standard).

Calibration check means the procedure of testing a device against a known reference standard without adjusting its output.

Calibration drift means the difference between (1) the response of a gas monitor to a reference calibration gas and the known concentration of the gas, 2) the response of a flow monitor to a reference signal and the known value of the reference signal, or (3) the response of a continuous in-stack opacity monitoring system to an attenuation filter and the known value of the filter after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

Calibration gas means for the purposes of this Code, a known concentration of a gas (1) that is traceable to either a standard reference material (SRM) or a U.S. National Institute of Standards and Technology (NIST), 2) an authorized certified reference gas, or (3) a Protocol 1 gas.

Calibration gas cell or a filter means a device that, when inserted between the transmitter and detector of the analyzer, produces a desired output level on the data recorder.

Centroidal area means a concentric area that is geometrically similar to the flue, duct or stack cross section and is not greater than 1% of the stack or duct cross-sectional area.

Continuous means that a device is capable of making a measurement at least once every 15 minutes and operates with an availability greater than 90% on a monthly basis.

Continuous emission monitoring system (CEMS) means the equipment required to analyze, measure, and provide, on a continuous basis, a permanent record of emission and other parameters as established by this code.

Cylinder gas audit (CGA) means a challenge of the monitoring system with a cylinder gas of a known concentration which is traceable to standard reference materials (SRMs) of the U.S. National Institute of Standards and Technology (NIST) according to Protocol 1 of the US EPA.

Data acquisition system (DAS) means one or more devices used to receive, compute, store, and report CEMS measurement data from single or multiple measurement devices.

Data backfilling means the act of transferring data from one portion of the data acquisition system to another after electronic communications have been restored. For example, delayed transfer of data from a datalogger to the main or central computer normally used for data processing and storage.

Data recorder means a device capable of providing a permanent record of both "raw" and "summary" data.

Data substitution means the procedure using data from a calculation or alternate device as a source of replacement data for periods of time during which a continuous emission monitoring system was "out-of-control," as defined in Table 15. For example, data generated by other means such as a "predictive emissions" program or an alternative monitoring system (or some combination) would be designated as substituted data.

Diluent gas means a major gaseous constituent in a gaseous pollutant mixture or the gas used to dilute the pollutant mixture in dilution type analyzer systems. For combustion sources, carbon dioxide, nitrogen and oxygen are the major diluent gases.

Director means a person designated as a Director for the purposes of the Environmental Protection and Enhancement Act by the Minister of Alberta Environmental Protection.

Drift means an undesired change in output, over a period of time, that is unrelated to input or equipment adjustments.

Dual span system means a pollutant concentration monitor, flow monitor, or in-stack opacity monitor that has two ranges of values over which measurements are made.

Emission standard level means the maximum emission level (either as a concentration or mass) as stated in an approval issued under the Environmental Protection and Enhancement Act.

Equivalent diameter means a calculated value used to determine the upstream and downstream distances for locating flow or pollutant concentration monitors in flues, ducts or stacks with rectangular cross sections.

Extractive monitoring system means one that withdraws a gas sample from the stack and transports the sample to the analyzer.

Flow monitor means an analyzer that measures the velocity and volumetric flow of an effluent stream.

Full scale reading means the upper value of the monitor or analyzer range (as contained in Section 2.0).

In-situ monitor means a monitor that senses the gas concentration in the flue, duct or stack effluent stream and does not extract a sample for analysis.

Inspection means a check for conditions that are likely to affect the reliability of the system. Examples of these conditions could include the following: damage to system components, leaks, a low flow condition in sample transport system, alarms, adequate supply of consumables such as chart paper and calibration gases, etc.

Interference rejection means the ability of a CEMS to measure a gaseous species without responding to other gases or substances, within specified limits.

Invalid data means data that were generated while the measurement device(s) was out-of-control.

Linearity means the degree to which a CEMS exhibits a straight line (first order) response to changes in concentration (or other monitored value), over the range of the system. Nonlinearity is expressed as the percentage difference of the response from a straight line response.

Lower detection limit means the minimum value that a device can measure, which may be a function of the design and materials of construction of the device rather than of its configuration.

Month means a calendar month.

NIST/EPA-approved certified reference material means, a reference material for which one or more of its values are certified by a technically valid procedure, such as Traceability Protocol 1 (U.S. Code of Federal Regulations (40 CFR 75 Appendix H), accompanied by or traceable to a certificate or other documentation that is issued by a certifying body and approved by U.S.-EPA. A current list of certified reference material cylinder gases and certified reference material vendors is available from the Quality Assurance Division (MD-77), Environmental Monitoring Systems Laboratory, U.S.-EPA, Research Triangle Park, NC 27711.

Operational period means a minimum period of time over which a measurement system is expected to operate within certain performance specifications, as set forth in this code, without unscheduled maintenance, repair, or adjustment.

Orientation sensitivity means the degree to which a flow monitoring system is affected by its change in orientation to give an accurate flow measurement.

Path continuous emission monitoring system means a CEMS that measures the pollutant concentration along a path greater than 10% of the equivalent diameter of the flue, duct or stack cross section.

Point continuous emission monitoring system means a CEMS that measures the pollutant concentration either at a single point or along a path equal to or less than 10% of the equivalent diameter of the flue, duct or stack cross section.

Precision means the closeness of a measurement to the actual measured value expressed as the uncertainty associated with repeated measurements of the same sample or of different samples from the same process (e.g., the random error associated with simultaneous measurements of a process made by more than one instrument). A measurement technique is determined to have increasing precision as the variation among the repeated measurements decreases.

Protocol 1 gas means a calibration gas mixture prepared and analyzed according to "Revised Traceability Protocol No. 1," U.S Code of Federal Regulations, 40 CFR 75 Appendix H to Part 75. The certified concentrations for calibration gas mixtures developed using "Revised Traceability Protocol No. 1" are traceable to a standard reference material or an NIST/EPA-approved certified reference material.

Quality assured data means data generated from a CEMS when the CEMS is in control, and meets both the design and performance specifications of this Code.

Range means the algebraic difference between the upper and lower limits of the group of values within which a quantity is measured, received or transmitted.

Raw data means the generation and recording of data at the minimum specified frequency where required in this code and the generation and recording of data associated with quality control activities where required by this code or as a result of a facility's quality assurance plan.

Reference Method means any method of sampling and analyzing for a substance or determining the flow rate as specified in the Alberta Stack Sampling Code (as amended from time to time), or any other such method as authorized by the Director.

Reference value means the known concentration of a verification or calibration gas or the known value of a reference thermometer or output value of a temperature, pressure, current or voltage calibrator.

Relative accuracy is the absolute mean difference between the gas concentration or emission rate determined by a CEMS and the value determined by an appropriate Reference Method plus the 2.5 percent error confidence coefficient of a series of tests, divided by the mean of the Reference Method tests. The relative accuracy provides a measure of the systematic and random errors associated with data from a CEMS.

Response time means the amount of time required for the CEMS to display on the data recorder 95% of a step change in pollutant concentration. This period includes the time from when the sample is first extracted from the flue, duct or stack (if extractive system) to when the concentration is recorded.

Sample interface means that portion of a system used for one or more of the following: sample acquisition, sample transportation, sample conditioning, or protection of the monitor from the effects of the flue, duct or stack effluent stream.

Sensitivity means the minimum change of input to which a device is capable responding and is defined as two times the noise level.

Span means the algebraic difference between the upper and lower range values.

Standard absolute pressure means 760 mm Hg (101.325 kpa) at 25°C.

Standard absolute temperature means 25°C, 298°K, 77°F, or 537°R.

Standard reference material means a reference material distributed and certified by the National Institute of Standards and Technology (NIST) or the Canadian Standards Association (CSA).

Temperature-responsive zero drift means the zero drift of an analyzer for any 10° C change in temperature over the temperature range of 5 to 35°C.

Temperature-responsive span drift means the span drift of an analyzer for any 10° C change in temperature over the temperature range of 5 to 35°C.

Valid hour means data for a given hour consisting of at least four equally spaced data points. For example, if scans occur once every 15 minutes, then four 15-minute scans must be collected for the hour to be valid.

Valid in-stack opacity period means data for a given time period consisting of at least 36 equally spaced data points. For example, for a 6-minute time period, a minimum of 36 samples (cycles) must be obtained, based on a standard rate of sampling at no less than 6 samples (cycles) per minute.

Verification means to ascertain the extent of error in a device or system by comparing the output of that device or system to the reference value.

Zero drift means the difference between the CEMS's response to a lower range calibration value and the reference value after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

APPENDIX B - RELATIVE ACCURACY SAMPLE CALCULATIONS

APPENDIX B - RELATIVE ACCURACY SAMPLE CALCULATIONS

Relative Accuracy Test Audit Calculations

Example data from RATA on a SO₂/O₂ CEMS are shown in Table B.1.

$$\text{CEMS}_{\text{ppm, dry}} = \frac{\text{CEMS}_{\text{ppm, wet}}}{1 - B_{\text{ws}}} \quad \text{Equation B-1}$$

where: B_{ws} = moisture fraction of the CEMS gas sampled.

Table B.1 Relative Accuracy Test Audit Data for SO₂ and O₂ CEMS

Run Number	SO ₂	SO ₂	O ₂	O ₂	SO ₂	SO ₂	SO ₂
	Rm _{d'} ppm	CEMS _{d'} ppm	Rm _{d'} %	CEMS _{d'} %	Rm _{d'} ng/J	CEMS _{d'} ng/J	Diff ng/J
1	500	475	3.0	3.1	422.4	403.5	18.9
2	505	480	3.0	3.1	426.6	407.7	18.9
3	510	480	3.0	3.0	430.8	405.4	25.4
4	510	480	2.9	2.9	428.4	403.2	25.2
5	500	480	2.9	3.0	420.0	405.4	14.6
6	500	500	3.0	3.1	422.4	424.7	-2.3
7	510	510	3.0	3.1	430.8	433.3	-2.5
8	505	505	2.9	3.0	424.2	426.6	-2.4
9	510	520	2.9	3.0	428.4	439.3	-10.9
Avg	---	---	---	---	426.0	413.1	9.43

Rm_{d'} = reference method data, dry basis

CEMS_{d'} = monitor data, dry basis

The SO₂ and O₂ CEMS and RATA data in Table B.1 were converted to the units of the applicable standard using Equation B-2:

$$E = CF \frac{20.9}{20.9 - \text{percent O}_2} \quad \text{Equation B-2}$$

where

E = pollutant emission, ng/J (lb/million Btu),

C = pollutant concentration, ng/dsm³ (lb/dscf),

F = factor representing a ratio of the volume of dry flue gas generated to the caloric value of the fuel, dsm³/J (dscf/million Btu), and

Percent O₂ = oxygen content by volume (expressed as percent), dry basis.

Note: For the calculations shown in Table B.1, ppm of SO₂ was converted to ng/J using a conversion factor of 2.66 x 10⁶ ng/scm/ppm and an F factor of 2.72 x 10⁻⁷ dsm³/J.

For complete explanation of the equations and calculations, see 40 CFR; Part 60; Appendix A; Method 19; 5. Calculation of Particulate, Sulfur Dioxide, and Nitrogen Oxides Emission Rates.

After the data are converted to the units of the standard, the Relative Accuracy (RA) is calculated by using the equations in Section 4.5.8. For convenience in illustrating the calculation, these equations (B-3 through B-8) are also shown here.

The average difference \bar{d} , is calculated for the SO₂ monitor using Equation B-3.

$$\begin{aligned} \bar{d} &= \frac{1}{n} \sum_{i=1}^n (X_i - Y_i) = \frac{1}{n} \sum_{i=1}^n d_i \\ &= \frac{1}{9} (84.9) = 9.43 \text{ ng/J} \end{aligned} \quad \text{Equation B-3}$$

where

n = number of data points,

X_i = concentration from reference method (Rm_d in Table B.1), ng/J,

Y_i = concentration from the CEMS (CEMS_d in Table B.1),

d_i = signed difference between individual pairs, X_i and Y_i, ng/J, and

Σd_i = algebraic sum of the individual differences, d_i, ng/J.

The standards deviation S_d is calculated using Equation B-4:

Equation B-4

$$S_d = \sqrt{\frac{\sum_{i=1}^n d_i^2 - \frac{1}{n} (\sum_{i=1}^n d_i)^2}{n-1}}$$

$$= \sqrt{\frac{(2344) - \frac{1}{9} (84.9)^2}{8}} = 13.9 \text{ ng/J}$$

5. The 2.5 percent error confidence coefficient, CC, is calculated using Equation B-

Equation B-5

$$CC = t_{0.975} \frac{S_d}{\sqrt{n}}$$

$$= 2.306 \frac{13.9}{\sqrt{9}} = 10.68 \text{ ng/J}$$

where

$t_{0.975}$ = t-values in Table B.2 for $n = 9$

Table B.2 Values of t for 95 Percent Probability^a

n^a	$t_{0.975}$	n^a	$t_{0.975}$	n^a	$t_{0.975}$
2	12.706	7	2.447	12	2.201
3	4.303	8	2.365	13	2.179
4	3.182	9	2.306	14	2.160
5	2.776	10	2.262	15	2.145
6	2.571	11	2.228	16	2.131

^a The values in this table are already corrected for $n-1$ degrees of freedom. Use n equal to the number of individual values.

The RA for the RATA is calculated using Equation B-6

$$RA = \frac{|\bar{d}| + |CC|}{\overline{RM}} \times 100$$

Equation B-6

$$= \frac{|9.43| + |10.68|}{426} \times 100 = 4.72\%$$

Where

- RA = relative accuracy, %,
- $|\bar{d}|$ = absolute value of the mean differences from Equation B-3, ng/J.
- $|CC|$ = absolute value of the confidence coefficient from Equation B-5, ng/J, and
- \overline{RM} = average reference method value or applicable standard, ng/J.

APPENDIX C - BIBLIOGRAPHY

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WASTE TO ENERGY

A Technical Review of Municipal Solid Waste Thermal Treatment Practices

FINAL REPORT

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February 25, 2011

Project No: 1231-10166

BC Ministry of Environment
Environmental Standards Branch
PO Box 9341, Stn Prov Govt
Victoria, BC
V8W 9M1

Attention: Tony Wakelin, Section Head Industrial Air Emissions

Dear Mr. Wakelin:

Reference: Waste to Energy: A Technical Review of Municipal Solid Waste Thermal Treatment Practices – Final Report

Attached is the final report *Waste to Energy: A Technical Review of Municipal Solid Waste Thermal Treatment Practices*.

The report was prepared by Stantec Consulting Ltd., with assistance from Rambol Denmark A/S. We also acknowledge the assistance and input from the Ministry of Environment in the preparation of this comprehensive review of the Waste to Energy industry.

On behalf of Stantec, we would like to thank you for the opportunity to be of service to BC Environment in the preparation of this document. We look forward to working with you on similar projects in the future.

Respectfully submitted,

Stantec Consulting Ltd.

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EXECUTIVE SUMMARY

The province of British Columbia is committed to achieving ambitious goals for sustainable environmental management, including realizing greenhouse gas reductions, leading the world with the best air quality bar none and ensuring municipal solid waste (MSW) is managed to minimize environmental impacts. Representing approximately 3% of the province's available biomass resources, a portion of the municipal solid waste stream is a bioenergy source produced in all our communities that has the potential to be used as a fuel supply for the generation of electricity or for the generation of hot water or steam for community energy systems.

Anticipating increased interest in Waste to Energy (WTE) projects, the province is considering updates and revisions to the 1991 Emission Criteria for Municipal Solid Waste Incinerators. This WTE background report supports the Ministry of Environment's scoping phase, and is intended to be used as a supporting document for subsequent steps, including preparation of emission guidelines. This background report addresses the concept of what constitutes good performance, based on best practices in the WTE field in order to provide guidance on potential stack emissions limits and the design and operation of WTE facilities.

The report was prepared through the collaborative efforts of Stantec Consulting Ltd. and Ramboll Denmark A/S. Stantec has direct recent experience with the WTE sector in North America and Ramboll brings thermal treatment experience from the European Union.

The report includes the following main sections:

Thermal Treatment Technologies

A review of the thermal treatment processes applied to the MSW stream has been summarized. Both current, conventional combustion technologies and emerging WTE technologies are described in general terms. Conventional mass burn thermal treatment systems are most common in the industry, with some application of waste gasification, plasma arc and pyrolysis technologies. Emerging technologies include gasplasma, thermal cracking, thermal oxidation and waste-to-fuels technology.

WTE Facility Discharges

The report includes a discussion of typical discharges from WTE facilities, including emissions to the atmosphere, liquid effluent, and solid residues. Air emissions include, but are not limited to, particulate matter (total particulate, PM₁₀ and PM_{2.5}), sulphur oxides (SO_x), nitrogen oxides (NO_x), certain volatile organic compounds (VOCs), and carbon monoxide (CO). The section also describes additional air emissions of interest, sometimes described as Hazardous Air Pollutants (HAPs). These typically include acid gases, organic constituents, trace metals, mercury, polycyclic aromatic hydrocarbons, and dioxins and furans. Point source air emissions (from stacks) and fugitive emission sources are described. The management of liquid wastes produced by WTE facilities is described. The primary potential sources of liquid wastes are certain air pollution control equipment (wet scrubbers). Liquid wastes typically require on-site treatment prior to recycling and/or discharge to the sanitary sewer system.

Air Emission Control Systems

The report reviews air emission control systems commonly applied to thermal treatment technology, including operational controls and air pollution control (APC) system equipment. Operational controls relate to the handling of the MSW and how the operators control the combustion parameters to optimize facility performance. There are a wide variety of primary APC systems available for WTE facilities and typically these are used in combination to minimize the potential emissions. The APC system train selection is generally made after first selecting the scrubber system (dry, semi-dry or wet), and then other components that are complementary to the scrubber selection are added. The use of wet or dry scrubbers to control acid gases has been documented to achieve 87 – 94% removal of HCl and 43 – 97% removal of HF. Nitrogen Oxide control is accomplished using either Selective Catalytic Reduction (SCR) or Selective Non-Catalytic Reduction (SNCR) approaches, which use ammonia to react with oxides of nitrogen in the flue gas to reduce the concentration of NO_x. A reduction of NO_x in the order of >90% is typically achieved for SCR and 30% to over 75% for SNCR. Particulate removal efficiencies of up to 99.9% have been documented for both baghouses and electrostatic precipitators.

Expected Emission Rates

This section provides an overview of the typical emissions rates from combustion and control systems and the factors that affect the quality and quantity of emissions. Reported facility emission data for the WTE sector for facilities in Metro Vancouver, Ontario, USA, China and the European Union are tabulated for comparison. The factors that affect emission concentrations and rates from a WTE facility are discussed in overview.

Refuse Derived Fuel – An Overview

Refuse derived fuel (RDF) has the potential to be used as an industrial facility fuel supply for specific applications. RDF is typically defined as processed MSW, but can also include waste generated through construction and demolition (C&D). Examples of the use of RDF and C&D wastes in power boilers and cement kilns as fuel substitutes is discussed, with specific application to British Columbia. The potential effect of the use of such fuels on emission profiles and rates from industrial facilities are discussed.

Associated Costs and Energy Efficiency

As part of the comparison of WTE technologies, the report includes a review of costs and energy efficiency for the various thermal treatment and APC technologies. The capital and operating cost for WTE facilities varies on a per tonne basis depending on the scale of the facility and specific design parameters. Generally, actual cost information is difficult to verify, and much of the available cost data is based on vendor information that has been provided outside of formal procurement processes. The sale of recovered energy in a WTE facility, in the form of electricity or as heat (steam), is typically critical to the financial viability of the facility, particularly when compared to other MSW management options.

The report includes an overview of the European Energy Equation (Equation) and its application to the WTE sector. The Equation originated with the European Union (EU) Waste Framework Directive

(WFD) and is applied to categorize waste incineration facilities as recovery facilities, as opposed to waste disposal facilities which are lower on the waste hierarchy, where energy recovery/efficiency above a specified target (0.6 to 0.65 in accordance with the Equation) can be shown. Facilities that cannot meet this target are classified as waste disposal facilities. The ministry's Environmental Protection Division operational policy already states a preference for any MSW incineration facilities to meet energy recovery criteria (over disposal, determined using an approach similar the Equation). There are also aspects of the "*The BC Energy Plan: A Vision for Clean Energy Leadership*" related to efficiency and alternative energy within which a similar equation (modified to suit the BC context) could play a role to support development of efficient WTE approaches.

Monitoring Systems

An overview of emission and ambient monitoring systems is provided. This includes continuous emissions monitoring, periodic (non-continuous) source testing and ambient air quality monitoring techniques. References to the applicable monitoring procedures are provided. A discussion on averaging periods for continuous and periodic stack testing methods is included in relation to determining compliance with emission criteria and permit limits.

Emission Limits and Application

The report includes a discussion of the regulatory environment and regulatory practices in various jurisdictions, including Canada, USA and the EU, with specific focus on the generation and application of criteria and permit limits in BC. The Ministry's Environmental Protection Division has an interim Best Achievable Technology (BAT) policy to be used in the identification and setting of new waste discharge standards and criteria. A brief overview of the interim policy is provided.

This section also includes review of regulatory emission limits for Criteria Air Contaminants (CACs) and Hazardous Air Pollutants (HAPs) for the WTE sector. Two tables comparing emission limits are provided. One is a summary of maximum allowable concentrations of CACs and other parameters for WTE facilities as defined by criteria or standards in various jurisdictions. The second table is a comparison of actual permitted limits (from Permits or Certificates of Approval/Authorization) from actual facilities. Typical WTE facilities are capable of achieving emissions that are below maximum permitted hourly or daily average limits.

This section also contains a table summarizing emission limits by parameter and their corresponding averaging periods. The comparison includes the 1991 BC Emission Criteria for Municipal Solid Waste Incinerators, the new Ontario A-7 standard (October 2010), and the European Union's Waste Incineration Directive (WID) limits and 2006 BREF guidelines (European Union Best Achievable Technology Reference Documents).

This section concludes with proposed amendments to the 1991 Emission Criteria for Municipal Solid Waste Incinerators for BC, including the numerical value of the criteria by parameter and the recommended corresponding measurement and averaging methods. The proposed amended guidelines are also provided in the Recommendations (Section 11).

Ash and Residue Management

This section discusses the composition of bottom ash, fly ash and APC residues from WTE facilities. The quality of the residues is directly linked to the quality of the MSW input to the facility and some ash and APC residue quality data from EU facilities is presented. Gasification process residues are also described. The degree of sorting and source separation has a large effect on the quality of the ash. The report discusses beneficial use of these residues, including recovery and recycling of metals and the use of bottom ash as a construction aggregate or as a feedstock to the cement industry.

The section also describes the regulatory environment governing WTE residuals management in BC, North America and the EU. The section then focuses on the specifics for management of ash and residues in BC, including determining if the material is hazardous waste, identifying potential alternative uses, and safe disposal options.

Posting of financial security may be necessary where the land filling of ash from a WTE facility poses a potential risk to the environment. The report discusses in general terms how the need for financial security is determined in BC for contaminated sites and how the value of the financial security is determined. Financial security is based on a site-specific risk determination.

Conclusions and Recommendations

Conclusions and recommendations reached following the review of technologies, BAT, Best Available Control Technology (BACT) and the regulatory approaches in other jurisdictions, and considerations for updates to emissions criteria in B.C. are summarized as follows:

Conclusions

1. Mass burn incineration continues to be the most common method of thermal treatment for WTE facilities. It is reasonable to anticipate that this technology would be proposed for new WTE facilities contemplated in BC.
2. Other thermal treatment technologies such as gasification, plasma gasification and pyrolysis have historically had certain limitations due to their complexity, difficulty in handling variations in the waste stream (which can be managed by waste pre-treatment), and lower net energy recovery (electricity and heat energy) once in-plant parasitic consumption is accounted for. These factors tend to make these other thermal treatment technologies less viable. However, the industry continues to evolve and facilities that treat a portion of the waste stream are being proposed, developed and commissioned. As more actual performance data is generated, it will be better understood if the limitations of these approaches can be resolved.
3. The 1991 BC Emission Criteria for Municipal Solid Waste Incinerators (1991 BC Criteria) cut off between small and large facilities of 400 kg/hour (equivalent to 9.6 tonnes per day) was put in place to differentiate between small facilities used for remote locations and/or on-site waste management and larger WTE facilities. In Europe WTE operations generally handle an average of 20 to 30 tonnes of MSW per hour (480 to 720 tonnes per day). To-date, various studies indicate that it is difficult for commercial WTE facilities to be economically viable at annual capacities less than 10 tonnes per hour (equivalent to 100,000 tonnes per

year actual throughput), unless there is a local economic driver (e.g., high value local market for heat energy, high transportation costs and/or difficult logistics associated with other disposal options). In some jurisdictions (e.g., Ontario) the differentiation between large and small facilities results in differentiation of approvals processes (large WTE requires full Environmental Assessment (EA) Screening, small WTE does not) however, in regards to air emissions the same criterion/limits apply regardless of size to all WTE applications except for very small scale research applications. Other jurisdictions (e.g., United States Environmental Protection Agency (US EPA)) apply different criterion/limits for smaller scale WTE approaches. For the purpose of regulating MSW incineration in the BC context, it seems reasonable that the cut-off of 400 kg/h between small and large facilities should be maintained.

4. The 1991 BC Criteria currently include the key substances of concern that would be released from the main stack (point source) of an existing or new WTE facility. The 1991 BC Criteria do not, however, provide limits for speciated total particulate matter in the 10 micron (PM_{10}) and 2.5 micron ($PM_{2.5}$) size fractions. This approach is consistent with emission limits observed in other jurisdictions evaluated in this report. The value of specifying limits for speciated particulate matter has not been demonstrated and thus limits for these parameters have not been identified in the proposed revisions.
5. The 1991 BC Criteria do not consider fugitive emissions including dust, odour, and Volatile Organic Compounds (VOCs).
6. The specification of temperature and retention time in the combustion zone varies between North America and the EU, although generally these jurisdictions define the combustion zone in a similar fashion (measured after the last point of air injection). In North America, a minimum temperature of 1,000°C with a retention time of 1 second is typical. In the EU, the specification is minimum 850°C with a retention time of 2 seconds. Operated correctly within the design criteria for the incinerator, both specifications should produce an acceptable quality of emission before entering the APC. Flexibility in specifying these operating parameters should be considered and the appropriate balance of temperature and retention time applied on a facility-specific basis.

In most jurisdictions, guidance on design and operation of WTE facilities is provided including recommendations related to combustion temperature and residence time, and also for other parameters such as combustion air distribution, oxygen availability, operation of APC systems and ash management. In these jurisdictions as in BC, the recommendations are not intended to restrict technology development or to dictate facility design or equipment selection. Alternative designs and operating conditions may be proposed for approval, and considered by the regulatory authority, provided that the systems are designed and operated such that the Emission Limit Values (ELVs) can be achieved. Proponents are expected to provide sufficient technical information to the regulatory authority to justify alternative design and operational parameters. Once approved, these parameters are reflected in the operational permit(s) and/or conditions set out for the facility.

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7. The most common and effective air pollution systems applied to WTE facilities are dry/semi dry, wet and semi wet systems. Several types of “end of pipe” air pollution controls have been applied to WTE facilities. The selection of best technology (either BACT or BAT) depends on the nature of the waste, design of the combustion process, flue gas composition and fluctuation, energy supply, energy recovery and a number of other considerations.
8. Modern WTE facilities are capable of achieving substantial emission reduction through the use of emission control technology. Reductions in the contaminants of concern across the air pollution control system (APC) typically range from 90% up to 99.95% through the application of typical APC systems.
9. Management of NO_x can be accomplished through both Selective Non-Catalytic Reduction (SNCR) and Selective Catalytic Reduction (SCR) systems, with economics in the form of direct costs (including reagent and energy consumption) or financial incentives (e.g., tax regimes) playing a role in the decision regarding which system is selected and in how the system is operated. Lower NO_x emissions can regularly be achieved through SCR. With SNCR, the level of NO_x reduction achieved is often linked to immediate economic drivers since increasing quantities of ammonia injection (i.e., use of additional reagent) are required to achieve lower emission levels. There is also a trade-off with SNCR, as the odour associated with ammonia slippage (stack ammonia releases due to excess ammonia not reacting with NO_x) must be considered.
10. Emission releases from WTE facilities have decreased substantially in the US between 1990 and 2005. SO_x and NO_x have been reduced by 88% and 24% respectively. The reductions have resulted from improvements in thermal treatment technology and operational control, improvements in waste diversion and source separation prior to thermal treatment, and improvements in the design and operation of the APC equipment.
11. The EU Energy Efficiency Equation will be adopted by EU member states by the end of 2010 as a means of differentiating between the energy recovery performance of WTE facilities. In general, the formula can be used for differentiating between energy recovery and disposal within a waste hierarchy. The application of the equation varies between the various EU member states. Further development and definition of the scope and application of the equations is expected. The ministry’s Environmental Protection Division operational policy already states a preference for any MSW incineration facilities to meet energy recovery criteria (over disposal, determined using an approach similar the Equation). Therefore, it may be reasonable to modify the Equation to suit a BC context (i.e., modify the energy equivalency factors for electrical and thermal energy as appropriate) as part of future policy development in the Province. However, new WTE facilities in BC may not be able to achieve an energy efficiency of 60% without further development of infrastructure such as district heating that would facilitate the use of heat generated by a WTE facility, recognizing that a high efficiency is difficult to reach through the production of electricity alone.

12. In regards to the use of Refuse Derived Fuel (RDF) as substitute fuel in existing industrial or power generating facilities, the majority of jurisdictions examined in this study use a regulatory approach that combines some facets of the regulatory environment associated with WTE facilities (e.g., many of the same stack emissions limits, the same AAQO requirements) but also tailor these approaches in a more industry specific fashion. Generally, the approach applied to regulate use of RDF in other jurisdictions includes:
- a) Ensuring that the composition of the RDF is similar in regards to fuel value and general chemical composition to the primary fuel source for the intended combustion facility (e.g., use of cellulosic waste materials in wood-fired boilers).
 - b) Requirement for RDF fuel analysis and comparison to current fuels to determine the potential shift in contaminant mass balance and thus facility emissions.
 - c) The requirement to complete test burns and stack testing to measure and validate predicted shifts in emission quality, if any.
 - d) Application of RDF quality standards, specific to parameters that cannot be reasonably managed in the proposed industrial application (e.g., avoidance of fuels with high PVC content if the control of acid gases is unfeasible).
 - e) Application of the same stack limits applied to WTE facilities, for parameters that are directly associated with fuel quality (e.g., heavy metals, persistent organic pollutants (POPs)) but not for emission parameters that are driven largely by the primary purpose and design of the facility (e.g., not including SO_x emissions for cement kilns as these emissions are largely driven by raw material quality).
13. In the EU, it is common for emission limits to be linked to monitoring techniques and corresponding averaging periods. Typically, one-half hour average limits are specified for parameters measured by continuous monitors, whereas daily average limits are specified for parameters measured by periodic monitoring. For some parameters, limits for both continuous and for periodic monitoring are specified. In the US, daily average emission limits are specified regardless of the monitoring method. The industry trend is towards increased use of continuous monitoring devices where they can be correlated as equivalent to periodic monitoring techniques.
14. In the EU, where one-half hour average limits and daily average limits are specified for a parameter, the one-half hour limit is numerically higher than the daily average limit. The dual limits acknowledge that the daily average takes into account the fluctuations in the emission over time, whereas the one-half hour limit more closely represents the maximum allowable discharge concentration over the shorter averaging period.
15. This report highlights the potential use of the dual standards for some parameters as applied in the EU. When comparing the emission limits proposed in this report to the 1991 BC Criteria, the potential monitoring methods applicable for each parameter must be considered. The proposed limits allow for continuous monitoring where appropriate and technically feasible and in general these values are greater than the daily average. The limits also allow for periodic monitoring for parameters that require stack testing and these

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proposed daily average limits are equal to, or more stringent than, the 1991 BC Criteria. New Ministry of Environment policy indicates that all WTE projects will be required to go through an Environmental Impact Assessment process. This is similar to the approach in jurisdictions such as Ontario, where all WTE projects (above a minimum size limit) are required to go through screening under the *Ontario Environmental Assessment Act*.

16. The BC Hazardous Waste Regulation specifies the methodology for testing leachability of a waste material and determining if it is classified as hazardous waste. Bottom ash, fly ash and APC residue should be subjected to the TCLP test and the ash should then be handled according to the classification.
17. Bottom ash is normally not classified as hazardous waste and it is acceptable practice to deposit bottom ash in a permitted sanitary landfill or for the ash to be utilized for a beneficial use, such as intermediate cover, concrete or asphalt aggregate substitution or road base material. Jurisdictions such as Ontario, recognize that bottom ash from facilities that process non-hazardous municipal waste and that has organic content of less than 10%, is a non-hazardous material and do not require that TCLP testing be carried out on such ash. Fly ash and air pollution control (APC) residue are more likely to contain leachable contaminants and be classified as hazardous waste. Fly ash and APC residue must be disposed of in a secure landfill authorized to receive this class of material. Alternatively, the fly ash/APC residue may be pre-treated/stabilized to reduce leachability prior to deposition in a municipal sanitary landfill site. There is limited opportunity for beneficial use of fly ash and APC residues in BC, even when stabilized, at the present time.
18. The Waste to Energy sector continues to evolve with the advent of new incineration and new pollution control equipment technology and the further advances in municipal waste diversion and separation technologies. Regulatory agencies including Ontario Ministry of the Environment and the US EPA have either recently revised or are considering revisions to current regulations and criteria. The BC Ministry of Environment should take into account both the technical and regulatory advances underway in comparable jurisdictions when developing revised guidelines.

Recommendations

1. The 1991 BC Criteria for municipal solid waste incineration should be updated to reflect advancements in thermal treatment and pollution control technology and standards applied in other jurisdictions. A table summarizing the recommended emission limits is provided at the end of this section.
2. It is recommended that the Waste Discharge Regulation (WDR) exemption for remote incinerators to accommodate fewer than 100 persons (section 3(7)) remain in place for remote operations. If a facility is serving over 100 persons and is processing less than 400 kg/hr of municipal solid waste, site specific emission limits should be authorized by the Ministry. Facilities over the 400 kg/hr capacity limit should be required to meet new revised emission guidelines as set by the Ministry.

3. The design and operation requirements in the 1991 criteria should continue to apply including the recommended minimum incineration temperature of 1,000°C and minimum residence time of 1 second (after final secondary air injection ports). This requirement should be maintained as the default specification; however proponents should be provided an opportunity to seek an alternate temperature/retention time specification that would result in equivalent thermal destruction efficiencies without impacting emission quality. Flexibility in the application of the temperature and retention time specification is possible, as long as the quality of the emission is maintained for a specific facility. A minimum temperature of 850°C with a retention time of 2 seconds could be considered equivalent, depending on the proposed technology. Adjustments to the temperature profile and retention time for a proposed facility should be demonstrated as equivalent by a facility proponent at the application stage, and would be reflected in the approved operating conditions set out for the facility.
4. The potential for fugitive emissions from WTE facilities should be addressed through site specific design considerations such as maintaining appropriate areas of the facility (e.g., receiving and tipping floor) under negative pressure, using indoor facility air for combustion and specific measures for loading, transfer, storage, accidental loss of containment, as well as the handling of auxiliary fuels and reagents for the APC systems. Revisions to the 1991 BC Criteria should address fugitive emissions with references to Best Management Plans, meeting ambient objectives and/or odours at the fence-line or other enforceable criteria.
5. The revised emission limits presented at the end of this section (also as Table 8-21) should be considered by the Ministry as proposed new emission criteria for WTE facilities in BC.
6. The recommended revised emission criteria generally reflect two approaches to setting in-stack emissions limits. The one-half hour limit is intended to be used where the facility uses continuous monitoring techniques. The one-half hour limit generally represents the maximum allowable concentration of a contaminant not to be exceeded at any time. The daily average limit applies when periodic stack sampling is used to characterize the emissions. The daily average limit should be considered to be the default limit where the facility must use periodic sampling to determine compliance or where continuous monitoring methods are not available or practical. Both the daily average and one-half hour limits should apply to parameters for which continuous monitoring is feasible and conducted, and where periodic stack sampling is required.
7. The recommended revised emission criteria for particulate, adopts a hybrid approach to emission limit values from other jurisdictions. Where continuous monitoring systems are used, it is proposed that the concentration of total particulate be less than 9 mg/Rm³ for 97% of the operating period on a 12 month rolling average, and less than 28 mg/Rm³ for 100% of the operating period on a 12 month rolling average. Where continuous monitoring systems for particulate are used, opacity monitoring may not be necessary as a compliance parameter unless the continuous monitoring system is not functioning. During this scenario, opacity monitoring can be used as a temporary surrogate until the continuous monitoring system for particulate is reinstated.

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8. The recommended revised emission criteria for trace metals lead (Pb), arsenic (As) and chromium (Cr) should be set as the sum of the three metals as determined by periodic sampling with the ELV being set at 64 ug/Rm^3 .
9. Where a non-MSW thermal treatment facility intends to substitute fuel with RDF, or C&D waste, the facility should be required to meet these revised WTE emission criteria for parameters that are directly associated with fuel quality, such as trace heavy metals and persistent organic pollutants. For particulate emissions, the facility could be required to meet new applicable guidelines (for biomass boilers the Ministry may set new limits of 35 mg/m^3 for facilities ranging in size from 3 to 39 MWh, and 20 mg/m^3 for facilities of 40 MWh and larger). The facility should still meet their permitted emission parameters that are established based on the primary purpose and design of the facility, such as SO_x , CO and NO_x . The range of permitted emission parameters that are established based on the primary purpose and design of the facility will vary as appropriate between specific types of existing industrial installations. This approach is permissive by allowing fuel substitution to occur but also protective by requiring compliance with the appropriate, more stringent, limits for potentially harmful contaminants related to the substituted fuel.
10. Generally, the approach applied to regulate use of RDF in BC should be similar to that used in other jurisdictions, including application of the following sequence of steps during the permitting process:
 - a) Ensuring that the composition of the RDF is similar in regards to fuel value and general chemical composition to the primary fuel source for the intended combustion facility (e.g., use of cellulosic waste materials in wood-fired boilers).
 - b) Requiring RDF fuel analysis and comparison to current fuels within the applications to use RDF, along with analysis that identifies the potential shift in contaminant mass balance and thus facility emissions.
 - c) For use of dissimilar fuels and/or use of RDF where there is some potential for more significant shifts in emissions or concern regarding the degree of emissions shift demonstrated through desk top analysis, in addition to the fuel tests/analysis there should be a requirement to complete test burns and stack testing to measure and validate predicted shifts in emission quality.
 - d) Development and application of RDF quality standards and specifications, specific to parameters that cannot be reasonably managed in the proposed industrial application (e.g., avoidance of fuels with high PVC content if the control of acid gases is unfeasible). This would include development of a definition for various fractions of sorted MSW and construction and demolition waste, for example defining what constitutes 'clean' versus 'contaminated' wood waste suitable for use as a substitute fuel for wood waste boilers.
 - e) Application of the same stack limits applied to WTE facilities, for parameters that are directly associated with fuel quality (e.g., heavy metals, POPs) but not for emission parameters that are driven largely by the primary purpose and design of the facility

(e.g., not including SO_x emissions for cement kilns as these emissions are largely driven by raw material quality). For those parameters that are driven largely by the primary purpose and design of the facility, facility specific ELVs will be determined and applied, potentially resulting in some adjustment to the ELVs for these parameters as set out in the operating permit.

The above represent preliminary recommendations. Further study is required to determine the appropriate RDF fuel quality specifications applicable in BC, and to determine the approach to stack emissions that would be most applicable to each of the major sectors (pulp mill boilers, lime kilns, cement kilns) that would represent industrial users of RDF in BC. The Province should consider development of specific regulatory instruments to address RDF composition (similar to other jurisdictions that regulate RDF composition for various applications) and use as a fuel alternative.

11. Dispersion modelling should be conducted to assess risks associated with the location and potential operation of a new WTE facility. Modelling results should show in all cases that AAQOs established or accepted by the Ministry would not be exceeded with a wide margin of safety for all conceivable modes of operation including upsets.
12. Potential effluent discharges from a WTE facility originating from process wastewater (associated wet flue gas treatment), originating from bottom ash storage, or from other process wastewater streams (boiler feed water, sanitary wastewater, storm water (either contaminated or clean) or used cooling water should be authorized as part of the Solid Waste Management Plan or under a waste discharge permit with limits determined on a site specific basis.
13. The current approach in BC used for leachability testing of bottom ash, fly ash and APC residues is consistent with other jurisdictions. Testing the leachability of the ash continues to be critical in the decision process for reuse and /or disposal of the bottom ash and APC residues. The TCLP leachate extraction test prescribed in the BC HWR is a suitable test method and widely accepted. Bottom ash found to be non-leachable is not hazardous waste and can have some beneficial use or can be deposited in a permitted landfill. APC residue from MSW treatment systems will likely be leachable and require stabilization prior to disposal in a landfill or should be managed as hazardous waste.
14. Separate handling of bottom ash and APC residues represents best practice in order to optimize recovery and/or beneficial use of bottom ash. New incineration technologies should be required to identify the characteristics of the facility residuals. If residuals are determined to have beneficial use characteristics the proponent should demonstrate the associated environmental benefits and liabilities. If beneficial reuse is not practical, consideration for comingling the ash for landfilling, with stabilization as may be necessary, may be permitted.
15. In the development of revised WTE guidelines, BC Ministry of Environment should take into account ongoing technical and regulatory advancements currently evolving in Ontario, the EU and USA.

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Table 1: Proposed Revisions to Emission Criteria for Municipal Solid Waste Incineration in British Columbia

Contaminant	Concentration Units	RECOMMENDED EMISSION LIMITS				
		C: Continuous P: Periodic ⁽¹⁾	Daily Average	Average Period and Monitoring Method	Half Hourly Average	Average Period and Monitoring Method
Total Particulate Matter (TPM)	mg/Rm ³ @ 11% O ₂	C (P for existing facilities)	9	Existing facilities without CEMS may use the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	9 ⁽²⁾ 28	1/2 hour average as determined by a continuous emissions monitoring system, achieved 97% of the operating period on a 12 month rolling average. 1/2 hour average as determined by a continuous emissions monitoring system, achieved 100% of the operating period on a 12 month rolling average
Carbon Monoxide (CO)	mg/Rm ³ @ 11% O ₂	C	50	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	100	1/2 hour average as determined by a continuous emissions monitoring system
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	C	50	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	190	1/2 hour average as determined by a continuous emissions monitoring system
Nitrogen Oxides (NO _x as NO ₂)	mg/Rm ³ @ 11% O ₂	C	190	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	350	1/2 hour average as determined by a continuous emissions monitoring system
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	C	10	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	60	1/2 hour average as determined by a continuous emissions monitoring system
Hydrogen Fluoride (HF)	mg/Rm ³ @ 11% O ₂	P/C	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	4	1/2 hour average as determined by a continuous emissions monitoring system ⁽³⁾ .
Total Organic Carbon	mg/Rm ³ @ 11% O ₂	C	10	Calculated as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	20	1/2 hour average as determined by a continuous emissions monitoring system
Arsenic (As)	µg/Rm ³ @ 11% O ₂	P	See Pb, As and Cr group	Calculated as the sum of three metals determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Cadmium (Cd)	µg/Rm ³ @ 11% O ₂	P	7	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Chromium (Cr)	µg/Rm ³ @ 11% O ₂	P	See Pb, As and Cr group	Calculated as the sum of three metals determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Lead (Pb)	µg/Rm ³ @ 11% O ₂	P	See Pb, As and Cr group	Calculated as the sum of three metals determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Sum of Lead (Pb), Arsenic (As), Chromium (Cr)	µg/Rm ³ @ 11% O ₂	P	64	Calculated as the sum of three metals determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Mercury (Hg)	µg/Rm ³ @ 11% O ₂	P or C ⁽⁴⁾	20	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	N.D.	

Contaminant	Concentration Units	RECOMMENDED EMISSION LIMITS				
		C: Continuous P: Periodic ⁽¹⁾	Daily Average	Average Period and Monitoring Method	Half Hourly Average	Average Period and Monitoring Method
Chlorophenols ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Chlorobenzenes ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Polycyclic Aromatic Hydrocarbons ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	5	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Polychlorinated Biphenyls ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Total Dioxins and Furans (as PCDD/F TEQ)	ng/Rm ³ @ 11% O ₂	P	0.08	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Opacity ⁽⁶⁾	%	C (P optional for existing facilities)	N.D.		5	1/2 hour average from data taken every 10 seconds, measured by a CEMS

NOTES:
Concentration units: Mass per reference cubic metres corrected to 11% oxygen. Reference conditions: 20°C, 101.3 kPa, dry gas
N.D. = Not Defined
⁽¹⁾ Where Periodic stack test measurements (P) are indicated, the daily averaging period applies. For Continuous monitoring (C), the 1/2 hour averaging period applies. P/C indicates both technologies are available; ELV will be linked to sampling method.
⁽²⁾ 97% of the half-hour average values over an annual rolling average will not exceed 9 mg/Rm³. 100% of the half-hour average values will not exceed 28 mg/Rm³.
⁽³⁾ This requirement may be omitted at the discretion of the Regional Manager should treatment stages for HCl demonstrate that the ELV for HCl is not exceeded.
⁽⁴⁾ Daily Average ELV for mercury applies regardless of monitoring method.
⁽⁵⁾ Proponents may be able to demonstrate that monitoring both Total Organic Carbon (TOC) and Total Dioxin and Furans could negate the need to monitor Chlorophenols, Chlorobenzenes, Polycyclic Aromatic Hydrocarbons and Polychlorinated Biphenyls.
⁽⁶⁾ Opacity will not be required for compliance purposes for facilities utilizing continuous particulate monitoring systems. Opacity monitoring is recommended for operational monitoring purposes. However, monitoring opacity can be used as a temporary surrogate for total particulate monitoring in the event of a particulate monitoring system failure. Under these circumstances, the ELV of 5% opacity over a 1/2 hour averaging period should apply.

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Appendix ADatabase of Current Technology Vendors and Thermal Treatment Technologies
Appendix B BC Emission Criteria for MSW Incinerators (June 1991)

[File Name and Path: P:_Oracle Projects\PC 1231 EM\123110166\Final Report\11Feb7 BCMOE WTE Emissions final Master no format.docx]

GLOSSARY

AAQC	Ambient Air Quality Criteria
AAQO	Ambient Air Quality Objectives
APC	Air Pollution Control
APC residues	Air Pollution Control residues comprise: (i) dry and semi-dry scrubber systems involving the injection of an alkaline powder or slurry to remove acid gases and particulates and flue gas condensation/reaction products (scrubber residue); (ii) fabric filters in bag houses may be used downstream of the scrubber systems to remove the fine particulates (bag house filter dust); and (iii) the solid phase generated by wet scrubber systems (scrubber sludge). APC residues are often combined with fly ash.
BACT	Best Available Control Technology meaning the technology that can achieve the best discharge standards relative to energy, environmental and economic impacts. BACT is often used more specific for 'end of pipe' control technologies such as Air Pollution Control systems, as opposed to BAT which can also refer to operating systems.
BAT	<p>Best Achievable Technology or Best Available Technology. Best Available Technology represents the most effective techniques for achieving a high standard of pollution prevention and control. BAT mechanisms in the USA and the EU are designed to provide flexibility to balance technical and economic feasibility, and weigh the costs and benefits of different environmental protection measures. This approach is referred to as Best Achievable Technology.</p> <p>BCMOE has an interim Best Achievable Technology policy to be applied when setting new discharge parameters for any discharge media and to be used as the basis for setting site specific permit limits.</p> <p>Within the EU, the concept of BAT was introduced as a key principle in the IPPC Directive 96/61/EC (Directive 2008/1/EC codified version).</p>
BATAEL	Best Achievable Technology (or Best Available Technology) Associated Emission Levels
BCEAA	<i>British Columbia Environmental Assessment Act</i>
BCMOE	British Columbia Ministry of Environment
Bottom Ash	Comprises heterogeneous material discharged from the burning grate of the incinerator (grate ash) and material that falls through the burning grate to be collected in hoppers below the furnace (grate riddlings).

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Glossary

BPEO	Best Practicable Environmental Option is a set of procedures adopted by Great Britain which considers a range of environmental, social and economic factors that should be taken into account when making decisions on the future management of waste.
BREF	European Union Best Available Technology Reference Documents
CAC	Criteria Air Contaminants
CEAA	Canadian Environmental Assessment Agency
CFBC	Circulating Fluidized Bed Combustion is a combustion system in which the fuel (usually processed waste fuels such as coarse refuse-derived fuel) are burned within a bed of fine inert material fluidized by a high velocity air stream. The off-gas and entrained solids are separated in a high efficiency cyclone and the solids are returned to the bed.
CHP	Combined Heat and Power produces electricity and heat in the same process.
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
Co-disposal	Co-disposal is the practice of mixing wastes of different origins in the same landfill or other disposal facility.
Criteria	Criteria, Standards and Guidelines are used often interchangeably and sometimes incorrectly in BC. Criteria and Guidelines are target levels established by good practice and determined to be protective of the environment. Standards are limits established by regulation. It should be noted that in the 1990s the Ministry referred to stack emission standards as “criteria”. These are now currently referred to as “guidelines”.
DEFRA	Department for Environmental and Rural Affairs (UK)
DOC	Dissolved Organic Carbon is organic material, from the decomposition of plant and animal material, dissolved in water.
EC	European Commission is the executive body of the European Union. The body is responsible for proposing legislation, implementing decisions and upholding the Union’s treaties and general operation of the Union.
EFW	Energy from Waste, also known as waste to energy (WTE), is the conversion of waste into a useable form of energy, e.g., heat or electricity. A common conversion process is waste combustion.

ELVs	Emission Limit Values, equivalent to permit limits
EMA	<i>Environmental Management Act</i> is an authorization framework intended to protect human health and the quality of water, land and air in British Columbia. EMA enables the use of administrative penalties, informational orders and economic instruments to assist in achieving compliance.
ESP	Electrostatic Precipitator is a particulate collection device that uses the force of an induced electrostatic charge to remove particles from a flowing gas.
EU	European Union is a political and economic union of 27 member states.
FGT	Flue Gas Treatment
FBC	Fluidized Bed Combustion is a combustion system in which a fine inert material, such as sand, is maintained in a fluid condition by air blowing upwards through it. Used in combination with processed waste fuels, such as coarse refuse-derived fuel.
Fly Ash	Finely divided particles of ash which are normally entrained in the combustion gases. Fly ash is recovered from the gas stream by a combination of precipitators and cyclones.
GEM	Graveson Energy Management
GHG	Greenhouse Gases
GVRD	Greater Vancouver Regional District
HAP	Hazardous Air Pollutants
HF	Hydrogen Fluoride
HWR	Hazardous Waste Regulation enacted under the BC EMA for managing hazardous waste.
IAWG	International Ash Working Group
IEA	International Energy Agency an intergovernmental organization which acts as energy policy advisor to 28 member countries in their effort to ensure reliable, affordable and clean energy for their citizens.
IPPC	Integrated Pollution Prevention and Control
ISWA	International Solid Waste Association

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ISWRM	Integrated Solid Waste and Resource Management
LAP	Landelijk Afvalbeheer Plan
Mass-Burn Incineration	The incineration of waste in a grate combustion system
Monofill	Landfill site practice whereby only one type of waste material (e.g., MSW bottom ash) is placed in landfill.
MSW	Municipal Solid Waste is waste which is collected for treatment and disposal by a local authority. MSW generally comprise waste from households, civic amenity sites, street-sweepings, local authority collected commercial waste, and some non-hazardous industrial waste.
MW	Megawatts (10^6 W) is a unit of power equal to one million watts
NCV	Net Calorific Value
NO _x	Mono-nitrogen oxides (NO and NO ₂). These oxides are produced during combustion.
NPRI	National Pollutant Release Inventory is Canada's legislated publicly accessible inventory of pollutant releases (to air, water and land), disposals and transfers for recycling.
PAH	Polycyclic aromatic hydrocarbons consist of fused aromatic rings and do not contain heteroatoms or carry substituents.
PCB	Polychlorinated biphenyls consist of 1 to 10 chlorine atoms attached to biphenyl, which is a molecule composed of two benzene rings.
PCDD	Polychlorinated dibenzo-p-dioxins
PCDF	Polychlorinated dibenzofurans
PM _{0.1}	Particulate Matter consisting of airborne particles with a mass median diameter less than 0.1 micrometers. Includes as a sub-set nanoparticles (<10 nm or 0.001 micrometers)
PM _{2.5}	Particulate Matter consisting of airborne particles with a mass median diameter less than 2.5 micrometers.
PM ₁₀	Particulate Matter consisting of airborne particles with a mass median diameter less than 10 micrometers

Pozzolan	A silica-rich or silica and alumina-rich material which in itself possesses little or no cementaceous value, but which will, in finely divided form and in the presence of moisture, react chemically with calcium hydroxide to form compounds possessing cementaceous properties.
RDF	Refuse Derived Fuel is a fuel product recovered from the combustible fraction of household waste.
REOI	Request for Expressions of Interest
Rm ³	Referenced cubic metre, representing a standard volume of gaseous emission at the reference conditions specified in a jurisdiction
SCR	Selective Catalytic Reduction is a method used to reduce NO _x to N ₂ and H ₂ O through the injection of ammonia into the flue gas stream which then reacts with NO _x within a catalyst bed.
SNCR	Selective Non-Catalytic Reduction is a method to lessen nitrogen oxide emissions in conventional power plants that burn biomass, waste and coal, through the injection of ammonia into hot flue gases at a suitable temperature range to support the chemical reaction to convert NO _x to N ₂ and H ₂ O.
SO _x	Oxides of Sulphur
SRF	Solid Recovered Fuel (interchangeable with RDF) being a fuel product recovered from the combustible fraction of household waste.
SSO	Source Separated Organics
SWMP	Solid Waste Management Plan, prepared for each Regional District in BC, and including the authorization to operate a municipal solid waste landfill
Syngas	The name given to a gas mixture synthesized from waste materials that contains varying amounts of carbon monoxide and hydrogen (but may contain smaller amounts of other gases)
TCDD	2,3,7,8-Tetrachoro dibenzo-p-dioxin
TEQ basis	2,3,7,8-Tetrachoro dibenzo-p-dioxin toxic equivalent, based on the 1989 International toxic equivalency factors
TOC	Total Organic Carbon, is the amount of carbon within organic molecules (carbon chains or rings that also contain hydrogen) versus inorganic molecules (e.g., carbon monoxide, carbon dioxide, carbonates). In regards to air emissions a portion of TOC would be comprised of VOCs (see below).

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TWG	Thematic Working Group
TWh	Terawatt hours (10^{12} Watt hours)
UK	United Kingdom
US EPA	United States Environmental Protection Agency founded to protect human health and to safeguard the natural environment including air, water, and land.
VOC	Volatile Organic Compounds are organic substances of concern (carbon chains or rings that also contain hydrogen) that have high enough vapour pressures under normal conditions to significantly vapourize and enter the atmosphere (i.e., with a vapour pressure greater than 2mm of mercury (0.27 kPa) at 250°C or a boiling range of between 60 and 250°C) excluding methane.
WAG	Welsh Assembly Government
WFD	Waste Framework Directive
WHRG	Waste Heat Recovery Generator
WID	Waste Incineration Directive
WTE	Waste to Energy, also known as Energy from Waste (EFW) is the conversion of waste into a useable form of energy, e.g., heat or electricity. A common conversion process is waste combustion.

1 INTRODUCTION

The province of British Columbia is committed to sustainable environmental management including leading the world in air quality. In fact, one of the province's five Great Goals for a Golden Decade^[1] is to “*lead the world in sustainable environmental management, with the best air and water quality, and the best fisheries management, bar none*”. Through airshed management planning, industrial emission standards, and a host of local air initiatives progress is being made toward this goal for air quality.

The province has also made significant climate change commitments. The 2007 *Greenhouse Gas Reduction Targets Act* (GGRTA) sets legislative targets for immediate action toward reducing greenhouse gas emissions. The act sets a GHG emissions reduction target of 33% for 2020 and 80% for 2050, with low interim targets leading up to 2020. The province has taken a number of proactive steps toward reducing GHGs from all sectors including introducing a carbon tax and developing the framework for a cap and trade system for large emitters. These are outlined in the BC Climate Action Plan.^[2]

The BC Bioenergy Strategy^[3] supports the shift from carbon-intensive fossil fuels to biomass fuels as a practical approach to a low-carbon future. The growth in community energy projects and the establishment of municipal landfill methane gas capture systems are both initiatives that demonstrate the commitment to bioenergy in BC today. MSW represents up to 3% of the province's available biomass resources, recognizing that a portion of the municipal solid waste stream is biomass. Various measures can be used to manage the biomass portion of the MSW stream such as recycling, composting and anaerobic digestion. However, experience in other jurisdictions indicates that even with such programs, a portion of MSW would continue to be comprised of biomass.

Waste to energy facilities, which produce heat and power through thermal treatment of MSW, could be used to recover energy from MSW including the biomass fraction. Carbon pricing (established through carbon tax and/or a cap and trade program) may make a Waste to Energy project more financially favourable if the project reduces emissions compared to a business-as-usual scenario in the process of producing power. However, the province has yet to determine how GHG emissions reduction policy will apply to municipal landfills and Waste to Energy operations.

The Waste Discharge Regulation, under the BC *Environmental Management Act*, includes a definition for “municipal waste incineration or burning industry” as an activity that would be allowable in the province with appropriate waste discharge authorizations in place.^[4] To date, the Metro Vancouver Burnaby incinerator is the only sizeable WTE facility in BC. The emission limits for this facility are

¹ British Columbia Strategic Plan 2010/2011 – 2012/2013. Website: http://www.bcbudget.gov.bc.ca/2010/stplan/2010_Strategic_Plan.pdf

² BC Climate Action Plan. Website: <http://www.livesmartbc.ca/government/plan.html>

³ BC Bioenergy Strategy, BC Ministry of Energy, Mines and Petroleum Resources, 2007

⁴ BC *Environmental Management Act*. Waste Discharge Regulation. Website: http://www.bclaws.ca/Recon/document/freeside/--%20e%20--/environmental%20management%20act%20sbc%202003%20c.%2053/05_regulations/50_320_2004.xml

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contained in the 1995 Greater Vancouver Regional District Solid Waste Management Plan (SWMP).^[5] Emission criteria for municipal solid waste incinerators were produced by the province in 1991 to be used as a basis for setting SWMP or permit limits for these facilities. The emission limits for the Burnaby incinerator contained in the GVRD SWMP are consistent with these criteria.

This report provides a technical review of the leading municipal solid waste thermal treatment practices currently in use globally and a summary of the associated emission criteria and standards for those technologies. The report also reviews the management of residuals from waste to energy facilities. Finally, the report provides a set of conclusions and recommendations for the province to consider in the development of current guidelines for WTE facilities.

1.1 Project Outline

Waste to Energy, or WTE, typically involves the conversion of solid waste to energy resulting in the generation of electricity from the recovered heat, and/or the generation of hot water or steam to be used for community-based industrial, commercial or residential heating applications. WTE technology has been adopted in many jurisdictions globally and has merit for consideration in BC.

The BC Ministry of Environment (BCMOE) Environmental Protection Division has adopted an interim policy “Determining Best Achievable Technology Standards” that provides guidance on the setting of emissions criteria, standards or regulations. The intent of the policy is to promote the use of best achievable technologies (BAT) in new and existing facilities, and to set criteria and/or permit limits in accordance with BAT.

There are seven steps to determine BAT to be considered in the setting of standards and criteria for the province and for facilities. These steps include:

1. Identification of all potential technologies or options
2. Eliminating technically infeasible options
3. Consideration of the reliability of each option
4. Ranking of technically feasible options by control effectiveness
5. Consider the cost effectiveness of each option
6. Selection of the appropriate BAT for the specific application
7. Determining the appropriate waste discharge criteria or standard.

This report is intended to provide background information on items 1 through 6, and has been structured as follows:

- **Section 2** examines the thermal treatment technologies currently in use globally, and examines emerging technologies that may gain increasing market share in the future.

⁵ 1995 Greater Vancouver Regional District Solid Waste Management Plan. Website:
<http://www.metrovancouver.org/about/publications/Publications/SolidWasteManagementPlan1995.pdf>

- **Section 3** provides an overview of the potential discharges from WTE facilities, including air emission constituents and liquid and solids wastes.
- **Section 4** discusses air emission controls.
- **Section 5** discusses the expected emission rates from WTE facilities, including a summary of actual emissions from facilities operating worldwide.
- **Section 6** discusses the use of Refuse Derived Fuel (RDF), potential emissions from RDF applications and identifies a proposed regulatory approach for RDF.
- **Section 7** discusses the efficiencies and costs of thermal treatment based on available information. It also discusses the use of energy efficiency equations for differentiating between energy recovery and disposal systems under a waste management hierarchy.
- **Section 8** provides an overview of air emission monitoring systems, including continuous emission monitoring, stack sampling and ambient air quality monitoring.
- **Section 9** discusses the regulatory environment governing the WTE sector and how revisions to emissions criteria, standards and permit limits are set in BC according to Best Achievable Technology policy. International, national and regional aspects of emissions management are reviewed, with comparisons of the various objectives, criteria and standards in place across these jurisdictions. A compilation table of various emission limits has been provided to highlight the BC situation relative to other jurisdictions. This section concludes with proposed amendments to the existing BC 1991 Emission Criteria for Municipal Solid Waste Incineration.
- **Section 10** discusses residuals management, including fly ash, bottom ash, pollution control system residuals and gasification process residuals, from various global jurisdictions including the BC experience. Beneficial reuse of ash and safe disposal are discussed. For the BC situation, there is also discussion on the setting of financial security relative to environmental risk for facilities receiving fly ash.
- **Section 11** contains the recommendations to be considered by BCMOE in the setting of amended criteria and standards for the WTE sector in BC.

1.2 Project Authors

1.2.1 Stantec Consulting Ltd.

Stantec was founded in 1954 providing environmental services in Western Canada. Since then it has grown into a full service engineering firm with over 10,000 employees in 150 offices throughout North America. With specific reference to environmental remediation, Stantec has over 1,000 employees completing environmental remediation projects each day.

This capacity allows Stantec to offer our clients enhanced services and greater local presence with global reach. We provide our clients with consistent, safety conscious, high-quality services and personnel they have come to expect and rely on. These services are backed up by experts in their

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field practicing in varied disciplines and geographies bringing the knowledge of many to your project. Stantec's multidisciplinary suite of services in environmental site assessment, remediation, landfill design, landfill monitoring, environmental sciences, sustainability, and geotechnical and materials engineering complement one another, heightening our ability to serve clients throughout the project life cycle from conception to closure.

Principle authors of this report were Janine Ralph and Eric Windhorst of the Stantec, Burlington, ON office and Douglas Whitar, Magdalena Kingsley, Sarah Willie and Kelly Carswell of Stantec, Burnaby, BC. Senior review was completed by David Payne of Stantec, Burlington and Peter D. Reid of Stantec, Calgary, AB.

1.2.2 Ramboll Denmark A/S

Ramboll Group A/S of Denmark, is a consulting company which was founded in 1945. The Ramboll Group has approximately 9,000 employees and is the largest Northern European consulting group. The Ramboll Group specializes in a broad variety of consulting services with WTE as one of the key fields of expertise. Ramboll has worked in the WTE business for more than four decades and has during this period assisted in implementing more than 70 WTE facilities worldwide.

Ramboll is at present involved in more than 30 ongoing WTE projects. The projects are at various stages from project definition through to procurement and supervision during construction, commissioning and follow-up on operation and maintenance which gives an excellent hands-on knowledge of both technology systems and regulatory matters.

Ramboll is member of national and international WTE associations. As active members of the working groups under these associations Ramboll has been directly involved in the discussion with the European Union on regulatory matters.

One of Ramboll's staff is known internationally for his work on the thermal treatment of waste with the European Commission (EC), where for three years he was leader of the EC BAT expert working group of over 100 people. This group was responsible for the production of the official EC guidance on the Best Available Techniques (BAT) for the thermal treatment of wastes, the "BREF" (2006).

Ramboll staff contributing to this report included Bettina Kamuk and Soren Dalager with input from various other staff.

2 THERMAL TREATMENT PRACTICES

This section describes the technology currently available and in use globally for the thermal treatment of MSW. This section also provides information on new and emerging technologies that may not have proven track record, but should be considered in context with existing technologies.

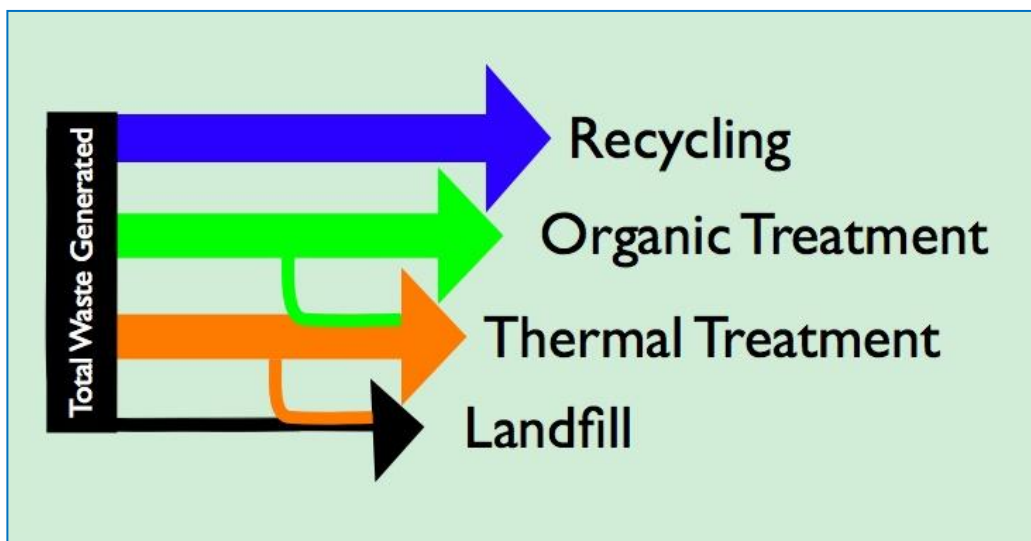
2.1 Overview of Thermal Treatment Processes

The thermal treatment of solid waste is only one part of an integrated waste management system. Thermal treatment can play a number of important roles in an integrated waste management system. Thermal treatment can:

- Reduce the volume of waste, therefore preserving landfill space (thermal treatment does not replace the need for landfills as various residuals still need disposal).
- Allow for the recovery of energy from the solid waste stream.
- Allow for the recovery of minerals and chemicals from the solid waste stream which can then be reused or recycled.
- Destroy a number of contaminants that may be present in the waste stream.
- Often, reduce the need for the “long-hauling” of waste.

In most jurisdictions, thermal treatment of waste is applied to manage the remaining waste stream after source-separated diversion of recyclables and organics. Figure 2-1 presents a schematic diagram illustrating how thermal treatment fits into a conventional waste management system that includes source-separated recycling and organics diversion components.

Figure 2-1: Schematic Overview of the Role of Thermal Treatment in Waste Management



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As noted in Figure 2-1, it is typical in many jurisdictions that WTE is used to manage the majority of post-diversion residual wastes. The diversion of recyclables and organic materials often results in an overall increase in the heat value of the remaining waste stream, rendering it suitable for potential use in WTE applications.

Table 2-1 presents an example of a typical post-recycling residual MSW stream that could be suitable for WTE in BC (Metro Vancouver), and an example of the composition of a typical post-recycling and SSO diversion residual MSW stream in a typical municipal jurisdiction with expanded diversion programs (Durham/York). The estimates for the Durham/York waste stream represent the typical residual waste composition in Ontario for a municipal jurisdiction with a mature source separated recycling and source-separated organic collection and processing system. The portion of the waste stream that is generally comprised of biomass generally does decrease following introduction of SSO programs. However, the remaining garbage should still be expected to have a reasonable proportion of biomass materials.

Table 2-1: Metro Vancouver and Durham/York Residential Post-diversion Waste Category Breakdown Suitable for WTE

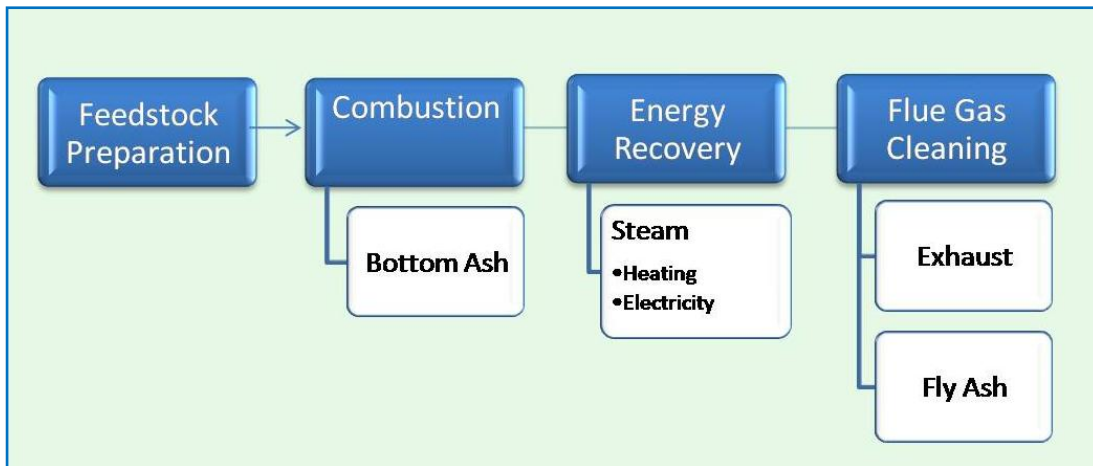
Waste Category	Metro Vancouver Residential Post-diversion (w/o Organics Diversion) (2007) % Composition ^[6]	Durham/York Residential Post-diversion (with Organics Diversion) (2011 Estimates) % Composition ^[7]
Paper	16.7%	18.1%
Plastics	10.2%	12.4%
Metals	1.5%	2.3%
Glass	4.5%	3.9%
HHW	0.4%	0.3%
Organics (food waste, grass, yard waste)	30.2%	13.6%
Animal waste	1.3%	6%
Textiles	1.1%	2.4%
Building renovations	13.3%	4% (includes wood)
Furniture/Bulky goods	3.9%	21.5%
White goods	0.01%	0%
Sanitary products	3.3%	8.7%
Electronics/appliances	2.3%	0.2%
Other	1.8%	6.5%
Wood	9.5%	Not Defined
Approximate % Biomass	60%	50%

⁶ Technology Resource Inc. 2008. SOLID WASTE COMPOSITION STUDY for Metro Vancouver (Greater Vancouver Sewerage and Drainage District)

⁷ Stantec Consulting Limited. Durham/York Environmental Assessment (EA) Study Document as Amended November 27, 2009

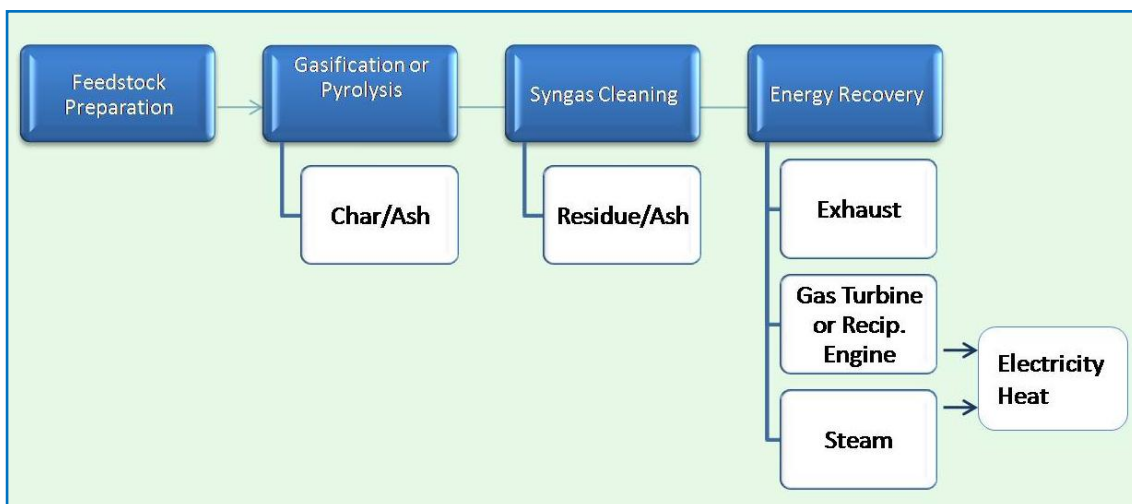
Thermal treatment covers a range of technologies that extract energy from the waste while reducing its volume and rendering the remaining fraction mostly inert. These technologies can be generally grouped into two main categories: conventional combustion and advanced thermal treatment. Conventional combustion technologies include mass burn incineration and fluidized bed incineration among others. Mass burn incineration is the most common type of WTE technology used worldwide. Figure 2-2 provides a simple flow diagram of a conventional WTE approach.

Figure 2-2: Overview of Conventional WTE



Advanced thermal treatment technologies include gasification, pyrolysis and plasma gasification. These technologies tend to be less proven on a commercial scale and involve more complex technological processes. Figure 2-3 provides a simple flow diagram of an advanced thermal treatment WTE approach.

Figure 2-3: Overview of Advanced Thermal Treatment WTE



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Thermal treatment of MSW involves the oxidation of combustible materials found within the waste. Generally speaking, there are three main stages of any thermal treatment process:

- **Drying and degassing** – here, volatile content is released at temperatures generally between 100 and 300°C. The drying and degassing process are only dependent on the supplied heat.
- **Pyrolysis and gasification** – pyrolysis is the further decomposition of organic substances in the absence of added oxygen at approximately 250 – 700°C which results in the production of syngas (a gas mixture consisting primarily of H₂ and CO), tars (high molecular mass hydrocarbons), and char. Gasification is the partial thermal degradation of organic substances in the presence of oxygen but with insufficient oxygen to oxidize the fuel completely (sub-stoichiometric conditions). Gasification occurs at temperatures, typically between 500 – 1,000°C and results in the in the formation of syngas. Overall, this stage results in the conversion of solid organic matter to the gaseous phase.
- **Oxidation** – the combustible gases (i.e., syngas) created in the previous stages are oxidized, depending on the selected thermal treatment method, at temperatures generally between 800 and 1,450°C.

Typically, these individual stages overlap but they may be separated in space and/or time depending on the particular thermal treatment process being considered.^[8]

2.2 Current and Emerging Combustion and Thermal Treatment Practices and Associated Control Technologies

This subsection reports on a literature and market review of current and emerging combustion and thermal practices and their associated emission control technologies. It concisely summarizes the state-of-the-art in thermal treatment. A brief overview of the range of technologies in the marketplace for which there are current operating facilities is provided. Also noted is the stage of development of the technology (i.e., pilot or full-scale) and the availability of supporting technical information.

2.2.1 Current Combustion and Thermal Treatment Technologies

A comprehensive literature review was conducted by Stantec with input from Ramboll, to determine candidate technologies and vendors for the treatment of residual MSW, resulting in the development of a database of over 100 vendors and technologies. The literature review retrieved reports from various government and vendor websites as well as sources held by Stantec. A number of cities and counties (i.e., City of Los Angeles, New York City, City and County of Santa Barbara, Metro Vancouver) have completed in-depth studies and reviews regarding alternative waste treatment approaches. It is important to note that much of the information that was generally available is vendor information provided through “Requests for Expressions of Interest” (REOIs) and other

⁸ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

means and therefore it has not necessarily been verified through a third party and/or verification is not readily available.

Some of the technology information has also been derived from proposals by respondents through Requests for Qualifications (RFQ) processes, Requests for Proposals (RFP) processes and studies for other municipal jurisdictions undertaken by Stantec Staff. Generally, the information derived from official procurement processes has a higher degree of veracity.

The four most prevalent WTE technologies used to treat MSW are described below, namely, conventional combustion, gasification, plasma arc gasification, and pyrolysis. Of the four technologies mentioned, conventional combustion and gasification are the most commonly used methods of converting waste into energy. A subsection on new and emerging technologies is also provided. A database of current technology vendors (current as of March 2010) is provided in Appendix A.

It should be noted that mass burn incineration (conventional combustion) is the most well established and commercially proven thermal treatment technology. There are over 800 mass burn facilities currently in operation worldwide.

2.2.1.1 Conventional Combustion

Conventional combustion is a well-established technology developed over 100 years ago for energy generation from municipal solid waste. The first attempts to dispose of solid waste using a furnace are thought to have taken place in England in the 1870s.^[9] Since that time, vast technology improvements have been made making conventional combustion the most common WTE technology currently being used to treat MSW.

The most common conventional combustion approach is called single-stage combustion or mass burn incineration (sometimes referred to as grate-fired technology). Over 90% of WTE facilities in Europe utilize mass burn incineration technology with the largest facility treating approximately 750,000 tpy.^[10] The following paragraphs discuss the mass burn combustion process. Figure 2-4 provides a conceptual overview of a modern single-stage WTE facility.^[11]

⁹ Waste Online. 2004. History of Waste and Recycling. Accessed February 22, 2010 from <http://www.wasteonline.org.uk/resources/InformationSheets/HistoryofWaste.htm>

¹⁰ Thomas Malkow. 2004. Novel and innovative pyrolysis and gasification technologies for energy efficient and environmentally sound MSW disposal. In Waste Management 24 (2004) 53-79

¹¹ Stantec Consulting Limited. 2009. Durham/York Residual Waste Study Environmental Assessment

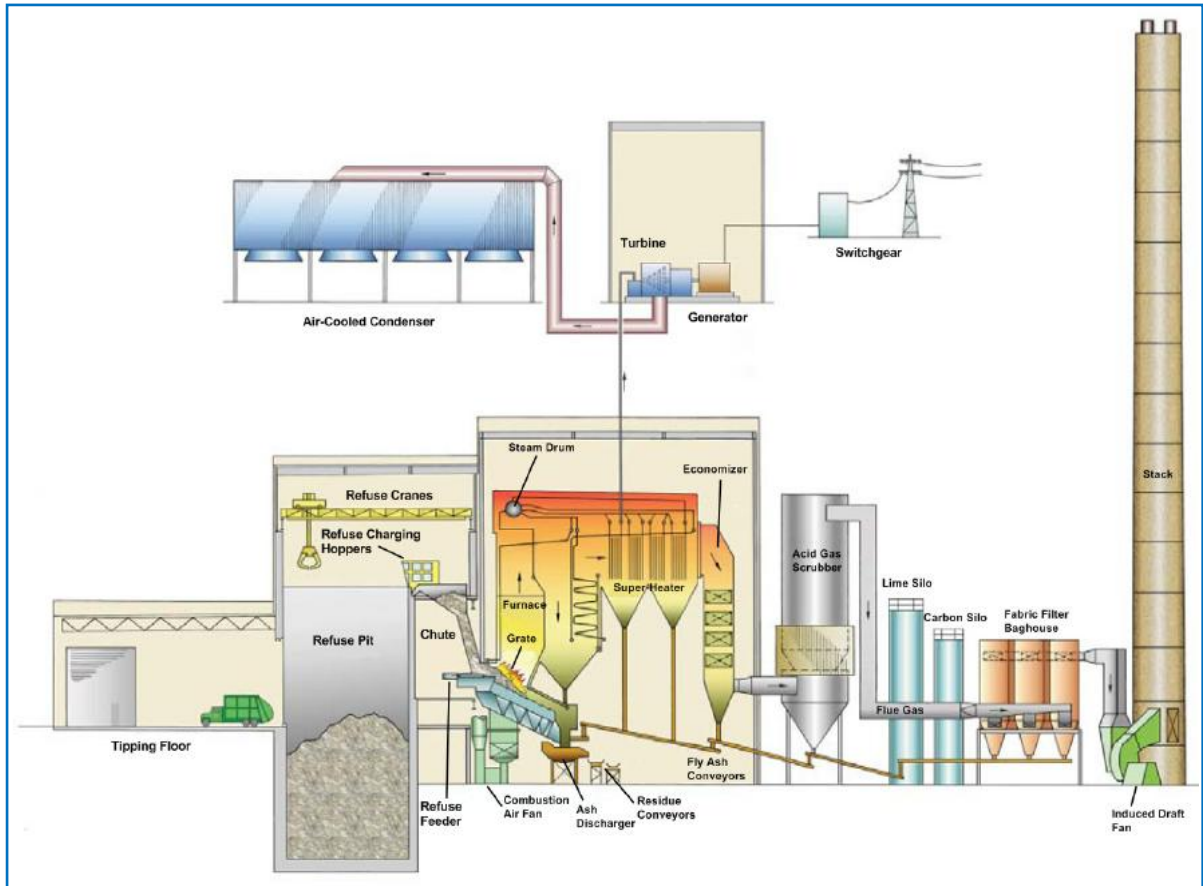
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Figure 2-4: Conceptual Overview of a Modern Single-Stage Mass Burn Incinerator



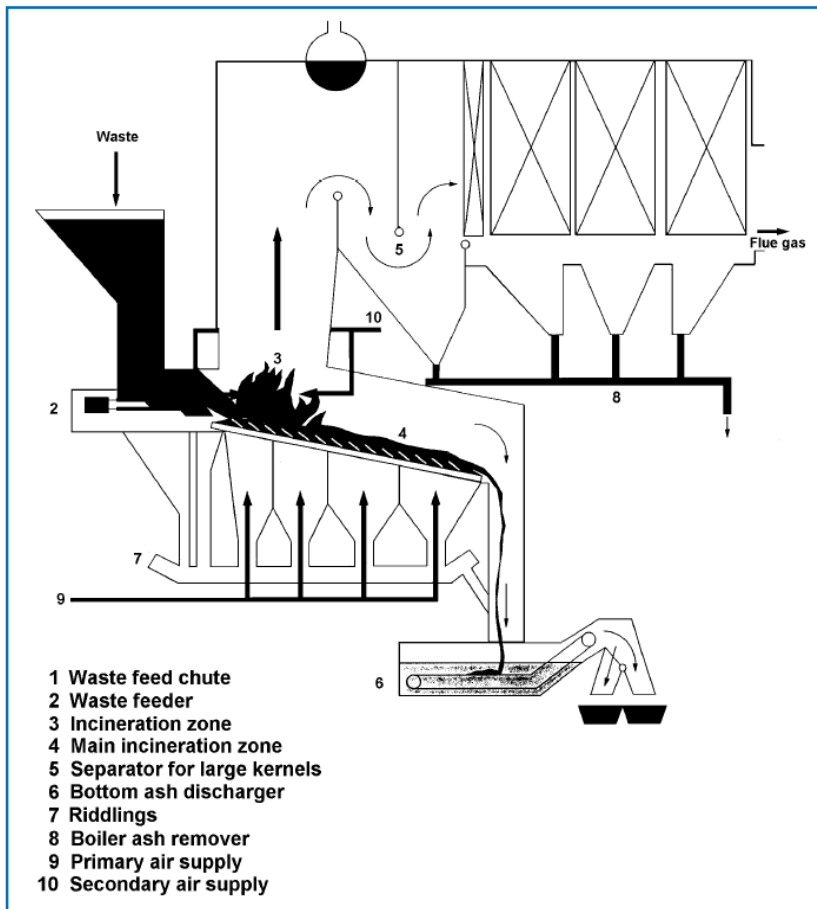
Source: Stantec Consulting Limited. 2009. Durham/York Residual Waste Study Environmental Assessment

At a mass burn facility, minimal pre-processing of MSW is required. Normally, trucks carrying refuse enter a building where they discharge their waste into a pit or bunker. From the pit, the waste is transferred into a hopper by an overhead crane. The crane is also used to remove large and non-combustible materials from the waste stream. The crane transfers the waste into a waste feed hopper which feeds the waste onto a moving grate where combustion begins.

Several stages of combustion occur in mass burn incinerators. The first step reduces the water content of the waste in preparation for burning (drying and degassing). The next step involves primary burning which oxidizes the more readily combustible material while the subsequent burning step oxidizes the fixed carbon. In single-stage combustion, waste is burned in sub-stoichiometric conditions, where sufficient oxygen is not available for complete combustion. The oxygen available is approximately 30 to 80% of the required amount for complete combustion which results in the formation of pyrolysis gases. These gases are combined with excess air and combusted in the upper

portions of the combustion chamber which allows complete oxidation to occur. Figure 2-5 shows an example of an inclined grate incinerator with a heat recovery boiler.^[12]

Figure 2-5: Example of a Grate Incinerator with a Heat Recovery Boiler



Source: German Federal Environment Agency. 2001. Draft of a German Report for the creation of a BREF-document “waste incineration”, Umweltbundesamt

Mass burn technology applications provide long residence times on the grate(s) which in turn results in good ash quality (i.e., less non-combusted carbon). Newer facilities have greatly improved energy efficiency and usually recover and export energy as either steam and/or electricity. Typical mass burn facilities have energy recovery efficiencies of 14% to 27% (assuming that the energy from combustion is being converted into electricity).^[13] Higher energy recovery efficiencies are achieved through the recovery of heat either in conjunction with or in lieu of electricity.

¹² German Federal Environment Agency. 2001. Draft of a German Report for the creation of a BREF-document “waste incineration”

¹³ AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

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Mass burn facilities can be scaled in capacity anywhere from approximately 36,500 to 365,000 tpy per operating unit.^{[14],[15]} These facilities generally consist of multiple modules or furnaces and can be expanded through addition of more units and supporting ancillary infrastructure as required. Generally it is preferred to design such facilities with multiple units allowing for individual modules to be shut down for maintenance or if there is inadequate feedstock.^[16] Multiple modules can often be accommodated on a single site with some sharing of infrastructure (e.g., share tip floor, ash management areas, stack).

The capacity of a mass burn incinerator is dependent upon the calorific value of the waste being treated. In Europe, the normal maximum size of a facility is 280,000 tpy, assuming that the waste has a calorific value of 11 MJ/kg. That said, over recent years, the trend in Europe has been to build slightly larger facilities.

Two other conventional combustion approaches are used to manage MSW, but are less common. These two other conventional approaches are modular, two stage combustion and fluidized bed combustion.

Modular, Two Stage Combustion

In modular, two-stage combustion, waste fuel is combusted in a controlled starved air environment in the first chamber. Off-gases are moved into a second chamber where they are combusted in an oxygen rich environment. The heat generated in the second stage is fed into a heat recovery boiler. Ash is generated in the first stage and is managed in a similar manner as that from moving-grate systems (mass burn incineration). Figure 2-6 provides a schematic overview of a two-stage incinerator.^[17] It should be noted that two-stage incinerators are sometimes referred to as a type of gasification technology. However, they are not true gasifiers and are therefore normally classified as a conventional combustion technology.

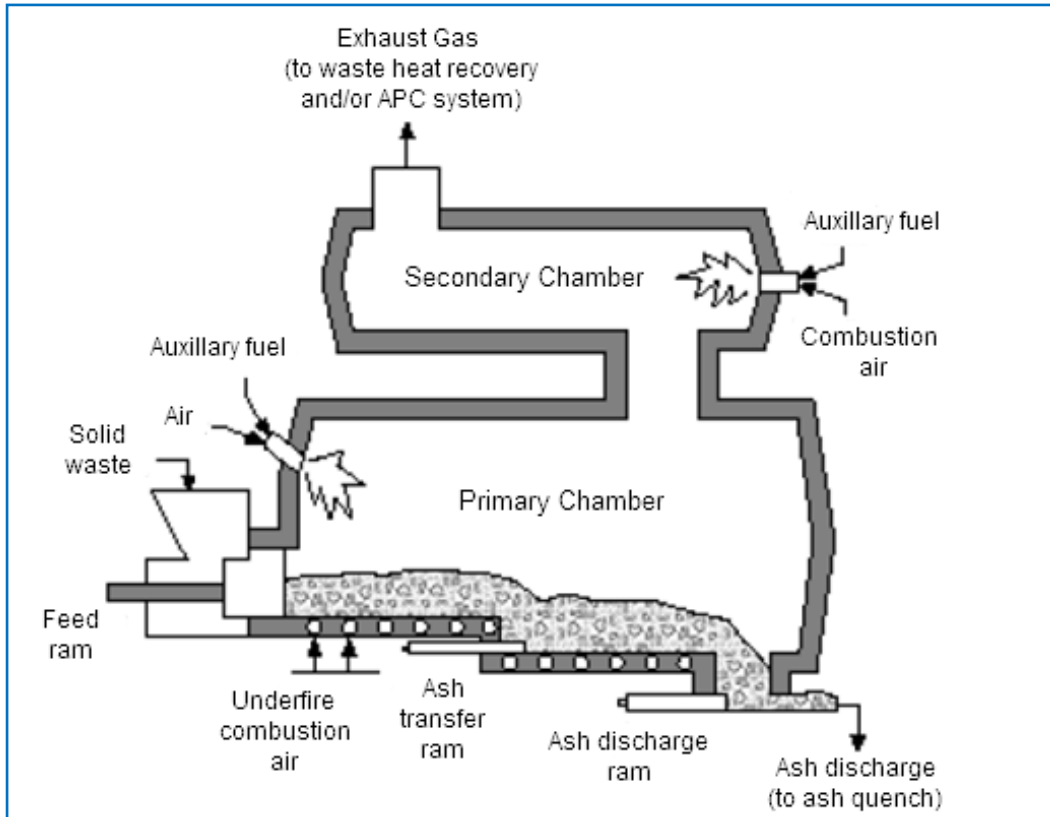
¹⁴ GENIVAR Ontario Inc. in association with Ramboll Danmark A/S, 2007. Municipal Solid Waste Thermal Treatment in Canada

¹⁵ AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

¹⁶ AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

¹⁷ A.J. Chandler and Associates Ltd. 2006. Review of Dioxins and Furans from Incineration In Support of a Canada-wide Standard Review

Figure 2-6: Schematic Overview of a Two-Stage Incinerator



Source: A.J. Chandler and Associates Ltd. 2006. Review of Dioxins and Furans from Incineration in Support of a Canada-wide Standard Review

Fluidized Bed Combustion

In fluidized bed combustion waste fuel is shredded, sorted and metals are separated in order to generate a more homogenous solid fuel. This fuel is then fed into a combustion chamber, in which there is a bed of inert material (usually sand) on a grate or distribution plate. The inert material is maintained in a fluid condition by air blowing upwards through it. Waste fuel is fed into or above the bed through ports located on the combustion chamber wall.

Drying and combustion of the fuel takes place within the fluidized bed, while combustion gases are retained in a combustion zone above the bed (the freeboard). The heat from combustion is recovered by devices located either in the bed or at the point at which combustion gases exit the chamber (or a combination of both). Surplus ash is removed at the bottom of the chamber and is generally managed in a similar fashion as bottom ash from a moving grate system (mass burn incineration). Figure 2-7 provides a schematic overview of a fluidized bed incinerator.^[18]

¹⁸ A.J. Chandler and Associates Ltd. 2006. Review of Dioxins and Furans from Incineration In Support of a Canada-wide Standard Review

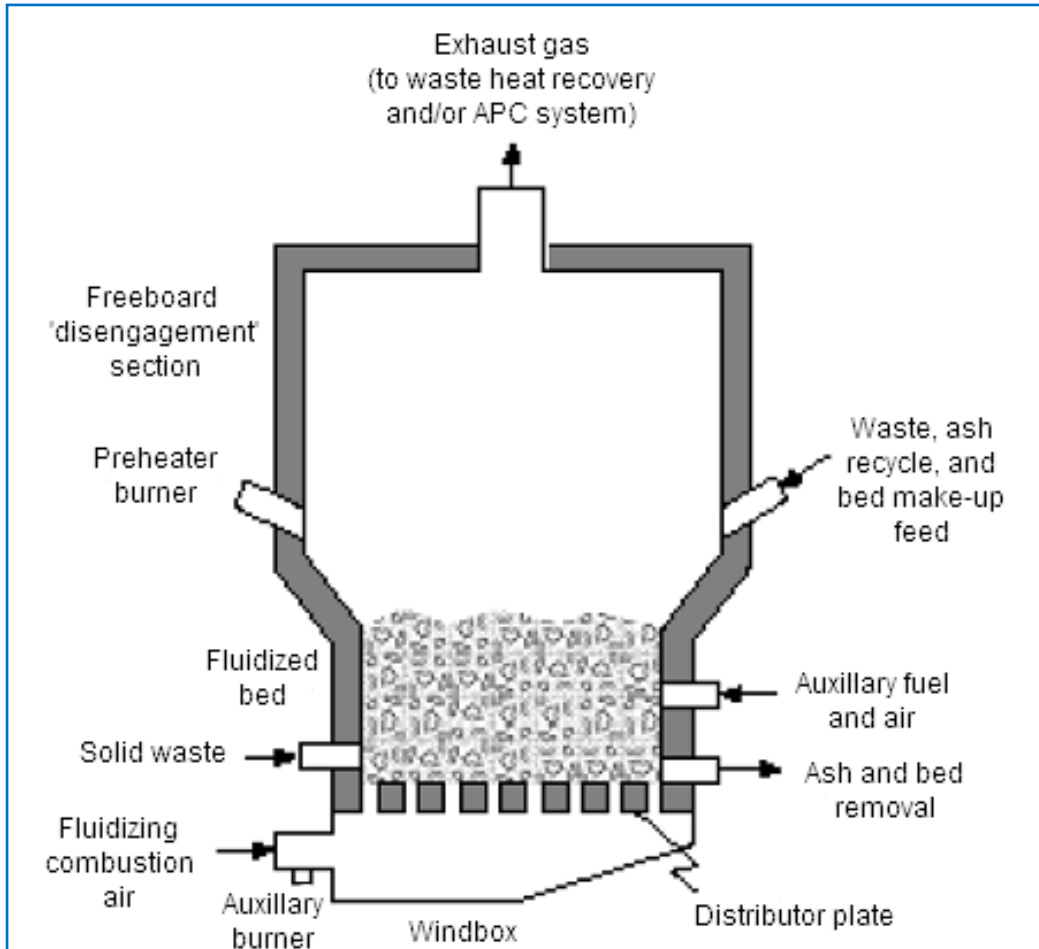
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Figure 2-7: Schematic Overview of a Fluidized Bed Incinerator



Source: A.J. Chandler and Associates Ltd. 2006. Review of Dioxins and Furans from Incineration in Support of a Canada-wide Standard Review

Both two-stage combustion and fluidized bed combustion approaches can be used to manage MSW, however, for fluidized bed applications the waste must be processed into a more homogenous feed. Both processes generally are more complex than single-stage mass burn incineration. For that reason, generally when considering conventional combustion systems in planning processes, single stage combustion systems are usually assumed.

Of the approximately 450 WTE facilities in Europe, 30 of them utilize fluidized bed technology. Most of these use a feed stock mixture of MSW, sewage sludge, industrial waste, pre-sorted organic waste, Refuse Derived Fuel (RDF) or woodchips. Very few facilities are using only MSW as feed stock because of the availability of supplemental fuels. One of the disadvantages of the fluidized bed systems is that a larger portion of fly ash is generated by the fluidized bed process (6% compared to 2% for mass burn systems) due to the particulate present in the fluidized bed itself.

Batch Combustion

In addition to mass burn, two stage and fluidized bed incineration, there are other incinerators referred to as batch waste incinerators that are capable of treating a variety of wastes including MSW. Batch waste incinerators are those that operate in a non-continuous manner (i.e., they are charged with waste prior to the initiation of the burn cycle, and the door remains closed until the ash has cooled inside the primary chamber). Batch waste incinerators tend to treat smaller amounts of waste than other conventional approaches (they are usually sized between 50 and 3,000 kg per batch) and are typically utilized in remote locations where landfill alternatives and/or wildlife concerns associated with landfills are present.

Batch waste incinerators normally utilize dual chamber controlled air technology (alike to two stage combustion but more simple). In batch incinerators, waste (which is normally pre-mixed) is charged into the primary chamber by the operator. The initial heat required to ignite the waste is supplied by a burner which shuts off once combustion becomes self-sustaining. Controlled amounts of underfire air are introduced through holes in the primary chamber and as combustion gases are created they move to the secondary chamber where combustion is completed with the air of additional over-fire air or a secondary burner.

Batch waste incinerators do not typically utilize heat recovery or air pollution control equipment but are still capable of meeting stringent emissions limits (e.g., Ontario Guideline A-7) if they are designed and operated in a proper manner.^[19]

Summary of Conventional Combustion Approaches

Conventional combustion incineration facilities that treat MSW produce unwanted emissions to air during the combustion of waste materials. Over the years, the amount of harmful byproducts produced has been greatly reduced due to the increased sophistication of the combustion and operational controls for such facilities. Emissions that are produced during combustion are reduced using Air Pollution Control (APC) systems which remove unwanted contaminants such as trace metals and various acid gases from the flue gas produced. Generally speaking there are three main types of APC systems used at conventional combustion facilities that treat MSW, namely Dry, Wet-Dry, and Wet systems. The specific aspects of these APC systems are discussed further in Section 4.2.2.

In Canada there are currently seven operational conventional combustion incinerators that treat MSW (greater than 25 tpd). These seven facilities are located in British Columbia (1), Alberta (1), Ontario (1), Quebec (3), and PEI (1).

Of these seven facilities, two are larger mass burn incinerators (L'incinérateur de la Ville de Québec, Quebec and Greater Vancouver Regional District Waste to Energy Facility, British Columbia), one is a smaller mass burn incinerator (MRC des Iles de la Madeleine, Quebec), two are defined as two-stage starved air modular incinerators (PEI Energy Systems EFW Facility, PEI and Algonquin Power Peel Energy-From-Waste Facility, Ontario), and one is defined as a three-stage incinerator (Wainwright Energy from Waste Facility, Alberta).

¹⁹ Environment Canada. 2010. Technical Document for Batch Waste Incineration

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Table 2-2 provides an overview of each of these facilities.^[20]

Table 2-2: Overview of Conventional Combustion Facilities in Canada that Treat MSW

Facility Name	Thermal Treatment Units	Number of Units	Approved/ Licensed Capacity (tpd)	Air Pollution Control System
Metro Vancouver Waste to Energy Facility (1988 start-up)	Mass-burn – Martin grates	3 x 240 tonnes per day	720 (approx. 273,318 tpy)	Selective non-catalytic reduction – NH ₄ injection, spray humidifier, dry lime injection, carbon injection and fabric filter
L'incinérateur de la Ville de Québec	Mass-burn – Von Roll grates	4 x 230 tonnes per day	920 (approx. 293,300 tpy)	Spray humidifier, dry lime injection, powdered activated carbon addition, fabric filter, electrostatic precipitator
L'incinérateur de la Ville de Lévis	Primary combustion chamber with afterburner	1 x 80 tonnes per day	80 (approx. 24,768 tpy)	Spray humidifier, dry lime injection, powdered activated carbon addition, fabric filter
MRC des Îles de la Madeleine	Mass-burn – step grate	1 x 31 tonnes per day	31 (approx. 4,500 tpy)	Spray humidifier, dry lime injection, fabric filter
Algonquin Power Peel Energy-From-Waste Facility, Brampton, ON (1992 start-up)	2-stage modular Consumat units	5 x 91 tonnes per day – 5th line added in 2002	455 (permitted to operate at 118% of rated capacity) (approx. 147,700 tpy)	Spray humidifier, selective catalytic reduction, dry lime injection, powdered activated carbon addition, fabric filter
PEI Energy Systems EFW Facility, Charlottetown PEI	2-stage Starved Air Modular Consumat CS-1600 units	3x 33 tonnes per day	99 (approx. 25,623 tpy)	Spray humidifier, dry lime injection, powdered activated carbon addition, fabric filter
Wainwright Energy From Waste Facility	3-stage Starved Air Modular System	1 x 29 tonnes per day	27 (approx. 3,681 tpy)	Dry lime injection, powdered activated carbon addition, fabric filter

There are also several mass burn incineration facilities currently in the planning or development stages. One such facility is being proposed to be built by the Regions of Durham and York in Ontario. Currently, the facility is in the planning stages and awaiting Environmental Assessment approval from the Ontario Ministry of the Environment. The proposed mass burn incineration facility will be sized initially to treat 140,000 tpy (436 tpd), however the facility design will allow for future expansion up to 400,000 tpy (1290 tpd). The vendor supplying the technology for this proposed facility is Covanta.^[21]

²⁰ GENIVAR Ontario Inc. in association with Ramboll Danmark A/S, 2007. Municipal Solid Waste Thermal Treatment in Canada

²¹ Stantec Consulting Limited. 2009. Durham/York Residual Waste Study Environmental Assessment

Conventional combustion (specifically mass burn) technology is well established, with a number of established vendors that supply some or all components of the technology. Based on a recent review, over 20 vendors worldwide were found to provide some components (grate systems, boilers) or provide services for the overall Design, Build and Operation (DBO) of conventional combustion facilities.

In Europe, the four main suppliers of grates and potentially other components of mass burn incineration technology are:

- Babcock & Wilcox Vølund (Denmark)
- Fisia Babcock Environment GmbH (Germany)
- Martin GmbH (Germany)
- Von Roll Inova (Switzerland).

The same four suppliers are the primary suppliers of grates in North America as well as in Asia. In Asia, Keppel Seghers have also supplied several grate fired plants.

The majority of new WTE facilities are based on mass burn systems and the order books from the four major suppliers of the grate systems show more than 100 new lines are planned in the period from 2000 – 2011. Recent projections developed by the European Confederation of Waste to Energy Plants (CEWEP) show that for Europe, it is projected that over 470 plants (with a combined capacity of 80 million tpy) will be in operation by the end of 2011 and 550 plants (with a combined capacity of 97 million tpy) will be in operation by 2016. Currently, there are 450 conventional combustion facilities (420 mass burn, 30 fluidized bed) in operation in Europe.

Table 2-3 provides a summary of conventional combustion processes, costs, scalability and reliability.

Table 2-3: Conventional Combustion – Summary of Information

Conventional Combustion Summary
Traditional mass burn incineration is a well-established technology developed over 100 years ago for energy generation from municipal solid waste.
There are hundreds of plants in operation, including approximately 450 in Europe (420 mass burn, 30 fluidized bed), 87 in the United States and over 400 in Asia. There are seven conventional combustion facilities in Canada.
Conventional combustion facilities have reasonably good energy efficiency (up to 30% for electricity only and 60% or more for combined heat and power or just heat recovery systems) and usually export their energy as either steam and/or electricity.
The largest facility in Canada is a mass burn facility, processing approximately 300,000 tpy of waste. (Quebec City). There are several mass burn facilities in Europe that treat over 300,000 tpy.
At least 20 companies offer mass burn incineration technology or components of this technology, or services to develop such facilities in North America and elsewhere. There are four primary suppliers of the combustion (grate) systems active in the EU and North America.

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Conventional Combustion Summary	
Other Summary Points	
Median Reported Capital Cost	▪ \$775/annual design tonne +/- 50% (2009\$ CDN)
Median Reported Operating Cost	▪ \$65/tonne +/- 30% (2009\$ CDN)
Feedstock	▪ MSW, biomass ▪ Minimal waste preparation/pre-processing required by technology ▪ Designed to process variable waste streams
Residual to Disposal	▪ 5% (by weight) if the majority of bottom ash can be marketed for other applications ▪ Up to 20 to 25% by weight if there is no market for recovered materials from the ash (0.2 to 0.25 tonnes per input tonne) ▪ Landfill capacity consumption reduced by 90 to 95%
Potential Energy and Revenue Streams	▪ Revenue potential for: electricity, heat (steam and/or hot water), recovered recyclable metals, construction aggregate ▪ Electricity production, 0.5 to 0.6 MWh/annual tonne of MSW for older facilities ^[22] ▪ Electricity production rates of between 0.75 to 0.85 MWh/annual tonne for newer facilities
Scalability	▪ Various sizes of mass burn units; use of multiple units also possible
Reliability	▪ Numerous facilities operating worldwide with proven operational success. ▪ Less complex than other WTE approaches ▪ Scheduled and unscheduled downtime reported as <10%. ^[23]

2.2.1.2 Gasification of MSW

Gasification is the heating of organic waste (MSW) to produce a burnable gas (syngas) which is composed of a mix of primarily H₂ and CO along with smaller amounts of CH₄, N₂, H₂O and CO₂. The syngas produced can then be used off-site or on-site in a second thermal combustion stage to generate heat and/or electricity. Gasifiers are primarily designed to produce usable syngas.

There are three primary types of gasification technologies that can be used to treat waste materials, namely fixed bed, fluidized bed and high temperature gasification. Of the three types of gasification technologies, the high temperature method is the most widely employed on a commercial scale. The waste passes through a degassing duct in which the waste is heated to reduce the water content of the waste (drying and degassing) and is then fed into a gasification chamber/reactor where it is heated under suitable conditions to convert the solid fuel to syngas. Oxygen is injected into the reactor so that temperatures of over 2,000°C are reached. The amount of oxygen required is just

²² Juniper Consultancy Services. 2007. a) and b), Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW

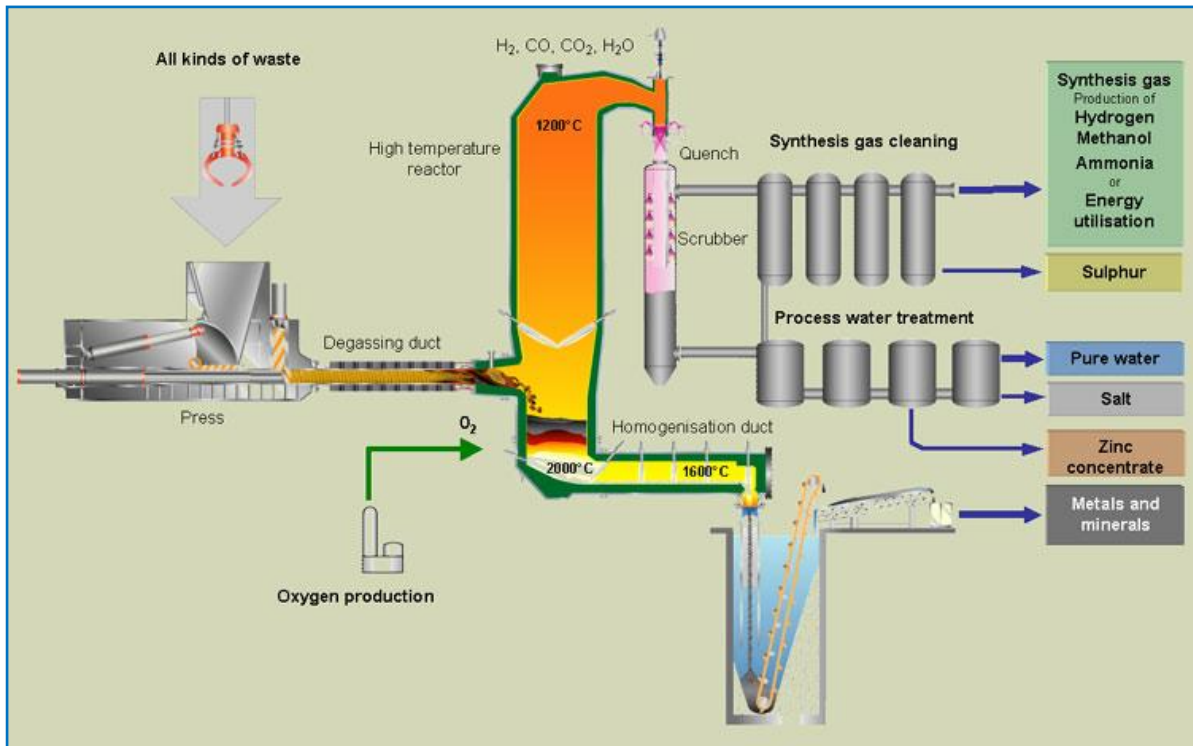
²³ AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

enough to maintain the heat that is necessary for the process to proceed. The high temperature causes organic material in the MSW to dissociate into syngas. The syngas is processed to remove water vapour and other trace contaminants, so that it can be used for power generation, heating or as a chemical feedstock.

The Thermoselect technology (which is licensed to JFE Environmental Solutions Corp. of Japan and Interstate Waste Solutions of the United States) is one gasification technology used to treat MSW. As of 2009, there were six plants operating in Japan which utilize the Thermoselect technology to treat MSW.^[24]

Figure 2-8 provides a conceptual overview of a high temperature waste gasification process used to treat MSW, based on the Thermoselect process.

Figure 2-8: Conceptual Overview of a High Temperature Waste Gasifier^[25]



Source: Thermoselect. 2003. Thermoselect – High Temperature Recycling. Accessed February 3, 2010.
<http://www.thermoselect.com/index.cfm?fuseaction=Verfahrensuebersicht&m=2>

²⁴ University of California. 2009. Evaluation of Emissions from Thermal Conversion Technologies Processing Municipal Solid Waste and Biomass

²⁵ Thermoselect. 2003. Thermoselect – High Temperature Recycling. Accessed February 3, 2010
<http://www.thermoselect.com/index.cfm?fuseaction=Verfahrensuebersicht&m=2>

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The following paragraph briefly illustrates the fixed bed updraft high temperature gasification process used by Nippon Steel in Japan. According to Juniper Consultancy Services, the technology utilized by Nippon Steel is the most proven waste gasification technology even though it is not well known outside of Japan.^[26] As of 2009, Nippon Steel was operating 28 facilities that utilized MSW as a feedstock.^[27]

Nippon Steel employs a high temperature gasification system, which they call a “Direct Melting System” (DMS). The process produces a ‘synthetic gas’ (syngas) that is combusted in a steam boiler, driving a steam turbine to produce electricity. The heating process begins by feeding waste into a gasification chamber/reactor. The high temperature causes organic material in the MSW to dissociate into syngas. The syngas is transferred to a combustion chamber which heats a boiler which in turn powers a turbine and produces electricity. The flue gas produced via combustion is then cleaned using a bag filter and an SCR (to reduce NO_x) before it is released into the atmosphere. The Air Pollution Control system is similar to that used for conventional combustion with the exception that no provisions for the control of acid gases have been identified in the information that is available. The ash management system is also similar to that required for conventional combustion. This system does have similarities to modular, two-stage combustion.

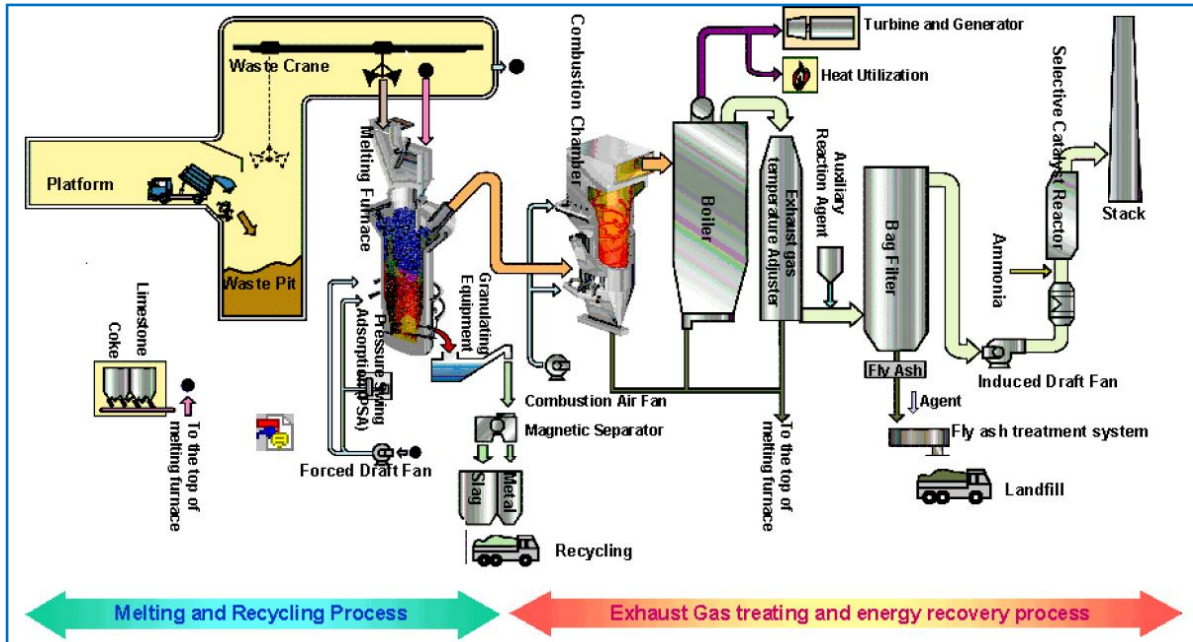
Figure 2-9 provides a conceptual overview of the high temperature waste gasification process employed by Nippon Steel.^[28]

²⁶ Juniper Consultancy Services Inc. 2009. Nippon Steel Gasification Process Review. Accessed February 22, 2010 from http://www.juniper.co.uk/Publications/Nippon_steel.html

²⁷ University of California. 2009. Evaluation of Emissions from Thermal Conversion Technologies Processing Municipal Solid Waste and Biomass

²⁸ Dvirka and Bartilucci Consulting Engineers. 2007. Waste Conversion Technologies: Emergence of a New Option or the Same Old Story? Presented at: Federation of New York Solid Waste Associations Solid Waste and Recycling Conference

Figure 2-9: Conceptual Overview of a High Temperature Waste Gasifier (Nippon Steel)



Source: Dvirka and Bartilucci Consulting Engineers. 2007. Waste Conversion Technologies: Emergence of a New Option or the Same Old Story? Presented at: Federation of New York Solid Waste Associations Solid Waste and Recycling Conference

Ramboll recently visited a gasification facility in China supplied by Kawasaki Steel Thermoselect System (now JFE Engineering after the fusion of Kawasaki, Nippon Steel and JFE).

Information obtained during the facility visit includes the following:

- The plant has been in operation since 2000.
- Designed with two lines, 2 x 15 t/h (actual capacity 250 – 260 tpd or between 159,000 tpy and 171,000 tpy based on actual plant availability).
- APC system includes the cleaning of syngas by water and catalyst before usage at the steel work. Production of sulphur.
- Received waste: 50% industrial waste (80% plastic and 20% wood/paper), 50 % pre-sorted plastic.
- The gate fee (tipping fee) is approximately \$365 US\$/tonne for industrial waste, and \$545 US\$/tonne for plastic.
- Input material is shredded to 5 – 15 cm.
- The facility used MSW feedstock for only the first 6 months, and now uses only more homogenous separated (pre-sorted) industrial waste and plastic as noted above.
- Residues: Bottom ash is cooled by water and vitrified, Iron is removed.
- Energy balance: produces 10 – 11,000 Nm³/h with calorific value 2,000 – 2,200 kcal/Nm³.

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- The facility appears to consume more energy than it produces, with a net energy output of approximately -3%.
- Plant availability: 5,300-5,700 hours/year (approximately 65%). Scheduled and unscheduled downtime was required due to change of refractory, leakages in the gasifier.

JFE indicated in the site tour that they did not intend to build any further gasifiers with the Thermoselect technology in Japan.

Outside of Japan, gasification is only used at a few facilities to treat MSW. This is primarily due to operational issues that arise due to the heterogeneous nature of MSW as the gasification process generally requires a fairly homogenous feedstock. In addition, gasification tends to have much higher range of operating and capital costs in comparison with conventional combustion facilities, given the requirement for waste pre-processing and the added complexity of the technology. Gasification also tends to have higher net costs, given that generally less energy (and thus less revenue) is recovered from the waste stream. ^[29]

In Europe, there are currently no commercially operating gasification facilities that treat MSW as the technology is considered too expensive and unproven. The only larger scale commercial gasifier using MSW as feedstock was a Thermoselect gasification plant that was operated in Karlsruhe, Germany for a few years, but it was shut down in 2004 due to technical and financial difficulties. ^[30] There are several (6 – 7) new gasification facilities operating at a commercial scale in Japan which have been constructed within the past 10 years. The use of gasification in Japan is partly driven by the regulatory environment which favours high temperature treatment (slagging) of the bottom ash/char due to the presence of low levels of dioxins. The Japanese regulatory approach is somewhat different from other jurisdictions as it regulates net dioxin emissions to the environment from all sources (air, waste water, ash). Such an approach has not been applied in other jurisdictions for WTE (e.g., the EU) as other regulatory approaches related to ash and effluent management have been used to minimize health and environmental impacts as discussed in later sections of this report.

Gasification facilities require APC systems to reduce unwanted emissions to air, although the APC approach will vary based on how the syngas is processed as discussed below. Gasification systems and mass burn systems are not directly comparable as the point in the process where combustion takes place differs, as does the APC approach. Although, gasification systems generally appear to have (or report to have) somewhat lower stack emissions than mass burn WTE plants, these results are based on testing from pilot-scale facilities, not actual commercial-scale operations. ^[31] Stack emissions test results from the Japanese facilities discussed above were not available when this report was being completed.

There are two key differences between APC systems for gasification systems and conventional mass burn combustion: first, some gasification approaches focus on cleaning of the syngas prior to

²⁹ Fichtner Consulting Engineers. 2004. The Viability of Advanced Thermal Treatment of MSW in the UK. Published by ESTET, London

³⁰ AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

³¹ RPS-MCOS Ltd. 2005. Feasibility Study of Thermal Waste Treatment/Recovery Options in the Limerick/Clare/Kerry Region

combustion, so that emissions control is based on the control of syngas quality; second, based on the composition of the syngas, it may be directly combusted and have some form of more conventional APC system, however these systems may be sized smaller and/or may not require certain APC components that would normally be necessary for a conventional approach. Table 2-4 provides a summary of gasification processes, costs, scalability and reliability.

It should be noted that the available costing information for gasification technologies is generally provided through informal processes and not on the basis of any contractual commitments to the parties involved. Therefore, it is not clear that reported capital costs address all capital and construction cost elements, nor is it clear that reported operating costs address all real costs associated with such facilities. The cost for each facility will vary on a site-by-site basis.

Table 2-4: Gasification – Summary of Information

Gasification Summary	
Gasification combusts fuel to create syngas.	
The technology has been in use for over a century, but only recently has MSW been used as a feedstock.	
At least 42 companies offer gasification technologies or components of this technology that are capable (or claim to be capable) of treating mixed MSW in North America and elsewhere.	
The earliest example of this technology being used for MSW was in 1991 in Taiwan.	
Other Summary Points	
Median Reported Capital Cost	<ul style="list-style-type: none"> ▪ \$850/annual design tonne +/- 40% (2009\$ CDN)
Median Reported Operating Cost	<ul style="list-style-type: none"> ▪ \$65/tonne +/- 45% (2009\$ CDN) (this reported cost by vendors seems well below the range of expected operating costs based on performance of gasification in the EU and Japan)
Feedstock	<ul style="list-style-type: none"> ▪ Automobile shredder residue (ASR), biomass, black liquor, coal, hospital waste, MSW, organic waste streams, plastics, PVC, refinery residues, sludge, tires ▪ Waste preparation/pre-processing required by technology ▪ Difficulties in accepting variable (heterogeneous) waste streams
Residual to Disposal	<ul style="list-style-type: none"> ▪ <1 % if bottom ash can be marketed for other applications ▪ 10 to 20% if it is not marketable (0.1 to 0.2 tonnes of residue per 1 tonne of input waste)^[32] ▪ Landfill capacity consumption reduced by 90 to 95%
Potential Energy and Revenue Streams	<ul style="list-style-type: none"> ▪ Revenue potential for: electricity, syngas, aggregate recovered from ash ▪ Electricity production, 0.4 to 0.8 MWh/annual tonne of MSW^[33]
Scalability	<ul style="list-style-type: none"> ▪ Usually built with a fixed capacity; modular ▪ Individual modules range in size from approximately 40,000 to 100,000 tpy^[34]

³² Juniper, 2007 a) and b), Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW

³³ Juniper, 2007 a) and b), Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW

³⁴ AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

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Gasification Summary

Reliability	<ul style="list-style-type: none">▪ At least seven plants in operation in Japan at a large scale with over two years of operating experience^[35].▪ Limited data available in other jurisdictions to assess operational success with MSW feedstock in regards to technical reliability▪ Complex operation▪ Scheduled and unscheduled downtime reported as approximately 20%^[36], However other reports indicate potential for up to 45% downtime.
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2.2.1.3 Plasma Arc Gasification

Plasma arc gasification uses an electric current that passes through a gas (air) to create plasma which gasifies waste into simple molecules. Plasma is a collection of free-moving electrons and ions that is formed by applying a large voltage across a gas volume at reduced or atmospheric pressure. The high voltage and a low gas pressure, causes electrons in the gas molecules to break away and flow towards the positive side of the applied voltage. When losing one or more electrons, the gas molecules become positively charged ions that transport an electric current and generate heat.

When plasma gas passes over waste, it causes rapid decomposition of the waste into syngas. The extreme heat causes the inorganic portion of the waste to become a liquefied slag. The slag is cooled and forms a vitrified solid upon exiting the reaction chamber. This substance is a potentially inert glassy solid. The syngas is generally combusted in a second stage in order to produce heat and electricity for use by local markets. In some cases, alternative use of the syngas as an input to industrial processes has been proposed.

Currently, plasma arc gasification is not commercially proven to treat MSW. The primary reason appears to be the high capital and operational costs for such facilities. The wear on the plasma chamber is very high and to keep the process operating redundant plasma chambers are needed.

Plasma technology for MSW management has been discussed in Europe since the late 1980s but full scale facilities for MSW have not yet been implemented. At some Japanese facilities, a back-end plasma component has been added to vitrify the bottom ash produced from conventional mass burn combustion facilities. Ramboll recently visited the plant in Shinminto, Japan, where MSW combustion is undertaken by a traditional grate fired WTE facility with a back-end ash melter. The downstream ash melter is operated by JFE and consists of two, 36 tonne per day units. Melting of the ash is undertaken by a plasma arc, operating at approximately 2,000 degrees centigrade. The melted ash is water quenched. The total amount of vitrified residues represents 50% by weight of the incoming ash. Approximately 1/3 of the material is used for construction purposes and the other 2/3 is used as landfill cover. The process consumes significant energy, generally producing net energy of only

³⁵ AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

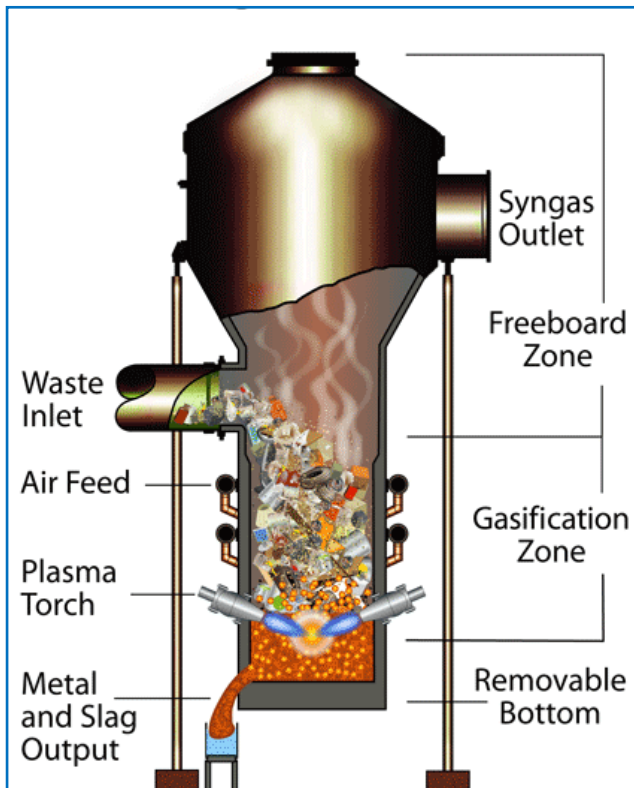
³⁶ AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

100 kW per tonne of incoming ash, due to the limited fraction of remaining carbon left in the ash which limits the production of any syngas and thus limits energy production. Note: most ash management processes are net consumers of energy. Plasma chambers in operation in Japan experience a three-month cycle where the chamber has to be taken out of operation for repair every three months mainly to change the refractory lining.

There are no large scale commercial plants in operation in North America or Europe but there are a number of plasma arc systems that are being tested or proposed to treat MSW. Two technologies which are currently being tested in Canada are the Alter NRG process and the Plasco process. Both are discussed further below.

In the Alter NRG process, a plasma torch heats the feedstock to high temperatures in the presence of controlled amounts of steam, air and oxygen. The waste reacts with these constituents to produce syngas and slag. Figure 2-10 provides a conceptual overview of the Alter NRG plasma gasification process.^[37]

Figure 2-10: Conceptual Overview of Alter NRG Plasma Gasification Unit



Source: Westinghouse Plasma Corporation. 2007. Westinghouse Plasma Corp. – Technology and Solutions – PGVR. Accessed February 3, 2010. http://www.westinghouse-plasma.com/technology_solutions/pgvr.php

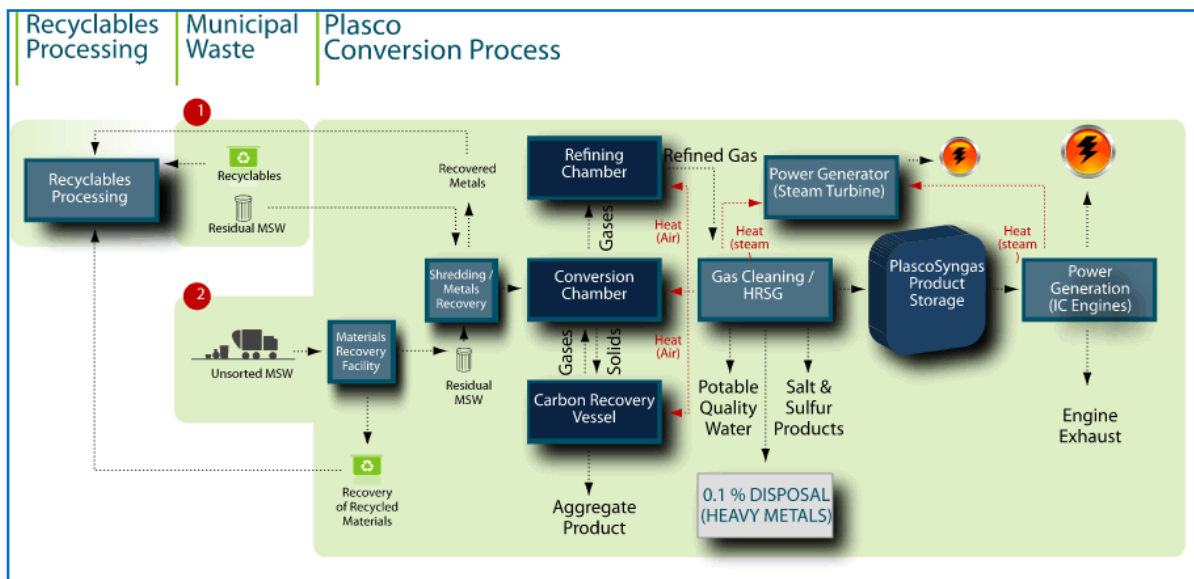
³⁷ Westinghouse Plasma Corporation. 2007. Westinghouse Plasma Corp. – Technology and Solutions – PGVR. Accessed February 3, 2010. http://www.westinghouse-plasma.com/technology_solutions/pgvr.php

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Plasco Energy Corp. (Plasco) has also developed a plasma arc gasification technology capable of treating MSW. Figure 2-11 presents a conceptual overview of the Plasco process.^[38]

Figure 2-11: Conceptual Overview of the Plasco Process



NOTE:

HRSG stands for heat recovery steam generator

Source: Plasco Energy Group. Accessed February 22, 2010

http://www.plascoenergygroup.com/images/Plasco_conversion_process_big.gif

In April 2006 Plasco entered into an agreement with the City of Ottawa to develop a demonstration facility on City-owned property next to the City's Trail Road Landfill. Construction began in June 2007, and the first waste was received at the facility in January 2008. The plant is permitted to process 85 tonnes per day of solid waste provided by the City using Plasco's conversion technology, and Plasco claims that the process would produce 1,150 kWh of power per tonne of waste when fully operational.

In the first year of operations (2008), the plant processed approximately 2,000 tonnes of MSW (6% of the permitted annual quantity of MSW), operating for 890 hours^[39] or approximately 37 days (10% plant availability). Commissioning has indicated the need for improvements to the front end of the plant, including pre-processing of the curbside MSW to ensure that the waste received is suitable for the conversion chamber. The 2009 operating report for the Ottawa plant was not available as of the end of March 2010. The demonstration plant is currently permitted to operate until January 21, 2011. Final documentation for the demonstration plant will include stack test emissions results that are not yet available.

³⁸ Plasco Energy Group. Accessed February 22, 2010. http://www.plascoenergygroup.com/images/Plasco_conversion_process_big.gif

³⁹ Plasco Energy Group. 2010. *Environmental Performance*. Accessed February 10, 2010
http://www.plascoenergygroup.com/?Environmental_Performance

In the Plasco process, the syngas produced in the primary conversion chamber is refined and cleaned. No emissions to air are generated during the creation of Syngas from MSW. The emissions to air from the process are associated with the combustion of the Syngas in gas engines to produce electricity. These emissions must meet requirements in the operating permit that are more stringent than those set out in Ontario guidelines for PM, Organic matter, HCl, NO_x, mercury, cadmium, lead and dioxins/furans.

Table 2-5 provides a summary of the plasma arc gasification process, costs, scalability and reliability.

Table 2-5: Plasma Arc Gasification – Summary of Information

Plasma Arc Gasification Summary	
Plasma gasification uses an electric current that passes through a gas to create plasma.	
Plasma arc is not a new technology; it has industrial applications and has been used for treating hazardous waste.	
The earliest facility found to use plasma arc gasification was a test facility which operated from 1987 – 1988.	
The largest facility currently operating in the world is located in Japan (Eco-Valley Utashinai Plant) and processes over 90,000 tpy of MSW and automobile shredder residue (ASR).	
24 companies supplying Plasma Arc gasification technologies and/or services have been identified that indicate use of MSW as a portion of their feedstock.	
Other Summary Points	
Median Reported Capital Cost	<ul style="list-style-type: none"> \$1,300/annual design tonne +/- 40% (2009\$ CDN)
Median Reported Operating Cost	<ul style="list-style-type: none"> \$120/tonne +/- 50% (2009\$ CDN)
Feedstock	<ul style="list-style-type: none"> MSW, ASR, hazardous waste, hospital waste, organic waste streams, shipboard waste, tires Waste preparation/pre-processing required by technology Difficulties in accepting variable waste streams
Residual to Disposal	<ul style="list-style-type: none"> Estimated at >1 to 10% (0.1 tonne of residue per 1 tonne of input waste), varying due to the nature of the waste and efficiency of the conversion process.^[40] Inert Slag, APC residue Landfill capacity consumption reduced by up to 99%
Potential Energy and Revenue Streams	<ul style="list-style-type: none"> Revenue potential for: electricity, syngas, aggregate substitute Electricity production, 0.3 to 0.6 MWh/annual tonne of MSW^[41] NOTE: Plasma arc facilities tend to consume more energy to operate than other types of facilities
Scalability	<ul style="list-style-type: none"> Modular facilities; multiple modules can be accommodated on a single site with some sharing of infrastructure.

⁴⁰ Juniper, 2007 a) and b), Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW

⁴¹ Juniper, 2007 a) and b), Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW

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Plasma Arc Gasification Summary

Reliability	<ul style="list-style-type: none">▪ Limited data available to assess operational success with MSW feedstock in regards to technical reliability▪ Eco-Valley Utashinai Plant, Japan processes over 90,000 tpy of material but feedstock is not 100% MSW▪ Only two plants (Japan) with 2 or more years of operations▪ Canadian facility (Plasco in Ottawa) has not been in regular (24/7) operation as of early 2010▪ Complex Operation, scheduled and unscheduled downtime, unknown^[42].
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2.2.1.4 Pyrolysis

The concept of pyrolysis of MSW gained popularity in the 1960s as it was assumed that since MSW is typically about 60% organic matter, it would be well suited to pyrolytic treatment. By the mid-1970s studies in Europe and the United States concerning the pyrolysis of MSW were completed, some of these studies involved the construction and operation of demonstration plants. By the late 1970s, however, both technical and economic difficulties surrounding the pyrolysis of MSW arose which resulted in the lowering of interest and expectations for the technology. Since that time, the pyrolysis of MSW has been investigated but continues to face technical limitations.

Pyrolysis is the thermal decomposition of feedstock at a range of temperatures in the absence of oxygen. The end product is a mixture of solids (char), liquids (oxygenated oils), and syngas (consisting of CO₂, CO, CH₄, H₂). The pyrolytic oils and syngas can be used directly as boiler fuel or refined for higher quality uses such as engine fuels, chemicals, adhesives, and other products. The solid residue is a combination of non-combustible inorganic materials and carbon.

Pyrolysis requires thermal energy that is usually applied indirectly by thermal conduction through the walls of a containment reactor since air or oxygen is not intentionally introduced or used in the reaction. The transfer of heat from the reactor walls occurs by filling the reactor with inert gas which also provides a transport medium for the removal of gaseous products.

The composition of the pyrolytic product can be modified by the temperature, speed of process, and rate of heat transfer. Liquid products (pyrolytic oils) are produced by lower pyrolysis temperatures while syngas is produced by higher pyrolysis temperatures. The syngas produced can be combusted in a separate reaction chamber to produce thermal energy which can then be used to produce steam for electricity production.

A full scale (100,000 tpy) facility began operating in 1997 in Fürth, Germany. Modifications to the facility were made between 1997 and 1998 but in August, 1998 the plant was closed following an explosion resulting from a waste 'plug' causing over pressurization of the reaction chamber. At

⁴² AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

present there are no large scale pyrolysis facilities are in operation in Europe. However, a smaller facility has been in operation in Burgau in the Eastern part of Europe.

There were a total of six pyrolysis plants in operation in Japan as of the end of 2007 based on the information available as of March 2010. Information on the current (2010) status of these facilities was not available as of the date that this report was prepared. A new facility was being built in Hamamatsu (2007/2008) using this technology, which is intended to process approximately 450 tpd. Ramboll recently visited a similar pyrolysis facility located at the Toyohashi Waste Treatment Recovery and Resource Center, Toyohashi Japan. Information obtained during the facility visit includes the following:

- The facility consists of two 200-tpd units that process MSW (or approximately 120,000 tpy based on availability).
- The facility was commissioned in 2002.
- The recovery and resource center also has a grate-fired mass burn facility to process MSW.
- The overall capital cost for the pyrolysis plant was approximately \$165 million USD (1998\$).
- The facility is similar to the plant in Fürth with modifications.
- The process involves low temperature pyrolysis (400°C) followed by a high temperature secondary combustion/residual vitrification stage.
- Aluminum and iron are removed after the pyrolysis drum.
- The APC train includes: quenching, baghouse for PM removal, SCR for NO_x, and flue gas recirculation.
- Incoming waste is shredded to 15x15 cm and has an average heat value of 9.2 MJ/kg.
- Residues: bottom ash 12.4%, with recovery of iron and aluminum.
- Energy production: yearly production 41 GWh electricity, with 90% used for internal consumption and pre-treatment. Only 4.46 GWh is sold.
- Heat produced is used to heat a public swimming pool.
- Availability: approximately 6,900 hours per year for line 1 and 7,400 hours per year for line 2 or over 80%. Scheduled and unscheduled downtime is required to repair the refractory lining of the reactor.
- Overall, the operators find the grate fired plant more reliable and flexible with higher availability in comparison with the pyrolysis plant.

Due to the pre-treatment of waste and the fuel burned in the high temperature chamber, the electrical output from the pyrolysis process is almost balanced with the internal energy consumption.

Pyrolysis generally takes place at lower temperatures than used for gasification which results in less volatilization of carbon and certain other pollutants, such as heavy metals and dioxin precursors. The relatively low temperatures allow for better metal recovery before the residual pyrolysis products enter the high temperature chamber where they are vitrified.

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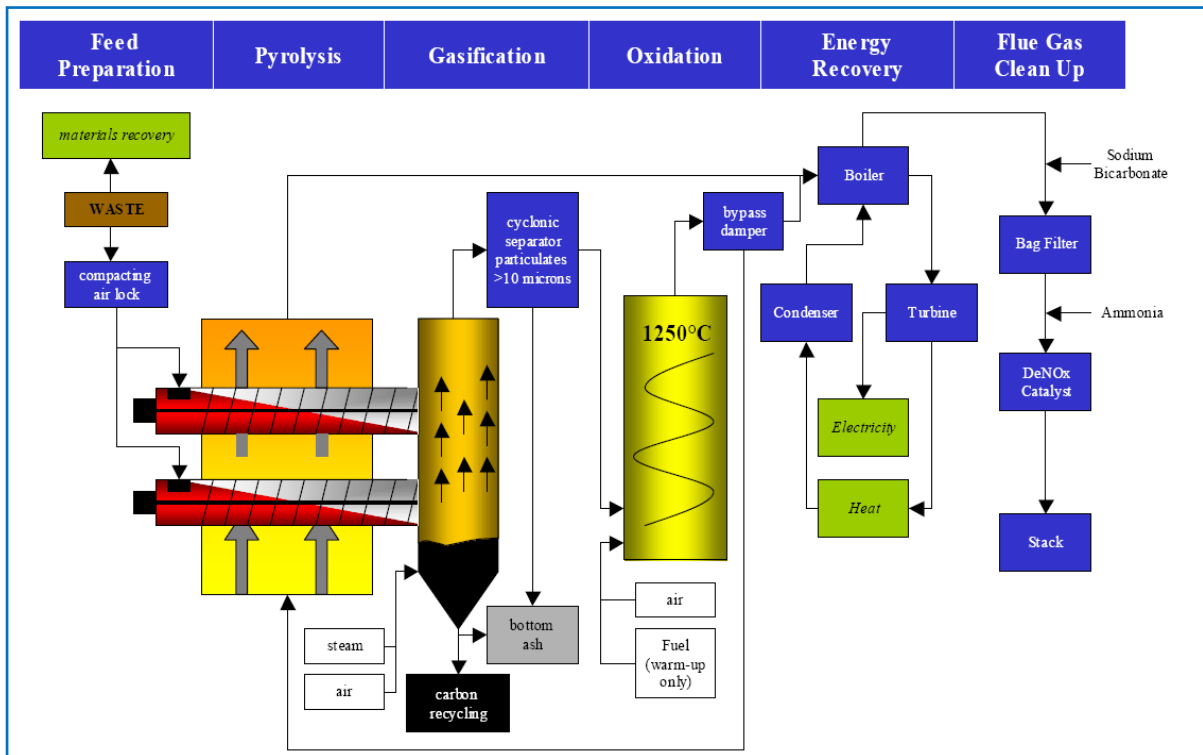
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Issues identified in relation to the pyrolysis process include:

- Low energy outputs
- The requirement for a properly sealed reaction chamber for safe operation. The pyrolysis process is highly sensitive to the presence of air. Accidental incursions of air can result in process upsets and increase the risk of explosive reactions.
- The requirement for pre-treatment of the MSW.

The following figure (Figure 2-12) presents a schematic overview of the Compact Power pyrolysis technology as developed by Compact Power Ltd. In the Compact Power process, sorted MSW is conveyed by a screw through the heated tubes for pyrolysis, followed by gas combustion in a cyclone where energy is captured to produce steam and then electricity. It should be noted that the Compact Power technology utilizes a gasification step following pyrolysis – this does not necessarily occur in all pyrolysis based WTE facilities.^[43]

Figure 2-12: Schematic Overview of the Compact Power Pyrolysis Process



Source: Thomas Malkow. 2004. Novel and innovative pyrolysis and gasification technologies for energy efficient and environmentally sound MSW disposal. In Waste Management 24 (2004) 53-79

⁴³ Thomas Malkow. 2004. Novel and innovative pyrolysis and gasification technologies for energy efficient and environmentally sound MSW disposal. In Waste Management 24 (2004) 53-79

Table 2-6 provides a general summary of pyrolysis process, costs, scalability and reliability. This cost data is less reliable than the costs presented in this report for other technologies since:

- It is unclear if the reported capital costs address all capital and construction cost elements.
- It is not clear that reported operating costs address all costs associated with such facilities.
- It was also noted that the values were consistently reported to be lower than other similar WTE technologies, but without supporting rationale for these differences.

Table 2-6: Pyrolysis – Summary of Information

Pyrolysis Summary	
Pyrolysis is the thermal decomposition of feedstock at high temperatures in the absence of oxygen.	
The longest operating pyrolysis facility is located in Burgau, Germany and has been operating since 1987.	
The largest facility (located in Japan) processes approximately 150,000 tpy of SRF.	
Over 20 companies market pyrolysis technologies or approaches for treating MSW.	
Other Summary Points	
Median Reported Capital Cost	<ul style="list-style-type: none"> ▪ No reliable data
Median Reported Operating Cost	<ul style="list-style-type: none"> ▪ No reliable data
Feedstock	<ul style="list-style-type: none"> ▪ Biomass, automotive shredder residue, coal, hospital waste, MSW, plastics, polyvinyl chloride, sludge, tires, wastewater ▪ Waste preparation/pre-processing required by technology ▪ Difficulties in accepting variable waste streams
Residual to Disposal	<ul style="list-style-type: none"> ▪ If treated, residues reduced to 0.1 to 0.3 tonnes per input tonne ▪ >30%, if residue not treated ▪ Landfill capacity consumption reduced by up to 90%
Potential Energy and Revenue Streams	<ul style="list-style-type: none"> ▪ Revenue potential for: electricity, syngas, pyrolysis oil ▪ Electricity production, 0.5 to 0.8 MWh/annual tonne of MSW^[44]

The flue gas from the combustion of the pyrolysis gas must be treated in an APC system of one of the types presented in Section 2.2.4.2 of this report. No fundamental differences have been identified to-date between flue gas from conventional grate fired plants and pyrolysis plants.

2.2.2 Emerging Combustion and Thermal Treatment Technologies

There is a great deal of flux in the thermal treatment marketplace, with regard to new and emerging technologies. However, many of the emerging technologies have yet to be proven and the financial capacity of many of the new technology vendors is limited.

With more proven technologies such as mass burn, the evolution of technology has focused on improving combustion and emissions performance through design adjustments, such as new grate

⁴⁴ Juniper, 2007 a) and b), Large Scale EFW Systems for Processing MSW; Small to Medium Scale Systems for Processing MSW

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design and improved combustion air management systems. Significant achievements associated with more conventional technologies include low-NO_x burners, improved efficiency, heat exchangers, waste heat recovery systems, and newly developed equipment for wet scrubbing and activated carbon absorption.

The following is a selected list of some emerging combustion and thermal treatment technologies. While there are other emerging technologies, the following represents technologies that are in development (preliminary development, test facilities or commercial scale proposals) in North America. The information has been made available from technology vendors and generally is yet to be verified by any independent parties.

2.2.2.1 Gasplasma

The gasplasma process is used by Advanced Plasma Power, a United Kingdom-based company. They currently have one small-scale, demonstration plant in operation. The gasplasma process uses waste feedstock to produce clean hydrogen-rich syngas and Plasmarok™, a vitrified recyclate, which reportedly can be used as a building replacement or replacement aggregate.

The gasplasma process is designed for post-diversion materials (i.e., those materials that cannot be recycled or composted). Although it can operate with a variety of feedstock, it operates most efficiently when treating a prepared SRF. Advanced Plasma Power utilizes three different technologies in their process: fluidized bed gasification, plasma arc treatment and a power island. The gasifier operates at a temperature of approximately 900°C. At this temperature, the material is thermally broken down into syngas. The plasma arc treatment “cracks” the dirty syngas coming out of the gasifier. The cracking process breaks the molecular structure of the syngas and reforms it into a simpler structure, thereby producing a hydrogen-rich fuel gas. The hydrogen-rich fuel gas is cooled and further cleaned before being fed into the gas engines at the power island. It is claimed that the electrical generating efficiency reaches 35 – 40%.

The fluidized bed gasifier used in the gasplasma process produces char and ash (approximately 10 – 15% of the feedstock), this material is recovered in Plasmarok™. Plasmarok™ is stated as being an environmentally stable material that can be re-used as a building aggregate (in the UK). The vendor claims Plasmarok™ significantly reduces the amount of residue requiring landfilling; from 60,000 tonnes of SRF, 450 tonnes of activated carbon from the gas scrubbers requires landfilling (over 99% reduction).^[45]

2.2.2.2 Thermal Cracking Technology (Fast Pyrolysis)

Graveson Energy Management (GEM) uses traditional petrochemical industry technology to convert MSW into clean synthetic gas. A GEM facility employing thermal cracking technology has been operating in Romsey, England since 1998. It can process up to 1,680 tonnes per day of RDF that has

⁴⁵ Advanced Plasma Power. 2010. *What is Gasplasma – The Process*. Accessed February 10, 2010
<http://www.advancedplasmapower.com/index.php?action=PublicTheProcessDisplay>

been ground to less than 2 mm particle size and dried to 5% moisture. Thermal cracking is also described as “fast pyrolysis” as it involves rapid heating of the waste fuel in the absence of oxygen.

In thermal cracking, prepared waste material is fed into the oxygen-free chamber. The chamber has stainless steel walls that are heated to 850°C. The waste material is instantly heated and thermally cracks to syngas in a matter of seconds. Syngas entering the Gas Filtration system is further filtered to remove finer particles and is cooled rapidly from 1,500°C to less than 400°C to prevent the formation of dioxins and furans. A small portion of the clean syngas is used to heat the GEM Converter, which reduces the need for fossil fuels. The remainder of the syngas can be used in boilers, engines, or turbines for generation into energy. Mineral solids are produced as a residual, typically in the amount of 8 – 10% for domestic waste.^[46]

2.2.2.3 Thermal Oxidation

Zeros Technology Holdings uses an Energy Recycling Oxidation System that can reportedly dispose of all classifications of waste. Zeros claims no emissions are produced in the process and other effluents can be sold as products or reintroduced into the system, however to our knowledge, these claims have not been supported by independent verification. The system is closed and uses pure oxygen for the oxidation process, as opposed to ambient air. The oxidation process used by this technology was originally developed for oil spill remediation. Several projects are in various stages of development, however there is currently no Zeros facility in operation.

Zeros combines six different technologies in their process: rotary kiln; gasification (Oxy-Fuel Technology); Rankine Cycle Technology; Fischer-Tropsch Fuels Technology; Gas Capture Technology; and Clean Water Technology. The gasification-oxidation process is a two stage process using limited oxygen and high temperature. The system gasifies the fuel source to produce primarily Carbon Monoxide and Hydrogen. This synthetic gas forms the building blocks for the transformation to liquid fuels such as diesel using the Fischer-Tropsch technology.^[47]

2.2.2.4 Waste-to-Fuels

Approaches to transform waste into fuels are generally based on the concept that rather than using the syngas produced through gasification as a direct energy source, the syngas can be used as a feedstock to generate various liquid fuels that could then be used off-site.

Enerkem intends to construct the world’s first facility intended to produce biofuels from MSW. Construction of the Edmonton facility is set to begin in April 2010 and operations are currently planned to begin in mid-2011.^[48] Enerkem indicates Alberta will reduce its carbon dioxide footprint by more than six million tons over a 25 year period, while producing 36 million liters of ethanol annually through the use of this facility.

⁴⁶ GEM Canada Waste to Energy Corp. 2009. *Process Description and Gas Production*. Accessed February 10, 2010. <http://www.gemcanadawaste.com/53257.html>

⁴⁷ Zeroes Technology. 2008. Accessed May 10, 2010 <http://www.zerosinfo.com/technology.php>

⁴⁸ Enerkem. 2010. Edmonton Biofuels Project Status and Schedule. http://www.edmontonbiofuels.ca/status.htm?yams_lang=en

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Enerkem converts urban biomass, agricultural residues and/or forest residues into biofuels by means of a four step process:

1. Pre-treatment of the feedstock which involves drying, sorting and shredding of the materials.
2. Feedstock is fed into the gasifier. The bubbling fluidized bed gasifier converts the residues into synthetic gas and operates at a temperature of approximately 700°C.
3. Synthetic gas cleaning and conditioning, which includes the cyclonic removal of inerts, secondary carbon/tar conversion, heat recovery units, and reinjection of tar/fines into the reactor.
4. Conversion of syngas into biofuels.

Enerkem intends to produce approximately 360 litres of ethanol from 1 tonne of waste (dry base).^[49]

Changing World Technologies employs a Thermal Conversion Process which converts waste into oil. They state: "The Thermal Conversion Process, or TCP, mimics the earth's natural geothermal process by using water, heat and pressure to transform organic and inorganic wastes into oils, gases, carbons, metals and ash. Even heavy metals are transformed into harmless oxides". Changing World Technologies does not have a commercial facility at this time; however they do have a test centre in Philadelphia, PA.^[50]

2.2.3 Summary of Major Thermal Treatment Technologies

Table 2-7 presents an overview of the four major types of WTE technologies used worldwide and a number of their key characteristics.

Table 2-7: Overview of the Four Major Types of WTE Technologies Used Worldwide

Characteristic	Conventional Combustion			Gasification	Plasma Gasification	Pyrolysis
	Mass Burn	Fluidized Bed	Two-Stage			
Applicable to unprocessed MSW, with variable composition	YES	NO	YES	NO	NO	NO
Commercially Proven System, with relatively simple operation and high degree of reliability	YES	YES	YES	Commercially proven to limited degree, more complex than combustion and less reliable, very costly	NO	NO
Reasonably Reliable set of Performance Data	YES	NO	YES	Limited data. Operational problems have been documented.	Limited data. Operational problems have been documented.	Limited data. Operational problems have been documented.

⁴⁹ Enerkem. 2010. *Technology Overview*. Accessed February 10, 2010
<http://www.enerkem.com/index.php?module=CMS&id=6&newlang=eng>

⁵⁰ Changing World Technologies. 2010. *What Solutions Does CWT Offer? What is Thermal Conversion Process (TCP)?*. Accessed February 10, 2010. <http://www.changingworldtech.com/what/index.asp>

3 POTENTIAL DISCHARGES FROM THERMAL TREATMENT

3.1 Air Emissions

3.1.1 Overview of Potential Emission Constituents

The following table (Table 3-1) illustrates the main sources of air emissions from WTE facilities.^{[51] [52]}

Table 3-1: Main Sources of Key Substances of Concern Released from WTE Facilities

Substances	Comments and Main Sources
Particulate matter (including PM ₁₀ , PM _{2.5} and ultrafine (nanoparticles))	Present in flue gas as fine ash from the incineration process entrained in the flue gas. There can also be fugitive releases of dust from waste storage areas and ash management if good operational controls are not in effect.
CO	Present in flue gas as a result of incomplete combustion of waste. e.g., if spontaneously evaporating or rapid-burning substances are present, or when combustion gas mixing with the supplied oxygen is poor.
NO _x	Present in flue gas as both thermal and fuel NO _x . Fuel NO _x originates from the conversion of nitrogen contained in the waste while thermal NO _x results from the conversion of atmospheric nitrogen from the combustion air. In WTE the proportion of thermal NO _x is often much greater than fuel NO _x .
SO ₂	Present in flue gas where sulphur is present in the waste stream. Common sources of sulphur in the waste stream are: waste paper, drywall (or gypsum plaster) and sewage sludge.
N ₂ O	Principally arises from SNCR. Modern MSW incinerators have low combustion-originated N ₂ O but, depending on the reagent, emissions can result from SNCR, especially when urea is used as the reducing agent.
Methane (CH ₄)	Normally not generated at all as long as combustion is carried out under oxidative conditions. May arise from the waste bunker if waste is stored for a long time resulting in anaerobic digestion taking place.
Metals (Heavy metals and compounds other than Hg and Cd) Sb, As, Pb, Cr, Cu, Mn, Ni, V, Sn,	Predominantly found in flue gas as particulate matter usually as metal oxides and chlorides. A portion can also be found in bottom ash, fly ash and sorbent. The proportion of each metal found in the particulate entrained in the flue gas versus that found in the bottom ash, is usually reflective of the volatility of the metal.

⁵¹ Environment Agency, Pollution Inventory Reporting: Environmental Permitting (England and Wales) Regulations 2007, Regulation 60(2), December 2009

⁵² European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

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Substances	Comments and Main Sources
Cd	Predominantly found in flue gas in gaseous form or bound to entrained PM. Common sources of cadmium in WTE facilities are electronic devices (including capacitors), batteries, some paints and cadmium-stabilized plastic. Other sources include hazardous wastes including effluent treatment sludges and drummed waste from metal plating works. It should be noted that BC is actively removing sources of cadmium from the waste stream with the electronic product stewardship program, and battery recycling see http://rcbc.bc.ca/education/retailer-take-back
Hg	Predominantly found in flue gas in gaseous form or bound to entrained PM. Originates from MSW containing batteries, thermometers, dental amalgam, fluorescent tubes, and mercury switches. High quantities of fish/seafood in the waste stream can also lead to mercury emissions. Also found in bottom ash, fly ash and sorbents. There are programs in place to remove mercury from the waste stream such as: Canada Wide Standards for Dental Amalgam Waste, and fluorescent light recycling product stewardship in BC.
VOCs (often presented as TOC)	Predominantly found in flue gas from incineration of organic waste. There is also some potential for fugitive releases from waste storage areas.
PAHs	Principally found in flue gas as products of incomplete combustion. Also found in bottom ash, fly ash and sorbents.
Dioxin like PCBs	Predominantly found in flue gas from most municipal waste streams and some industrial wastes. Low levels of PCBs are found in most municipal waste streams. Higher concentrations in some hazardous waste streams. Also found in bottom ash and APC Residue.
Dioxins and furans	Predominantly found in flue gas, as a result of re-combination reaction of carbon, oxygen and chlorine (de novo synthesis). May also be found in low levels in the incoming waste stream. Also found in boiler ash, bottom ash, fly ash and sorbents.
Ammonia	Predominantly found in flue gas where SNCR is used to control NO _x . May be present as a result of overdosing or poor control of reagents.
HCl	Predominantly found in flue gas from wastes containing chlorinated organic compounds or chlorides. In municipal waste approximately 50% of the chlorides come from PVC plastic (used for household sewerage pipes).
HF	Predominantly found in flue gas. Originates from fluorinated plastic or fluorinated textiles in MSW and a variety of fluorinated compounds found in household hazardous waste.

Like other combustion processes, WTE facilities can release small quantities of a broad spectrum of compounds into the atmosphere. Only a small fraction of these are considered to be air pollutants and are considered substances of concern. Typical substances of concern that are emitted from WTE facilities and often subject to regulatory limits include:

- Total Particulate Matter (including PM₁₀, PM_{2.5} and ultrafine (nanoparticles))
- Products of incomplete combustion: CO and Organic compounds (TOC, VOCs, organic matter)
- Acidic substances: SO_x, NO_x, HCl and HF
- Heavy metals: Hg, Cd, Tl, Pb, As, Ni, Co, Cr, Cu, V, Mn, Sb
- Organics: dioxins and furans.

Common or Criteria Air Contaminants (CACs) typically found in the atmosphere are PM, SO_x, NO_x, VOCs and CO. BC MOE Ambient Air Quality Objectives for these CACs are summarized in Section 8.1.2.3. Background information pertaining to each of the emitted WTE air pollutants of concern is provided below.

Particulate Matter

Particulate matter (PM) consists of solid and/or liquid particles that are suspended in the air column. PM is typically grouped into the following categories based on their aerodynamic diameter (in micrometers (µm)):

- Total Particulate Matter (TPM), consisting of all size fractions
- Coarse PM, less than 10 µm (PM₁₀)
- Fine PM, less than 2.5 µm (PM_{2.5})
- Ultrafine PM, less than 0.1 µm (PM_{0.1}).

In human physiology, coarse particles (those between 2.5 and 10 µm in diameter) are efficiently trapped and removed. They are either filtered out by the hair in the nose or by impacting on and sticking to moist surfaces in the upper respiratory tract. Coarse particles are mainly fine crustal elements. Coarse particles fall out of the atmosphere relatively quickly due to gravity and removal by precipitation.

Fine particles (those less than 2.5 µm in diameter) are able to penetrate deeper into the respiratory tract. Because of this property, fine particles are believed to be responsible for most adverse health effects associated with particulate matter exposure. Fine particles include very fine crustal elements and secondary particles that are essentially ultrafine particles that have formed into larger particles by a variety of physical and chemical processes (e.g., nucleation, condensation, coagulation). Fine particles persist in the atmosphere for long periods and travel long distances because they are relatively stable and their size makes them less susceptible to gravitational settling.

Canadian and American regulatory agencies have air quality objectives for PM₁₀ and more recently PM_{2.5} based upon concentrations in air (in micrograms per cubic metre (µg/m³)).

Ultrafine particles (PM_{0.1}) range in size from 0.1 to less than 0.01 µm in diameter (100 to <10 nanometre (nm)). Ultrafine particles are relatively short lived (minutes to hours) owing to the rapidity of the physical and chemical processes noted above.^{[53] [54]} Some authors use the term 'ultrafine particles' and 'nanoparticles' interchangeably to denote all particles in the nanometer size range. Some advocate the bifurcation of "ultrafine particles" as those between 100 to 10 nm in diameter, and "nanoparticles" as those less than 10 nm. Because of quantum effects, particles smaller than 10 nm in diameter behave differently than their bulk counterparts, and they are different morphologically

⁵³ AWMA, 2005a Nanoparticles and the Environment: Critical Review. Pratim Biswas and Chang-Yu Wu. JAWMA, v55, June 2005 pp 708 – 746

⁵⁴ AWMA, 2005b Nanoparticles and the Environment: Critical Review Discussion. Judith C. Chow, *et al.* JAWMA, v55, October 2005 pp 1411 – 1417

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and chemically compared to ultrafine particles^[55]. Research into the fate and behavior of particles of this size is ongoing. In this report, the designation PM_{0.1} will include ultrafine particles and nanoparticles unless otherwise designated.

The primary sources of PM_{0.1} include the condensation of hot vapours during high temperature combustion processes (i.e., diesel fumes, coal burning, welding, automobiles, wood fires), cooking of foods, biological processes, and secondary formations (i.e., from the nucleation of atmospheric species to form larger particles).^{[56] [57]}

Particles in the PM_{0.1} size range are ubiquitous in the atmosphere, and are at the heart of essential chemical and physical processes such as the sulphur and nitrogen cycle, and cloud formation. A growing body of literature is devoted to the measurement and study of the effects of PM_{0.1}.^[58] Since simple filtration is ineffective at capturing such small particles, measurements focus on particle sizing and particle number (count) by inertial impaction, electrical, and light scattering means.

In addition to size and concentration, the toxicity of nanoparticles is correlated with chemical composition. Smaller particles have proportionally greater surface area per mass and can interact more readily with cell surfaces. With the increase in surface area, the physical parameter of the surface Gibbs free energy increases causing the particles to be more chemically reactive with the surrounding tissue.^[59] As a consequence, health effects resulting from nanoparticles are not correlated with the total mass of particles entering the organism. Insoluble and non-soluble PM_{0.1} are of greatest concern because they eventually accumulate and can lead to toxic effects in specific organs (i.e., heart, lungs, reproductive system).^[60]

In addition to chemical composition, other factors such as surface dose, surface coverage, surface charge, shape, porosity, and the age of the particle can contribute to the toxicity of particles in the ultrafine range. However, not enough data is currently available to assess the significance of each of these factors on the toxicity of PM_{0.1}.

The current understanding of adverse health effects of exposure to PM_{0.1} indicates that the effects are as diverse as the types of particles themselves, making it very difficult to identify major trends. A detailed summary of the current state of knowledge of the impact of different types of PM_{0.1} on human health was completed by the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST) in 2008.

Carbon Monoxide

Carbon monoxide is a colourless, odourless gas. As a product of incomplete combustion, emissions sources include fossil fuel and wood combustion. Motor vehicles, industrial processes, and natural sources (fires) are some common sources.

⁵⁵ AWMA, 2005a Nanoparticles and Environment: Critical Review. Pratim Biswas and Chang-Yu Wu. JAWMA, v55, June 2005 pp 708 – 746

⁵⁶ Health Canada. National Ambient Air Quality Objectives for Particulate Matter – Executive Summary. Part 1: Science Assessment Document

⁵⁷ The Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST). Health Effects of Nanoparticles. November, 2008

⁵⁸ AWMA, 2005a Nanoparticles and Environment: Critical Review. Pratim Biswas and Chang-Yu Wu. JAWMA, v55, June 2005 pp 708 – 746

⁵⁹ The Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST). Health Effects of Nanoparticles. November, 2008

⁶⁰ The Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST). Health Effects of Nanoparticles. November, 2008

Volatile Organic Compounds (VOCs)

Volatile Organic Compounds are organic substances of concern (carbon chains or rings that also contain hydrogen) that have high enough vapour pressures under normal conditions to significantly vapourize and enter the Earth's atmosphere (i.e., with a vapour pressure greater than 2 mm of mercury (0.27 kPa) at 250°C or a boiling range of between 60 and 250°C) excluding methane. Individual jurisdictions have varying definitions for VOCs that may be tailored to the specific regulatory context in which the definition is applied. These gaseous organic substances are products of incomplete combustion. For WTE facilities, generally Total Organic Carbon (TOC) or Total Non-Methane Organic Carbon (TNMOC) which is largely comprised of VOCs, is measured continuously in flue gas as being representative of the mass of VOC emissions. This is necessary as there are a myriad of species of VOCs that may be present in extremely small concentrations within the flue gas and monitoring of individual species is not possible.

Sulphur Dioxide

Sulphur dioxide is a colourless gas with a distinctive pungent sulphur odour. It is produced in combustion processes by the oxidation of sulphur compounds, such as H₂S, in fuel. At high enough concentrations, SO₂ can have negative effects on plants and on animal health, particularly with respect to their respiratory systems. Sulphur dioxide can also be further oxidized and may combine with water to form the sulphuric acid component of acid rain.

Anthropogenic emissions comprise approximately 95% of global atmospheric SO₂. The largest anthropogenic contributor to atmospheric SO₂ is the industrial and utility use of heavy oils and coal. The oxidation of reduced sulphur compounds emitted by ocean surfaces accounts for nearly all of the biogenic emissions. Volcanic activity accounts for much of the remainder.^[61]

Oxides of Nitrogen

Nitrogen oxides are produced in most combustion processes, and almost entirely made up of nitric oxide (NO) and nitrogen dioxide (NO₂). Together, they are often referred to as NO_x. Nitrogen dioxide is an orange to reddish gas that is corrosive and irritating. Most NO₂ in the atmosphere is formed by the oxidation of NO, which is emitted directly by combustion processes, particularly those at high temperature and pressure, such as internal combustion engines.

Nitric oxide is a colourless gas with no apparent direct effects on animal health or vegetation at typical ambient levels. The concentration of NO₂ is the regulated form of NO_x. External combustion processes, such as gas-fired equipment and motor vehicles, are primary sources of anthropogenic NO_x emissions. The levels of NO and NO₂, and the ratio of the two gases, together with the presence of certain volatile organic compounds (VOCs) from motor vehicle emissions, solvent use and natural sources, and sunlight are the most important contributors to the formation of ground-level ozone.

Anthropogenic emissions comprise approximately 93% of global atmospheric emissions of NO_x (NO and NO₂). The largest anthropogenic contributor to atmospheric NO_x is the combustion of fuels

⁶¹ Wayne, R. Chemistry of Atmospheres. Oxford Science Publications, 1991.

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such as natural gas, oil, and coal. Forest fires, lightning, and anaerobic processes in soil account for nearly all biogenic emissions.^[62]

Acid Gases

Acid gases are those gaseous contaminants which contribute towards the formation of acidic substances in the atmosphere. In combustion, acid gases of concern include sulphur dioxide (SO₂), oxides of nitrogen (NO_x), hydrogen chloride (HCl) and hydrogen fluoride (HF).

Heavy Metals

Heavy metals are usually carried on particulate matter and occur naturally or can be emitted through anthropogenic sources (i.e., combustion). The concern for human and ecological health varies with each metal as well as its mobility through various environmental pathways. Some metals (such as mercury) have toxic effects if inhaled, ingested or absorbed through skin. Typical metals emitted as a result of MSW combustion include cadmium, thallium, chromium, arsenic, mercury and lead. Semi-volatile metals include lead or cadmium whereas mercury and thallium are highly volatile and vapourize readily.

Dioxins and Furans

Dioxins and Furans are organic compounds with a chemical structure that contains two benzene rings and up to eight chlorine atoms. They can be created as an undesired by-product of chemical processes such as the manufacture of pesticides, or chlorine bleaching of pulp. Dioxins and Furans can also be produced under certain conditions within combustion processes in which chlorine is present in the fuel burned, or where poor combustion operating conditions can result in de novo synthesis (as discussed below). Normally, a well functioning incinerator facility will destroy dioxins and furans within the combustion zone. The reference dioxin isomer is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD). Other isomers are usually expressed in terms of equivalents of TCDD. TCDD is almost insoluble in water, slightly soluble in fats and more soluble in hydrocarbons.

Dioxins and furans may form (referred to as de novo synthesis) in catalytic reactions of carbon or carbon compounds with inorganic chlorine compounds over metal oxides (e.g., copper oxide) during the waste incineration process. These reactions generally take place in the temperature range between 250 – 400°C which occurs as the flue gas cools after leaving the combustion zone of the incinerator. Modern incinerators are designed to ensure that the length of time flue gas spends in that temperature range is minimized so as to reduce the possibility of de novo synthesis of dioxins/furans and to control and destroy dioxin and furan in the emission before discharge.

3.1.2 Point Source Emissions

Point source emissions are those emissions resulting from a single point such as the emissions exhausted via a stack or vent, i.e., a single point source into the atmosphere. Point source emissions are usually the most significant emission source (in terms of annual mass releases) for combustion activities at WTE facilities. APC equipment (e.g., scrubbing units, fabric filters (bag house)) as

⁶² Wayne, R. Chemistry of Atmospheres. Oxford Science Publications, 1991

described further in this report, are incorporated into the exhaust system prior to discharge to atmosphere control the release of pollutants into the atmosphere.^[63] Point source emissions at a WTE facility are those that contain the treated exhaust from the process and typically it is this exhaust stream that is monitored for compliance with regulatory limits.

3.1.3 Fugitive Emissions

Fugitive emissions are those that are not released from a point source such as a stack, but rather from an area-based source. Typically fugitive emissions are uncontrolled, or are controlled on an as-needed basis, such as through the use of dust suppression techniques in dry conditions. Fugitive emissions from WTE facilities, including dust, odour and VOCs, are largely minimized by maintaining the WTE facility under negative pressure, using indoor facility air for combustion. Some examples of areas with potential for fugitive emissions and potential mitigative measures are:

- The loading and unloading of transport containers. To mitigate fugitive emissions from receiving areas these areas are usually fully enclosed, and the air from these areas is drawn into the combustion process, keeping the waste receiving area under negative pressure.
- Storage areas (e.g., bays, stockpiles, etc) for waste and residual materials. As noted above, mitigation includes enclosing these areas and using the air from these locations as sources for combustion air.
- Transferring material between vessels (e.g., movement of materials to and from silos, transfer of volatile liquids such as select liquid fuels). Filters are commonly added on silos for lime and other dusty materials.
- Conveyor systems, which are usually enclosed.
- Pipe work and ductwork systems (e.g., pumps, valves, flanges), which are maintained to prevent accidental losses.
- Abatement equipment by-pass, which must be designed to allow for retention of any accidental emissions.
- Accidental loss of containment from failed plant and equipment.
- Oil and ammonia storage tanks, which require appropriate preventative maintenance and other practices to ensure containment.^[64]

Generally the regulation of potential fugitive emissions from a WTE facility is addressed through the approval of the site specific design and operations plans for the facility and the issuance of the required permits for the facility operation, including specific terms and conditions that reflect the requirements for design and operation.

3.1.4 Factors Affecting Airshed Impacts

The addition of a new emission source within an airshed has the potential to impact ambient air quality. The potential impacts are a function of a number of factors:

⁶³ Environmental Agency. 2009. Pollution Inventory Reporting

⁶⁴ Durham/York Residual Waste Study Environmental Assessment, November 27, 2009, Stantec Consulting Limited

- **Discharge Characteristics.** The increase in mass loading to an airshed of contaminants of concern from a new facility has the potential to degrade ambient air quality. The greater the discharge rate, the greater the potential risk. Air pollution control systems are specifically designed to reduce the discharge of these constituents such that the impact is considered to be acceptable. The temperature and velocity of the discharge also can affect the effect on airshed quality. Generally, hotter and higher velocity discharges will disperse further from the point of discharge, effectively reducing ambient concentrations of the constituents of concern. The chemical reactivity of the constituents in the discharge will also determine the fate and behaviour in the ambient air. Stable compounds and small particulate may remain suspended in the airshed for a long time, whereas unstable compounds or large particulate will experience a shorter residence time in the ambient air.
- **Airshed Characteristics.** The dispersion and physical/chemical reactions of constituents are governed by the characteristics of the airshed. Topography, latitude, temperature, prevailing wind direction and pre-existing emissions all affect the dispersion of a discharge, and therefore affect the fate and behaviour of the constituents in the atmosphere. Some airsheds are affected by a combination of factors. For example, the lower Fraser Valley is a complex airshed, with confining mountains forming a basin around the river valley, prevailing winds that transport the air mass up and down the valley, seasonal 'sea breeze' effects that result in a daily reversal of wind direction, and a photochemical sensitivity to NO_x and volatile hydrocarbon emissions that react with sunlight to form elevated concentrations of low level ozone.

Examination of the permitted and actual emissions from WTE facilities (as shown in Table 5-2) that have been recently designed and are operating in a manner consistent with BACT indicates that the concentrations of the constituents of concern (Criteria Air Contaminants, Hazardous Air Pollutants, among other definitions) are quite low and often at least an order of magnitude less than their regulated limits. In comparison to other existing combustion-based industries, WTE facilities typically have lower discharge concentrations of the constituents of concern. While a new WTE facility will add, on a mass basis, additional constituents into the airshed, the increment will in almost all cases be insignificant in terms of overall ambient air quality and increased risk to human health and the environment. The proponents of a new facility have an obligation to demonstrate that this is the case through detailed meteorological and dispersion modeling studies and by quantitative human health and ecological risk assessment (HHERA) studies. One of the more recent examples of such site specific air modeling and HHERA studies undertaken in Canada for a WTE facility, are the recently completed studies for the Durham York Residual Waste EA Study.^[65]

3.2 Liquid Effluents

In addition to emissions to air, some WTE facilities also generate an effluent discharge. Whether or not an effluent discharge is produced depends on the type of APC system used as well as other design parameters.

⁶⁵ Stantec Consulting Limited. 2009. Durham/York Residual Waste Study Environmental Assessment.

Effluent management is more often required for WTE facilities that include wet scrubbers as a component in the APC train, (i.e., facilities with a wet APC train). Facilities that use other alternatives to control acid gases, as discussed in Section 4, generally are designed as zero effluent discharge facilities, and if they are likely to generate any effluent it would typically include storm water and/or sanitary wastewater which can easily be managed by conventional storm water and wastewater control systems.

Water is used at WTE facilities for various processes and effluent may result from any of the following sources.^{[66] [67]}

- APC process wastewater – normally from wet flue gas treatment (dry and semi-dry systems do not typically give rise to any effluent) although not all wet systems produce effluent that needs to be discharged from the facility (discussed further below).
- Wastewater from collection, treatment and (open-air) storage of bottom ash – not usually discharged but used as water supply for wet de-slaggers.
- Other process wastewater streams – e.g., wastewater from the water/steam cycle resulting from the preparation of boiler feed water and from boiler drainage. In many cases this water can be reused in the incineration and APC treatment process as make-up water and does not result in actual discharge from the facility.
- Sanitary wastewater (e.g., toilets and kitchen).
- Stormwater which originates from precipitation falling on surfaces such as roofs, service roads and parking lots and is usually discharged directly to storm sewers, though may receive passive or active treatment if storm water management is in place. Storm water may also be generated at waste unloading areas if these areas are uncovered. Such storm water would usually be segregated from other sources and treated prior to discharge.
- Used cooling water (e.g., cooling water from condenser cooling).

WTE facilities that utilize dry or semi-dry APC systems are often designed with zero wastewater discharge. This is accomplished via the reuse of wastewater produced by a facility. For example, facilities that utilize semi-dry APC systems can reuse boiler blowdown and reject water from the boiler as scrubber slaking and dilution water. As mentioned previously in this report, semi-dry and dry APC systems are the most common type used in North America.

WTE facilities that utilize wet APC systems can also be designed as zero wastewater discharge facilities but require a wastewater treatment system that allows the effluent resulting from the wet scrubbers to be re-used within the facility. The wastewater resulting from wet flue gas treatment

⁶⁶ Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste.

⁶⁷ European Commission. 2006. Integrated Pollution Prevention and Control: Reference Document on the Best Available Techniques for Waste Incineration.

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contains a wide variety of contaminants including heavy metals, inorganic salts (sulphates) and organic compounds (including dioxins/furans).^[68]

There are three main alternatives for the treatment or reuse of wastewater from wet flue gas treatment systems:

- **Physical/chemical treatment** – based on pH-correction and sedimentation. With this system a treated wastewater stream containing some dissolved salts must be discharged if not evaporated using one of the following two evaporation processes listed below.
- **In-line evaporation of process wastewater** – by means of a semi-dry system (e.g., for systems that use wet and semi-dry APC systems). In this case the dissolved salts are incorporated into the residue of the APC system. There is no discharge wastewater other than that evaporated with the flue gases.
- **Separate evaporation of wastewater** – the evaporated water is condensed, but can be discharged (or reused) without special measures.

As noted above the physical/chemical treatment and separate evaporation methods may result in a potential effluent discharge from the facility.

Table 3-2 provides an example of the composition of untreated effluent from MSW incinerators that utilize wet flue gas treatment systems. Typical contaminant concentrations following treatment are also indicated.

Table 3-2: Composition of Effluent from MSW Incinerators that Utilize Wet Flue Gas Treatment Systems

Parameter	Units	Average Before Treatment ^[69]	Typical Effluent Discharge Values from Dutch MSW Incinerators (2002) ^[70]	Range of Effluent Discharge Values from Austrian MSW Incinerators (2001) ^[71]
pH	–	–	–	6.8 – 8.5
TOC	mg/l	73,000	–	4.3 – 25
Sulphate	g/l	4,547	–	<1.2
Chloride	g/l	115,000	–	7 – <20
Fluoride	mg/l	25,000	–	<0.006 – <10
As	mg/l	–	0.01	<0.003 – <0.05
Hg	mg/l	6,200	0.005	<0.001 – <0.01
Pb	mg/l	250	0.1	<0.01 – <0.1
Cu	mg/l	100	0.02	<0.05 – <0.3
Zn	mg/l	690	0.2	<0.05 – <0.5

⁶⁸ European Commission. 2006. Integrated Pollution Prevention and Control: Reference Document on the Best Available Techniques for Waste Incineration.

⁶⁹ Draft of a German Report with Basic Information for a BREF-Documents “Waste Incineration”. 2001. German Federal Environmental Agency

⁷⁰ Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste

⁷¹ Federal Environment Agency – Austria. 2002. State of the Art for Waste Incineration Plants

Parameter	Units	Average Before Treatment ^[69]	Typical Effluent Discharge Values from Dutch MSW Incinerators (2002) ^[70]	Range of Effluent Discharge Values from Austrian MSW Incinerators (2001) ^[71]
Cr	mg/l	170	0.03	<0.05 – <0.1
Ni	mg/l	240	0.03	<0.05 – <0.5
Cd	mg/l	8	0.05	<0.001 – <0.05
Sn	mg/l	–	0.05	0.06
Mo	mg/l	–	1	–
Tl	mg/l	–	–	<0.01 – 0.02
PCDD/PCDF	ng/l	–	1,000	–

NOTES:

(–) means the value is not provided

Refer to Table 3-3 in Section 3.2.4 for an example of BAT discharge limit values for effluent resulting from MSW incinerators.

The following subsections describe each of the three primary wastewater treatment methods in more detail.

3.2.1 Physical/Chemical Treatment

The following figure (Figure 3-1) illustrates a typical configuration of a physical/chemical treatment unit for scrubber wastewater:

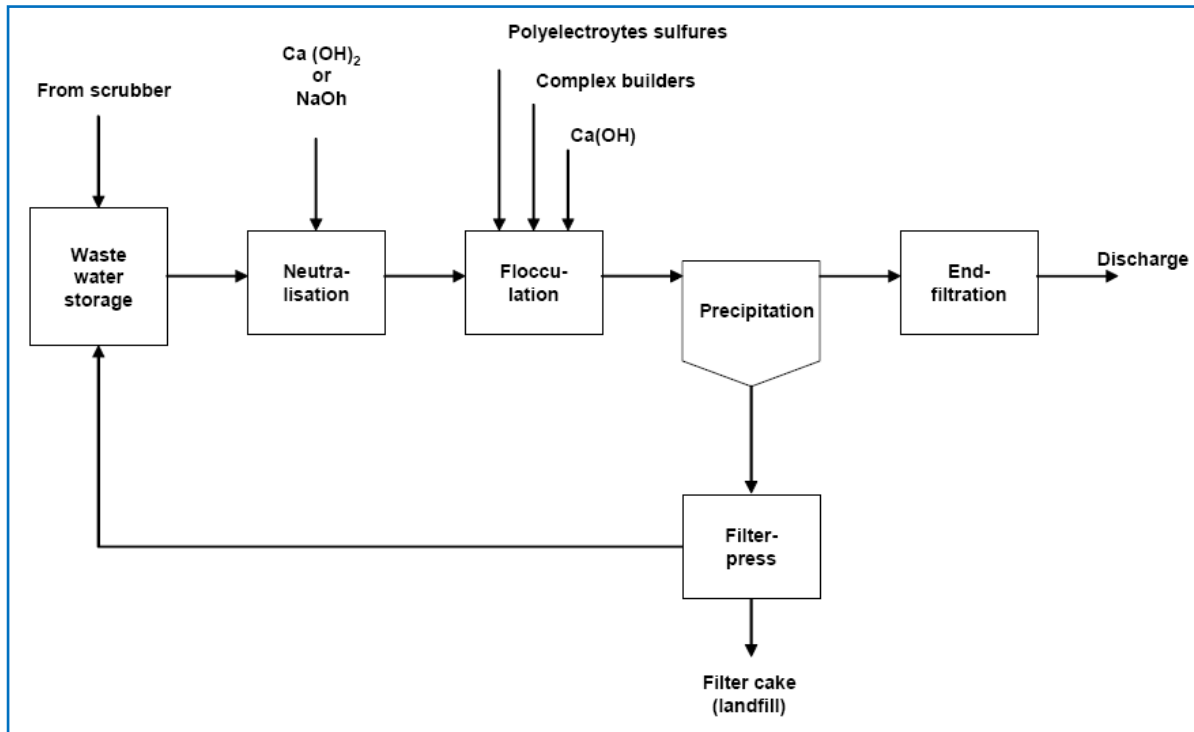
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Figure 3-1: Schematic Illustrating Physical/Chemical Treatment of Wastewater from a Wet APC System^[72]



Source: Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste

The process consists of the following steps:

- pH neutralization – normally lime is used resulting in the precipitation of sulphites and sulphates (gypsum)
- Flocculation and precipitation of heavy metals and fluorides – takes place under the influence of flocculation agents (poly-electrolytes) and FeCl_3 ; additional complex builders can be added for the removal of mercury
- Gravitation (precipitation) of the formed sludge – takes place in settling tanks or in lamellar separators
- Dewatering of sludge – normally achieved through dewatering filter presses
- End-filtration of the effluent (polishing) – via sand filters and/or activated carbon filters, removing suspended solids and organics such as dioxins/furans (if activated carbon is used).

⁷² Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste.

In addition to the process steps listed above, facilities may also apply:

- Sulphides for heavy metal removal
- Membrane technologies for removal of salts
- Ammonia stripping (if SNCR is used to control NO_x)
- Separate treatment of wastewater from the first and last steps of the scrubber system (allows for the production of high quality gypsum)
- Anaerobic biological treatment to convert sulphates into elemental sulphur.

3.2.2 In-line Evaporation of Wastewater

With this treatment option, the wastewater is reused in the process line in a spray-dryer. The waste water containing soluble salts is first neutralized and then injected into the flue gas stream. The water evaporates and the remaining salts and other solid pollutants are removed in the dust removal step of the APC train (e.g., bag filter). The neutralization step can be combined with flocculation and the settling of pollutants, resulting in a separate residue (filter cake). In some systems, lime is injected into the spray absorber for gas pre-neutralization.

This method is only employed at facilities that utilize spray-dryers and wet scrubbers. A spray dryer functions in a similar way to a spray adsorber (used in semi-dry APC systems). The main difference between the two is that the spray dryer uses wastewater from the wet scrubber (instead of lime) after the wastewater has been neutralized.

Figure 3-2 presents a schematic overview of in-line evaporation of wastewater.

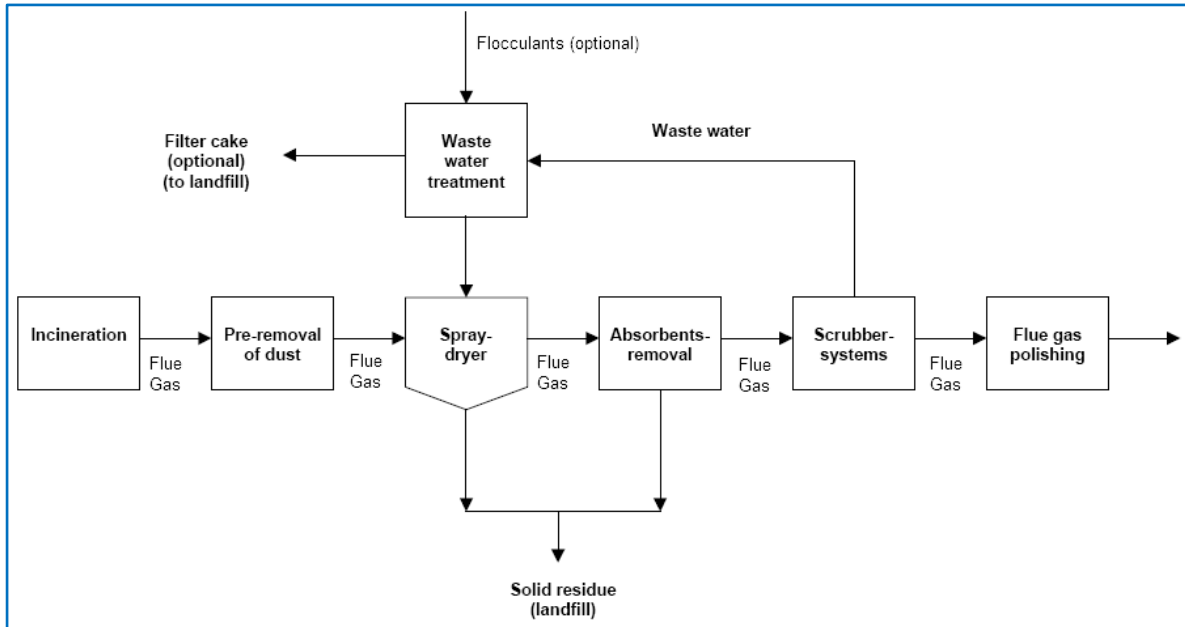
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Figure 3-2: Schematic Illustrating In-line Evaporation of Wastewater^[73]



Source: Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste

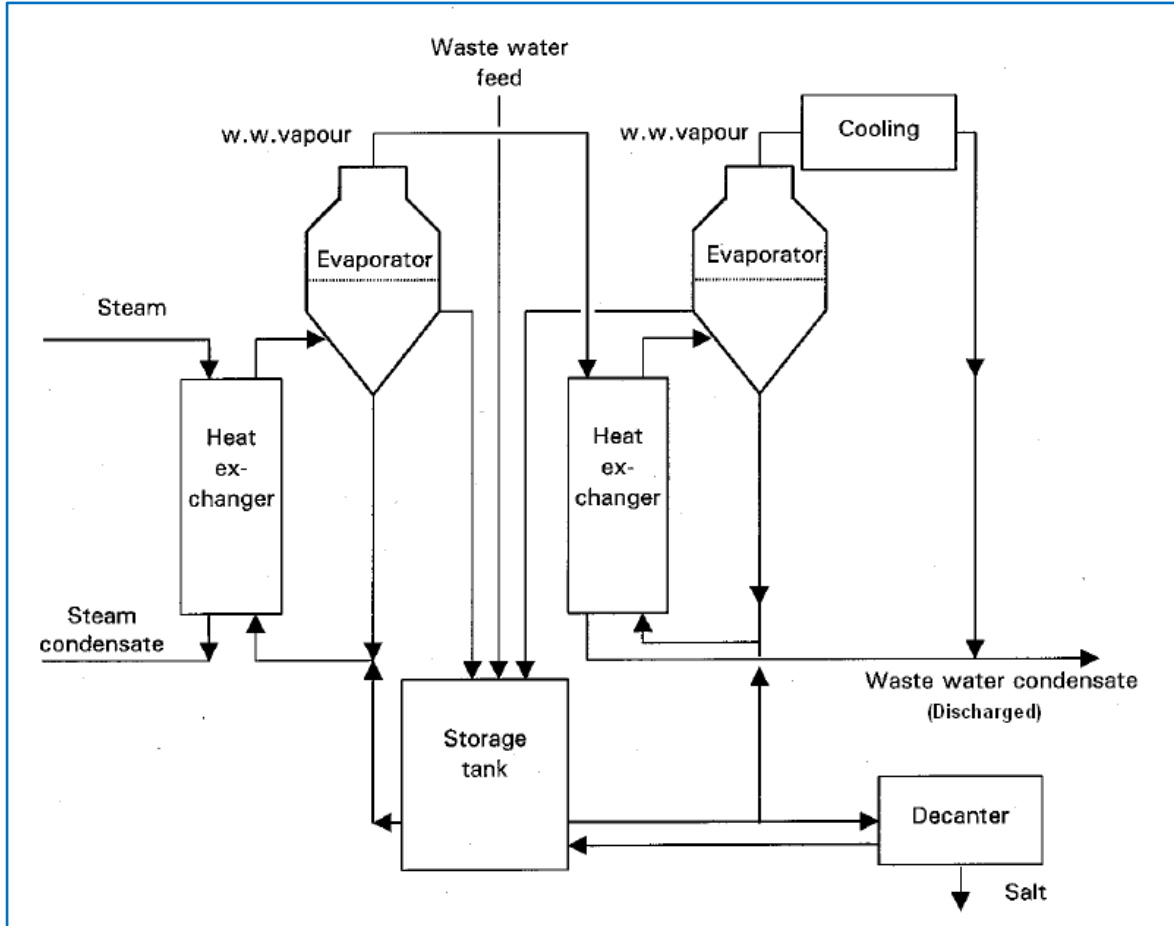
3.2.3 Separate Evaporation of Wastewater

In this process, wastewater is evaporated using a steam heated evaporation system. Wastewater is fed into a storage tank where it is heated (using heat supplied via a heat-exchanger). The heat acts to partially evaporate the liquid out of the storage tank. The un-evaporated liquid flows back to the storage tank while the vapours produced by evaporation eventually cool down resulting in a clean condensate which can be discharged directly from the facility. As evaporation continues the salt concentrations in the liquid rise, resulting in crystallization of the salts which can be separated in a decanter and collected in a container and disposed of in a landfill.

Figure 3-3 displays a two-stage process with two evaporators installed, where the input of heat into the second evaporator is the vapour from the first evaporator (results in less energy demand).

⁷³ Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste.

Figure 3-3: Schematic Illustrating Separate Evaporation of Wastewater^[74]



Source: Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste

3.2.4 BAT for Effluent Management

As discussed in Section 3.2, effluent management is more often required for WTE facilities that include wet scrubbers as a component in the APC train, (i.e., facilities with a wet APC train).

The following effluent treatment and operational parameters for wet APC systems are considered BAT.^{[75] [76] [77]}

⁷⁴ Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste

⁷⁵ Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on Bat

⁷⁶ Federal Environment Agency – Austria. 2002. State of the Art for Waste Incineration Plants

⁷⁷ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration.

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- The use of onsite physical/chemical treatment of effluent prior to discharge to achieve at the point of discharge from the effluent treatment plant (ETP) effluent concentrations within the range identified in Table 3-3.^[78]
- The separate treatment of the acid and alkaline wastewater streams arising from scrubber stages when there are particular drivers for additional effluent discharge reduction, and/or where HCl and/or gypsum recovery is to be carried out.
- The re-circulation of wet scrubber effluent within the scrubber system so as to reduce scrubber water consumption and in general the re-circulation and re-use of wastewater arising from the site (i.e., using boiler drain water for reuse in the wet scrubber).
- The provision of storage/buffering capacity for effluents to provide for a more stable treatment process.
- The use of sulphides or other mercury binders to reduce mercury in the treated effluent.
- The assessment of dioxin and furan build up in the scrubber and adoption of suitable measures to prevent scrubber breakthrough of these contaminants.
- When SNCR is used the ammonia levels in the effluent may be reduced using ammonia stripping and the recovered ammonia re-circulated for use in the SNCR.

Table 3-3: BAT Associated Operational Emissions Levels for Discharges of Wastewater from Effluent Treatment Plants Receiving APC Scrubber Effluent^[79]

Parameter	BAT Range in mg/L (unless stated)	Sampling and Data Information
Total Suspended Solids	10 – 30 (95%) 10 – 45 (100%)	Based on 'spot daily' or 24 hour flow proportional sample
Chemical Oxygen Demand	50 – 250	Based on 'spot daily' or 24 hour flow proportional sample
pH	6.5 – 11	Continuous measurement
Hg and its compounds	0.001 – 0.03	Based on monthly measurements of a flow proportional representative sample of the discharge over a period of 24 hours with one measurement per year exceeding the values given, or no more than 5% where more than 20 samples are assessed per year.
Cd and its compounds	0.01 – 0.05	
Tl and its compounds	0.01 – 0.05	
As and its compounds	0.01 – 0.15	
Pb and its compounds	0.01 – 0.1	Total Cr levels below 0.2 mg/L provide for control of Chromium VI.
Cr and its compounds	0.01 – 0.5	Sb, Mn, V and Sn are not included in Directive 2000/76. Average of six monthly measurements of a flow proportional representative sample of the discharge over a period of 24 hours.
Cu and its compounds	0.01 – 0.5	
Ni and its compounds	0.01 – 0.5	
Zn and its compounds	0.01 – 1.0	

⁷⁸ European Commission. 2006. Integrated Pollution Prevention and Control: Reference Document on the Best Available Techniques for Waste Incineration.

⁷⁹ European Commission. 2006. Integrated Pollution Prevention and Control: Reference Document on the Best Available Techniques for Waste Incineration.

Parameter	BAT Range in mg/L (unless stated)	Sampling and Data Information
Sb and its compounds	0.05 – 0.85	
Co and its compounds	0.005 – 0.05	
Mn and its compounds	0.02 – 0.2	
V and its compounds	0.03 – 0.5	
Sn and its compounds	0.02 – 0.5	
PCDD/F (TEQ)	0.01 – 0.1 ng TEQ/L	

NOTES:

1. Values are expressed in mass concentrations for unfiltered samples
2. Values relate to the discharge of treated scrubber effluents without dilution
3. BAT ranges are not the same as ELVs
4. pH is an important parameter for wastewater treatment process control
5. Confidence levels decrease as measured concentrations decrease towards lower detection levels

SPLIT VIEWS:

1. BAT 48: One Member State and the Environmental NGO expressed split views regarding the BAT ranges. These split views were based upon their knowledge of the performance of a number of existing installations, and their interpretation of data provided by the thematic working group (TWG) and also of that included in the BREF document. The final outcome of the TWG meeting was the ranges shown in the table above but with the following split views recorded: Hg 0.001 – 0.01 mg/l; Cd 0.001 – 0.05 mg/l; As 0.003 – 0.05 mg/l; Sb 0.005 – 0.1 mg/l; V 0.01 – 0.1 mg/l; PCDD/F <0.01 – 0.1 ng TEQ/l.
2. BAT 48: Based on the same rationale, the Environmental NGO also registered the following split views: Cd 0.001 – 0.02 mg/l; TI 0.001 – 0.03 mg/l; Cr 0.003 – 0.02 mg/l; Cu 0.003 – 0.3 mg/l; Ni 0.003 – 0.2 mg/l; Zn 0.01 – 0.05 mg/l; PCDD/F <0.01 ng TEQ/l.

As discussed previously in Section 3.2, not all WTE facilities that utilize Wet APC systems actually produce effluent discharge. Refer to Section 3.2.2 and 3.2.3 for a full description of these techniques.

3.3 Solid Wastes

Waste incineration leads to weight and volume reduction of wastes. The solid wastes generated by WTE facilities will vary based on the design of the plant, and can consist of: reject wastes (removed prior to combustion), bottom ash, metallic scrap, APC residues, slag (depending on the facility design), filter cake from wastewater treatment, gypsum and loaded activated carbon. These material streams are discussed briefly below.

3.3.1 Reject Waste

The MSW stream commonly includes various materials that should not enter the combustion chamber either as they will not efficiently combust due to their size and composition (e.g., metal appliances) or as they could cause damage within the combustion unit (e.g., propane tank). Depending on the design of the WTE facility, there will be a specified range of materials that will be identified as unacceptable for combustion. Generally, screening and removal of these materials will take place on the floor of the reception building as each load of material is emptied onto the tipping floor/bunker. In addition, operators who manage the loading of the combustion chambers also remove certain materials when they are observed in the loading process. Generally, approximately

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2% of the waste received at a WTE will be rejected and removed for alternate disposal. In addition, depending on the length of the scheduled or unscheduled down-time associated with plant maintenance, it is possible MSW would have to be redirected to alternate disposal.

3.3.2 Bottom Ash

Bottom ash is the mineral material left after the combustion of the waste. Bottom ash is a heterogeneous mixture of slag, metals, ceramics, glass, unburned organic matter and other non-combustible inorganic materials, and consists mainly of silicates, oxides and carbonates. Typically, bottom ash makes up approximately 20 – 25% by weight or 5 to 10% by volume of the original waste.^[80] At most incineration facilities, bottom ash is mechanically collected, cooled and magnetically or electrically screened to recover recyclable metals. The remaining residue is either disposed of at a landfill, or alternatively, it may be used as a construction aggregate substitute.^[81] Further information is presented in Section 9.1.1 and 9.3. In some cases (e.g., gasification) the mineral material left after combustion of the waste is generated as a slag, but is generally managed in a similar fashion as bottom ash.

3.3.3 Recycling of Metals

Most WTE facilities include equipment to remove ferrous metals from the bottom ash. Recovery of non-ferrous metals (primarily aluminum) has also become more common. Depending on the composition of the incoming MSW stream, recovered metals can represent up to 10% of the input tonnage to the WTE facility. Generally, WTE facilities can recover approximately 80% of ferrous and 60% of non-ferrous metals present in the bottom ash. Separated metallic scrap is either delivered to a scrap dealer or returned to the steel industry.

3.3.4 Primary APC Residues

APC residues are the residues resulting from the APC system and other parts of incinerators where flue gas passes (i.e., superheater, economizer). APC residues are usually a mixture of lime, fly ash and carbon and are normally removed from the emission gases in a fabric filter baghouse.

APC residues contain high levels of soluble salts, particularly chlorides, heavy metals such as cadmium, lead, copper and zinc, and trace levels of dioxins and furans. The high levels of soluble, and therefore leachable, chlorides primarily originate from polyvinyl chloride (PVC) found in MSW. Typically, APC residues make up approximately 2 – 4% by weight of the original waste.^[82] Generally APC residues are managed separately from bottom ash as they are often classified as a hazardous waste. Common practice for APC residue management is to stabilize or otherwise treat these

⁸⁰ AECOM Canada Ltd. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling. June, 2009.

⁸¹ AECOM Canada Ltd. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling. June, 2009.

⁸² Algonquin Power Energy from Waste Facility Fact Sheet, <http://www.peelregion.ca/pw/waste/facilities/algonquin-power.htm#ash>

residues and/or to dispose of them at a hazardous waste facility. Methods of managing these residues are discussed in Sections 9.1.2 and 9.3.

3.3.5 Other APC Residues

Other residues generated by APC systems generally consist of used reagent materials (e.g., activated carbon) or residues recovered through effluent treatment. The generation of these other APC residues is dependent on the APC design. In general, the filter cake from wastewater treatment is heavily charged with Hg, Zn and Cd. In most cases it must be managed as a hazardous waste and treated or disposed of at secure hazardous waste facilities. For WTE facilities that use activated carbon in their APC train, it has become more common to combust the loaded activated carbon together with waste.

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4 AIR EMISSIONS CONTROLS

When using any WTE technology to treat MSW, some emissions to air are produced. In conventional combustion, the emissions to air are the result of the actual combustion of MSW. In gasification or pyrolysis, the emissions to air are associated with the combustion of the syngas or pyrolysis products to produce usable energy.

Over the years, vast technological improvements have been made which have assisted in greatly reducing the quantity and toxicity of emissions being released into the atmosphere. Generally speaking, these emissions controls can be grouped into two main categories:

- Operational controls, which act to increase the efficiency of the WTE process leading to lesser production of harmful emissions
- Air Pollution Control (APC) systems, which are usually placed on the back end of a WTE facility and act to capture/treat emissions before they are released.

The following two subsections discuss these operational controls and air pollution control systems. Both of these controls are primarily discussed as they relate to mass burn incineration (conventional combustion) facilities as this is the most common form of WTE technology being used worldwide to treat MSW. Some information regarding operational and APC systems for gasification is also provided, however, much less information is available in comparison to that available for mass burn incinerators as there are very few gasification facilities in operation worldwide that treat MSW in comparison to hundreds of mass burn incinerators. As mentioned previously in this report, gasification is less commercially proven than mass burn incineration in the treatment of MSW.

Little information is available regarding the emissions controls applicable for other WTE technologies.

4.1 Operational Controls

There are a number of operational controls^[83] used in modern WTE facilities that act to increase system performance and efficiency and by doing so, assist in reducing the formation of unwanted byproducts and pollutants. Operational controls act to reduce emissions (to air and water) and also assist in improving the quality of ash produced by a WTE facility. These operational controls are in addition to conventional “back end” air pollution controls that will be discussed further in Section 4.2.

Many of these operational controls have been developed over time as the understanding of WTE processes has increased. This understanding has allowed engineers to fine-tune the waste treatment process to prevent or reduce the creation of unwanted byproducts during waste treatment rather than having to remove these byproducts at the back end of a facility using air pollution control equipment. As mentioned earlier, these operational controls have also helped to increase the performance and efficiency of waste treatment technologies. Better operational controls allow for

⁸³ Much of this material adapted from A.J. Chandler and Associates Ltd. 2006. Review of Dioxins and Furans from Incineration in Support of a Canada-wide Standard Review

more environmentally and economically friendly operation of WTE facilities, and are one of the reasons why such WTE approaches are more broadly accepted in jurisdictions such as the EU.

The operational controls currently being used in modern mass burn incinerators (conventional combustion) and gasification facilities are discussed below.

4.1.1 Operational Controls for Mass Burn Incineration (Conventional Combustion)

In mass burn incinerators, operational controls have been developed to reduce the formation and release of unwanted byproducts (such as NO_x, dioxins/furans, and CO) during the incineration of MSW. Modern mass burn incinerators are designed with highly complex operational controls that ensure the safe and efficient combustion of waste with the accompanying capture of energy.

The operational/combustion controls used in mass burn incinerators compensate for the compositional variability of MSW and act to control the rate of combustion reactions.

The composition of MSW is highly variable and depends on a number of uncontrollable factors such as the general behavior of residents, use of available waste diversion programs and the demographics of the community the WTE facility serves.

The variable composition of MSW affects operational efficiency because each component of the waste stream has its own particular energy content which must be matched with a particular amount of oxygen to ensure proper and efficient combustion of the waste stream. For example, if a large amount of paper is being placed in the refuse stream, this will increase the overall energy content of the material and affect its behavior as a fuel source. In order to ensure that proper combustion conditions are met, the MSW stream must be made as homogenous as possible before and during incineration.

One way to increase the homogeneity of MSW is to ensure that the waste material is well mixed prior to being combusted. This can be accomplished by mixing waste with the grapple crane prior to placing the waste material into the hopper. Even after proper mixing, however, MSW heat values are still quite variable.

This variability is accounted for within the furnace by operational controls. Mass burn incinerators monitor the heat being released from the waste at all times and are able to adjust air flow (oxygen) to compensate for changes in waste composition. Modern facilities also compensate by adjusting the waste fuel feed rate. For example, if too little heat is being produced, more waste can be fed to the incinerator to ensure enough energy is present in the combustion zone. Conversely, if waste with higher energy content enters the furnace, the feed rate can be reduced.

Combustion control is very important to reduce the creation of harmful byproducts (such as CO, TOC and NO_x) as much as possible. Many intermediate steps are involved in the oxidation of long chain hydrocarbons in the combustion gas to products of complete combustion (carbon dioxide and water). By ensuring complete combustion, the creation of unwanted byproducts is minimized and the amount of energy captured from the waste is maximized.

Generally speaking, proper combustion conditions that discourage the generation of unwanted byproducts are those that:

- Ensure that there is complete mixing of the fuel and the air
- Maintain high temperatures in the presence of an adequate amount of oxygen
- Have proper mixing or agitation to prevent the formation of quench zones or low temperature pathways that would allow partially-reacted solids or gases to exit from the combustion chamber.

It is particularly important to prevent the generation of soot in the system because carbon present in the fly ash will lead to increased formation of dioxins and furans. The formation of soot is reduced by following the proper operational controls as discussed above.

The furnace of a typical modern mass burn incineration facility used in the North American market is designed to provide at least a one second retention time at a temperature of approximately 1,000°C in the combustion zone (after the last point of air injection) while processing waste. This has generally been accepted in North American regulations/guidelines as an appropriate requirement. Maintaining 1,000°C for one second in the combustion zone has been recognized by the EU as a condition that can result in internal corrosion, in part as it may cause the fly ash present in the flue gas to melt. The requirements established in the EU are for a minimum two second retention time at 850°C. Both of these temperatures, in combination with the respective retention time, are high enough to ensure the complete destruction of organic substances present in the waste. Even during waste feeding and non-emergency shutdowns, the temperature in the combustion zone is not allowed to fall below 850 – 1,000°C.^[84] Auxiliary burners are used to maintain temperature and residence time in the furnace.

There is merit in considering application of the approach applied in the EU within the BC guideline. At issue is the combustion 'zone' in which the flue gas must be held at or above the required temperature. Generally, this is defined as the last point of air injection (i.e., the over-fire air provided to ensure complete combustion). Depending on the design of the WTE facility, maintaining 1,000°C for one second after this point of air injection may have undesirable consequences. Molten particles within the flue gas can cause fouling and/or corrosion of the heat transfer surfaces for the boiler. Design of the combustion chamber and boiler must address the need to cool the flue gas to approximately 650°C before it reaches the heat transfer surfaces of the boiler. Therefore, some flexibility in specifying the combination of temperature and residence time is necessary to take into account incinerator-specific operational factors.

Several new technologies have been developed to reduce the production of NO_x during combustion by re-circulating part of the flue gas (FGR). These technologies are often applied in Europe. One such technology is Covanta's very low NO_x (VLN™) system. This technology was developed by Martin GmbH in cooperation with partner companies such as Covanta and is described in more detail

⁸⁴ Durham/York Residual Waste Study Environmental Assessment, November 27, 2009, Stantec Consulting Ltd

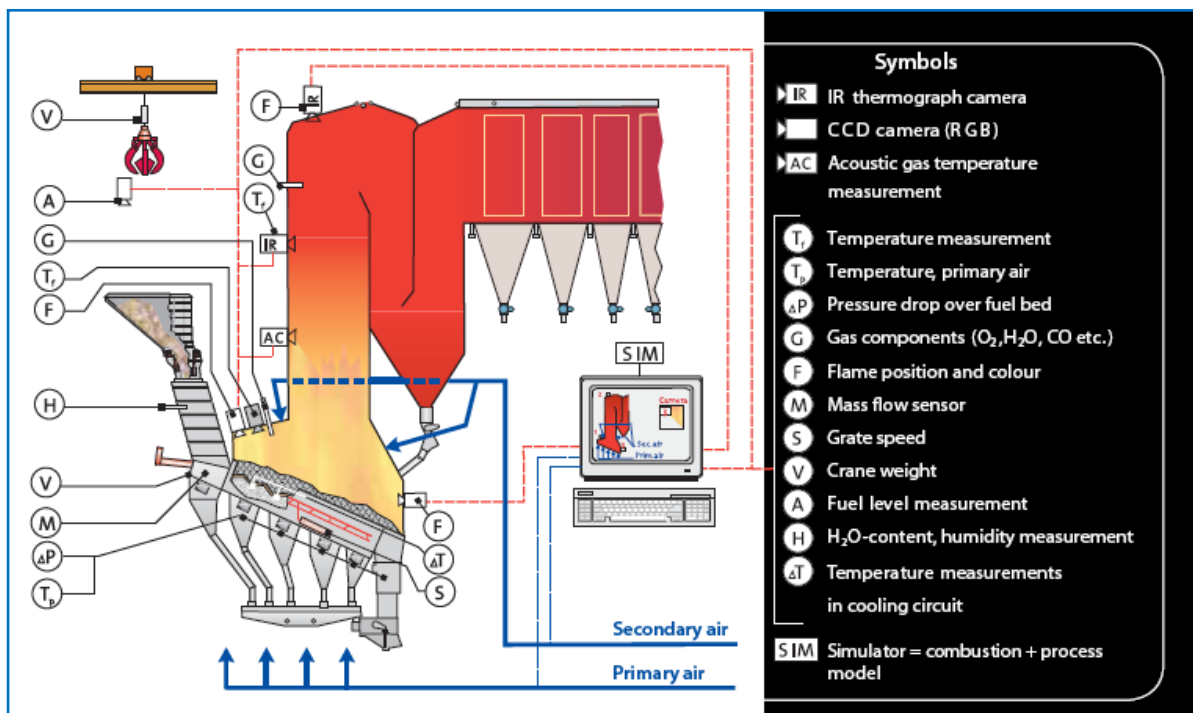
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below.^[85] Another NO_x reduction system has been developed by VonRoll/Wheelabrator, called the VLNR (very low NO_x reduction) system. The system is based on injection of ammonia/urea at various levels. The injection of ammonia/urea is strictly controlled in order to ensure reaction at the most optimal time. Other vendors are using the same principle where it is possible to inject ammonia/urea at different levels depending on the optimum temperature but have not promoted their systems under specific trade names.

Figure 4-1 provides a schematic overview of the furnace operational controls typical for a modern mass burn WTE facility.^[86]

Figure 4-1: Control Components of a Modern Furnace Control System



Source: Babcock and Wilcox Volund. 2009. 21st Century Advanced Concept for Waste-Fired Power Plants: A Solution to Asia's Mounting Waste Problems

The following list identifies a number of the advantages associated with the use of proper operational controls during the waste incineration process.^[87]

- Better bottom ash quality (due to sufficient primary air distribution and a better positioning of the incineration process on the grate)
- Less fly ash production (due to less variation in the amount of primary incineration air)

⁸⁵ Martin GmbH für Umwelt- und Energietechnik: http://www.martingmbh.de/index_en.php?level=2&CatID=6.79&inhalt_id=66, 2010

⁸⁶ Babcock and Wilcox Volund. 2009. 21st Century Advanced Concept for Waste-Fired Power Plants: A Solution to Asia's Mounting Waste Problems.

⁸⁷ Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste.

- Better fly ash quality (less unburned material, due to more stable process conditions in the furnace)
- Less CO and hydrocarbon formation (due to more stable process conditions in the furnace, i.e., no cold spots)
- Less (risk of) formation of dioxin (-precursors) (due to a more stable process in the furnace)
- Better utilization of the plant capacity (because the loss of thermal capacity by variations is reduced)
- Better energy efficiency (because the average amount of incineration air is reduced)
- Better boiler operation (because the temperature is more stable, there are less temperature 'peaks' and thus less risk of corrosion and clogging fly ash formations)
- Better operation of the flue gas treatment system (because the amount and the composition of the flue gas is more stable)
- Less maintenance and better plant availability.

The following subsection provides further details for one example of operational NO_x control that can be applied in North America.

Operational NO_x Control: Example Covanta VLN™

The Covanta VLN™ process utilizes a unique combustion air system design, combined with an advanced combustion monitoring and control system, to achieve substantial reduction in NO_x formation. The VLN™ process, in addition to the conventional primary and secondary air systems, features an internal recirculation gas (IRG) injection system located in the upper furnace. IRG is an internal stream drawn from the rear of the combustor, above the burnout zone of the grate. The distribution of flows between the primary air, secondary air and IRG gas streams is controlled to yield the optimal combustion gas composition and temperature profile to minimize NO_x and control combustion. The control methodology takes into account the heating value of the waste and the fouling condition of the furnace.

Figure 4-2 presents a schematic overview of the Covanta VLN™ Process.

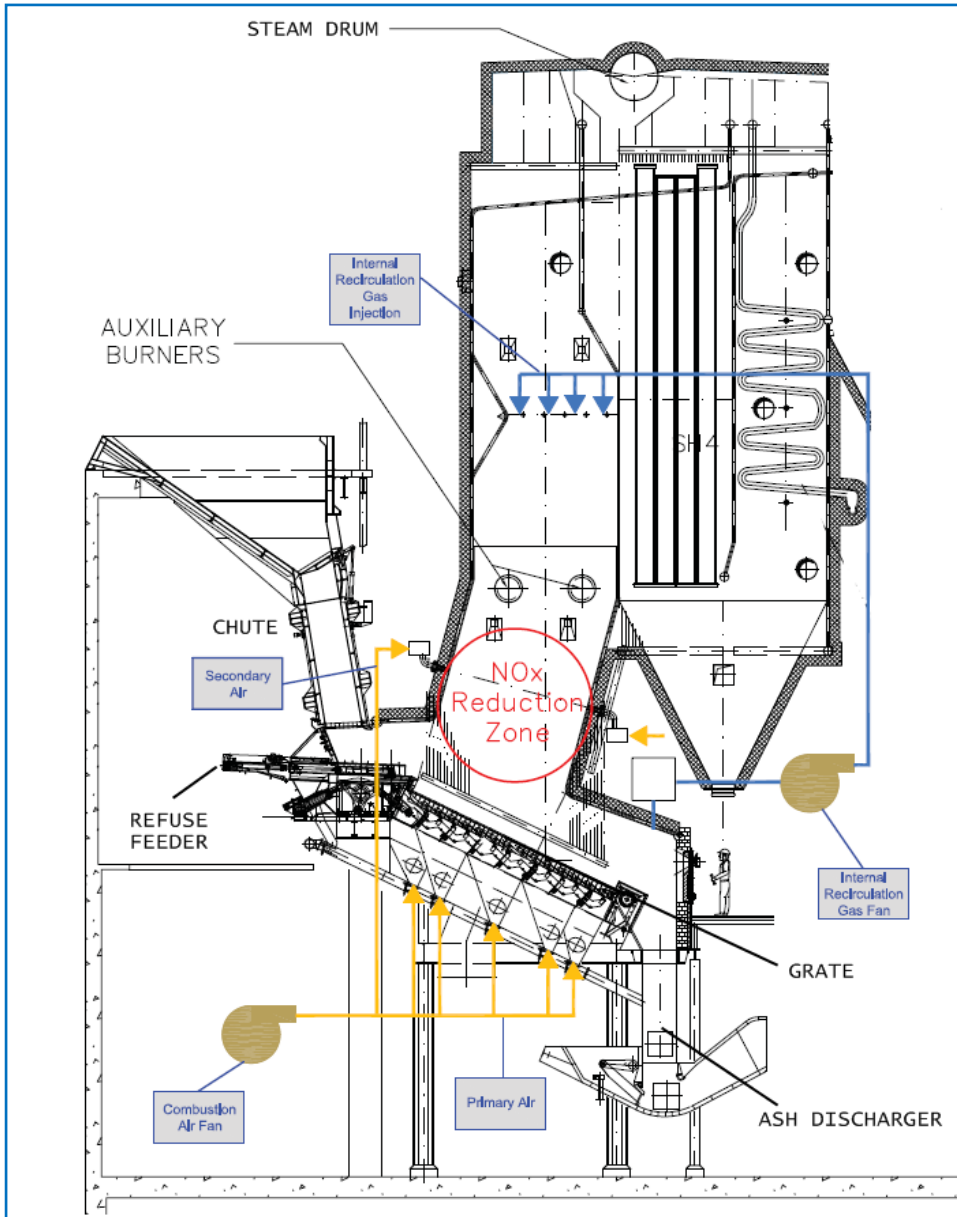
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Figure 4-2: Conceptual Schematic Diagram of Covanta VLN™ Process



Source: Durham/York Residual Waste Study Environmental Assessment, November 27, 2009, Stantec Consulting Ltd

4.1.2 Operational Controls for Gasification Systems

As mentioned previously in this report, technologies that gasify MSW are much less proven than conventional combustion technologies. For that reason, information describing the operational controls used by gasification technologies is quite sparse compared to the operational controls used by mass burn incinerators. Further, the operational controls used by a gasification facility will depend

on the specific gasification technology being considered. For instance, the operational controls used in the Nippon Steel gasification process discussed below are different from those used in the Thermoselect process because there are some fundamental differences between the technologies.

The following paragraphs describe the operational controls used by gasification facilities utilizing the Nippon Steel “Direct Melting System” technology. The Japanese Nippon Steel technology is discussed here as it is one of the more commercially proven MSW gasification technologies, as noted in Section 2.2.1.2. As of 2009, Nippon Steel had 28 operational plants in Japan and one in Korea, which together process more than 1.9 million tonnes of MSW, sewage sludge and other residues per year.^[88]

The Nippon Steel “Direct Melting System” operates as follows.^[89] MSW is fed into the top of the furnace (by a crane) with the required amounts of coke and limestone. The waste is charged into the melting furnace when the signal from the burden level meter (installed in the furnace) indicates that the burden level has dropped to the specified level. At the base of the melting furnace, molten materials are discharged into a water granulator and are then separated into slag and metal. The syngas produced is transferred to a combustion chamber. The heat is recovered from the gas via a hot-water generator and then the flue gas is treated by APC equipment before it is released from the stack.

The following list illustrates the digital control systems utilized by the Nippon Steel technology:

- The waste, coke and limestone feed rates and the molten residue generation rate are all measured and recorded to ensure proper feed rates.
- The pressure and temperature in the melting furnace and combustion chamber and the flow rate of air supplied to the melting furnace and combustion chamber are all continually monitored to ensure efficient operation.
- The composition of syngas leaving the melting furnace (CO, CO₂, O₂, CH₄, H₂) and supplied to the combustion chamber, and the composition of the waste gas leaving the combustion chamber (CO₂, O₂, CO, NO_x) are also continuously monitored.

All this data is sent into a distributed control computer and used for real-time analysis of material balance and to ensure the plant is operating at optimal efficiency. Figure 4-3 illustrates the instrumentation system used in one of Nippon Steel’s demonstration plants.^[90] It should be noted that the APC train depicted in the figure is from one of Nippon Steel’s older facilities. Their newer facilities tend to include a bag filter and NO_x reduction system.

⁸⁸ University of California, Riverside. 2009. Evaluation of Emissions from Thermal Conversion Technologies Processing Municipal Solid Waste and Biomass

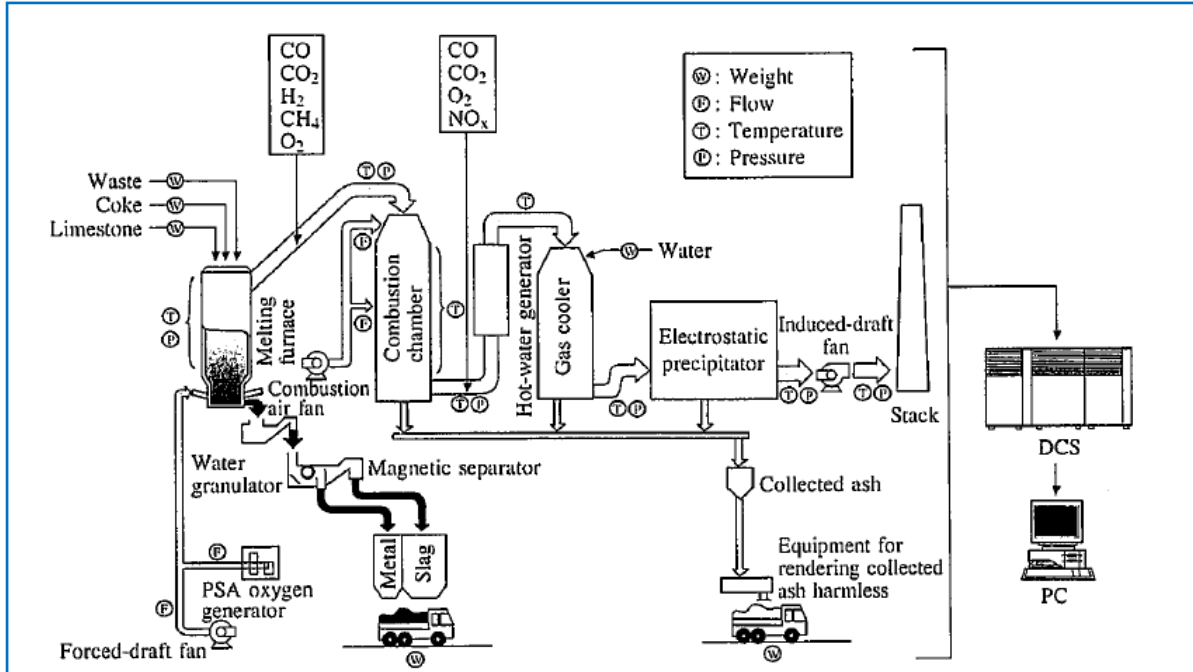
⁸⁹ It should be noted that all Nippon Steel facilities utilize the DMS technology.

⁹⁰ Nippon Steel Technical Report No. 70. July 1996. Research and Development of Direct Melting Process for Municipal Solid Waste

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Figure 4-3: Conceptual Diagram of Operational Controls Used by Nippon Steel



Source: Nippon Steel Technical Report No. 70. July 1996. Research and Development of Direct Melting Process for Municipal Solid Waste

4.2 Air Pollution Control Systems

WTE facilities convert municipal solid waste into gaseous, liquid and solid conversion products with a simultaneous or subsequent release of heat energy which is captured. Air emissions released from WTE facilities generally arise from the compounds present in the waste stream, and are formed as a normal part of the combustion process.

In order to reduce the environmental impacts associated with WTE facilities air pollution control (APC) systems have been developed. In general, APC systems are used to cool flue gases, scrub acidic gases and capture particulate matter and various contaminants such as heavy metals and trace organics.

Significant improvements have been made in APC systems of WTE incinerators over the past few decades and advancements continue to be made to the types of APC systems used for both MSW and Hazardous Waste incinerators.^[91]

Up to the mid-1960s, waste incineration flue gas treatment was relatively simple. A common method was to cool the flue gas down to a temperature of 250 – 300°C by injecting water (evaporative cooling) and the flue gas was passed through a cyclone to remove fly ash. In the late 1970s and

⁹¹ A.J. Chandler & Associates Ltd.

1980s, semi-dry and wet flue gas treatment systems were developed, followed by systems to address NO_x and dioxins (mainly based on activated carbon) in the late 1980s and 1990s. These systems included the introduction of bag filters for dust removal.^[92]

There are a large number of air pollution control technologies that are currently used by WTE facilities worldwide to control the release of harmful pollutants to the atmosphere. Most of these controls are post-combustion controls, or controls added to the back-end of an incinerator to remove the unwanted byproducts of incineration. The sub-sections below provide an overview of the most common air pollution control technologies and how they act to limit the release of pollutants.

These sub-sections generally describe the primary elements of a conventional APC system, followed by identification of some of the more common APC trains.

4.2.1 Primary Air Pollution Control System Components

This section provides an overview of the primary components that would be included in the APC train for a WTE facility. Further discussion in Section 4.2.2 describes factors and aspects considered to select and combine these various components together within APC trains.

4.2.1.1 Activated Carbon Adsorption (Mercury, Dioxin/Furan Control)

Activated Carbon is used in an APC system to control the release of trace organics (including dioxins/furans) and mercury into the atmosphere. Activated carbon achieves this by adsorbing these chemicals onto its surface.

There are two main types of activated carbon adsorption systems, namely powdered activated carbon (PAC) injection and carbon bed filters (known commercially as activated char reactors (ACR) or absorbers). By far, the most common type used in WTE facilities is PAC injection (six of the seven facilities currently operating in Canada use this form of carbon adsorption).^[93] The following paragraphs present an overview of the two types of systems.

PAC injection systems are used at the back end of WTE facilities as the first step in flue gas treatment following incineration. This is the method that is being considered in the proposed Durham/York incinerator project and is currently used at the Algonquin Power incinerator in the Peel Region.^{[94],[95]} PAC injection systems operate in the following way. Powdered activated carbon is injected into the flue gas prior to a fabric filter baghouse (this will be discussed later) and dioxins/furans and volatilized mercury are adsorbed onto the carbon particles. The particles of activated carbon with adsorbed organic molecules are then captured in the fabric filter baghouse where it forms a cake on the filter's surface allowing for additional adsorption as well as filtering. While PAC injection systems have lower removal efficiency as compared with fixed activated carbon

⁹² Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT For the Incineration of Waste

⁹³ GENIVAR Ontario Inc. in association with Ramboll Danmark A/S, 2007. *Municipal Solid Waste Thermal Treatment in Canada*

⁹⁴ <http://www.peelregion.ca/pw/waste/facilities/algonquin-power.htm#apc>

⁹⁵ Durham/York Residual Waste Study Environmental Assessment, November 27, 2009, Stantec Consulting Ltd

bed filter systems, the injection of powdered activated carbon into the gas stream is a far less expensive method of removing dioxin/furans and mercury from the flue gas.

Fixed activated carbon bed filters can be installed at the end of the APC system to clean gases and remove trace organics and mercury before the flue gas is released into the atmosphere. The carbon bed filter consists of a vertical chamber with a bed depth of typically between 0.5 to 1 m. Carbon bed filters allow for a maximum flue gas velocity of 0.2 m/s and require an operating temperature of between 120 and 150°C to avoid condensation.

Carbon bed systems have the highest known removal efficiency for dioxins and furans (>99.9%) as well as for many other pollutants and are commonly used in Europe, Asia and Australia. The major disadvantage of the carbon filter system is the capital investment and operating costs associated with these systems, as well as the need for proper disposal of spent carbon adsorbent. In Europe, the spent carbon adsorbent is usually combusted in the incinerator. Both PAC injection systems and carbon bed systems can be used to achieve regulatory compliance in the jurisdictions studied within this report, and can achieve compliance with the most stringent of the regulatory limits. As a result, the decision to use either system may often be based on cost, as part of a reasonable BACT assessment process.

4.2.1.2 Fabric Filter Baghouses (Particulate Matter Control)

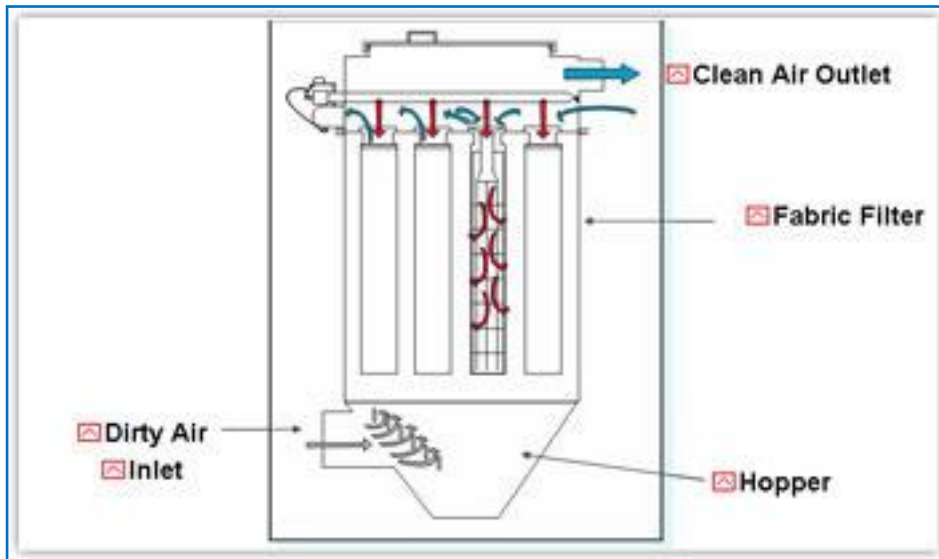
Fabric filter baghouses are used to remove particulate matter from the WTE flue gas before it is released into the atmosphere. Their operation is fairly simple: as flue gases pass through a tightly woven fabric, particulate matter collects on the fabric, preventing it from being released into the atmosphere. The “dust cake” which forms on the surface of the filter due to the collection of particulate matter also helps (up to a point) to increase the filtering efficiency by creating an increased barrier to air movement.

Baghouses are classified based on the method used to clean them. There are two main types of baghouse systems: reverse air baghouses and pulse-jet fabric filters. In a reverse-air baghouse, the flue gas flows upward through the insides of vertical bags which open downward. Fly ash from the flue gas collects on the insides of the bags, and the flow of gas keeps the bags inflated. To clean the bags, a compartment of the baghouse is taken off-line, and the gas flow in this compartment reversed. This causes the bags to collapse, and collected dust to fall from the bags into hoppers. The cleaning cycle in a reverse-air baghouse typically lasts about three minutes per compartment. Because reverse-air cleaning is gentle, reverse-air baghouses typically require a low air-to-cloth ratio.

In a pulse-jet fabric filter, the dirty flue gas air flows from the outside of the bags inward, and the bags are mounted on cages to keep them from collapsing. Dust which collects on the outsides of the bags is removed by a reverse pulse of high-pressure air. This cleaning does not require isolation of the bags from the flue gas flow, and thus may be done on-line. Because pulse-jet cleaning is harsh, the bags remain relatively clean, so that a higher air-to-cloth ratio (i.e., a smaller baghouse as

compared to reverse-air) may be used. Figure 4-4 illustrates a schematic overview of a pulse-jet type fabric filter baghouse.^[96]

Figure 4-4: Schematic Overview of a Pulse-Jet Fabric Filter Baghouse



Source: http://www.neundorfer.com/FileUploads/RichTextboxImages/Image/pulse_jet_baghause.jpg

Baghouse performance is determined by a variety of factors including the fabric chosen, the cleaning frequency and methods, and the particulate characteristics. A number of different fabrics can be used in baghouses. Fabrics can be chosen which will intercept a greater fraction of the particulate. Some fabrics are coated with a membrane with very fine openings for enhanced removal of submicron particulate. However, often these highly efficient fabrics are much more expensive than more conventional materials.

It is important to realize that the particles are not only caught by interception. Electrostatic forces and Brownian movements also play a role, especially for particles that seem to be too small to be caught by the fabric (or the accumulated dust cake). Consequently, baghouse filters have their lowest collection efficiency at a particle size around 0.3 μm . Both smaller (i.e., nanoparticles) and larger particles are more effectively removed.

Baghouses are often capable of 99.9% removal efficiencies. Removal efficiency is relatively level across the particle size range (except at around 0.3 μm), so that excellent control of PM_{10} and $\text{PM}_{2.5}$ can be obtained.^[97]

⁹⁶ http://www.neundorfer.com/FileUploads/RichTextboxImages/Image/pulse_jet_baghause.jpg

⁹⁷ <http://www.icac.com/i4a/pages/index.cfm?pageid=3398>

4.2.1.3 Electrostatic Precipitators (ESP) (Particulate Matter Control)

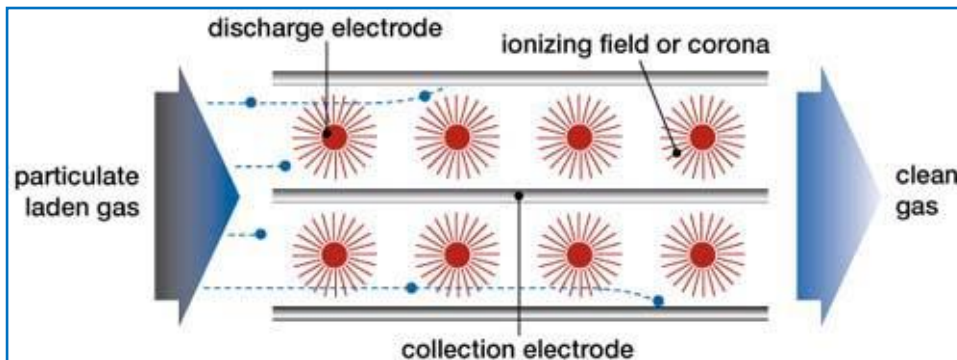
Electrostatic precipitators (ESPs) use electrical fields to remove particulate matter from flue gas. ESPs have been in common use for a long time. Typically, ESPs have low energy requirements and operating costs.

Basically, there are three steps that an ESP uses to remove particulate matter from the flue gas.^[98]

- Particle charging
- Particle collection
- Removal of collected particulate.

In an ESP, an intense electric field is maintained between high-voltage discharge electrodes and grounded collecting electrodes or plates. A corona discharge^[99] from the discharge electrodes ionizes the gas passing through the precipitator, and gas ions subsequently ionize other particles. The electric field drives the negatively charged particles to the collecting electrodes. Periodically, the collecting electrodes are rapped mechanically to dislodge collected particulate, which falls into hoppers for removal. Figure 4-5 provides a conceptual overview of an ESP.^[100]

Figure 4-5: Conceptual Overview of an ESP



Source: <http://web.njit.edu/~avs9/Procedure%20Draft%20Final.htm>

Most precipitators have three to five independent electrical sections in series (referred to as sectionalization). Each independent section removes a fraction of the particulate in the gas stream; this arrangement allows the use of higher voltages in the first sections of the precipitator, where there is more particulate to be removed. Lower voltages must be used in the final, cleaner precipitator sections to avoid excessive sparking between the discharge and collecting electrodes.

⁹⁸ <http://hamon-researchcottrell.com/HRCTechnicalLibrary/Reviving%20an%20Electrostatic%20Precipitator.pdf>

⁹⁹ A corona discharge is an electrical discharge brought on by the ionization of a fluid surrounding a conductor, which occurs when the potential gradient (the strength of the electric field) exceeds a certain value, but conditions are insufficient to cause complete electrical breakdown or arcing.

¹⁰⁰ <http://web.njit.edu/~avs9/Procedure%20Draft%20Final.htm>

Precipitator sectionalization also allows for the collection of particles re-entrained (due to rapping) in the flue gas stream to be collected in downstream sections of the precipitator.

There are several factors which contribute to ESP performance and particle removal efficiency including precipitator size, flow uniformity, re-entrainment, and particle resistivity.

- **Precipitator Size** – determines particle treatment time. The larger (longer) the precipitator the higher chance a particle will be charged and collected.
- **Flow Uniformity** – flow non-uniformity and re-entrainment are factors that decrease precipitator performance. Uniform gas flow ensures that there is no high gas velocity resulting in short treatment time paths through the precipitator. Attaining flow uniformity also minimizes "short circuiting," or gas flows bypassing the electrical fields.
- **Re-entrainment** – re-entrainment of collected particles can occur during rapping (particle collection). The amount of re-entrainment can be reduced through proper rapper design and timing and maintenance of hopper ash levels and flow uniformity.
- **Resistivity** – resistivity is the resistance of particles to the flow of electric current. Particles with resistivity in the range of $10^7 - 10^{10}$ ohm-cm lend themselves to collection by ESPs as they are easy to charge and only lose their charge once they are deposited on the collection electrode. Particles with low resistivity (less than 10^7 ohm-cm) are more difficult to collect using ESP. These particles lose their charge to a collecting electrode so rapidly that they tend not to adhere to the electrode. This results in a high rate of particle loss. High-resistivity particles form ash layers which adhere very strongly to the collecting electrodes which again may lead to injection of positively charged ions into the space between the discharge and collecting electrodes ("back corona"), thus reducing the charge on particles in this space and lowering collection efficiency.

ESPs are capable of removal efficiencies of up to 99.9% with common efficiencies of 99.5%. Precipitators with high overall collection efficiencies will have high collection efficiencies for particles of all sizes, so that excellent control of PM_{10} and $PM_{2.5}$ will be achieved with well designed and operated electrostatic precipitators. In practice, 97 – 98% of all particulate matter under 5 μm in diameter are removed by ESPs.^[101] That said, similar to baghouse filters, ESPs also have their lowest collection efficiency at a particle size of around 0.3 μm due to electrostatic forces and Brownian movements.

4.2.1.4 Mechanical Collectors (Particulate Matter Control)

Mechanical collectors use mechanical means to remove particulate matter from the flue gas. One of the most common forms of mechanical collection is the cyclone separator. A cyclone separator is a vertical tank with the bottom end tapered into a pipeline and a section of the top open. Using centrifugal force, the cyclone separates larger particles from smaller ones. The efficiency of cyclone separators

¹⁰¹ <http://www.icac.com/i4a/pages/index.cfm?pageid=3398>

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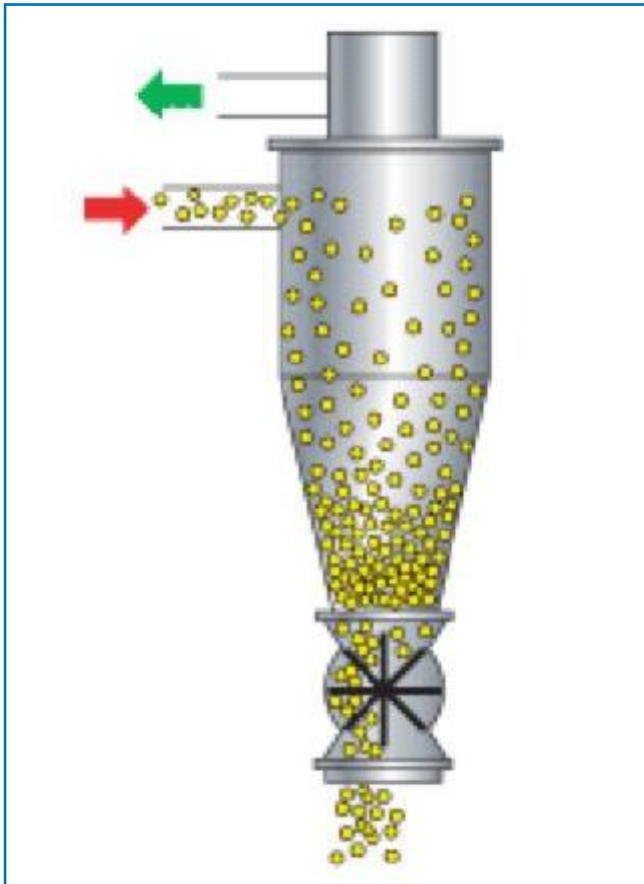
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depends largely on flue gas flow vis-à-vis the cyclone diameter: as velocity of the flue gas increases, so does the collection efficiency. Figure 4-6 illustrates the operation of a cyclone separator.^[102]

Figure 4-6: Schematic Overview of Cyclone Separator



Source: http://www.fmdaircontrol.com/cyclone_separators.jpg

Often cyclone separators are combined to increase removal efficiency and are referred to as multiple cyclones. A multiple cyclone consists of an array of cyclones in parallel. Overall, multiple cyclones have removal efficiencies of 70 – 90%. Removal efficiency is largely dependent on particle size; as particle size decreases, removal efficiencies met by the cyclone drop off quickly. The removal of finer particulates such as $PM_{2.5}$ is quite limited. Typically, cyclone removal efficiencies are approximately 90% for particles greater than PM_{10} , 70% for $PM_{2.5}$ and 50% for PM_1 .^[103]

Although multiple cyclones have no moving parts, they require regular cleaning and preventative maintenance to ensure that collection efficiency is maintained.

¹⁰² http://www.fmdaircontrol.com/cyclone_separators.jpg

¹⁰³ <http://www.icac.com/i4a/pages/index.cfm?pageid=3398>

In general, cyclones on their own cannot achieve the emission levels now applied to modern waste incinerators. They can, however, have an important role to play where applied as a pre-duster before other flue gas treatment stages.^[104]

4.2.1.5 Acid Gas Scrubbers (Multi-Pollutant Control)

“Scrubber” is a general term that describes APC devices that use both physical and chemical absorption to remove pollutants from the flue gas stream. Scrubbers, which are generally classified as either “wet” or “dry/semi-dry”, rely on a chemical reaction with a sorbent to remove acidic gases including sulfur dioxide (SO₂), hydrochloric acid (HCl) and hydrofluoric acid (HF) from the flue gas stream. In addition to acidic gases, scrubbers are also capable of removing particulate matter and heavy metals such as mercury.

According to the EPA and others, both wet and dry scrubbers have been shown to reduce HCl emissions by 95% and more, and wet scrubbers have been shown to reduce HF emissions by more than one-third. Others have reported ranges of 87 – 94% removal of HCl and 43 – 97% removal of HF by both wet and dry scrubbers.^[105] The following subsections discuss wet and dry scrubbers separately in more detail.

Wet Scrubbers

In a wet scrubber, the flue gas stream is brought into contact with a scrubbing liquid or sorbent. This is accomplished by various methods including spraying the flue gas with sorbent, forcing it through a pool of liquid or by some other method. The gaseous or particulate pollutants present in the flue gas stream come into direct contact with sorbent and are dissolved or diffused (scrubbed) into the liquid.

The sorbent is typically some kind of alkaline slurry of limestone which reacts with the acidic gases to form neutralized byproducts (i.e., SO₂ reacts to form calcium sulfite or calcium sulfate). The wet solid byproduct which is formed typically requires further treatment (dewatering, precipitation of heavy metals) before it is released from the facility. The dewatered, purified sludge can then be disposed of via other conventional methods and the treated wastewater can leave the site.

Alternatively, instead of using an alkaline sorbent, water can be used as the sorbent in the wet scrubber. When water is used, it mixes with the acidic compounds and increases the PH (reduces the acidity). Water is equally as effective as an alkaline sorbent at capturing particulate matter. A wet scrubber utilizing water requires an additional step which takes the watered solution and treats it with alkaline substances (i.e., limestone) to lower its acidity. This system also results in wastewater which must be treated to remove heavy metals resulting in sludge and a wastewater stream which leaves the site.

Generally, wet scrubbers have relatively small space requirements and require relatively little capital investment (although they tend to be more expensive than dry or semi-dry systems). Wet scrubbers are able to process high temperature, high acidity, and high humidity flue gas streams. Scrubber

¹⁰⁴ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

¹⁰⁵ <http://www.icac.com/i4a/pages/index.cfm?pageid=3398>

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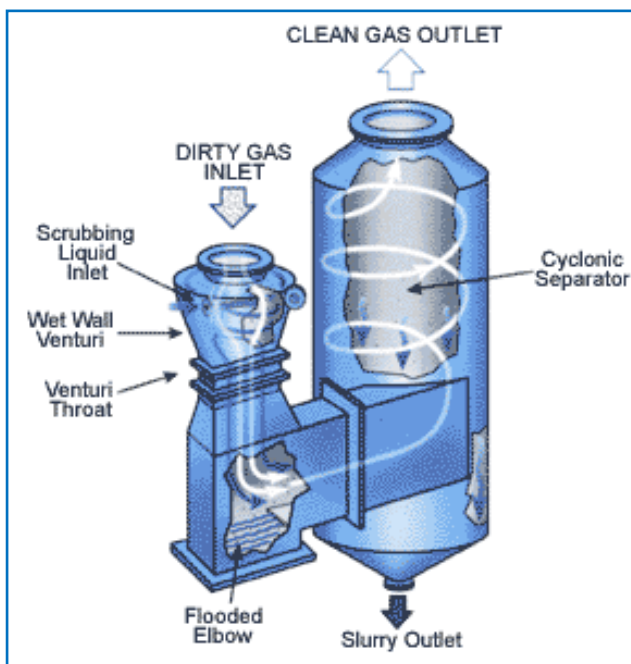
energy requirements have also continued to decrease, helping to lower operating costs. Design and operating parameters relating to the operating efficiency of wet scrubbers include the shape of the scrubber, liquid spray or injection locations, gas residence time, gas velocities, gas and liquid temperatures, gas and liquid pressure drop, and, the liquid/gas flow rate ratio.

Wet scrubbers can achieve high levels of multi-pollutant control, including the control of acidic gases, SO_2 , fine particulates and heavy metals (e.g., cadmium). New wet scrubbers achieve SO_2 removal efficiencies of 95%, with some scrubbers achieving removal efficiencies of up to 99%. In addition, wet scrubbers also provide for significant removal of arsenic, beryllium, cadmium, chromium, lead, manganese, and mercury parameters from flue gas.

As mentioned previously, wet scrubbers are capable of removing a large proportion of particulate matter from the flue gas stream. Venturi scrubbers (a kind of wet scrubber) are commonly used to remove particulate matter from flue gas.

In a venturi scrubber, the “scrubbing” liquid and flue gas are accelerated through a duct which narrows to a small opening and then opens back up. As they reach the small opening, the flue gas and scrubbing liquid are moving at very high velocities which cause the scrubbing liquid to break apart into very fine droplets. These very fine droplets each provide a surface on which particulate matter can be absorbed. Venturi scrubbers are often combined with cyclone separators to remove the water droplets from the flue gas stream. Venturi scrubbers are often capable of removing greater than 90% of particles with diameters above 10 microns. The efficiency of removal for smaller particles is much lower. Figure 4-7 presents a schematic overview of a venturi scrubber.

Figure 4-7: Schematic Overview of a Venturi Scrubber



Source: Mikropul. 2009. Wet Scrubbers

Dry/Semi-Dry Scrubbers

In a dry or semi-dry scrubber, particles of an alkaline sorbent are injected into the flue gas, producing a dry solid by-product. In some cases moisture is added to the sorbent prior to injection (semi-dry scrubber) and in some cases no moisture is added to the sorbent (dry scrubber). If no water is added to the sorbent (dry scrubber), a wet spray humidifier is often placed prior to the dry scrubber in the APC train to humidify the flue gas and to aid in the dry scrubber's operation. Due to the lower levels of moisture used in the dry scrubber, there is no wastewater produced in the dry or semi-dry systems.

Dry/semi-dry scrubber systems can be grouped into three categories: spray dryers (semi-dry), circulating spray dryers (semi-dry), and dry injection systems (dry). All three of these systems offer multi-pollutant control opportunities by combining acid gas, SO₂, particulate, and heavy metal control.

In a spray dryer, alkaline reagent slurry (typically lime based) is atomized into the hot flue gas to absorb pollutants. The resulting dry material, including fly ash, is collected in a downstream particulate control device such as a fabric filter baghouse. Spray dryers commonly are designed for SO₂ removal efficiencies of 70 – 95%.^[106]

A circulating dry scrubber uses an entrained fluidized bed reactor for contacting the reagent, usually hydrated lime, with acid gas and particulate laden flue gas. The fluidized bed promotes an intensive gas-solid mixing that encourages the reaction of acidic gases in the flue gas with the dry lime particles. Similar to spray dryers the mixture of reaction products, unreacted lime, and fly ash is carried to a downstream particulate collector such as a fabric filter baghouse. In a circulating dry scrubber, water spray is introduced into the fluidized bed separately. This enhances the performance of the system by optimizing the surface moisture content of the lime which allows for lesser amounts of lime to be used by the system. Circulating dry scrubbers can provide removal efficiencies of more than 90%.^[107]

¹⁰⁶ <http://www.icac.com/i4a/pages/index.cfm?pageid=3398>

¹⁰⁷ <http://www.icac.com/i4a/pages/index.cfm?pageid=3398>

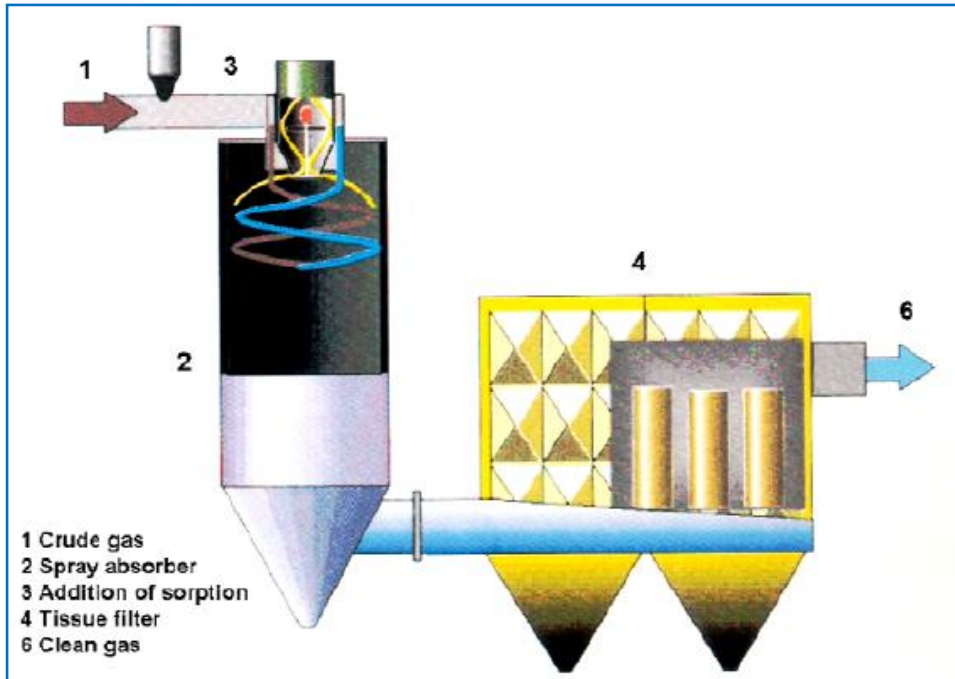
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Figure 4-8: Overview of a Circulating Dry Scrubber



Source: European Commission. 2006. *Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration*

Generally, dry/semi-dry scrubbers are simple and have low capital and maintenance costs associated with them. Dry scrubber energy requirements, while less than wet scrubber systems, continue to decrease which helps to lower operating costs.

4.2.1.6 Nitrogen Oxide Control

Selective Catalytic Reduction (SCR) (Nitrogen Oxide Control)

The basic principle of SCR is the reduction of NO_x to N_2 and H_2O . This is accomplished by injecting ammonia (NH_3) into the flue gas stream which then reacts with NO_x gases within a catalyst bed.

The basic operation of an SCR system is quite simple. It consists of a reactor chamber with a catalyst bed, and an ammonia handling and injection system, with the ammonia injected into the flue gas upstream of the catalyst. The system involves no moving parts and other than spent catalyst, the SCR process produces no waste products.

Several different catalysts are available for use at different exhaust gas temperatures. In use the longest and most common are base metal catalysts, which typically contain titanium and vanadium oxides, and which also may contain molybdenum, tungsten, and other elements. Due to the catalyst the reaction can take place at a lower temperature normally around 250°C , however, references to a temperature interval between $180 - 350^\circ\text{C}$ are available.

In principle, SCR can provide reductions in NO_x emissions approaching 100%. In practice, commercial SCR systems have met control targets of over 90% in many cases.

SCR (as opposed to SNCR) is typically used if there is a strict regulatory limit or if a financial incentive to reduce the NO_x emission is introduced. Normally SCR processes achieve emission levels of between 20 – 70 mg/Nm₃.

The SCR process is typically located at the downstream (tail-end) portion of the APC plant where SO₂ and SO₃ levels in the flue gas are reduced to prevent precipitation of ammonia hydrogen sulphate. It also prolongs the lifetime of the catalyst when Hg, HCl and dust are removed.

A disadvantage with the tail-end SCR process is that the flue gas temperature within this portion of the APC train is lower than required, normally around 140 – 150°C, and reheating of the flue gas is necessary. Reheating is normally done through a combination of a heat exchanger where the ingoing flue gas to the SCR-process is preheated by means of the flue gas leaving the SCR and additional heating by approximately 25°C which can be done by the usage of steam from the boiler or the turbine or by means of natural gas/oil.

For the tail-end SCR process, where the concentration of other pollutants in the flue has already been reduced, reactions can be carried out at a lower temperature without incurring too high a risk for precipitation. Some plants have tested SCR at temperatures from 180 – 220°C but the experience is so far not sufficient and the majority of the suppliers still recommend operating temperatures of around 250°C.

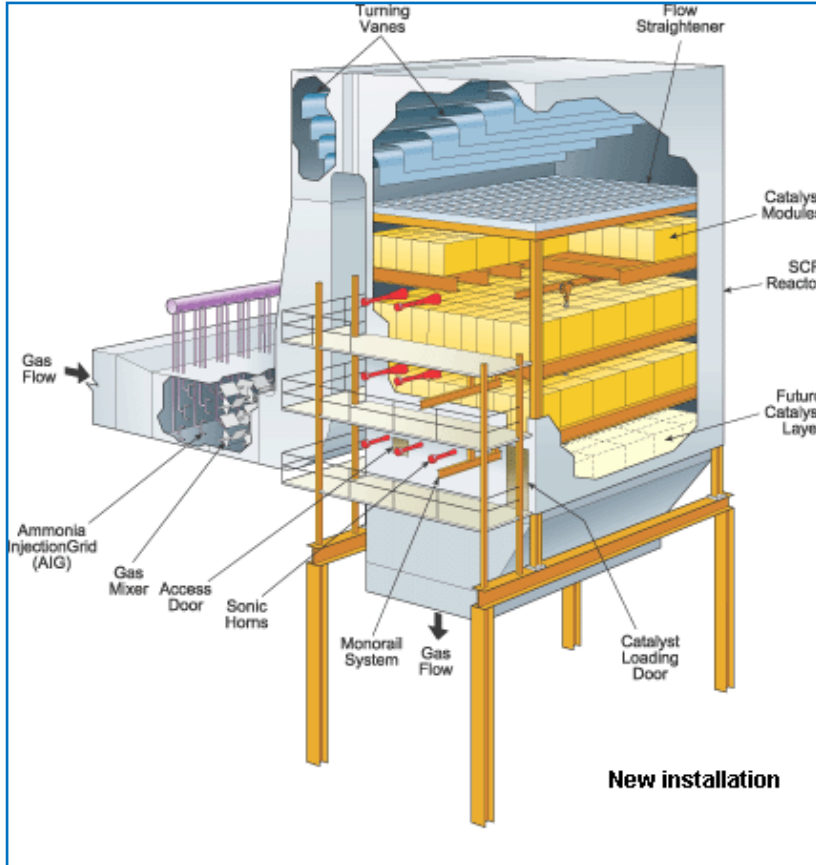
Alternatively the SCR process can be placed before the flue gas treatment plant. To have a sufficiently high temperature without needing reheating of the flue gas, the most advantageous placement is at the outlet of the boiler and before the economizer. Due to the high sulphur content the temperature in the SCR process has to be approximately 280°C to prevent precipitation. The experience with high dust catalysts is very limited, and the few plants with high dust SCR system have experienced problems.

If considerations are taken during the design of the catalyst, SCR can absorb dioxin as well. The adsorption of dioxin is dependent on the chemical composition of the catalyst as well as the size of the catalyst.

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Figure 4-9: Diagram of a Selective Catalytic Reducer



Source: The Babcock and Wilcox Company. 2010. Environmental Equipment: Selective Catalytic Reduction (SCR) System. http://www.babcock.com/products/environmental_equipment/scr.html

Selective Non-Catalytic Reduction (SNCR) (Nitrogen Oxide Control)

Similar to SCR, SNCR is a chemical process that converts NO_x into N_2 and H_2O using ammonia (NH_3). At suitably high temperatures ($870 - 1,150^\circ\text{C}$), the desired chemical reactions occur.

The operation of an SNCR system is quite simple. Ammonia (or urea) is injected/sprayed into and mixed with the hot flue gas. The ammonia or urea then reacts with the NO_x in the flue gas stream, converting it into nitrogen and water vapour. The main difference from SCR is that SNCR does not utilize a catalyst. SNCR is "selective" in that the reagent reacts primarily with NO_x , and not with oxygen or other major components of the flue gas.

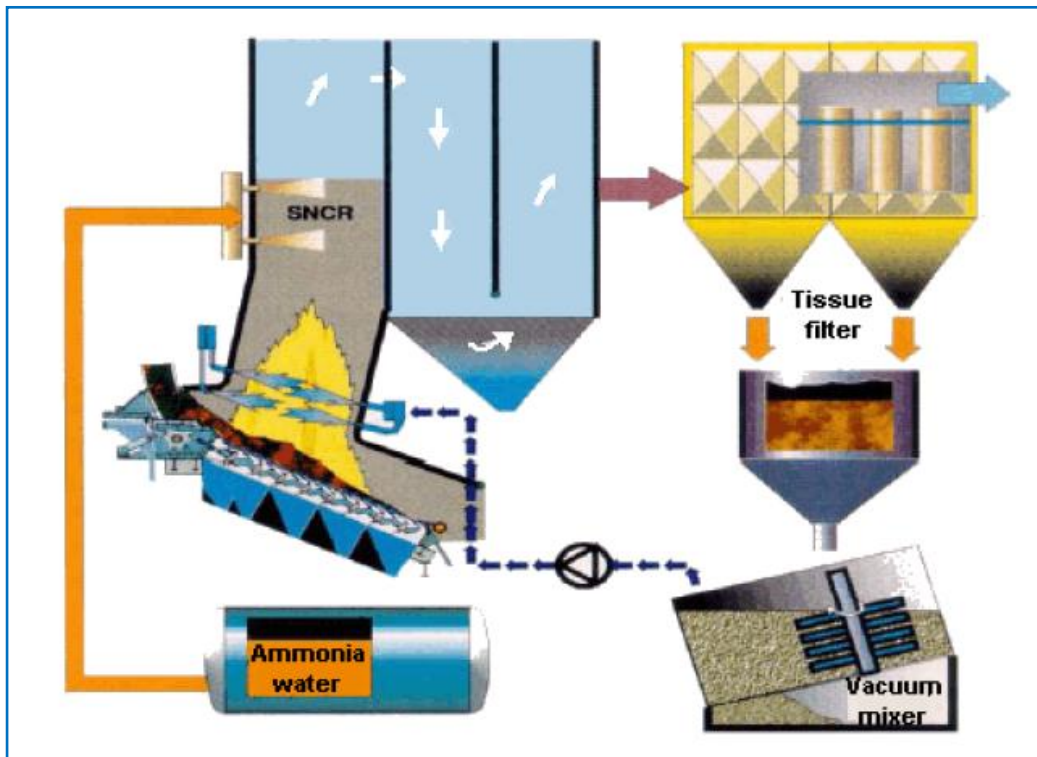
The principal components of an SNCR system are the reagent storage and injection systems, which includes tanks, pumps, injectors, and associated controls, and often NO_x continuous emissions monitors (CEMs). Given the simplicity of these components, installation of SNCR is easy relative to the installation of other NO_x control technologies. SNCR retrofits typically do not require extended source shutdowns.

While SNCR performance is specific to each unique application, NO_x reduction levels ranging from 30% to over 75% have been reported. Temperature, residence time, reagent injection rate, reagent-flue gas mixing, and uncontrolled NO_x levels are important in determining the effectiveness of SNCR.

Emission values around 150 mg/Nm^3 are common for the SNCR process. Lower values – to around 100 mg/Nm^3 – are possible with the SNCR process but the consumption of ammonia is relative high and the risk for ammonia slip will increase.

The ammonia slip is normally limited to $5 - 10 \text{ mg/Nm}^3$ as ammonia may result in a light odour of the flue gas residues.

Figure 4-10: Overview of SNCR System



Source: European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for Waste Incineration

4.2.1.7 Conditioning Towers or Wet Spray Humidifiers

Some WTE facilities utilize a conditioning tower or wet spray humidifier as part of their APC equipment. A conditioning tower consists of a vertical tower where water is sprayed into the gas stream, humidifying the gas stream while decreasing the temperature to about $160 - 185^\circ\text{C}$.

With current APC design, conditioning towers are often used to cool the flue gases prior to the inlet of the baghouse filter at the end of the APC train, in order to protect the baghouse filters and to ensure the optimal temperature range for chemical reactions with lime.

Conditioning towers/humidifiers can be used to reduce gas temperature and elevate humidity to allow for a more effective operation of other downstream APC equipment such as dry acid gas scrubbers. Conditioning towers can also decrease the potential for dioxin and furan formation by dropping flue gas temperatures rapidly below the temperature range for de novo synthesis.

4.2.2 APC System Design and Operation

The individual components of an APC system are combined into APC trains to provide an effective overall system for the treatment of pollutants that are found in the flue gases. There are several common APC trains currently used at operating WTE facilities, to control the release of unwanted pollutants into the atmosphere. The selection of an air pollution control train for a WTE facility depends on a number of factors, such as the desired emissions reductions necessary to meet applicable regulations, the ability of various APC components to function with one another (not all APC equipment is compatible) and the cost of the equipment (capital and operating).

Generally speaking, when choosing an APC train for a WTE facility the first thing considered is how to control the release of acid gases such as SO₂, HCl and HF. After an appropriate control for acid gases is chosen, compatible and appropriate components can be selected for the control of particulate matter, dioxins, mercury and NO_x. In other words, the selection of the APC component to treat acid gases forms the backbone of the APC train and affects the type and placement of other APC controls that manage the release of other chemicals of concern.

There are three main types of treatment systems that treat acidic compounds, and thus three main types of APC trains that are built around the acid gas control measures:

- Dry/semi-dry systems
- Wet systems
- Semi-wet systems (combination of dry/semi-dry and wet systems).

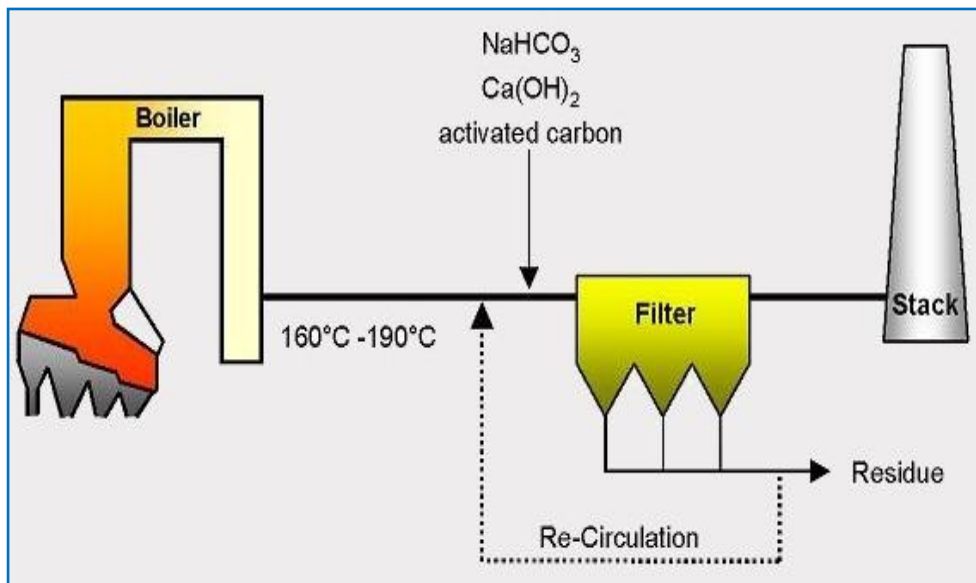
The most common form of APC system currently used by WTE facilities in Canada is the dry/semi-dry system.^[108] The following sections provide an overview of each of these systems.

¹⁰⁸ GENIVAR Ontario Inc. in association with Ramboll Danmark A/S, 2007. Municipal Solid Waste Thermal Treatment in Canada

4.2.2.1 Dry/Semi-Dry Systems

As discussed previously, dry/semi-dry systems for acid gas control^[109] can be grouped into three categories: spray dryers (semi-dry)^[110] circulating spray dryers (semi-dry), and dry injection systems (dry), but the basic operation of each system is similar. In each system, the acidic compounds in the flue gas react in a vessel with a sorption agent (normally calcium hydroxide ($\text{Ca}(\text{OH})_2$) for the dry system and lime milk (a suspension of calcium hydroxide) in the semi-dry system. Alternatively dry sodium bicarbonate (NaHCO_3) can be used as the sorption agent. In dry systems, wet spray humidifiers are often added to the front of the APC train to assist in the operation. Figure 4-11 presents a simple schematic overview of a Dry/Semi-Dry APC system.

Figure 4-11: Schematic Overview of a Dry/Semi-Dry APC System



Source: Fisica Babcock Environment GmbH. 2007. Wet Scrubbing. Accessed March 15, 2010 from <http://www.fisia-babcock.com/index.php?id=183>

The injected sorption agent reacts with the acidic compounds converting them into solid compounds ($\text{HCl} \rightarrow \text{CaCl}_2$, $\text{HF} \rightarrow \text{CaF}_2$, $\text{SO}_2 \rightarrow \text{CaSO}_3$ or CaSO_4). The solid by-products formed are removed later on in the APC train in a fabric filter baghouse or other dust collecting device such as an ESP. By this process, the majority of the acidic compounds present in the flue gas are neutralized and prevented from being released into the atmosphere.

In addition to the adsorption of acidic compounds the dry/semi-dry system also assists in the reduction of other harmful pollutants including particulate matter and heavy metals.

¹⁰⁹ Ramboll

¹¹⁰ Spray dryers followed by fabric filters have become the norm for WTE facilities in the United States (Air Pollution Control For Waste to Energy Plants – What Do We Do Now?, 1997)

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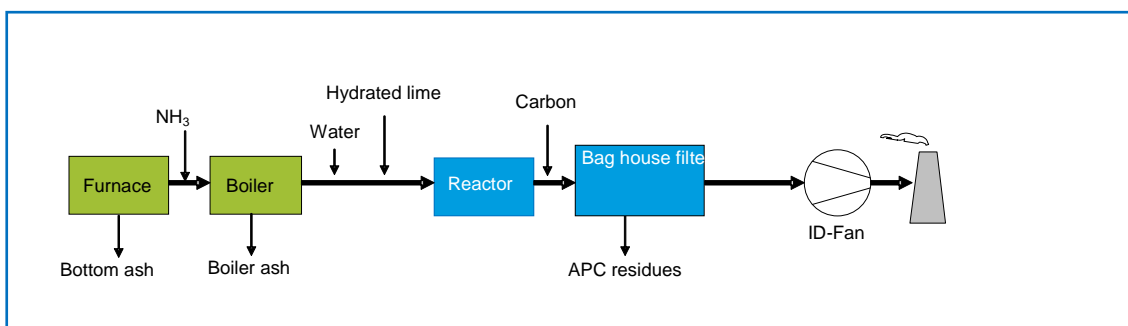
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In the dry/semi-dry system, other APC components can then be added to the APC train to assist in the reduction of dioxin/furans, mercury and NO_x emissions. Normally, an activated carbon injection system is added after the acidic gas reactor to adsorb both mercury and dioxins which are then captured in the fabric filter baghouse preventing them from being released into the atmosphere. The last step would be adding a SCR or SNCR APC component, respectively to reduce NO_x emissions.

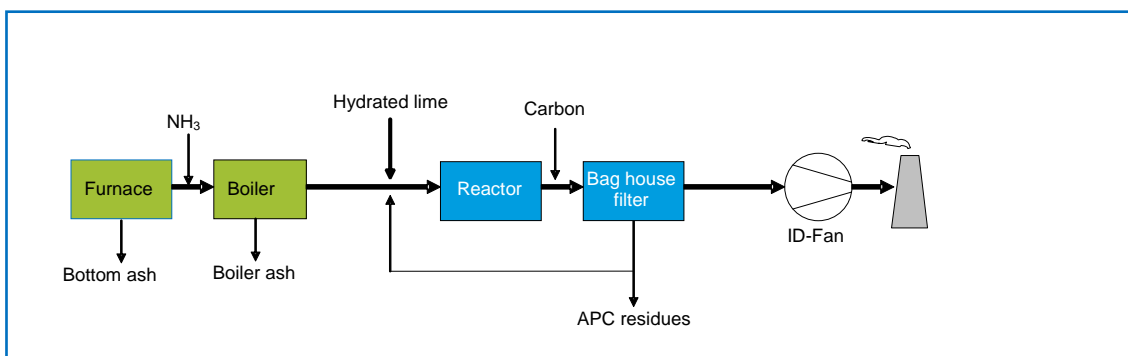
Figures 4-12 to 4-14, below provide an overview of three types of common dry/semi dry APC trains and the combination of key APC components compatible with dry/semi dry acid gas control.

Figure 4-12: Dry APC System



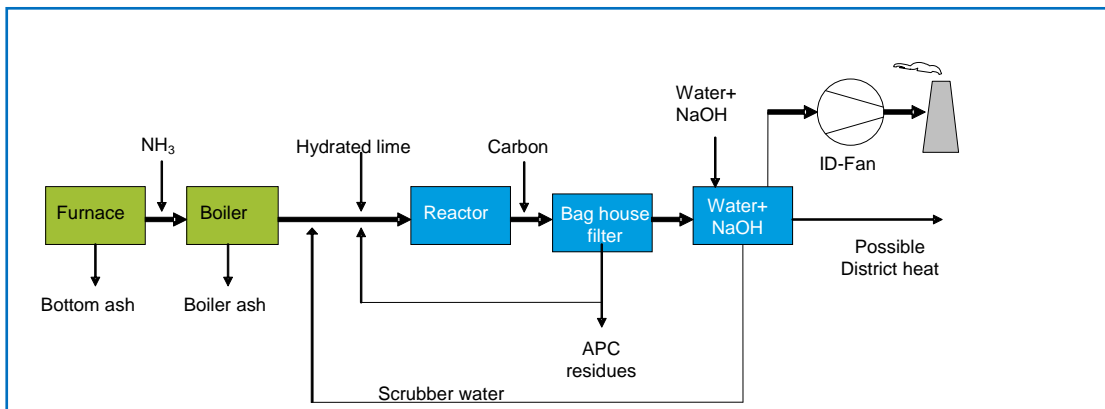
This system includes SNCR for NO_x control, a dry scrubber, use of activated carbon injection to control dioxins/furans and mercury, and a bag house to control particulate and the majority of heavy metals.

Figure 4-13: Semi-Dry System, Example 1



This system includes SNCR for NO_x control, a dry scrubber with recirculation of recovered water from APC residue treatment for humidification, use of activated carbon injection to control dioxins/furans and mercury, and a bag house to control particulate and the majority of heavy metals.

Figure 4-14: Semi-Dry System, Example 2

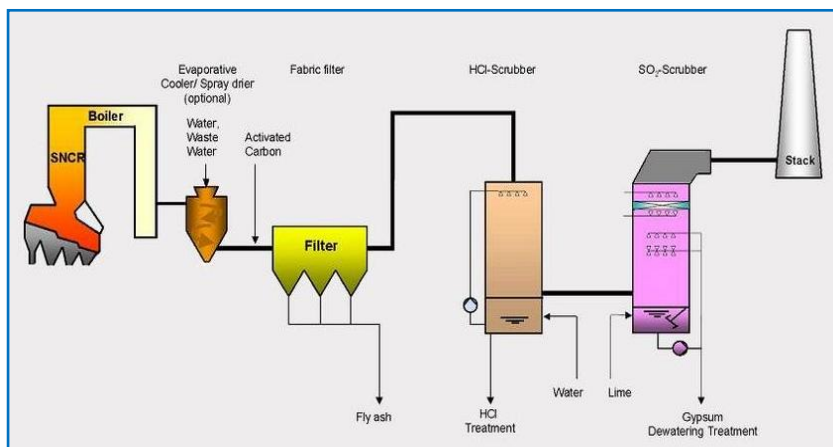


4.2.2.2 Wet Systems

Of all three flue gas treatment methods, the wet system is the only one which generates wastewater to be discharged and based upon our research is the least common type of APC train used in WTE facilities in North America. That said, the wet system is often used in Europe where additional incentives are in place to reduce emissions to air and as up until recently, wet systems were typically able to reduce emissions to a greater degree than dry/semi-dry systems.

Wet systems can be grouped into numerous different categories based upon their geometric shape and method for gas-liquid interaction including packed-bed, counter-flow, cross-flow, bubble-plate, open spray (single and double loop) tower, dual-flow tray, cyclonic, etc. Generally speaking, however, they all function in a similar manner. Figure 4-15 provides a general schematic overview of a wet APC system.

Figure 4-15: Schematic Overview of a Wet APC System



Source: Fiscia Babcock Environment GmbH. 2007. Wet Scrubbing. Accessed March 15, 2010 from <http://www.fiscia-babcock.com/index.php?id=183>

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The first stage in a wet system is normally the removal of dust and particulate matter from the flue gas with either an ESP or fabric filter baghouse prior to the wet scrubber. This filtration helps to remove some particulate matter and reduce the concentration of heavy metals in the flue gas. In the next treatment stage in the wet system, the acidic compounds present in the flue gas are washed with water in an “acid scrubber” which produces a wastewater stream. Washing the flue gas with water removes the majority of HCl as it becomes a diluted hydrochloric acid solution. The liquid effluent from the water washing is then passed on to a wastewater treatment stage (to neutralize the acid and to remove heavy metals which may still be present in high concentrations).

The flue gas moves on to an “alkaline” scrubber, in which it is washed with a solution of either sodium hydroxide or a suspension of limestone which removes the majority of SO₂ from the flue gas. The waste liquid remaining after the alkaline scrubber is also sent to wastewater treatment prior to being released from the facility.

After both scrubbing stages, the flue gases are then treated with activated carbon injection to remove the remaining dioxins/furans and mercury. The activated carbon with adsorbed material is then captured in a downstream fabric filter baghouse.

The wastewater from the acid and alkaline scrubbers is normally neutralized to approximately pH 9 by CaCO₃ and NaOH. The heavy metals and other solids present in the wastewater are then precipitated out by the addition of chemicals such as CaCl₂, NaOH, FeCl₃ and TMT 15. The precipitates are dewatered in a filter press before proper disposal while the treated wastewater is discharged from the facility. Similar to dry/semi-dry systems, wet systems also assists in the reduction of other harmful pollutants including particulate matter and heavy metals. Figures 4-16 to 4-18, below, provide examples of typical wet APC systems.

Figure 4-16: Wet APC System, (a)

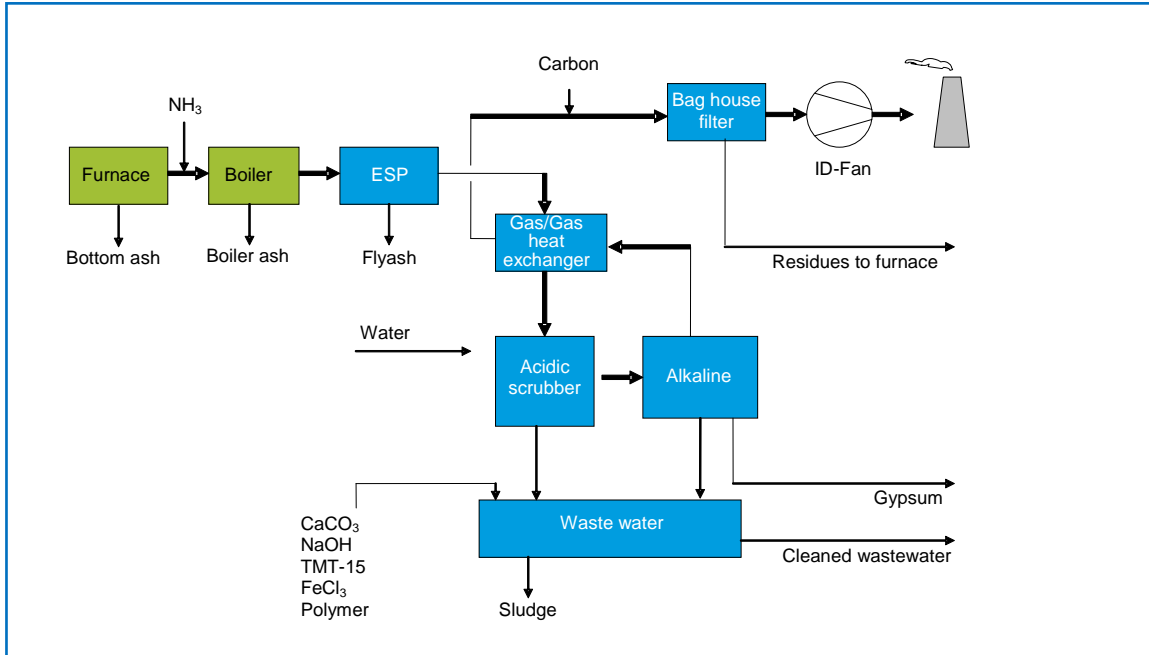
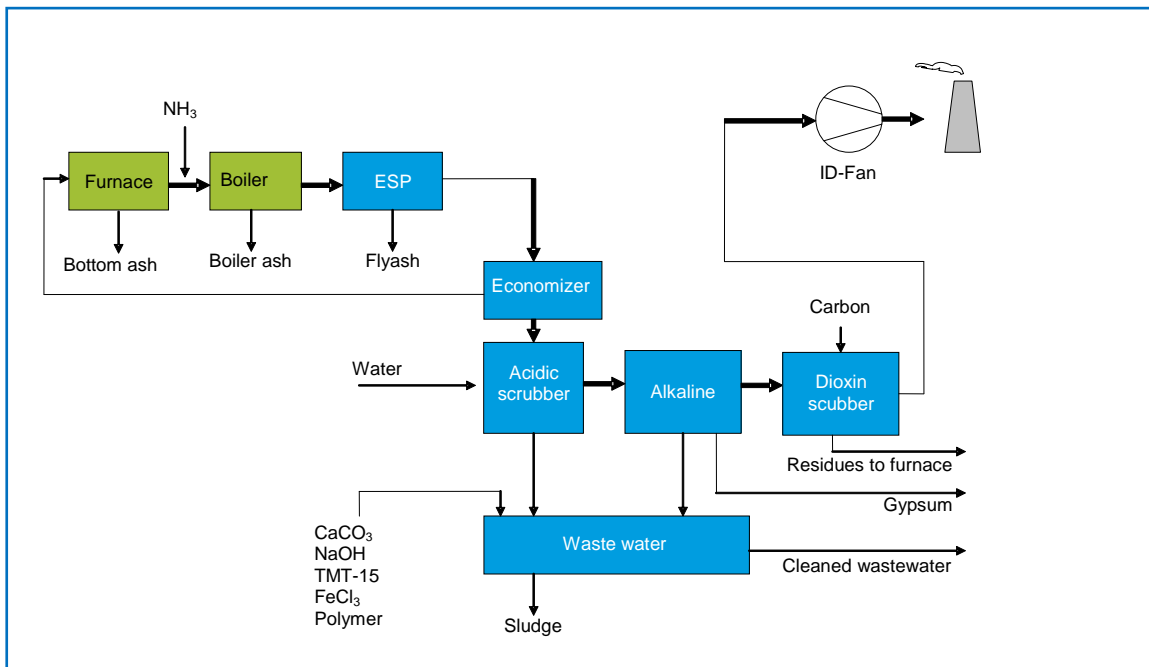


Figure 4-17: Wet APC System, (b)



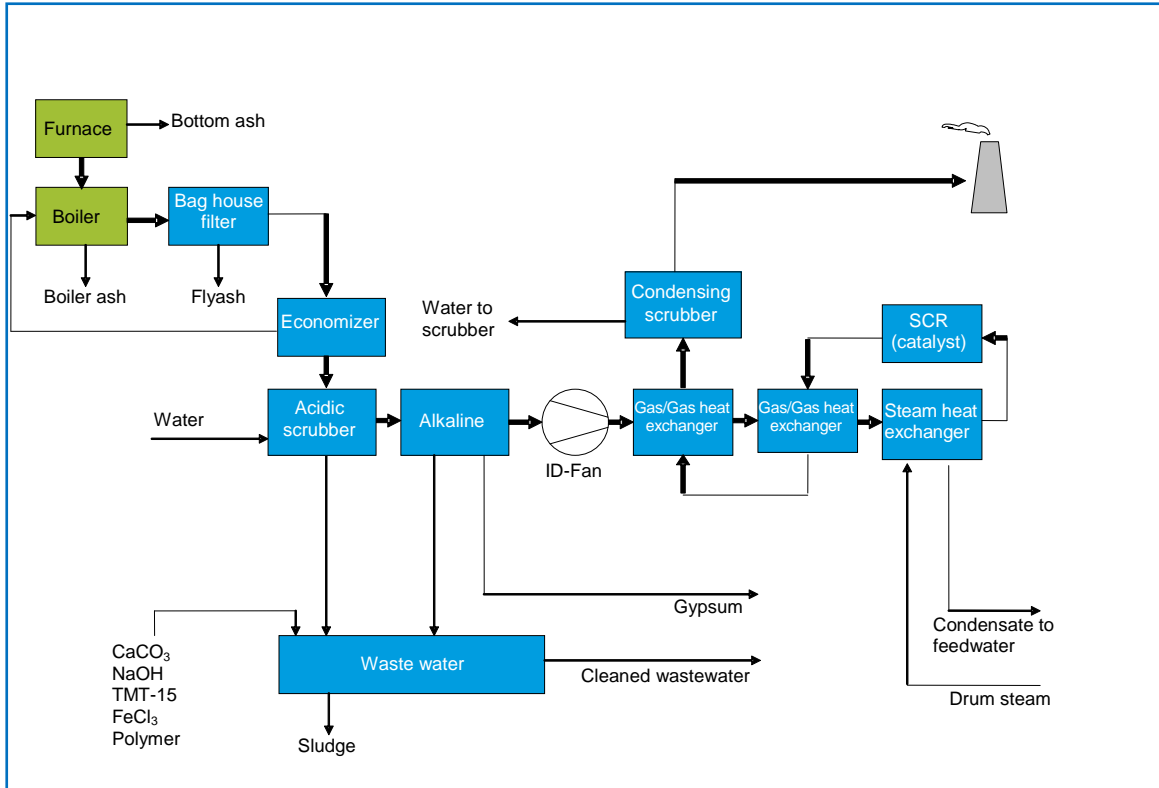
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Figure 4-18: Wet APC System (c)



4.2.2.3 Semi-Wet Systems

Semi-wet systems are basically a combination of semi-dry and wet systems. The semi-wet system combines the semi-dry system with a polishing wet stage in such a way that the water from the wet stage can be used in the preparation of the lime suspension for the semi-dry treatment. Because of this, the semi-wet system is wastewater-free. By adding NaOH to the water in the wet stage the removal efficiency is increased and the production of solid residue decreased correspondingly.

Summary of Acid Gas Control Systems

Table 4-1 illustrates the relative advantages and disadvantages of the dry/semi-dry, wet, and semi-wet Systems. As mentioned previously, based upon our research the majority of current WTE facilities in Canada utilize a dry/semi dry APC system while wet systems are more common in the EU.

Table 4-1: Advantages and Disadvantages Associated with Dry/Semi Dry, Wet, and Semi-Wet Flue Gas Treatment Systems

	Dry/Semi Dry System	Wet System	Semi-Wet System
Advantages	<ul style="list-style-type: none"> Simple technology No wastewater Relatively low capital costs Requires less space than a wet system 	<ul style="list-style-type: none"> High efficiency Small amount of solid residue Possible destruction of dioxins in the furnace Generally large margin to limit values Little sensitivity to HCl and SO₂ peaks in the flue gas Relatively low operational costs 	<ul style="list-style-type: none"> Generally large margin to limit values Less sensitive of HCl and SO₂ peaks in flue gas than Dry/Semi Dry System Lower capital costs than wet system No wastewater Less space requirements than Wet System
Disadvantages	<ul style="list-style-type: none"> Uses large quantities of lime and thereby has high operational costs Large amount of solid residue Dioxins in the solid residue Often little margin to the limit values Consumption of lime and amount of solid residues are sensitive to high content of HCl and SO₂ in the flue gas 	<ul style="list-style-type: none"> Many process stage Production of wastewater Relatively high capital costs Requires more space than a dry/semi-dry system 	<ul style="list-style-type: none"> More expensive than dry/semi-dry system Medium amount of solid residue

4.2.2.4 NO_x Control System Components

After the acidic gas control system has been selected, the type of NO_x control is determined. As discussed previously, there are two types of NO_x control systems normally used in WTE facility APC trains. Namely, these are Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction (SNCR). Both NO_x control systems are currently in use in Canada, for example the Greater Vancouver Regional District Waste to Energy Facility utilizes SNCR while the Algonquin Power Peel Energy-From-Waste Facility utilizes SCR.^[111]

In state-of-the-art WTE facilities, sophisticated control systems have been developed that greatly reduce the production of NO_x during regular combustion. However, these control systems are usually not able to reduce NO_x emissions to below applicable regulatory limits and thus additional NO_x controls must be put in place.

¹¹¹ GENIVAR Ontario Inc. in association with Ramboll Danmark A/S, 2007. Municipal Solid Waste Thermal Treatment in Canada

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In SNCR, ammonia is injected into the flue gas stream directly in the furnace at the location where the temperature is around 850°C.

In SCR, the reaction between NO_x and ammonia takes place in a catalytic bed at temperatures normally between 200 and 250°C. In SCR, the catalytic bed is often the last treatment step in the APC train (final treatment device) as dust and SO₂ greatly decrease the lifespan of the catalytic surface. Because of this, the flue gas is often at too low a temperature for the catalytic reaction to take place, requiring the flue gas to be preheated prior to the SCR. Often the incoming flue gas into the SCR system is preheated by the flue gas leaving the SCR which reduces the need for additional heating (which can be done with high pressured steam or natural gas). The consumption of ammonia for an SCR system is normally 1.5 kg 25% NH₃ per kg of NO_x.

The types and choice of Denox currently being used in Europe include both SNCR and SCR, with the choice of system being based both on regulatory requirements and economics. For example:

- In Denmark all Denox systems are based on the SNCR technology as the emission limit of 200 mg/Nm³ can be met with such systems. A NO_x tax has recently been implemented but given the current low level of the tax there is no incentive for further reductions in NO_x emissions.
- In Sweden a high NO_x tax has increased the feasibility of SCR such that most of the new WTE plants are equipped with SCR systems which operate with very low emission levels – often below 20 mg/Nm³.
- In Norway (not member of EU) the regulation can be fulfilled with SNCR but a tax on NO_x based on the size of the WTE facility make the choice of SNCR or SCR comparable.
- Austria has implemented a NO_x emission limit at 70 mg/Nm³ compared to the 200 mg/Nm³ in EU WID and thus in order to meet this limit, SCR systems have been used for many years. The plant in Vienna, Spittelau, has had SCR for close to 20 years. The experience with the catalyst itself is good, however, the design of the preheat-system as well as the possibility for manual inspection and cleaning of the catalyst is not optimal. For new SCR-systems these problems have been addressed and new installations operate satisfactory.
- In Germany the 200 mg/Nm³ emission limit for NO_x was introduced by the national regulation before the EU-regulation was implemented. Many of the German plants are equipped with SCR and have significant operational experience. Some of the older plants have experienced clogging problems. Clogging problems refer to the SCR catalyst being blocked by the chemical reaction products which is mainly due to the design of the catalyst itself because awareness concerning the SO₂ content of the flue gas was not known when initially designing these facilities. For new facilities the reliability of the SCR is high.
- In Italy most WTE plants use SNCR processes. ASM Brescia has experienced good operation and very low emission levels with SNCR. However, the Italian regulation is becoming more stringent especially in the northern part of Italy and ASM Brescia is testing a catalyst system at present.

- Switzerland (not a member of EU) has, like Austria, introduced a NO_x emission limit of 80 mg/Nm³. Most of the WTE facilities in Switzerland are equipped with SCR and have experienced good operation. The SCR is commonly a tail-end solution. One of the Swiss suppliers has good experience from operation of high temperature-low dust SCR solutions.
- In France and Belgium both SNCR and SCR processes are installed.
- In the Netherlands the emission limit is 70 mg/Nm³ and due to that most of the WTE facilities, and all new facilities, are equipped with SCR.

Summary of NO_x Control Systems

The following table (Table 4-2) illustrates the advantages and disadvantages of SNCR and SCR.

Table 4-2: Advantages and Disadvantages Associated with SNCR and SCR

	SNCR	SCR
Advantages	<ul style="list-style-type: none"> ▪ Simple technology ▪ Low capital costs 	<ul style="list-style-type: none"> ▪ Lower consumption of ammonia ▪ Lower emissions possible (10 mg NO_x/m³ can be obtained if enough NH₃ is added)
Disadvantages	<ul style="list-style-type: none"> ▪ Consumes about 30% more ammonia than SCR ▪ Small quantities of ammonia can slip through and pollute the solid residue in dry/semi-dry systems or the wastewater of the wet systems ▪ Typically, vendors may guarantee limits between 100 to 150 mg NO_x/m³ 	<ul style="list-style-type: none"> ▪ High capital costs

4.2.2.5 Mercury and Dioxin/Furan Control System Components

The release of mercury and dioxins/furans from WTE facilities is normally reduced via an activated carbon injection system. Basically, the gaseous mercury and dioxin/furan compounds are adsorbed onto the surface of the activated carbon particles which are later collected in a fabric filter baghouse. This type of control system is capable of removing mercury and dioxin/furans from the flue gas to below regulatory concentration limits. The dioxin filter can either be wet or dry. The dry system is the most commonly used.

4.2.2.6 Trace Heavy Metal Control System Components

The concentration of heavy metals released from WTE facilities is reduced by more than one component of the APC train. In other words, heavy metal control is not specifically associated with any one APC component.

For example, acid gas scrubbers are typically quite efficient in removing large quantities of heavy metals from the flue gas even though this is not their primary purpose. Specifically, wet scrubbers can provide for the significant removal of arsenic, beryllium, cadmium, chromium, lead, manganese and mercury from the flue gas.

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ESPs and fabric filter baghouses also play an important role in the reduction of heavy metals in the flue gas. They accomplish this because volatilized heavy metals often bind to fly ash particles in the flue gas and large quantities of this particulate matter are captured in an ESP or a fabric filter baghouse. In this way, by removing the particulate matter, large quantities of heavy metals are also captured.

Activated carbon is reported to be also used for reducing heavy metals emissions.^[112]

The control of specific heavy metals depends on their distinctive physical and chemical characteristics. For example, mercury is a unique heavy metal in that it vapourizes at a fairly low temperature (357°C) in comparison to other heavy metals. Mercury remains in a gaseous state after passing through the furnace and boiler and its removal from the flue gas depends largely on the speciation of mercury in the flue gas. The speciation of mercury depends on a number of factors such as the amount of mercury present in the waste and the chlorine content of the waste.

At higher chlorine contents (MSW usually contains a sufficient quantity) mercury will be primarily in an ionic form which can be removed by acid gas scrubbers. Metallic mercury (on the other hand) is much harder to control because it is very insoluble in water. Metallic mercury is normally controlled by being transformed into ionic mercury (by adding oxidants) so that it can then be captured by the wet scrubber; or by direct deposition on activated carbon and captured in a downstream ESP or fabric filter baghouse. A small amount of mercury is released into the atmosphere in a vaporous state during the combustion process, while the majority ends up in the APC residue after treatment. Very little mercury ends up in the bottom ash.

Other heavy metals (e.g., arsenic, beryllium, cadmium, lead, manganese etc.) are converted mainly into non-volatile oxides during the incineration process and bind to particulate matter in the flue gas and are then captured by ESPs and fabric filters (some are also captured by activated carbon). The majority of these heavy metals end up in the APC residue after treatment. Typically, a lesser amount of these heavy metals remain in the bottom ash (although for some there is a fairly even distribution between the bottom ash and APC residue).^[113]

4.2.2.7 Particulate Matter Control System Components

As discussed in detail in Section 4.1, particulate matter control is achieved using an electrostatic precipitator or a fabric filter baghouse.

4.2.2.8 Other APC Systems

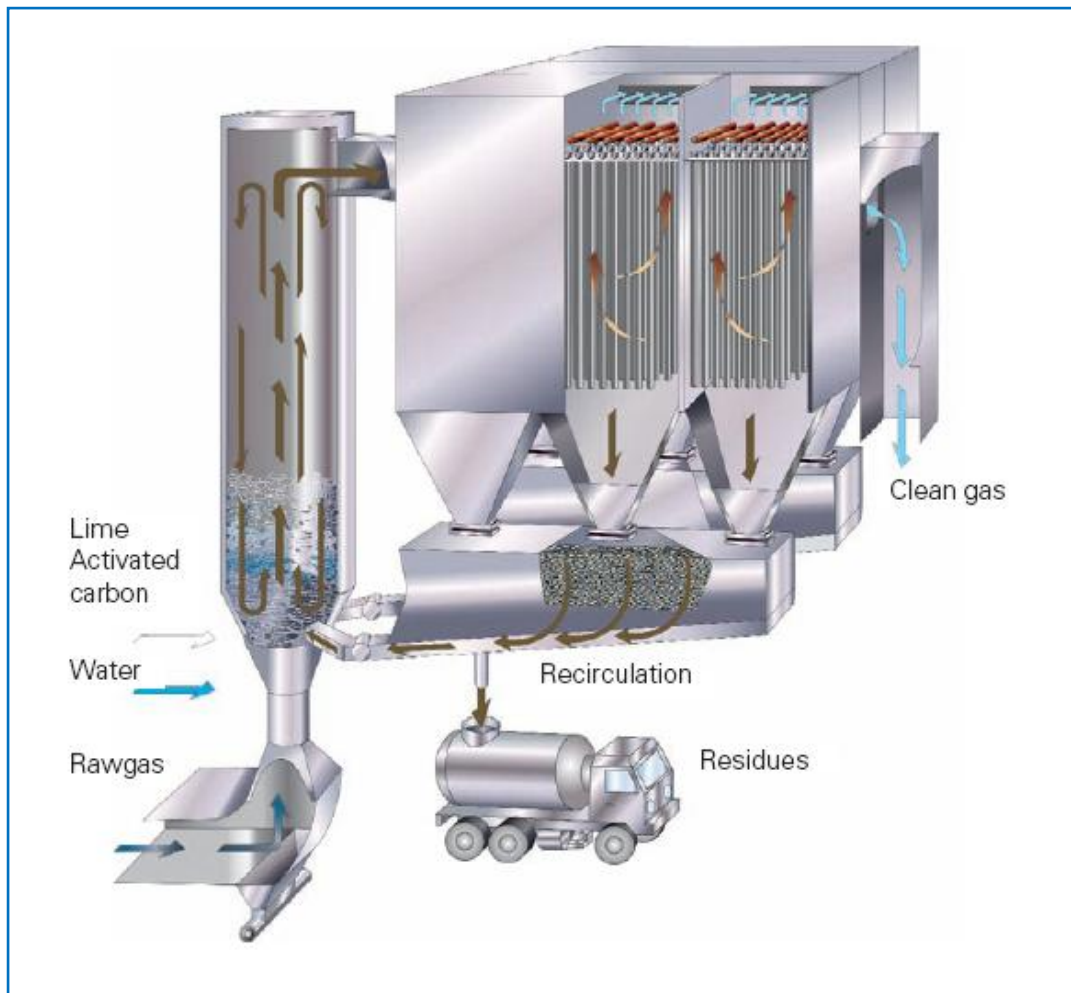
There are several other fairly new APC systems currently being used in Europe. Recently some of the European technologies have been proposed in US. An overview of two such technologies is provided below.

¹¹² European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

¹¹³ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

The Turbosorp solution is promoted by Von Roll Inova. The Turbosorp® process employs a turboreactor with fluidized lime activated carbon and a downstream bag filter. Briefly, the Turbosorp® process works this way: Downstream of the combustion section and steam generator, flue gases are channelled directly into the turbosorber without pre-treatment. Reagents for separation (hydrated lime or calcined lime and activated carbon) are metered into the stream here and water is injected at the same time. The temperature drops below 160°C as a result, improving separation while activating the lime. Pollutants react with the additives in the turbosorber forming products that can be trapped by the downstream fabric filter.^[114] Figure 4-19 provides a schematic overview of the Turbosorp process.

Figure 4-19: Schematic Diagram of the Turbosorp® Turboreactor



Source: Von Roll Inova. 2007. Accessed March 15, 2010 from http://www.aee-vonrollinova.ch/aee_vonroll_inova/products_services/abgasreinigung/turbosorp_r

¹¹⁴ Von Roll Inova. Turbosorp Flue Gas Purification

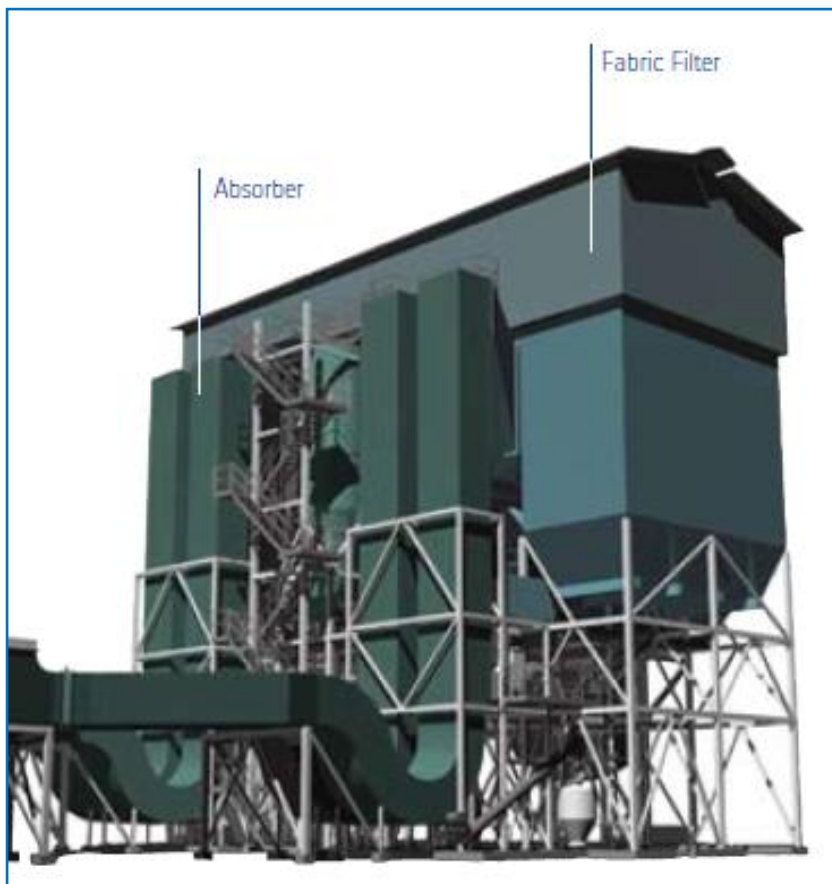
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The NID™ system is a Dry Flue Gas Desulphurization (DFGD) process that is based on the reaction between SO_2 and $\text{Ca}(\text{OH})_2$ in humid conditions. The humidified mixture of hydrated lime and reaction product is injected into the NID system absorber and cools the inlet flue gas by evaporation. The cooled flue gas then flows to the dust collector, preferably a Fabric Filter (FF) or an Electrostatic Precipitator (ESP), where the particles in the flue gas are removed and recycled back through the NID FGD system. In addition to desulphurization, the cooled, humid flue gas combined with a fabric filter provide excellent filtration and reaction conditions, resulting in very low particulate emissions and additional gas absorption (SO_2 , HCl , SO_3 , HF , Hg) in the dust cake.

Figure 4-20 presents a schematic overview of the NID System.

Figure 4-20: Schematic Diagram of the NID System



Source: NID™ Flue Gas Desulphurization System for the Power Industry. Alstom. Brochure

4.2.3 APC for Gasification Facilities

The requirement for an APC system for a gasification facility and the type of system it would use, depends primarily on whether or not the syngas being produced is being utilized onsite for energy generation (in which case some type of APC system would be required) or if the syngas is exported

for use off-site.^[115] If the syngas is exported offsite and used for an alternative purpose (i.e., production of hydrogen or methanol) there may be no emissions to air associated with the facility's operation.

The APC system associated with the Nippon Steel "Direct Melting System" and the APC system associated with the Thermoselect technology are discussed below as both are representative of facilities where the syngas is used on-site.

In the Nippon Steel "Direct Melting System", the syngas produced by the melting furnace is combusted immediately within the facility for energy generation. From limited but various sources, Stantec determined that the typical APC train used at these facilities is as follows. After the combustion chamber, the gas is cooled in a conditioning tower (wet spray type). The cooled gas is then passed through a bag filter (to remove particulate matter) and finally, NO_x is reduced via Selective Catalytic Reduction before the flue gas is released via a stack into the atmosphere. At one of their demonstration plants, Nippon Steel utilized an electrostatic precipitator rather than a bag filter. As can be observed, the APC system utilized by Nippon Steel is very similar to that used by mass burn facilities, although some common treatment steps are not present (i.e., activated carbon injection).^{[116],[117]} Based upon the limited data available, it appears that the Nippon Steel technology is capable of meeting European emissions standards.^[118]

Whether or not a gasification facility utilizing Thermoselect technology requires an APC system depends on how the syngas produced by the facility is to be used. A Thermoselect facility is capable of utilizing the syngas onsite to produce energy (via gas engines for electrical power generation or via boilers for heat or power generation) or export offsite to be used to produce energy or as a reagent in the production of various useful products such as methanol or ammonia. If the syngas is to be utilized onsite for energy generation, some type of APC system would be required.

At Thermoselect facilities, high efficiency gas engines are often used on site to produce electricity by combusting the syngas. In this case, the exhaust gas from the engine would be treated by SCR to reduce NO_x emissions and a catalytic converter would be used to reduce CO emissions (convert it to CO₂). Alternatively, the syngas could be used onsite to produce energy via a steam boiler in which case flue gas produced during the process would be treated prior to being released into the atmosphere. NO_x would generally be reduced via SNCR and a dry adsorption unit could be added to the facility to primarily reduce SO₂ and mercury emissions (sodium bicarbonate injection followed by fabric filter).

One way in which the Thermoselect technology assists in reducing the potential emissions to air associated with the combustion of the syngas it produces is via thorough syngas cleaning. Other gasification technologies also often utilize some form of syngas cleaning. Besides the main

¹¹⁵ If the syngas is exported and combusted offsite, the emissions to air associated with the combustion would truly be associated with the gasification facility itself

¹¹⁶ Nippon Steel Technical Report No. 70. July 1996. Research and Development of Direct Melting Process for Municipal Solid Waste.

¹¹⁷ Nippon Steel Technical Report No. 92. July 2005. Development of High-performance Direct Melting Process for Municipal Solid Waste.

¹¹⁸ University of California, Riverside. 2009. Evaluation of Emissions from Thermal Conversion Technologies Processing Municipal Solid Waste and Biomass.

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components of syngas (CO , CO_2 , H_2 , and H_2O), raw syngas also contains HCl , HF , H_2S , dust and metal compounds. The Thermoselect technology cleans syngas in several steps as follows:

- The hot syngas from the high temperature reactor is quenched rapidly preventing the de novo synthesis of dioxins/furans. The quench consists of a graphite cylinder with spraying nozzles.
- The syngas is then “pre-cleaned” by acidic scrubbing. HCl and HF are dissolved in the quench. This lowers the pH value of the quench to approximately a pH of 2 which assists in dissolving heavy metals as chlorides and/or fluorides and also binds trace amounts of ammonia as ammonia chloride.
- Following acidic scrubbing, dust is removed from the syngas. Dust is removed via a de-dusting scrubber (a water jet pump device) which removes dust and carbon particles from the syngas.
- After dust removal, the syngas undergoes desulphurization. This takes place through the adsorption of H_2S and the partial oxidation to elementary sulphur. Iron chelate is sprayed into the syngas flow causing the reaction.
- Fine dust is then removed from the syngas by a wet electrostatic precipitator if the downstream syngas utilization requires very low levels of dust.
- Finally, the syngas is reheated if a wet electrostatic precipitator is used. By reheating, the temperature of the syngas is raised slightly to avoid water condensation in downstream equipment.

As the list illustrates, the syngas cleaning process utilized by Thermoselect is quite thorough and greatly reduces the contaminants present in the syngas, thereby preventing the potential release of these substances into the air if the syngas is combusted. It should be noted that the Thermoselect process does not produce any wastewater. The water condensed during the different phases of the gas treatment is fed into the process water treatment. The process water undergoes a multiple stage treatment and is then reused for cooling purposes.^[119]

4.3 BACT for APC Systems

In both the Netherlands and Austria, for large waste incineration plants, wet flue gas treatment is considered as BACT. These two countries are considered leaders in the use of WTE and have some of the lowest emissions limits in the world, and information regarding the consideration of BACT in these jurisdictions was considered in the development of the European Commission BREF document on BAT for waste incineration.

The EU waste incineration BREF does not suggest the best method for air pollution control as the decision depends on a number of different factors depending on the particular circumstances

¹¹⁹ Thermoselect. 2005. Thermoselect Plant and Process Description

surrounding a facility. The selection of an APC system should be based on the optimal reduction of air emissions, but should also consider other aspects such as ^[120] ^[121]:

- Type of waste, its composition and variation
- Type of combustion process, and its size
- Flue gas flow and temperature
- Flue gas content and fluctuations in flue gas composition
- Land and space availability
- Availability and cost of outlets for residues accumulated/recovered
- Availability and cost of water and other reagents
- Energy supply possibilities
- Availability of subsidiaries for exported energy
- Tolerable disposal charge for the incoming waste
- Reduction of emissions by primary methods (operational controls)
- Generation of noise
- Minimization of effluent discharge
- The additional overall system compatibility issues that arise when retrofitting existing installations
- Consumption of chemicals and energy
- Maximum energy recovery.

Those factors aside, the waste incineration BREF states that an APC system should be selected that can provide for the emissions levels listed in the following table (Table 4-3) for releases to air.

The BREF also provides a comparative matrix to use when selecting between wet, semi-dry and dry APC systems. Although the comparison is not exhaustive, it does provide a helpful overview of the advantages and disadvantages associated with each of the systems. Table 4-4 presents the comparative matrix as given in the BREF document.

In order to ensure that a WTE facility will meet current stringent emissions limits, vendors of WTE technology are often willing to guarantee that their facility will meet certain emission figures lower than the approved limit criteria. Normally, the contract between the client wishing to have the facility and the vendor building the facility will explicitly state the concentration range for each pollutant that would be guaranteed by the vendor. Further, vendors normally specify the raw gas values that they will assume when designing their air pollution control system and would guarantee the amount of substances that their air pollution control system will consume during treatment (i.e., ammonia, lime etc.).

¹²⁰ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

¹²¹ Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT

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Table 4-3: EU BREF: Operational ELV Ranges Associated with the Use of BAT

Substance(s) (in mg/Nm ³ or as Stated)	Non-Continuous Samples	½ Hour Average	24 Hour Average	Comments
Total dust		1 – 20	1 – 5	In general the use of fabric filters gives the lower levels within these emission ranges. Effective maintenance of dust control systems is very important. Energy use can increase as lower emission averages are sought. Controlling dust levels generally reduces metal emissions.
Hydrogen chloride (HCl)		1 – 50	1 – 8	Waste control, blending and mixing can reduce fluctuations in raw gas concentrations that can lead to elevated short-term emissions. Wet FGT systems generally have the highest absorption capacity and deliver the lowest emission levels for these substances, but are generally more expensive.
Hydrogen fluoride (HF)		<2	<1	
Sulphur dioxide (SO ₂)		1 – 150	1 – 40	
Nitrogen monoxide (NO) and nitrogen dioxide (NO ₂), expressed as NO ₂ for installations using SCR		40 – 300	40 – 100	Waste and combustion control techniques coupled with SCR generally result in operation within these emission ranges. The use of SCR imposes an additional energy demand and costs. In general at larger installations the use of SCR results in less significant additional cost per tonne of waste treated. High N waste may result in increased raw gas NO _x concentrations.
Nitrogen monoxide (NO) and nitrogen dioxide (NO ₂) expressed as NO ₂ for installations not using SCR		30 – 350	120 – 180	Waste and combustion control techniques with SNCR generally result in operation within these emission ranges. 24 hour averages below this range generally require SCR although levels below 70mg/Nm ³ have been achieved using SNCR e.g., where raw NO _x is low and/or at high reagent dose rates) Where high SNCR reagent dosing rates are used, the resulting NH ₃ slip can be controlled using wet FGT with appropriate measures to deal with the resultant ammoniacal wastewater. High N waste may result in increased raw gas NO _x concentrations.
Total Organic Carbon		1 – 20	1 – 10	Techniques that improve combustion conditions reduce emissions of these substances. Emission concentrations are generally not influenced greatly by FGT. CO levels may be higher during start-up and shut down, and with new boilers that have not yet established their normal operational fouling level.
Carbon monoxide (CO)		5 – 100	5 – 30	
Mercury and its compounds (as Hg)	<0.05	0.001 – 0.03	0.001 – 0.02	Adsorption using carbon based reagents is generally required to achieve these emission levels with many wastes – as metallic Hg is more difficult to control than ionic Hg. The precise abatement performance and technique required will depend on the levels and distribution of Hg in the waste. Some waste streams have very highly variable Hg concentrations. Continuous monitoring of Hg is not required by Directive 2000/76/EC but has been carried out in some MSs.
Total cadmium and thallium (and their compounds)	0.005 – 0.05			See comments for Hg. The lower volatility of these metals than Hg means that dust and other metal control methods are more effective at controlling these substances than Hg.
Σ Other metals	0.005 – 0.5			Techniques that control dust levels generally also control these metals.
Dioxins and furans (ng TEQ/Nm ³)	0.01 – 0.1			Combustion techniques destroy PCDD/F in the waste. Specific design and temperature controls reduce de-novo synthesis. In addition to such measures, abatement techniques using carbon based absorbents reduce final emissions to within this emission range. Increased dosing rates for carbon absorbent may give emissions to air as low as 0.001 but result in increased consumption and residues.
Ammonia (NH ₃)	<10	1 – 10	<10	Effective control of NO _x abatement systems, including reagent dosing contributes to reducing NH ₃ emissions. Wet scrubbers absorb NH ₃ and transfer it to the wastewater stream.
Benz(a)pyrene	For these substances there was insufficient data to draw a firm BAT conclusion on emission levels. However, the data indicates that their emission levels are generally low. PCBs, PAHs and benz(a)pyrene can be controlled using the techniques applied for PCDD/F. N ₂ O levels are determined by combustion technique and optimisation, and SNCR optimisation where urea is used.			Techniques that control PCDD/F also control Benz(a)pyrene, PCBs and PAHs
PCBs				
PAHs				
Nitrous oxide (N ₂ O)				Effective oxidative combustion and control of NO _x abatement systems contribute to reducing N ₂ O emissions. The higher levels may be seen with fluidized beds operated at lower temperatures e.g., below ~900°C

- NOTES:**
- The ranges given in this table are the levels of operational performance that may generally be expected as a result of the application of BAT – they are not legally binding emission limit values (ELVs)
 - Σother metals = sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V and their compounds expressed as the metals
 - Non-continuous measurements are averaged over a sampling period of between 30 minutes and 8 hours. Sampling periods are generally in the order of 4 – 8 hours for such measurements.
 - Data is standardized at 11 % Oxygen, dry gas, 273K and 101.3 kPa
 - When comparing performance against these ranges, in all cases the following should be taken into account: the confidence value associated with determinations carried out; that the relative error of such determinations increases as measured concentrations decrease towards lower detection levels
 - The operational data supporting the above-mentioned BAT ranges were obtained according to the currently accepted codes of good monitoring practice requiring measurement equipment with instrumental scales of 0 – 3 times the WID ELV. For parameters with an emission profile of a very low baseline combined with short period peak emissions, specific attention has to be paid to the instrumental scale. For example changing the instrumental scale for the measurement of CO from 3-times the WID ELV to a 10-times higher value, has been reported in some cases, to increase the reported values of the measurement by a factor of 2 – 3. This should be taken into account when interpreting this table.
 - One MS reported that technical difficulties have been experienced in some cases when retrofitting SNCR abatement systems to existing small MSW incineration installations, and that the cost effectiveness (i.e., NO_x reduction per unit cost) of NO_x abatement (e.g., SNCR) is lower at small MSWIs (i.e., those MSWIs of capacity <6 tonnes of waste/hour).

SPLIT VIEWS:

1. BAT 35: Based upon their knowledge of the performance of existing installations a few Member States and the Environmental NGO expressed the split view that the 24 hour NH₃ emission range associated with the use of BAT should be <5 mg/Nm³ (in the place of <10 mg/ Nm³)
2. BAT 35: One Member State and the Environmental NGO expressed split views regarding the BAT ranges). These split views were based upon their knowledge of the performance of a number of existing installations, and their interpretation of data provided by the TWG and also of that included in the BREF document. The final outcome of the TWG meeting was the ranges shown in the table, but with the following split views recorded: total dust 1/2hr average 1 – 10 mg/Nm³; NO_x (as NO₂) using SCR 1/2hr average 30 – 200 and 24hr average 30 – 100 mg/Nm³; Hg and its compounds (as Hg) non-continuous 0.001 – 0.03 mg/Nm³; Total Cd + Tl non-continuous 0.005 – 0.03mg/Nm³; Dioxins and furans non-continuous 0.01 – 0.05 ng TEQ/Nm³. Based on the same rationale, the Environmental NGO also registered the following split views: HF 1/2hr average <1 mg/Nm³; SO₂ 1/2hr average 1 – 50 mg/Nm³ and 24hr average 1 – 25 mg/Nm³

Table 4-4: Example of Some IPPC Relevant Criteria for Selection of APC Systems

Criteria	Wet FGT (W)	Semi-wet FGT (SW)	Dry Lime FGT (DL)	Dry Sodium Bicarbonate FGT (DS)	Comments
Air emissions performance	+	0	–	0	In respect of HCl, HF, NH ₃ and SO ₂ wet systems generally give the lowest emission levels to air. Each of the systems is usually combined with additional dust and PCDD/F control equipment. DL systems may reach similar emission levels as DS and SW but only with increased reagent dosing rates and associated increased residue production.
Residue production	+	0	–	0	Residue production per tonne waste is generally higher with DL systems and lower with W systems with greater concentration of pollutants in residues from W systems. Material recovery from residues is possible with W systems following treatment of scrubber effluent, and with DS systems.
Water consumption	–	0	+	+	Water consumption is generally higher with W systems. Dry systems use little or no water.
Effluent production	–	+	+	+	The effluents produced (if not evaporated) by W systems require treatment and usually discharge – where a suitable receptor for the salty treated effluent can be found (e.g., marine environments) the discharge itself may not be a significant disadvantage. Ammonia removal from effluent may be complex.
Energy consumption	–	0	0	0	Energy consumption is higher with W systems due to pump demand – and is further increased where (as is common) combined with other FGT components e.g., for dust removal.
Reagent consumption	+	0	–	0	Generally lowest reagent consumption with W systems. Generally highest reagent consumption with DL – but may be reduced with reagent re-circulation. SW, and DL and DS systems can benefit from use of raw gas acid monitoring.
Ability to cope with inlet variations of pollutant	+	0	–	0	W systems are most capable of dealing with wide ranging and fast changing inlet concentrations of HCl, HF and SO ₂ . DL systems generally offer less flexibility – although this may be improved with the use of raw gas acid monitoring.
Plume visibility	–	0	+	+	Plume visibility is generally higher with wet systems (unless special measures used). Dry systems generally have the lowest plume visibility.
Process complexity	– (highest)	0 (medium)	+	+	Wet systems themselves are quite simple but other process components are required to provide an all round FGT system, including a wastewater treatment plant etc.
Costs –capital	Generally higher	Medium	Generally lower	Generally lower	Additional cost for wet system arises from the additional costs for complementary FGT and auxiliary components – most significant at smaller plants.
Costs – operational	Medium	Generally lower	Medium	Generally lower	There is an additional operational cost of ETP for W systems – most significant at smaller plants. Higher residue disposal costs where more residues are produced, and more reagent consumed. W systems generally produce lowest amounts of reagents and therefore may have lower reagent disposal costs. Op. costs include consumables, disposal and maintenance costs. Op. costs depend very much on local prices for consumables and residue disposal.

NOTES:

- + means that the use of the technique generally offers an advantage in respect of the assessment criteria considered
- 0 means that the use of the technique generally offers no significant advantage or disadvantage in respect of the assessment criteria considered
- means that the use of the technique generally offers a disadvantage in respect of the assessment criteria considered

5 EXPECTED EMISSION RATES FROM COMBUSTION AND CONTROL SYSTEMS

WTE facilities must be well operated and well maintained to ensure that emissions resulting from their operation are as low as possible. Good combustion practices (i.e., operational controls) can reduce emissions by ensuring that the temperature in the combustion chamber and the retention time for the waste in the combustion chamber are kept at optimal levels. The emissions that are produced during combustion are then reduced further via APC equipment.

5.1 Typical Emissions from Mass Burn Facilities

Table 5-1 illustrates the typical concentration of pollutants in untreated flue gas from a modern conventional mass burn incinerator that treats 15 tonnes of waste per hour for 8,000 hours per year (120,000 tonnes per year). The table also includes the European Union emissions requirements (for comparison purposes) and the typical flue gas quality from a 120,000 tonne per year facility utilizing a semi-dry, wet, or semi-wet APC system.^[122]

As presented in this table and as discussed further within this section of the report, modern WTE facilities with modern APC systems in a variety of configurations are capable of high removal efficiencies for various parameters and can typically achieve emissions that are well within regulated limits. It should be noted that this table presents typical average values for new APC systems, in comparison to the EU emissions requirements. Information presented in Section 5.2, regarding the range of emissions performance for existing WTE plants, includes older facilities that may or may not have recent APC upgrades and thus provide an overview of the range of emissions associated with existing facilities. Care should also be taken in comparing the typical daily average values as presented in Table 5-1 with those that represent average data from either CEM's or Stack Tests (particularly in regards to the averaging periods) as they may not be directly comparable.

Table 5-1: Comparison of Emissions in Raw Flue Gas, EU Emissions Requirements, and Emissions Expected from Semi-Dry, Wet and Semi-Wet APC Systems

Component	Unit	Flue Gas Quality (typical, daily average values)					% Range in Reduction
		Raw Flue Gas	EU Emissions Requirements	Semi-Dry System	Wet System	Semi-Wet System	
Total Particulate Matter	mg/Rm ³	2,000 – 4,500	9.2	3	0 – 2	3	99.90 to 99.95 %
SO ₂	mg/Rm ³	180 – 550	46	<30	1 – 10	15	83.3 to 98.18%
NO _x (with SNCR)	mg/Rm ³	200 – 450	183	<120	<120	<120	40 to 73.3%
HCl	mg/Rm ³	450 – 2,000	9.2	<7	1	2	98.4 to 99.95%
HF	mg/Rm ³	5 – 10	0.92	0.01	0.05	0.05	99.0 to 99.90%
Hg	mg/Rm ³	0.1 – 1	0.046	0.01	0.002	0.002	90 to 99.8%

¹²² Ramboll. 2007. The Regions of Durham and York EfW Facility: Comparison of Flue Gas Treatment Systems

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Component	Unit	Flue Gas Quality (typical, daily average values)					% Range in Reduction
		Raw Flue Gas	EU Emissions Requirements	Semi-Dry System	Wet System	Semi-Wet System	
Cd	mg/Rm ³	1.09 – 2.0	N.A.	0.01	0.002	0.002	99.1 to 99.5%
Cd+Tl	mg/Rm ³	1.0 – 2.0	0.046	0.015	0.005	0.01	98.5 to 99.75%
Pb	mg/Rm ³	25 – 35	N.A.	0.005	0.005	0.005	99.98%
Sum of As, Ni, Co, Pb, Cr, Cu, V, Mn, Sb	mg/Rm ³	5 – 50	0.46	0.05	0.04	0.04	99.0 to 99.92%
Dioxins/Furans I-TEQ	ng/Rm ³	0.009 – 14	0.092	0.08	0.05	0.06	99.6%

NOTE:

Rm³ refers to 25°C

11% O₂, and dry fluegas

NA = Not applicable

5.2 Comparison of Emission Rates from Existing Facilities

The actual air emissions performance of several operating WTE facilities has been reviewed to provide a broad understanding of the emissions from current operating facilities.

Table 5-2 below summarizes the reported emissions from various existing and proposed WTE facilities globally. The emission components are only those actually reported for these facilities; not all facilities are required to report the same components. In regards to the reported values, in many cases the emissions reported are daily averages obtained from CEMs and/or average data reported from stack tests.

Examination of the reported emissions data indicates that in general:

- Modern WTE facilities in North American and EU jurisdictions emit many parameters within the same order of magnitude.
- The range of reported emissions values widens as older facilities are included in the reported range of values.
- The majority of North American and EU jurisdictions require monitoring and reporting of similar emissions, although there are some distinct differences in regards to the monitoring and reporting of trace metals and trace organic parameters.

Table 5-2: Comparison of Emissions from Various Existing WTE Facilities

Component	Unit	Metro Vancouver WTE Facility (2007) ^[1]	Modern Italian Waste Incinerator ^[2]	Emissions from retrofitted UK plant (2001) ^[3]	Sheffield Energy Recovery Facility (UK) (March 2010) ^[4]	SELCHP (UK) (December 2009) ^[5]	Range from European MSW Incinerators (2006) ^[6]			Average Values from 87 US WTE Facilities ^[7]	Average of Three High Performing US Facilities ^[7]	Average of 10 Finalists in WTERT 2006 Award ^[7]	SEMASS (US) (July 2006) ^[8]	Wels (Austria) (2000) ^[11]	Spittelau (Austria) (2000) ^[11]	Flotzersteig (Austria) (2000) ^[9]	Average Values from Dutch Incinerators (2002) ^[10]
				Daily Average	Daily Average	Daily Average	Annual Average	Daily Average	Half Hour Average		Daily Average	Daily Average		Half Hour Average	Half Hour Average	Half Hour Average	Daily Average
Total Particulate Matter	mg/m ³	3.8	1.9	0.84	0.75	3.63	0.093–3.73	0.093–9.32	<0.047–13.98	2.8	1.0	2.9	1.7	<0.47	0.75	1.96	0.47–2.8
CO	mg/m ³	23	9.3	4.7	1.86	5.59	1.86–42	0.93–93	0.93–140		11.5	22.4	37.7	18.6	24.5	14.2	4.66–47
SO ₂	mg/m ³	85	7.5		8.39	1.86	0.19–19	0.47–47	0.093–233	11.2	5.3	2.8	71.7	<1.86	1.96	9.69	1.86–28
NO _x	mg/m ³	265	130.4	255.3	85.53	144.42	18.6–168	28–186	18.6–419	227.7	46.3	104	204	50.3	21.4	28.4	37.2–65
HCl	mg/m ³	23.6	6.5	18.6	5.40	4.85	0.093–5.6	0.093–9.3	0.093–75	10.6	1.5	7.9	8.4	<0.093	0.75	0.093	0.47–4.7
HF	mg/m ³	0.1	0.65	<0.093			0.009–0.09	0.09–0.093	<0.019–0.9					<0.047	<0.019	0.13	0.093–0.47
VOCs	mg/m ³		3.07														
TOC	mg/m ³				0.93	0.19	0.093–4.7	0.093–9.3	0.093–23		0.65	0.95			0.47		0–9.32
Methane	mg/m ³	4.3															
Hg	mg/m ³	0.002	0.009				0.00019–0.047	0.0047–0.047	0.0013–0.034	0.007	0.0028	0.0093	0.0009	<0.0019	0.065	0.0335	0.0047–0.019
Cd	mg/m ³	0.0006	0.009	<0.00093				0.0003–0.003		0.0007			0.0001	<0.0019	0.00093	0.00186	
Cd,Tl	mg/m ³						0.0002–0.028										0.0009–0.0093
Pb	mg/m ³	0.0059	0.093					<0.002–0.041		0.014			0.0127	<0.0019	0.0112	0.041	
Sum of As, Ni, Co, Pb, Cr, Cu, V, Mn, Sb	mg/m ³			<0.932			0.0002–0.047										
PAH	µg/m ³	0.13					<9.324										
PCB	µg/m ³	0					<4.66										
Dioxins/Furans I-TEQ	ng/m ³	0.002	0.047	0.0056			0.00019–0.075			0.04	0.0019	0.0186	0.024	0.0028	0.0186	0.0168	0.009–0.047

NOTES:

Reference conditions: 101.3 kPa, 20°C, dry gas, 11% O₂

¹ AECOM Canada Ltd. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

² M. Guigliano, *et al.* 2008. Energy Recovery from Municipal Waste: A Case Study for a middle-sized Italian District. In Waste Management 28 (2008) 39 – 50 (representative of modern WTE plants equipped with a dry flue gas cleaning system (dry scrubbing + activated carbon) followed by a fabric filter. Nitrogen oxides are controlled by selective non-catalytic reduction activated by urea.)

³ Porteous. 2001. Energy from waste incineration - a state of the art emissions review with an emphasis on public acceptability.

⁴ Sheffield Energy Recovery Website (<http://www.veoliaenvironmentalservices.co.uk/sheffield/pages/emissions.asp>) (All based on continuous measurements).

⁵ SELCHP Website (<http://www.selchp.com/emissions.asp?year=2009&emissionId=48>) (All based on continuous measurements). APC system is comprised of SNCR, semi-dry lime and activated carbon injection.

⁶ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration. (All based on continuous measurements except for heavy metals and dioxins/furans which are based on sampling periods generally in the order of 4 – 8 hours).

⁷ C.S. Psomopoulos, *et al.* 2009 Waste-to-energy: A review of the status and benefits in USA. (All based on continuous measurements except for heavy metals and dioxins/furans which are based on spot samples).

⁸ SEMASS Boiler NO. 3 Test Results.

⁹ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration. APC system includes ESP, three wet scrubbers, and SCR. TPM, HCl, SO₂, TOC, CO, NO_x are based on CEMS, rest are based on discontinuous measurements.

¹⁰ Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste. (All based on continuous measurements except for heavy metals and dioxins/furans which are based on spot samples). Almost all Dutch incinerators employ wet scrubbers and SCR.

¹¹ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration. APC system includes ESP, two wet scrubbers, and activated coke filter, and SCR, TPM, HCl, HF, SO₂, TOC, CO, NO_x are based on CEMS, rest are based on discontinuous measurements.

¹² European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration. APC system includes SNCR, two fabric filters and wet scrubbing. TPM, HCl, SO₂, TOC, CO, NO_x are based on CEMS, rest are based on discontinuous periodic measurements.

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It should be noted that the basis on which emission rates are calculated vary by jurisdiction. Emissions from combustion facilities must be adjusted, or 'corrected', to pre-determined standard conditions. Most emissions are reported on a mass per volume basis, such as milligrams per standard or reference cubic metre (mg/Rm³). The correction to standard conditions is necessary because, as a gas, the volumetric rate of discharge will vary as a result of temperature and pressure (gauge and absolute). The rate also varies with the composition of the gaseous constituents, such as percent O₂ and CO₂. BC Standard Conditions are 20°C, 101.325 kPa, dry gas (0% moisture) and include site specific standard conditions for %O₂ or %CO₂.

5.3 Air Emissions Quality Trends

Air emissions from modern state-of-the-art WTE facilities are greatly reduced in comparison to older facilities that have less stringent operational controls and less effective air pollution equipment and monitoring systems. WTE tends to be highly regulated in consideration of the potential effects of emissions on human health and the environment, and public perception. For this reason, developed countries have very strict emissions standards. Contemporary air pollution control technologies have been developed to stay well within these limits.^[123]

In the United States, there are currently 89 operating WTE facilities that treat MSW. The emissions from WTE facilities have decreased substantially over the past number of decades due to improvements made to waste combustion technologies. A memorandum released by the United States Environmental Protection Agency in 2007 presented the overall emissions reductions achieved by large and small municipal waste combustion (MWC) units which were retrofitted with Maximum Achievable Control Technology from 2000 to 2005. The table presents the emissions from these large and small municipal waste combustion (MWC) Units in 1990 (prior to retrofits) and in 2005 (after retrofits). As the table illustrates, the reduction of emissions was quite significant.^[124]

Table 5-3: Emissions from Large and Small MWC Units at MACT Compliance (US EPA)

Pollutant	1990 Emissions (tpy)	2005 Emissions (tpy)	Percent Reduction
Dioxins/Furans, TEQ basis	4,400	15	99+%
Mercury	57	2.3	96%
Cadmium	9.6	0.4	96%
Lead	170	5.5	97%
Particulate Matter	18,600	780	96%
HCl	57,400	3,200	94%
SO ₂	38,300	4,600	88%
NO _x	64,900	49,500	24%

¹²³ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

¹²⁴ United States EPA. 2007. Memorandum: Emissions from Large and Small MWC Units at MACT Compliance

5.4 Factors Affecting Emission Rates

A number of factors affect the emissions rates from the thermal treatment of MSW. Generally, the following factors are the main contributors to emission performance:

- Waste composition and content (depends on jurisdiction and diversion practices in place)
- Thermal treatment technology (the design and operation of the thermal treatment facility)
- Design and operation of the APC equipment.

The following subsections will discuss each of the factors that affect emissions in greater detail.

5.4.1 Waste Composition and Content

Several of the substances of concern that are emitted to air from WTE facilities originate from the MSW being treated. For example, the release of heavy metals such as mercury and cadmium as well as acidic gases such as SO₂ and HCl from WTE facilities is driven largely by the presence of these substances in the post-diversion waste stream.

As an illustration, if the post-diversion waste stream contains a lot of mercury laden waste (compact fluorescent light bulbs, mercury thermometers), more mercury is likely to be released into the atmosphere, even after the flue gas is treated with state-of-the-art APC equipment. Therefore, it is desirable in jurisdictions which utilize thermal treatment to try and minimize contaminants present in the residual waste stream. The composition of MSW depends on the types and quantities of materials being placed in the garbage stream by residents. This depends on the types of diversion programs available in a given jurisdiction, the public's participation in these programs, as well as the types of materials being used and disposed of in a given jurisdiction.

BC has been particularly active at removing these contaminants from the waste stream – further information is available on the web at: <http://rcbc.bc.ca/education/retailer-take-back>.

The following table illustrates how the removal of various materials from the residual waste stream will affect the thermal treatment of the remaining waste stream.^[125]

Table 5-4: Impact of Material Removal and Pre-treatment on Residual Waste

Materials Removed	Impact on the Remaining Waste
Electronics	<ul style="list-style-type: none">▪ Increase in calorific value▪ Decrease in hazardous metal loading, may reduce chlorine loads
Glass and Metals	<ul style="list-style-type: none">▪ Increase in calorific value▪ Decrease in quantity of recoverable metals in slag (or bottom ash)
Paper, Cardboard and Plastic	<ul style="list-style-type: none">▪ Decrease in calorific value▪ Possible reduction in chlorine loads if PVC plastic is common

¹²⁵ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

Materials Removed	Impact on the Remaining Waste
Organic Wastes (food and garden materials)	<ul style="list-style-type: none"> Reduction in the moisture loads (particularly during peak loads) Increase in calorific value
Bulky Wastes	<ul style="list-style-type: none"> Reduced need for removal/shredding of such wastes
Hazardous Wastes	<ul style="list-style-type: none"> Reduction in hazardous metal loading Reduction in some other substances (e.g., Cl, Br)
Construction and Demolition Waste	<ul style="list-style-type: none"> Reduction in sulphur content (gypsum from drywall).

Having a diversion program in place does not necessarily mean that it will capture the targeted materials unless residents participate regularly in the program. For example, if a resident discards compact fluorescent light bulbs but chooses not to participate in his/her community's hazardous waste diversion program, this will lead to increased levels of mercury in the waste stream and thus increase the potential for mercury release during thermal treatment. Most jurisdictions try to increase public participation in their diversion programs through aggressive promotion and education campaigns.

Finally, even if a jurisdiction has a mature waste management system and regular participation by residents in the diversion programs, this does not definitively mean that potential hazardous materials will be removed from the garbage stream. For example, if manufacturers increase the use of non-recyclable PVC plastic within their products, the overall chlorine content of the waste will increase leading to a potential increase in HCl production during the thermal treatment of the waste material. The removal of potentially hazardous materials from the residual waste stream is difficult as policies which govern materials such as packaging and product formulation are usually out of the local jurisdiction's control.

5.4.2 Selection of Thermal Technology

The thermal treatment technology being used to treat MSW also has a significant impact on the emissions released. Differences will be observed from technology to technology and within each technology grouping.

The proper operation of a thermal treatment facility plays a significant role in emissions performance. If appropriate operational controls are maintained over the combustion process (proper temperature and residence time, adequate overfire air) less emissions of organic compounds and products of incomplete combustion will be realized (e.g., dioxins/furans, CO). Additionally, the waste stream can be pretreated to ensure proper homogenization and removal of undesirable materials. The above examples are by no means an exhaustive list of potential operational considerations but are meant for illustrative purposes only.

5.4.3 Design and Operation of APC Equipment

The design and operation of a WTE facility's APC equipment will have a significant impact on the type and rate of emissions arising from its operation. As discussed in previous sections, different types of APC trains (i.e., wet, semi-dry) are capable of reducing emissions to varying levels. Wet

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systems tend to provide more flexibility and are typically able to reduce emissions to a greater degree than dry systems.

In addition to the type of APC system, the operation of a given system will also have a great effect on emissions reduction performance. If a system is well maintained and operated under optimal conditions, the rate of emissions will be reduced. For example, in a fabric filter baghouse, the filter cake should be kept at a particular thickness so as to capture the majority of particulate matter without reducing air flow too significantly.

As another example, SNCR systems are capable of reducing NO_x emissions well below emissions requirements depending on the quantity of reagent (NH₃) added to the flue gas stream. The amount of reagent added depends on the desired emissions levels as well as the costs associated with reagent supply.

6 EMISSIONS FROM USE OF REFUSE DERIVED FUEL

6.1 RDF Overview

The composition of Refuse Derived Fuel (RDF) produced from MSW varies according to the origin of the waste material and the sorting/separation process used to produce the RDF. The following table (Table 6-1) presents an overview of the typical composition of RDF produced through the processing of MSW.^[126]

RDF, which is also often called Solid Recovered Fuel (SRF), is typically produced by processing municipal solid waste through: shredding, selective materials recovery (metals), dehydrating and packaging for transport into bale, brick or pellet form. RDF can be comprised of more homogenous residue streams generated by industry such as off-cuts from production of packages, or inorganic (plastic) residues removed from finished compost. RDF can also be generated through source separation of specific material streams such as separation of clean or contaminated wood waste materials from construction and demolition wastes.

Other waste materials can also be processed into waste derived fuels. Waste tires have been used as a fuel supplement as tire derived fuel (TDF) in cement kilns and pulp mill power boilers.

Table 6-1: Typical Composition of RDF Derived from MSW

Waste Fraction	Flemish Region		Italy	UK
	Resulting from Sorting Process (%)	Resulting from Mechanical/Biological Treatment (%)	%	%
Plastic	31	9	23	11
Paper/Cardboard	13	64 ⁽¹⁾	44	84
Wood	12	25 ⁽²⁾	4.5	5 ⁽⁴⁾
Textiles	14		12	
Others	30		14 ⁽³⁾	
Undesirable material (glass, stone, metal)		2	2.5	
Dry-solid content	66%	85%	–	–

NOTES:

⁽¹⁾ Includes, paper, textile, wood

⁽²⁾ Includes rubber, synthetic material

⁽³⁾ Includes organic degradable waste

⁽⁴⁾ Includes glass, wood, textiles and metals

In all cases, the application of this supplemental fuel in industrial or other applications, involves waste materials that have been processed in some way to make them more suitable for introduction

¹²⁶ European Commission – Directorate General Environment. 2003. Refuse Derived Fuel, Current Practice and Perspectives (B4-3040/2000/306517/MAR/E3) Final Report

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into the fuel feed system and to optimize thermal and emissions performance. Unprocessed, raw MSW is not used as a supplemental fuel supply for industrial applications as it would generally not be considered suitable from an operational standpoint given that it is highly heterogeneous.

Beyond the practical advantages of blending the fuel supply, the biogenic portion of RDF may have an environmental and/or monetary value in terms of GHG offsets from fuel substitution if GHG emissions are reduced compared to a business-as-usual scenario and the fuel substitution meets applicable criteria.

Refuse derived fuel (RDF) can be produced from municipal solid waste (MSW) through a number of different processes including the following:

- Separation at source
- Sorting or mechanical separation
- Size reduction (shredding, chipping and milling)
- Separation and screening
- Blending
- Drying and pelletizing
- Packaging
- Storage.

Processing includes removal of any components that could pose quality and environmental concerns. The purpose of the processing of MSW is to generate a fuel source that is relatively homogenous and free of any undesired components.

There are two primary approaches which can produce a high calorific fraction from domestic MSW, which can be used as RDF:

- Mechanical Biological Treatment
- Dry Stabilisation Process.

In a mechanical biological treatment facility (MBT), mixed solid wastes are separated into the following:

- Metals (recovered for recycling)
- Inert materials
- Organic materials (often stabilized using composting processes or anaerobic digestion)
- A residual fraction that has a high-calorific value as it is composed mainly of dry residues of paper, plastics and textiles that can be used as an RDF.

RDF can also be produced through a 'dry stabilization' process, in which residual waste (following removal of the inert portion of the waste and metals) are effectively dried (and stabilized) through a composting process, leaving the residual mass with higher calorific value and suitable for combustion.

The quantity of RDF produced per tonne of processed MSW varies depending on the type of collection, treatment process and quality requirements. The rate of RDF production from MSW can vary between 25 and 85% by weight of waste processed depending on the treatment process used.

The final form and characteristics of RDF produced through processing facilities is usually tailored to the intended industrial application of the material, as the specifications in regards to fuel quality, composition, particle size and density etc. can vary significantly from application to application. The following sections provide discussion on two specific applications of RDF within BC industry, followed by general discussion on how the use of RDF in general should be regulated within the province.

6.2 RDF Use in Wood Fired/Pulp Mill Boilers

6.2.1 General Discussion

Typically, pulp mill boilers are designed to combust relatively clean wood waste in the form of bark, sawdust and small dimension chunks of woody debris, commonly called hog fuel. Contaminants in the hog fuel will vary depending on the location of the mill and source of hog fuel. For example, coastal mills burning wood residuals from timber boomed in salt water will have elevated concentrations of chloride. Timber boomed in a river will have a higher concentration of silt and sand mixed in, potentially forming a nuisance slag in the furnace. There are few other contaminants in the fuel supply for wood fired boilers. Metal, plastic and chlorinated organic compounds are, for the most part, absent from the fuel supply.

Pulp mill boiler APC equipment typically consists of cyclones, baghouses and ESPs, used singly or in combination. Systems to control acid gas or to capture toxic organic compounds are not normally installed on these types of boilers, as these contaminants of concern are not normally produced. Particulate emissions, opacity of the discharge and gaseous components including NO_x, SO_x, CO and unburned hydrocarbons are typically the emissions of concern with wood fired boiler systems. If salt laden wood is burned dioxins and furans are also released (for these situations Ministry permits contain appropriate emission limits). The BC MOE previously commissioned a report on emissions from wood fired combustion equipment in BC which discusses facility and APC design and costs, current performance and achievable emissions limits for various wood fired combustion approaches.^[127]

There is interest in BC to use wood fired boilers for treatment of construction and demolition wastes that have been processed to remove undesirable constituents, such as gypsum, plastic and metals. The option is attractive given the potential to supplement fuel in areas where fibre and fuel supply is constrained. It also eliminates the need for landfilling these wastes while providing the opportunity to convert the waste to energy in the form of electricity, process steam or potentially district heat.

There are a number of constraints to the use of wood fired combustion boilers for treatment of MSW, RDF or construction and demolition debris, including:

¹²⁷ Envirochem, 2008. Emissions from Wood-Fired Combustion Equipment
http://www.env.gov.bc.ca/epd/industrial/pulp_paper_lumber/pdf/emissions_report_08.pdf

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- The waste type needs to be of similar type to the design fuel source intended for the boiler. Issues around calorific value, moisture content and the presence of contaminants of concern can be minimized if the fuel supply is limited to predominantly wood. Raw MSW and most types of RDF will not be suitable for this application as a result of elevated plastic and metal in the fuel supply. Unsorted demolition waste is also not likely to be compatible with the combustion and APC systems as a result of contamination by plastic, gypsum, textile wastes and metals.
- The facility has to have the ability to feed the wastes into the boiler in a manner that maintains operational control and performance without adversely affecting emission quality. It would be necessary to shred (hog) woody debris to make it suitable for feeding into the boiler.
- Given that even processed RDF or construction and demolition waste may include contaminants not present in hog fuel from a sawmill, controlling and monitoring emission quality relative to the ELVs in the facility permit and/or other emission criteria or standards is critical. For example, the current emission limit values for total particulate from wood fired power boilers is typically higher than the value for WTE facilities. Particulate ELVs in BC for wood fired boilers in a non-urban setting range between 120 mg/m^3 to 230 mg/m^3 , in contrast to the current WTE facility particulate ELV of 20 mg/m^3 . The current ELVs for wood fired boilers typically do not specify concentrations of trace metals or toxic organic compounds whereas these are important criteria for a WTE facility.
- In many cases it is reasonable to anticipate that it will be uneconomic to retro-fit APC systems to treat the host of other emissions (in addition to particulate for instance) not normally produced by firing wood waste. Therefore, the emission quality has to be essentially unchanged from the design emission produced by the facility when operating solely on wood waste.

The following sub-sections discuss proposed approaches for the application of two RDF streams in wood fired boilers being wood waste and tire-derived fuel, as these are the potential RDF streams in which the most interest has been demonstrated to-date for such applications.

6.2.2 Use of Wood Waste in Pulp Mill/Wood Fired Boilers

Construction and demolition wastes includes discarded materials generally considered to be not water soluble and non-hazardous in nature, including but not limited to steel, glass, brick, concrete, asphalt material, pipe, gypsum wallboard, and wood waste, from the construction or destruction of a structure or from the renovation of a structure. Wood wastes arising from construction include off cuts from structural timbers, timber packaging, scaffolding, wooden hoardings, whereas wood wastes arising from demolition include used structural timbers, e.g., floorboards, joists, beams staircases and doors.

For the purpose of distinguishing between wood waste sources that could be used as alternative fuels for wood fired boilers, the following defines the two broad categories of wood waste based fuels that may be suitable when recovered from the construction and demolition waste stream.

1. “Clean” wood waste means uncontaminated wood or wood products, from which hardware, fittings and attachments, unless they are predominantly wood or cellulose, have been removed (e.g., clean wooden shakes and shingles, lumber, wooden siding, posts, beams or logs from log home construction, fence posts and rails, wooden decking, millwork and cabinetry), and **excludes**:
 - Any engineered or chemically treated wood products, such as products with added glues or those treated for insect or rot control (oriented strand board, plywood, medium density fibre board, wood laminates or wood treated with chromated copper arsenate, ammoniacal copper arsenate, pentachlorophenol or creosote)
 - Upholstered articles
 - Painted or varnished wood articles or wood with physical contaminants, such as plaster, metal, or plastic
 - Any wood articles to which a rigid surface treatment is affixed or adhered.

Clean wood waste also excludes other materials found in the construction and demolition waste stream such as gypsum or drywall, fibreglass, asphalt or fibreglass roofing shingles, metals or plastics.

2. “Contaminated” wood waste is primarily composed of wood or wood products, but may include of engineered wood products, painted or treated wood, gypsum or drywall, fibreglass, asphalt or fibreglass roofing shingles, metals or plastics.

Land clearing waste is not considered as part of the construction and demolition waste stream for the purpose of this discussion. The sources of land clearing waste can range from land clearing by individual property owners on acreages to developers clearing areas for entire subdivisions.

Generally entire trees are removed, including the root systems which contain soil. In many cases this debris is not left to season before it is disposed of, which results in less than optimal fuel because of the high moisture content and the existence of large quantities of soil.

The chemical composition of clean wood waste and its fuel characteristics are essentially the same as the current permitted fuel stream for existing wood fired boilers. Combustion of clean wood waste as defined above, within existing wood waste boilers, can be accommodated by existing facilities within the currently permitted emissions limits and would be regarded as a minor modification to current operations. Fuel testing would be necessary both initially (to support minor permit changes) and during regular operations to ensure that the wood waste fuel accepted for combustion, continues to meet regulated specifications for ‘clean’ wood waste.

Combustion of wood waste contaminated with organic and inorganic wood protection and wood preservation chemicals has been conducted in BC power boilers over the past two decades. This includes wood contaminated with creosote (railway ties and some structural timber), and pentachlorophenol treated wood (utility pole and some structural timber). It should be noted that chlorophenol use as a wood protection (anti-sapstain) chemical was discontinued in the early-1990s and chlorophenols are now only found in limited wood preservation applications. Therefore, the presence of chlorophenols in refuse derived fuel is now considered to be unlikely. In the past, these

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waste streams have been included on a limited fuel substitution basis in trial burns. While these tests have generally resulted in acceptable emissions from the facility, other constraints including public concern and waste material handling have prevented adoption of larger programs of fuel substitution with these materials. Other applications of 'contaminated' wood waste have included the use of wood waste contaminated by other construction and demolition materials.

Substitution and supplementing fuel supply with 'contaminated' wood waste should be acceptable under specific conditions and would require amendment of current facility permits as follows:

- Use of 'contaminated' wood waste as fuel would likely be considered a major modification to the operations for a given facility and would require permit amendments to address operational changes and revised ELVs, which for a number of parameters would be consistent with those proposed for WTE facilities.
- Testing of the proposed fuels including mass balance analysis to determine the potential shift in emissions concentrations at various substitution rates would be required. This should be accompanied by fuel trials undertaken to demonstrate the actual shift in emissions concentrations associated with use of the proposed fuels.
- As part of the permit amendments, revised ELVs would be necessary in order to limit the potential for effects from air emissions. Revised ELVs could reflect the following:
 - Revised particulate limits to reflect new performance expectations in accordance with those identified in the Envirochem report "Emissions from Wood-Fired Combustion Equipment" which suggests that achievable particulate emission limits for wood fired boilers are in the order of 35 mg/m³ for facilities ranging in size from 3 to 39 MWh or 20 mg/m³ for facilities of 40 MWh and larger.^[128]
 - Retention of the existing limits for CO and NO_x given that emissions performance for these parameters is based on general facility design and operations.
 - Application of the limits proposed for other parameters (heavy metals, persistent organic pollutants) based on those proposed for municipal solid waste incinerators (Section 9.3).
- Fuel quality testing should be undertaken initially to ensure the proposed source and type of material is suitable for consideration, during fuel testing to demonstrate the potential fate of various parameters in the fuel during the combustion process and on a regular basis during operations to ensure that fuel quality specifications (both regulated and unregulated) are being met. During normal operations, it would be reasonable in the first few years for the facility to test its contaminated wood waste fuel supply at least quarterly through random samples to ensure compliance with permits and to ensure that the fuel suppliers meet the requirements set out by the operator.

¹²⁸ Envirochem, 2008. Emissions from Wood-Fired Combustion Equipment
http://www.env.gov.bc.ca/epd/industrial/pulp_paper_lumber/pdf/emissions_report_08.pdf

- Proponents that intend to use a 'contaminated' wood waste as a portion of their fuel stream, would need to identify the proposed rate of fuel substitution and would have to demonstrate their ability to meet the revised ELV's as discussed above, at the proposed maximum substitution rate.

6.2.3 Use of Tire Derived Fuel in Pulp Mill/Wood Fired Boilers

In North America, the use of supplementary fuels in the pulp industry has generally been limited to TDF. About 26 million tires per year are consumed as fuel in US pulp and paper mill power boilers. These facilities typically use wood waste as the primary fuel supply, but the operators have found that the use of TDF increases the stability of the boiler performance. TDF is used in many plants as a supplement to wood because of its high heat value and low moisture content. TDF produces 100 – 200% more energy than wood on a mass basis, according to the US Environmental Protection Agency. The main problem in using TDF in the pulp industry is the need to use de-wired tires. Pulp mills use TDF instead of whole tires because metal wires clog the feed systems. De-wired TDF can cost up to 50% more than regular TDF.^[129]

Within BC, one coastal paper mill supplements the wood waste fuel supply with TDF in one of its three boilers. The boilers were redesigned in the late 1990s to accommodate the use of TDF, believed to be a necessary addition resulting from shortages in fuel supply and an apparent downward trend in the quality of fuel. TDF was selected as a supplementary fuel partly due to the proximity of a local tire recycling facility.

Potential environmental issues relating to the use of TDF at this facility included the risk of:

- Increase in particulate emissions
- Increase in zinc content of the fly ash
- Increase in sulphur content potentially resulting in acid gas generation
- Increase in other trace toxic organic emissions (such as dioxins and furans) that may affect emissions and ambient air quality.

After receiving approval to allow 2 – 5% TDF, performance monitoring results revealed stabilization of the boiler operation when burning lower quality hog fuel, increased fluidized bed temperature, and approximately 5% increase in hog fuel burn rate. Emission monitoring revealed that there was no impact of TDF addition on the total particulate emissions, SO₂ emissions, and no increase in any of the metals in the stack emissions compared with the baseline measurements. Zinc and iron content in fly ash and bottom ash increased. There was no increase in the trace levels of dioxins and furans in the fly ash from TDF addition to the boiler.^[130]

¹²⁹ United States Environmental Protection Agency (September 2008), *Tire-Derived Fuel*, Retrieved February 23, 2010, from <http://www.epa.gov/osw/conservation/materials/tires/tdf.htm>

¹³⁰ L. Cross and B. Ericksen, *Use of Tire Derived Fuel (TDF) in a Fluidized Bed Hog Fuel Paper Boiler at Pacifica Papers Inc.*, Retrieved February 23, 2010, from http://www.portaec.net/local/tireburning/use_of_tire_derived_fuel.html

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Proper equipment or modifications to reduce emission levels are required to burn TDF in these boilers. Several emission control devices and techniques are known, and these have decreased emission levels to within standards. Only a small percentage of industrial boilers have the required combination of system design and fuel type conducive to appropriate TDF substitution and controlling SO_x and particulate emissions is required. SO_x can be controlled by scrubbers present in some systems, especially if the scrubbers operate at a neutral or basic pH. An efficient particulate control device (electrostatic precipitator) is required to prevent increased particulate emissions when burning TDF.^[131] A proper feed system to provide a consistent and well controlled TDF feed rate is recommended. Proper combustion air control on the boiler is required to ensure efficient combustion of the TDF.^[132]

Existing boilers can be modified to meet the requirement for such high temperatures; however these modifications, in addition to TDF processing, can be expensive depending on the model. Until the cost of processing and equipment are lowered the use of TDF will be limited.^[133]

6.3 Use of RDF by Cement Kilns

Cement is a fine grey powder that is mixed with gravel, sand, and water to form concrete, the most widely used construction material in the world. In 2008, the Canadian cement industry produced 14 million tonnes of cement, worth more than \$1.8 billion. Currently, there are 16 operating cement plants in Canada, with three of these located in BC.^[134]

The production of cement consumes a significant amount of raw materials and energy. For example, a dry process cement plant needs roughly 1,600,000 tonnes of raw materials and 150,000 tonnes of fuel (high quality coal) to produce 1,000,000 tonnes of Portland cement clinker per year.^[135] Due to the high consumption of natural resources used in cement production, the cement industry has for many years been investigating the use of alternative raw materials and fuels to help offset the consumption of natural resources without compromising the quality of the cement produced or increasing the environmental impact of cement manufacture.

The European cement industry has been increasingly substituting the use of natural resources for raw materials and fuels with alternative waste-derived materials in order to decrease the environmental impact of their operations. Often these alternative materials are selected industrial by-products and waste streams which have been found to be suitable for cement production due to their physical and chemical properties.

¹³¹ T.A.G. Resource Recovery (November 1997), *Tire Derived Fuel: Environmental Characteristics and Performance*, Retrieved February 23, 2010, from <http://www.p2pays.org/ref/24/23765.pdf>

¹³² L. Cross and B. Ericksen, *Use of Tire Derived Fuel (TDF) in a Fluidized Bed Hog Fuel Paper Boiler at Pacifica Papers Inc.*, Retrieved February 23, 2010, from http://www.portaec.net/local/tireburning/use_of_tire_derived_fuel.html

¹³³ Unknown Author, *Recycling Options*, Retrieved February 23, 2010, from <http://www.p2pays.org/ref/11/10504/html/biblio/htmls2/cgh4.html>

¹³⁴ The Cement Association of Canada. 2010. The Cement Association of Canada – Economic Contribution

¹³⁵ CEMBUREAU. 2004. The Sustainable Use of Alternative Resources in the European Cement Industry

Common alternative waste-derived raw materials used in cement manufacturing in Europe include fly ash, blast furnace slag, silica fume, iron slag, paper sludge, pyrite ash, spent foundry sand, soil containing oil and artificial gypsum (gypsum produced from industrial processes such as acid neutralization). These waste materials are suitable as they are chemically appropriate and provide the constituents required for the production of clinker.^[136]

Alternative waste-derived fuels are also commonly used in cement manufacture. The suitability of an RDF for use in a cement kiln as a fuel is contingent upon the material having the appropriate consistency, heat value and composition as follows:

- The particle size of the fuel is an important factor in determining the suitability of a fuel for use in a cement kiln. Fuels with a particle size of less than 12 mm are acceptable to be introduced directly into the kiln. Fuels with a particle size of less than 50 mm are acceptable to be injected into the precalciner for those facilities that include a precalciner in their design.
- Fuels with a calorific value ranging from 15 to 18 MJ/kg are more suitable to be introduced into the precalciner and fuel with a higher calorific value ranging from 20 to 25 MJ/kg are more suitable to be injected into the kiln.
- The composition of the fuels must be in the appropriate range in regards to moisture content, ash content, sulphur and chlorides as well as trace heavy metals.

In many jurisdictions where the use of alternative fuels has been well established, there are regulations/guidelines in place to regulate their use. The regulatory requirements/guidelines for the maximum levels of contaminants in alternative fuels from some of these jurisdictions are presented in Table 6-2, below. The focus is on regulating contaminants that could contribute to the emissions of chlorinated organic pollutants and heavy metals. It should be noted that generally the mass of chlorine and trace heavy metals within a cement kiln will be dominated by the contribution of these parameters from the raw materials used in cement manufacture. The contribution to the discharge of these contaminants from any fuel source is comparatively small.

Common alternative waste based fuels used in cement manufacturing industry^[137] in Europe are listed in Table 6-2.

¹³⁶ CEMBUREAU. 2006. Air emissions and alternative fuels in the European cement industry

¹³⁷ European Commission. 2009. Integrated Pollution Prevention and Control Draft Reference Document on Best Available Techniques in the Cement, Lime and Magnesium Manufacturing Industries

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Table 6-2: Alternative Fuels Regulatory Requirements/Guidelines for Cement Kilns

		Austria		Switzerland	Germany	Finland			Sweden		Lebanon	United States
		MSW (25 MJ/kg)	Plastic, paper, textile, wood waste	MSW - 25 MJ/kg	Plastic, paper, textile, wood waste	RDF Class I	RDF Class II	RDF Class III	Specialbränsle A	Lattbränsle		
Chlorine	%	1	2	–	1.5	0.15	0.50	1.5	1.0	1.0	–	–
Antimony (Sb)	mg/kg	5	20	5	120	–	–	–	–	–	–	50
Arsenic (As)	mg/kg	15	15	15	13	–	–	–	–	–	10	50
Beryllium (Be)	mg/kg	5	–	5	2	–	–	–	–	–	2	–
Cadmium (Cd)	mg/kg	2	27	2	9	1.0	4.0	5.0	10	5	5	40
Chromium (Cr)	mg/kg	100	300	100	250	–	–	–	300	30	–	200
Copper (Cu)	mg/kg	100	500	100	700	–	–	–	–	–	150	600
Lead (Pb)	mg/kg	200	500	200	400	–	–	–	350	100	100	500
Mercury (Hg)	mg/kg	0.5	2	0.5	1.2	0.1	0.2	0.5	–	5	1	20
Nickel (Ni)	mg/kg	100	200	100	160	–	–	–	–	10	50	50
Thallium (Tl)	mg/kg	3	10	3	2	–	–	–	–	–	2	40
Tin (Sn)	mg/kg	10	70	10	70	–	–	–	–	–	70	100
Vanadium (V)	mg/kg	100	–	100	25	–	–	–	–	50	20	50
Zinc (Zn)	mg/kg	400	–	400	–	–	–	–	2000	–	–	1000

NOTE:

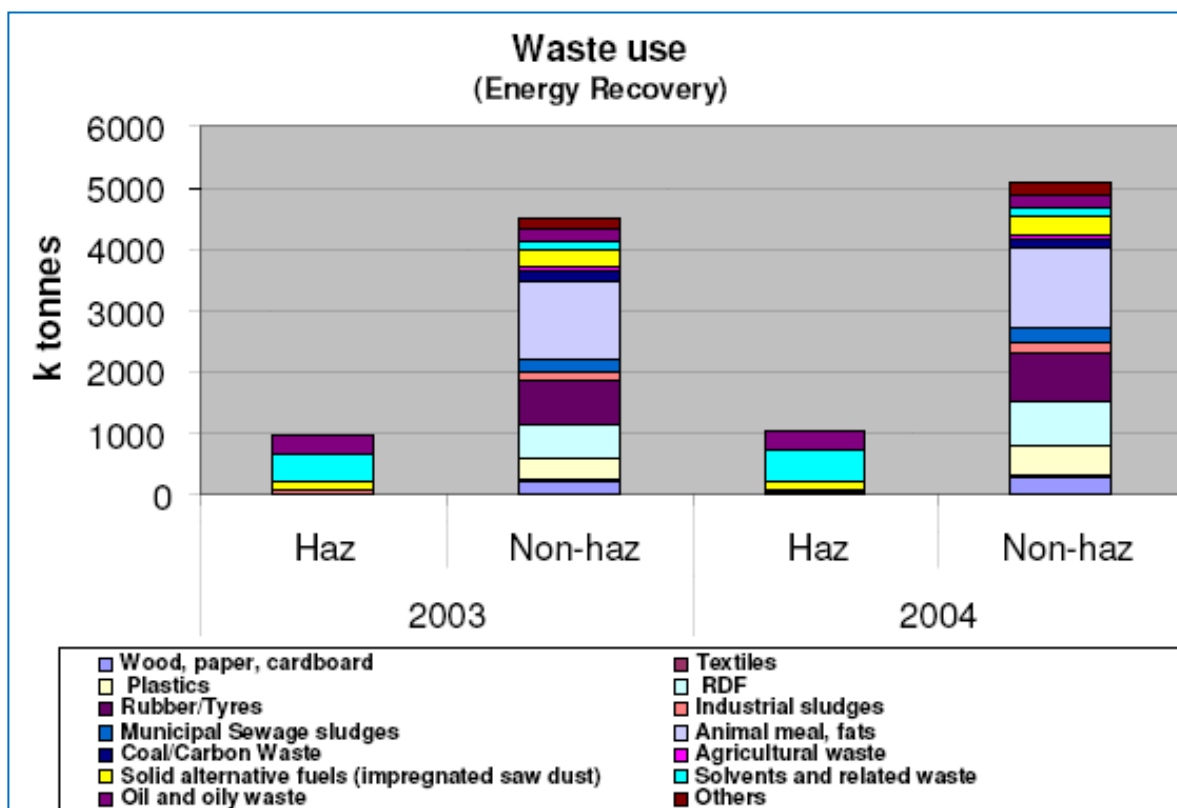
“–” indicates that no regulated value has been set for that parameter by that jurisdiction.

Table 6-3: Types of Alternative Fuels Used in the European Cement Industry

Types of Waste Fuels (Hazardous and Non-Hazardous)	
Wood, paper, cardboard	Municipal sewage sludge
Textiles	Animal meal, fats
Plastics	Coal/carbon waste
Processed MSW fractions (e.g., RDF)	Agricultural waste
Rubber/tires	Solid waste (impregnated sawdust)
Industrial Sludge	Solvents and related waste
Oil and oily waste	

Figure 6-1 illustrates the consumption of different types of hazardous and non-hazardous waste used as fuel in cement kilns in the EU-27 in 2003 and 2004.

Figure 6-1: Consumption of Different Types of Hazardous and Non-hazardous Waste Used as Fuels in Cement Kilns in the EU-27



Source: European Commission. 2009. Integrated Pollution Prevention and Control Draft Reference Document on Best Available Techniques in the Cement, Lime and Magnesium Manufacturing Industries

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Characteristics of the cement production process lend itself to beneficial waste-to-energy and material recycling applications. The following is a list of characteristics of cement production which lend it to the beneficial use of waste materials as fuel:

- Maximum temperatures of approximately 2,000°C (main firing system, flame temperature) in rotary kilns
- Gas retention times of about 8 seconds at temperatures above 1,200°C in rotary kilns
- Material temperatures of about 1,450°C in the sintering zone of the rotary kiln
- Oxidising gas atmosphere in the rotary kiln
- Gas retention time in the secondary firing system of more than two seconds at temperatures of above 850°C; in the precalciner, the retention times are correspondingly longer and temperatures are higher
- Solids temperatures of 850°C in the secondary firing system and/or the calciner
- Uniform burnout conditions for load fluctuations due to the high temperatures at sufficiently long retention times
- Destruction of organic pollutants due to achievement of high temperatures at sufficiently long retention times
- Sorption of gaseous components like HF, HCl, SO₂ on alkaline reactants
- High retention capacity for particle-bound heavy metals
- Short retention times of exhaust gases in the temperature range known to lead to 'de novo-synthesis' of dioxins and furans
- Complete utilization of fuel ashes as clinker components and hence, simultaneous material recycling (e.g., also as a component of the raw material) and energy recovery
- Product specific wastes are not generated due to a complete material utilization into the clinker matrix; however, some cement plants in Europe dispose of bypass dust
- Chemical-mineralogical incorporation of non-volatile heavy metals into the clinker matrix.^[138]

Emissions control in cement kilns is largely based on the use of bag houses to capture particulate matter from the flue gas (which also controls emissions of most heavy metals as discussed below). More modern facilities or retrofitted plants may be equipped with NO_x control, specifically SNCR. Emissions of other parameters such as POPs or acid gases are generally controlled through the operating characteristics of cement facilities as noted above. Monitoring of cement plant emissions generally includes CEMs (for parameters such as NO_x, SO_x, CO, TOC etc.) which serve a dual purpose in both monitoring emissions and determining if the facility is operating appropriately within the parameters required to manufacture quality cement product. Periodic stack testing is usually also required both to ensure effective calibration of the CEMs and to establish performance against regulated ELVs for a broader range of parameters.

¹³⁸ European Commission. 2009. Integrated Pollution Prevention and Control Draft Reference Document on Best Available Techniques in the Cement, Lime and Magnesium Manufacturing Industries

The impact on emissions from cement manufacturing due to the use of waste materials as alternative fuels or alternative raw materials is relatively minor. The following bullet list summarizes the assumed impacts as outlined by the European Commission.^[139]

- Dust emissions remain unaffected by using wastes.
- The use of suitable waste has only a minor influence on metal emissions due to the high retention of metals in the finished product. Non-volatile metals tend to be bound almost entirely in the clinker matrix. Semi-volatile metals such as lead or cadmium tend to be captured in the clinker stream or in dust. Highly volatile metals such as mercury and thallium tend to be of greater concern as they tend to vapourize and leave the kiln system. For this reason, it is important to limit the amount of highly volatile metals in the waste being used.
- NO_x, HCl, HF, SO₂, CO, and TOC are largely unaffected.
- The combustion conditions in rotary kiln systems ensure low emissions concentrations of dioxins and furans. The biggest factor impacting these emissions is what location waste materials are fed into the system (i.e., wastes that are fed into the main firing system tend to reach high enough temperatures and retention times to limit dioxin/furan emissions while wastes fed into the secondary firing zone may not reach high enough temperatures or long enough retention times).

Table 6-4 provides an example of the impact that utilizing waste as a fuel source could have on the emission profile from a typical cement kiln. Note: while the report cited does not specify the original sources of the waste in each application, RDF generation in Germany is generally derived from processing MSW materials (not including specialized waste streams such as construction/demolition material). Also it should be noted that while the monitoring approach for each parameter is not noted, cement kilns in the EU and North America typically use CEMs for parameters such as SO_x and NO_x and periodic stack testing for other parameters (PAHs, metals). As the table illustrates, utilizing waste as a fuel has a minimal impact on the emissions released from the plant, with some parameters decreasing and others increasing within the same order of magnitude.^[140]

Table 6-4: Emission Profile from a Cement Kiln Using RDF

Parameter	Measure	Individual Measurements	
		No Utilization of Wastes	Utilization of Wastes
Total Particulate	mg/m ³	2.8 – 12.9	12.0 – 15.9
HCl	mg/m ³	0.88 – 5.93	0.87 – 1.32
SO _x	mg/m ³	714 – 878	311 – 328
HF	mg/m ³	0.13 – 0.23	0.02 – 0.04
NO _x	mg/m ³	789 – 835	406 – 560

¹³⁹ European Commission. 2009. Integrated Pollution Prevention and Control Draft Reference Document on Best Available Techniques in the Cement, Lime and Magnesium Manufacturing Industries

¹⁴⁰ UBA. 2001. Draft of a German Report with basic information for a BREF-Documents "Waste Incineration". Umweltbundesamt

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Parameter	Measure	Individual Measurements	
		No Utilization of Wastes	Utilization of Wastes
Total C	mg/m ³	11.7 – 23.2	5.7 – 7.1
PAHs	mg/m ³	–	0.0026
Benzene	mg/m ³	0.27 – 0.54	0.45 – 0.55
Cd	mg/m ³	<0.005	<0.007
Tl	mg/m ³	<0.005	<0.005
Hg	mg/m ³	0.014 – 0.044	0.003 – 0.006
Sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn	mg/m ³	<0.3	<0.5
PCDD/PCDF, I-TEQ	mg/m ³	0.001 – 0.002	0.005 – 0.0065

The following sections provide an overview of the regulatory framework governing the use of waste as a raw material or alternative fuel in cement kilns in Ontario and the European Union.

6.3.1 Regulatory Approach in Ontario

Guideline A-7 (October 2010) applies to all thermal treatment facilities processing municipal waste including manufacturing facilities such as cement and lime kilns, if they use municipal waste as an alternative fuel. The Guideline sets out specific in-stack emission limits for cement and lime kilns which take into account operational differences for these facilities as compared to other “dedicated” thermal treatment facilities (see the following table).

Table 6-5: Emission Limits for Existing Cement and Lime Kilns Burning Municipal Waste (Guideline A-7)

Parameter	In-Stack Emission Limit	Verification of Compliance ⁷
Particulate Matter (PM)	50 mg/Rm ³ or a site specific emission limit where a more stringent stack concentration limit is already in place for existing raw materials and conventional fuels ¹	Results from compliance source testing or calculated as the rolling arithmetic average of four (4) hours of data measured by a continuous emission monitoring system that provides data least once every fifteen minutes
Cadmium (Cd)	7 µg/Rm ³ unless existing raw materials and conventional fuels result in higher concentration ²	Results from compliance source testing (periodic stack testing)
Lead (Pb)	60 µg/Rm ³ unless existing raw materials and conventional fuels result in higher concentration ²	Results from compliance source testing (periodic stack testing)
Mercury (Hg)	20 µg/Rm ³ unless existing raw materials and conventional fuels result in higher concentration ²	Results from compliance source testing (periodic stack testing) or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes

Parameter	In-Stack Emission Limit	Verification of Compliance ⁷
Dioxins and Furans	80 pg/Rm ³	Results from compliance source testing (periodic stack testing); results expressed as I-TEQ
Hydrochloric Acid (HCl)	18 ppm _{dv} (27 mg/Rm ³) unless existing raw materials and conventional fuels result in higher concentration ³	Calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
Sulphur Dioxide (SO ₂)	Site specific limit not to exceed the in-stack SO ₂ concentration resulting from existing raw materials and conventional fuels. ^{4,6}	Calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
Nitrogen Oxides (NO _x)	Site specific limit not to exceed the in-stack NO _x concentration resulting from existing raw materials and fossil fuels ^{5,6}	Calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
Organic Matter	Section 50 of Ontario Regulation 419/05	Calculated as the rolling arithmetic average of 10 minutes of data measured by a continuous emission monitoring system that provides data at least once every minute
Opacity	Section 46 of Ontario Regulation 419/05	Calculated as the rolling arithmetic average of six (6) minutes of data measured by a continuous opacity monitor that provides data at least once every minute

NOTES:

- 1) If there is no limit for particulate matter in an existing Certificate of Approval issued to the facility, the limit of 50 mg/Rm³ can be expected to be included in the Certificate of Approval that will allow burning of municipal waste as an alternative fuel. Where a more stringent site-specific limit for particulate matter is already incorporated into an existing Certificate of Approval for manufacturing of cement or lime using existing raw materials and conventional fuels, the existing limit will be retained if it is more stringent than 50 mg/Rm³.
- 2) Limits for cadmium, lead and mercury can be expected to be included in a Certificate of Approval that will allow burning of municipal waste as an alternative fuel, unless the proponent can demonstrate that one or more of the specified metals are present in the existing raw materials and conventional fuels in such a quantity that the relevant limit(s) would be exceeded without the use of municipal waste as a fuel. In such a case, site-specific limits for one or more of the above metals may be established and incorporated into a Certificate of Approval. The site specific limits can be expected to be developed based on a review of relevant facility specific data that includes information on the discharge of cadmium, lead, and/or mercury from the facility (e.g., source testing data, analytical data for raw materials, mass balance calculations). Such site specific limits will take into account the variability of the raw material composition.
- 3) It is expected that cement and lime kilns can comply with the hydrogen chloride (HCl) limit. A site-specific emission limit for HCl may, however, be incorporated into a Certificate of Approval based on HCl concentrations when using existing raw materials and conventional fuels. This will prevent any increase in HCl emissions resulting from use of municipal waste as fuel for the kiln.
- 4) A site-specific emission limit for sulphur dioxide (SO₂) can be expected to be incorporated into a Certificate of Approval based on SO₂ concentrations when burning conventional fuels. This will prevent any increase in SO₂ emissions resulting from use of municipal waste as fuel for the kiln. For kilns required to use continuous emission monitoring (or a method that will provide estimates of emissions that are at least as accurate as the estimates that would be provided by a continuous emission monitoring system) for SO₂ under Ontario Regulation 194/05 (Industry Emissions – Nitrogen Oxides and Sulphur Dioxide), the limit will be determined based on a review of a minimum of 6-months of Continuous Emission Monitoring System (CEMS) data (or data obtained using another method) for the kiln (1-hour, 24-hour and 30-day SO₂ averages in ppm_{dv} or mg/Rm³). The Ministry will continue to monitor the development of SO₂ control technology worldwide. As new proven technology is developed suitable for this industry sector, the Ministry will review this guideline to determine if limits can be adjusted.

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- 5) A site-specific emission limit for oxides of nitrogen (NO_x) can be expected to be incorporated into a Certificate of Approval based on NO_x concentrations when burning conventional fuels. This will prevent any increase in NO_x emissions resulting from use of municipal waste as fuel for the kiln. For kilns required to use continuous emission monitoring (or a method that will provide estimates of emission that are at least as accurate as the estimates that would be provided by a continuous emission monitoring system) for NO_x under Ontario Regulation 194/05, the limit will be determined based on a review of a minimum of 6-months of CEMS data (or data obtained using another method) for the kiln (1-hour, 24-hour and 30-day NO_x averages in ppm_{dv} or mg/Rm³). The Ministry will continue to monitor the development of NO_x control technology worldwide. As new proven technology is developed suitable for this industry sector, the Ministry will review this guideline to determine if limits can be adjusted.
- 6) Lime kilns that do not currently have CEMS for SO_2 , and NO_x , can be expected to carry out a monitoring program to determine the normal ranges for the parameters when burning conventional fuels. The proponent of an alternate fuel should consult staff of the Ministry when planning such a program. The results of the monitoring program are expected to be included with an application for a Certificate of Approval to burn municipal waste as an alternate fuel.
- 7) Compliance source testing as set out in the facility's Certificate of Approval. Owners and operators of cement and lime kilns can expect to be required, by conditions in Certificates of Approval, to maintain CEMS for SO_2 , NO_x , THC, HCl and opacity.

The approach used in Ontario clearly acknowledges that it is not reasonable to apply exactly the same ELVs to cement or lime kilns that use a waste derived fuel. Rather the approach that is taken applies the same stack limits applied to WTE facilities, for parameters that are directly associated with fuel quality (e.g., heavy metals, POPs) but not for emission parameters that are driven largely by the primary purpose and design of the facility (SO_x , NO_x , PM). For some heavy metals (mercury, cadmium and lead) it is also recognized that the contribution from the raw material stream for some of these trace metals can be more significant than from the fuels, and in those cases site specific ELVs are set.

In order to use RDF as a fuel in Ontario, industrial facilities have to apply for or amend their operating permits (certificates of approval) issued under the *Environmental Protection Act* (EPA).

The permitting/application process generally involves the following:

- Fuel testing and comparison of the RDF fuel quality against the conventional fuels. Mass balance analyses are generally used to establish any potential shift in emissions concentrations that could result from the use of the fuels.
- Determination of the appropriate RDF feed rate, based on the outcome of the analysis above and based on review of the impact of various fuel characteristics (e.g., heat value).

The approach used for proposed RDF applications has been to encourage and permit the use of RDF for a fuels test/trial run, the results of which are used to demonstrate that RDF can be used within the current ELVs established for the facility and/or to determine site specific ELVs for various parameters that would apply during regular use of the RDF.

6.3.2 European Union

As noted previously, the use of waste fuels in the manufacture of cement is commonly practiced in Europe. On average, alternative fuels were substituted for 17% of conventional fuels in the

manufacture of cement in EU-23 countries (in 2007). This rate of substitution is equivalent to saving about 4 million tonnes of coal.^[141] For some facilities, the rate of substitution can be as high as 100%.

Two directives apply to the use of waste in cement manufacturing in the EU, namely the Integrated Pollution Prevention and Control Directive (Directive 2008/1/EC) and the Waste Incineration Directive (Directive 2000/76/EC).

The IPPC Directive applies to installations for the production of cement clinker in rotary kiln with a production capacity exceeding 500 tonnes per day.^[142] As discussed previously, the IPPC is aimed at minimizing the emissions of pollutants from large industrial installations through the use of an environmental permit. Permits contain emission limit values (ELVs) and set conditions based on the application of best available technology (BAT). The permits also address energy efficiency, waste minimization, prevention of accidental emissions, and site restoration.^[143] If a cement manufacturing operation uses waste derived fuel or raw materials derived from waste, the facility would still be required to emission limit values (ELVs) set out in its permit.

In May, 2009, the European Commission released a draft reference document on the best available techniques in the cement, lime, and magnesium oxide manufacturing industries. The document goes into considerable detail concerning the use of waste as alternative raw material and fuel in cement manufacturing. The following table (Table 6-6) provides a summary of the best available techniques for the cement industry relating to the use of wastes.^[144]

Table 6-6: Summary of BAT for the Cement Industry Relating to the Use of Wastes

Safety management for the use of hazardous waste materials	<ul style="list-style-type: none"> Apply safety management for the handling, e.g., storage, and/or feeding of hazardous waste materials, such as using a risk based approach according to the source and type of waste, for the labelling, checking, sampling and testing of waste to be handled
Waste Quality Control	<ul style="list-style-type: none"> Apply quality assurance systems to guarantee the characteristics of wastes and to analyse any waste that is to be used as raw material and/or fuel in a cement kiln for parameters/criteria (constant quality, physical criteria, chemical criteria). Control the amount of relevant parameters for any waste that is to be used as raw material and/or fuel in a cement kiln, such as chlorine, relevant metals (e.g., cadmium, mercury, thallium), sulphur, total halogen content Apply quality assurance systems for each waste load

¹⁴¹ CEMBUREAU. 2006. 2004 and 2005 statistics on the use of alternative fuels and materials in the clinker production in the European cement industry

¹⁴² EEF: Integrated Pollution Prevention and Control (IPPC). 2009. [http://www.eef.org.uk/policy-media/policy-briefs/briefings/Integrated-Pollution-Prevention-Control-\(IPPC\).htm](http://www.eef.org.uk/policy-media/policy-briefs/briefings/Integrated-Pollution-Prevention-Control-(IPPC).htm)

¹⁴³ EEF: Integrated Pollution Prevention and Control (IPPC). 2009. [http://www.eef.org.uk/policy-media/policy-briefs/briefings/Integrated-Pollution-Prevention-Control-\(IPPC\).htm](http://www.eef.org.uk/policy-media/policy-briefs/briefings/Integrated-Pollution-Prevention-Control-(IPPC).htm)

¹⁴⁴ European Commission. 2009. Integrated Pollution Prevention and Control Draft Reference Document on Best Available Techniques in the Cement, Lime and Magnesium Manufacturing Industries

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Waste feeding into the kiln	<ul style="list-style-type: none"> Use the appropriate feed points to the kiln in terms of temperature and residence time depending on kiln design and kiln operation Feed waste materials containing organic components that can be volatilised before the calcining zone into the adequately high temperature zones of the kiln system Operate in such a way that the gas resulting from the co-incineration of waste is raised in a controlled and homogeneous fashion, even under the most unfavourable conditions, to a temperature of 850°C for two seconds Raise the temperature to 1,100°C, if hazardous waste with a content of more than 1% of halogenated organic substances, expressed as chlorine, is co-incinerated Feed wastes continuously and constantly Stop co-incinerating waste for operations such as start-ups and/or shutdowns when appropriate temperatures and residence times cannot be reached
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The IPPC Directive also provides BAT for emissions limits from cement manufacturing. The following table provides the emissions limit values as laid out in the document.

Table 6-7: BAT Emissions Limits for Cement Manufacturing in the IPPC Directive

Contaminant	Concentration Units	Integrated Pollution Prevention and Control Directive (2008/1/EC)
Total Particulate Matter (TPM) ¹	mg/Nm ³	<10 – 20
Hydrogen Chloride (HCl)	mg/Nm ³	10
Sulphur Dioxide (SO ₂)	mg/Nm ³	<50 – <400 ⁴
Hydrogen Fluoride (HF)	mg/Nm ³	1
Nitrogen Oxides (NO _x) (pre-heater kilns)	mg/Nm ³	<200 – 4,502 ³
Nitrogen Oxides (NO _x) (lepol and long rotary kilns)	mg/Nm ³	400 – 800
Mercury (Hg) ⁶	ug/Nm ³	<0.05
Cd + Tl ⁶	ug/Nm ³	<0.05
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V) ⁶	ug/Nm ³	<0.5
PCDD/F TEQ (I) (Dioxins and Furans) ⁵	ng/Nm ³	<0.05 – 0.1

NOTES:

Under the following conditions: 273 K, 101.3 kPa, 10% Oxygen, Dry Gas. Daily average values unless otherwise noted.

¹ Dust emissions from kiln firing processes – when applying a fabric filter or new or upgraded ESP, the lower level is achieved.

² BAT-AEL is 500 mg/Nm³, where after primary measures/techniques the initial NO_x level is >1000 mg/Nm³

³ Existing kiln system design, fuel mix properties including waste, raw material burnability can influence the ability to be in the range. Levels below 350 mg/Nm³ are achieved at kilns with favourable conditions. The lower value of 200 mg/Nm³ has only been reported as monthly average for three plants (easy burning mix used)

⁴ Range takes into account the sulphur content in the raw materials

⁵ Average over the sampling period (6 – 8 hours)

⁶ Average over the sampling period spot measurement, for at least half an hour.

The Waste Incineration Directive also applies to cement manufacturing facilities that utilize waste as a feedstock. The WID defines cement facilities that utilize waste as “co-incineration” plants. A “co-

incineration plant” is defined in the Directive as any stationary or mobile plant whose main purpose is the generation of energy or production of material products and:

- Which uses waste as a regular or additional fuel, or
- In which waste is thermally treated for the purpose of disposal.

The Directive states that no “co-incineration plant” shall operate without a permit from the appropriate governing agency. The permit must outline a number of specific parameters including ensuring that cement facility is properly designed and is using the appropriate equipment. Further, the permit must list the categories of waste to be treated and the quantities of waste to be treated, include the total waste co-incinerating capacity of the plant, and specify the sampling and measurement procedures to satisfy the obligations imposed for periodic measurements of each air and water pollutants.

If the cement facility is to treat hazardous materials, the permit has to also outline the quantities of different categories of hazardous waste that may be treated and the minimum and maximum mass flows of those hazardous wastes, their lowest and maximum calorific values and their maximum concentration of pollutants (e.g., PCB, chlorine, heavy metals).

The Directive also provides guidance concerning the reception and delivery of waste at the facility so as to limit the effects on the environment and direct risks to human health. It states that the facility operator shall determine the mass of each category of waste prior to accepting the material on site. For hazardous waste, the facility should obtain the physical and as far as practicable chemical composition of the waste as well as the hazardous characteristics of the waste.

The Directive goes on to state that co-incineration plants need to be designed and operated in such as way that waste is treated at a temperature of 850°C for two seconds, (or 1,100°C if the waste has more than 1% of halogenated organic substances) which is the same requirement for a regular waste incineration plant.

The air emissions limit values set out in the Directive for co-incineration plants are slightly different than those set out for incineration plants. The co-incineration plant must be designed, equipped, built and operated in such as way that the emission limit values set out in the following table are not exceeded in the exhaust gas. The primary difference in the WID in regards to emissions from co-incineration plants is that the ELV for NO_x is set significantly higher than that for WTE facilities.

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Table 6-8: Emissions Limit Values for Cement Kilns in the Waste Incineration Directive

Contaminant	Concentration Units	Waste Incineration Directive (2000/76/EC)
Total Particulate Matter (TPM)	mg/m ³	30
Hydrogen Chloride (HCl)	mg/m ³	10
Sulphur Dioxide (SO ₂) ¹	mg/m ³	50
Hydrogen Fluoride (HF)	mg/m ³	1
Nitrogen Oxides (NO _x) (existing plants)	mg/m ³	800
Nitrogen Oxides (NO _x) (new plants)		500
TOC ¹	mg/m ³	10
Mercury (Hg)	µg/m ³	0.05
Cd + Tl	µg/m ³	0.05
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	µg/m ³	0.5
PCDD/F TEQ (I) (Dioxins and Furans)	ng/m ³	0.1

NOTES:

Under the following conditions: 273 K, 101.3 kPa, 10% Oxygen, Dry Gas

¹ Exemptions may be authorized by a competent authority in cases where these emissions do not result from the incineration of waste

6.4 Proposed Regulatory Approach for RDF

The preceding sections discuss use of RDF by two industrial sectors, for which there is current and general interest in the use of alternative solid fuel materials. Pulp mill/wood fired boilers and cement kilns are not the only industrial sectors where there could be future interest in the use of RDF for co-firing or co-incineration. A consistent regulatory approach that addresses use of RDF by any industry sector is required.

Reviewing the regulatory approach applied in various jurisdictions to the use of RDF as a fuel for co-firing or co-incineration along with current experience with RDF applications in BC, indicates that a reasonable approach to mitigating the risk associated with the use of waste derived fuels would consist of the following:

- Generally when looking across the spectrum of RDF use in co-combustion (some examples of which are discussed above) the RDF usually has the same general characteristics as the conventional fuels used by the facilities. For example, wood fired boilers generally use RDF that is similar in composition (e.g., primarily cellulosic) to conventional wood waste. Cement kilns use a wide range of RDF fuels including waste plastics, given that the conventional fuels used by these facilities are fossil fuel based.

- It would be reasonable to define which waste materials are considered 'waste derived' fuels which would require major modifications and permit amendments, and those that would be considered equivalent to current fuels. For example, as discussed above, it would be reasonable to set a definition for 'clean' wood waste that could be separated from construction and demolition waste for use in wood fired boilers as part of their regular fuel stream and 'contaminated' wood waste that would require major modifications and permit amendments. The BC MOE should develop definitions and potentially RDF fuel specifications similar to those used in other jurisdictions relative to RDF for cement applications. These definitions/specifications and/or proponent driven specifications would be set out in the amended air emission permits.
- Testing of RDF will be required generally either to demonstrate compliance with a regulatory limit for fuel quality and/or to ensure that the fuel falls within the range of specifications required to ensure that the material can be used without compromising the operations of the facility proposing to use RDF as a full or partial fuel substitute. The results of fuel tests would be reported in the application process for regulatory approval, and compared against the quality of the conventional fuels used at the facility. These results could be used to determine through a mass balance analysis if the contribution of parameters in the RDF would result in a shift in emissions concentrations if the RDF was used (e.g., presence of chlorine shifting the emissions concentration of HCl).
- Fuel trials should be undertaken to demonstrate that the proposed RDF can be effectively used as fuel, and to establish site/facility specific ELVs where applicable. Fuel trials will also allow for the facility operator to review standard operations and to determine the appropriate adjustments needed to use RDF effectively as a fuel. Fuel trials should reflect the proposed RDF substitution rates, so that the proponent can demonstrate how at the maximum proposed fuel substitution rate the facility will comply with current and/or proposed ELVs.
- Generally within the air emission permits, the same stack limits (ELVs) would be applied to industrial facilities that use RDF as would be applied to WTE facilities (as set out in Section 8.3), for parameters that are directly associated with fuel quality (e.g., heavy metals, POPs) but not for emission parameters that are driven largely by the primary purpose and design of the facility. For wood fired boilers, design parameters would include parameters such as NO_x and CO, while for cement kilns this would include a broader spectrum of parameters (SO_x, NO_x, CO, TOC, particulates) that are driven by raw material quality and standard facility design.
- Once permitted, facilities would have to implement quality assurance systems to guarantee the characteristics of the RDF and to analyze the RDF for key parameters/criteria including consistency, physical criteria (related to suitability for use at the facility) and chemical criteria (related to ELV compliance). Generally, RDF would have to be tested at random at least quarterly within the first few years of operation. Results from the quality assurance systems would be included with in annual compliance reporting.

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7 ASSOCIATED COSTS AND ENERGY EFFICIENCY

This section investigates the capital and operating costs for WTE and discusses the energy efficiency associated with WTE facilities and potential revenues associated with energy recovery.

7.1 Capital Expenditure and Operating Costs

This subsection provides a summary of current capital and operating costs for the majority of thermal treatment technologies. These are expressed as capital cost per annual design tonne (commonly used for capital cost comparison) and operating costs per annual design tonne. The data presented is based on financial information from jurisdictions in which thermal treatment approaches have been implemented and financial information made available directly from technology vendors.

The range of capital and operating costs reported by individual vendors are influenced by the unique circumstances associated with siting a facility, such as jurisdictional constraints, size of facility, and the form in which the energy is recovered and used. This summary therefore includes:

- i. The potential range of order of magnitude costs, identifying the key factors for both the low and high end of the range and the median values for both capital and operating costs for various technologies.
- ii. Where available, the cost differentials between these technologies and the factors which contribute to these differences.
- iii. Costs specifically associated with the applicable emissions control and/or thermal process control options.

Identification of costs in a North American context can be quite difficult. Few new facilities have reached the stage of development in either Canada and the USA and for proposed facilities, either the financial information is proprietary (particularly if the proposed facility is intended to be owned/operated by a private sector entity) or may not be based on guaranteed pricing through formal procurement processes.

Implementation of projects in North America can be based on a variety of contractual arrangements, each of which has the potential to affect the potential costs and allocation of risk between the technology vendor and the owner/operator of the plant. Some of the typical contractual arrangements for such facilities include:

- **Design/Build:** the intended owner/operator (e.g., municipality) seeks pricing for design and construction of the facility. In such a context the majority of the risk is borne by the owner/operator.
- **Design/Build/Operate:** the intended owner seeks a contract from a technology vendor (usually consortium representing proprietary technology vendors, construction firms and an operating entity) to design and build the facility and to operate the plant for a fixed period of time. Often the owner passes on some of the risk associated with the facility through performance guarantees that have to be met by the preferred vendor.

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- **Design/Build/Finance/Operate (P3):** the intended owner seeks a contract similar to that noted above, wherein the vendor also holds a financing role, seeking return on the investment in the capital cost for the facility over a longer contractual period. Generally, there is increased sharing of risk and concomitant increases in overall unit costs.
- **Design/Build/Own/Operate:** the party requiring capacity for WTE seeks pricing for the use of WTE capacity that is entirely owned/operated/financed by the vendor. These arrangements can be coupled with the provision of some assistance in the form of siting, provision of infrastructure etc. between the parties. Generally long-term fixed “put or pay” contracts are necessary to guarantee revenues to the vendor. Such contracts guarantee that the vendor will receive a set minimum revenue value, associated with a set minimum waste supply. Should the generator not have sufficient waste supply, it is still required to pay the vendor the set minimum fee. Also, generally the unit cost for use of the WTE capacity would be higher given that the risk is almost entirely borne by the vendor.

The potential capital and operating costs and net costs can vary significantly for all WTE technologies as noted in the range of order of magnitude costs as discussed below. Factors that affect the range of costs for conventional combustion as noted below could also be considered to affect the costs for the other technologies as the same considerations would apply.

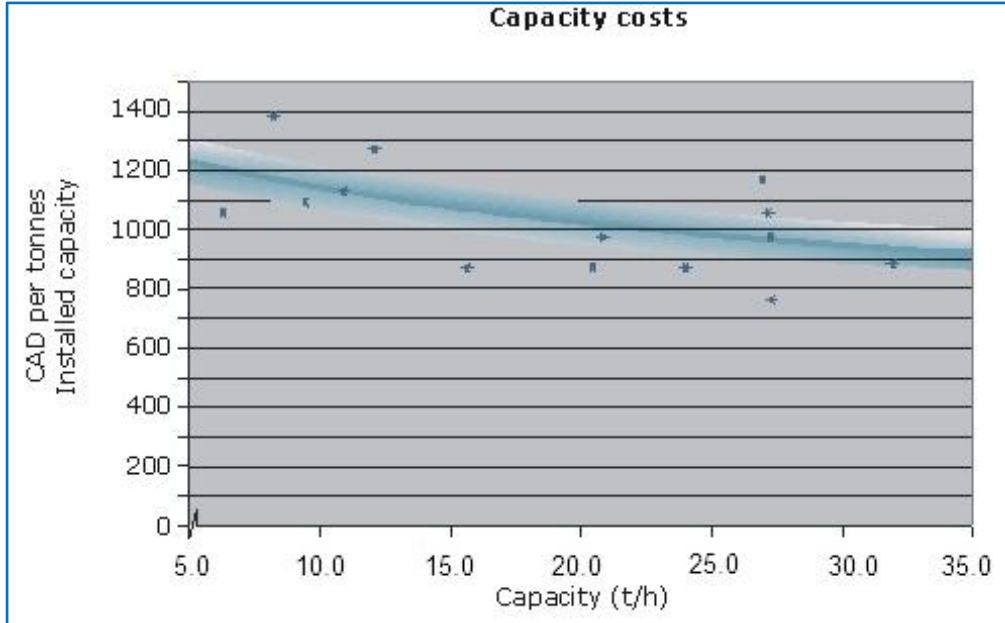
7.1.1 Range of Order of Magnitude Costs

In Figure 7-1, the effect of the size of the WTE plant on the capital costs per tonne of waste are illustrated. The curve shown is based on known capital costs for a wide range of new European Energy from Waste lines, in which Ramboll has been involved during the last 10 years. The background data from 14 European Energy from Waste plants is shown as dots (stars) on the Figure. The background data are actual capital costs adjusted to 2006 price level.

As seen from Figure 7-1, the capital costs per tonne of waste based on European price level are generally \$900 – \$1,200 per tonne of installed capacity. The capital costs between a small (5 tph) and a large (30 tph) incineration plant differs by about 25% (on a cost per throughput tonne basis).

The background data indicated on Figure 7-1 shows that the capital costs differs significantly even for plants of similar size and erected in the same country. This variation indicates that when looking at a preliminary overall level, the capital costs for WTE plants can only be roughly estimated.

Figure 7-1: Comparison of Capital Costs for WTE Facilities per Installed Capacity



Source: Ramboll. 2007. Memo to MacViro during the Durham/York Environmental Assessment

It should be noted that the capital costs noted exclude the purchase of a site and exclude external infrastructure like roads, water, electricity/grid connections, etc. outside the premises of the site.

The capital costs can be split into different components. In Table 7-1 the total capital costs are split into five main components or parts. For each main component, the percentage of the total capital costs related to the specific component is shown. The proposed distribution of capital costs between the different components is based on the general experience with the European market. Of course large variations within the distribution of capital costs between the different main components are foreseen. Furthermore, there might be some differences between the North American market and the European market which will influence the distribution of the total capital costs between the different components/parts. However, the shown distribution can be generally assumed.

Table 7-1: General Distribution of WTE Total Capital Costs

Component	Percentage of Capital Costs
Thermal processing equipment (incinerator/boiler)	40%
Energy production equipment (turbines and generators)	10%
APC system (flue gas treatment)	15%
Building (civil works)	25%
Miscellaneous (approvals, general site works, ash processing, electrical transmission and interconnect etc.)	10%

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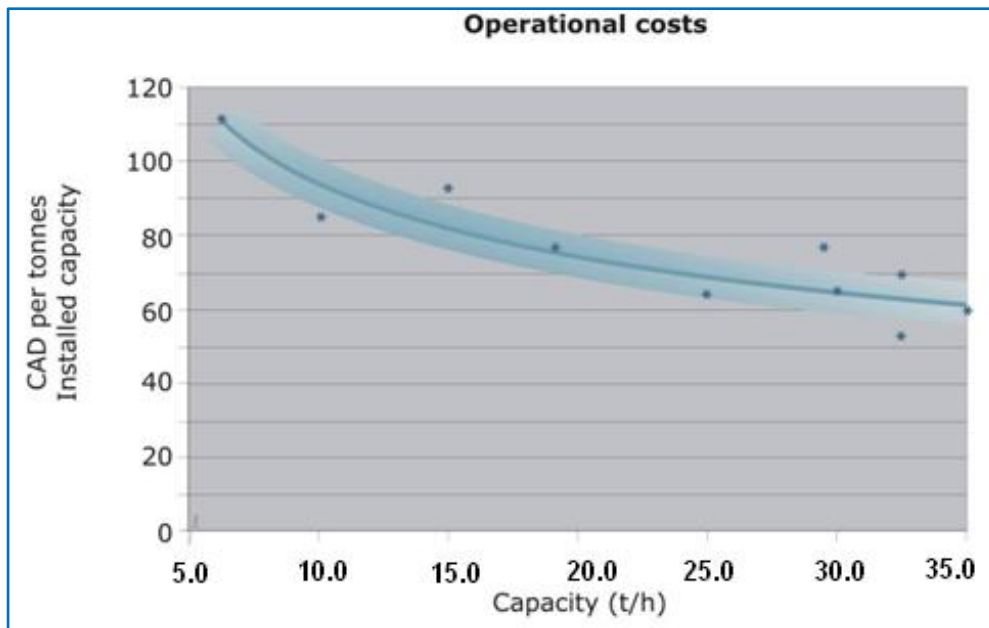
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When estimating the operational costs of WTE facilities, the size of the plant will influence the total costs in the same way as indicated for the capital costs. Furthermore, the total operational costs are to a large extent affected by local conditions such as local labour costs and the cost of consumables.

In Figure 7-2, the effect of the size of the plant on the operational costs per tonne of waste is illustrated. The curve shown is based on estimated operational costs for a range of new or planned European Energy from Waste lines. It is important to be aware that the background data are mainly estimates based on local conditions related to each plant. This includes e.g., type of APC-system, transport-expenses for the residues and the degree of automation of the plant (cranes, gate-control and weighting of incoming waste and outgoing residues etc.). It should also be noted that Figure 7-2 provides information related to gross operating costs, and thus does not take into account income from the sale of energy.

Figure 7-2: Range of Operational Costs for WTE Facilities in the EU



Source: Ramboll. 2007. Memo to MacViro during the Durham/York Environmental Assessment

As seen from Figure 7-2, the operational costs per tonne of waste based on European price level are generally \$60 – \$90 per tonne of installed capacity. The operational costs between a small (6 tph) and a large (35 tph) incineration plant differs by almost 50% (on a cost per throughput tonne basis). The operational costs can be split into different components as indicated:

- Labour and administration 25 – 30%
- Maintenance 35 – 40%
- Utilities and supplies – 20%
- Residues (management and disposal) – 20%.

The following sections discuss the potential range in capital and operating costs for the various WTE technologies presented in Section 2, based on publicly reported data.

7.1.1.1 Conventional Combustion

Capital costs were estimated based on five project estimates found during the literature review.^{[145],[146],[147],[148],[149]} The highest reported cost was \$1,684/annual design tonne (assuming a 200,000 tonne per year capacity where applicable, 2009 CDN\$). The lowest reported cost was \$640/annual design tonne. The median capital cost was \$771/annual design tonne with a standard deviation of 50.27%. For new WTE facilities a certain, and often high capital cost is incurred to improve the architectural appearance of the plant and makes investment costs difficult to compare. In most European countries the APC plant is placed in a building, whereas in North America this has not been the common practice.

Operating costs were also calculated. The maximum reported operating cost/tonne was \$105 and the minimum was \$38.90. The median operating cost/tonne was \$64.09 with a standard deviation of 36%.

These reported values are within the range of true capital and operating costs incurred in many jurisdictions that have been guaranteed through contractual arrangements.

The differences in capital and operating costs between conventional combustion facilities often reflect the following:

- **Size:** economies of scale indicate that larger facilities tend to have lower capital and operating costs per annual design tonne. For example, an Austrian study found that based on recently incurred costs in other EU nations that as the throughput of a WTE facility tripled (from 100,000 to 300,000 tpy) the cost per tonne (operating and capital) for the front end systems to manage MSW and the back end systems to manage ash decreased by 28%.^[150] In regards to the firing system and boiler for such facilities, as the throughput doubled (from 75,000 to 150,000 tpy) the cost per tonne (operating and capital) decreased by 6%.
- **Configuration:** for example, a facility that includes a single 100,000 tpy mass burn combustion unit (boiler) would generally incur capital costs in the order of 25% (or more) less than a facility consisting of two 50,000 tpy combustion units.

¹⁴⁵ European Commission, Integrated Prevention and Control. 2006. Reference Document on Best Available Technology for Waste Incineration

¹⁴⁶ Confidential

¹⁴⁷ Jacques Whitford Stantec Limited. 2009. Durham/York Residual Waste Study Environmental Assessment

¹⁴⁸ MacViro. 2007. City of Ottawa REOI Report

¹⁴⁹ MacViro. 2007. County of Dufferin RFQ Process

¹⁵⁰ Austrian Federal Ministry of Agriculture and Forestry, Environment and Water Management –State of the Art for Waste Incineration Plants, Vienna November 2002

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- **Architecture/Design:** a facility in a high profile location that would warrant special architectural treatments, additional landscaping and other design elements to reduce visual impacts, would generally incur capital costs in the order of 25 to 50% more than a facility located in an industrial zone with minimal requirements to improve the appearance of the facility.
- **APC Train:** as discussed further in this section, there are differences in both capital and operating costs associated with the APC trains suitable for such facilities.
- **Availability of Local Infrastructure:** WTE facilities generally require access to good transportation networks, electricity supply and access to the grid, supply of natural gas, supply of potable water and wastewater services.
- **Potential for Energy Utilization:** the net cost per tonne for WTE facilities declines based on the increased ability of the facility to sell energy. Generally, facilities that are able to sell heat directly to the market incur the lowest range of net costs per tonne, followed by facilities that are able to market both electricity and heat, with the facilities that incur the highest net cost per tonne being those that are only able to sell electricity. Furthermore, costs are affected by infrastructure required to access those markets, and the market price for electricity and heat. In a Canadian context, the ability to market heat at the present time is limited given that there are few policies and little initiative as yet to support district heating schemes. The ability of a WTE to market heat improves with access to industrial users of heat (steam) and/or new commercial/industrial areas where infrastructure for district heating could be considered.
- **Market price for Energy:** the market for energy from WTE varies significantly across North America and the globe, and is affected by energy policy and other legislative initiatives. For example, in jurisdictions such as many Scandinavian nations that have an energy policy that discourages dependence on fossil fuels, higher prices for electrical and heat energy are the norm. Energy pricing in jurisdictions such as Ontario, does not recognize the value of the energy from WTE in the same fashion as that from renewable sources such as biomass, although 50% or more of the energy from such facilities is usually derived from the biomass portion of the waste stream.

Table 7-2 compares two potential WTE facilities under consideration in Ontario, one of which represents the proposed facility for Durham/York Regions and the other representing a plant under consideration elsewhere in the Province. There is a significant difference in the capital costs that have been identified to-date for the two facilities, and some difference in the potential operating costs, based on some of the key factors noted above.

Table 7-2: Comparison of Capital Costs for Two Mid-Size WTE Facilities

	Durham/York 140,000 tpy, Mass Burn	Potential 100,000 to 200,000 tpy Mass Burn
Identified Capital Cost (2009\$)	\$1,500 to 1,700 per annual design tonne	\$900 to \$1,000 per annual design tonne
Identified Annual Operating Cost (2009\$)	\$100 to \$110 per annual design tonne	\$80 to \$90 per annual design tonne
Major Differences in Design	Two-unit facility (two 70,000 tpy mass burn combustion units, potential for two additional 70,000 tpy units) APC designed to achieve BAT EU and Ontario A-7 specifications High-profile location, Clarington Energy Park. Extensive architectural and landscaping treatment. Option for sale of electricity and heat through district heating/cooling.	One-unit facility (one 100,000 tpy mass burn combustion unit, potential for twinning in future) APC designed to meet Ontario A-7 guidelines. Low profile location in existing heavy industrial zone. Minimal architectural treatment or landscaping required. No option for district heating/cooling.
Similarities in Design	Reasonable access to local infrastructure (site servicing). Primary focus on sale of electricity, potential price 8 cents per kwh.	Site is fully serviced. Focus on sale of electricity, potential price 8 cents per kwh.

7.1.1.2 Gasification of MSW

Capital costs were estimated based on ten project estimates found during the literature review.^{[151],[152],[153],[154],[155]} A summary of the reported capital and operating costs for gasification facilities is presented in Table 7-3.

Table 7-3: Summary of Reported Capital and Operating Costs for Gasification Facilities (2009\$ CDN)

	Capital Costs (Annual Design Tonne)	Operational Costs
Lowest Reported Cost	\$134	\$37.22
Highest Reported Cost	\$1,410 (200,000 tpy capacity)	\$117.67
Median Reported Cost	\$803 +/- 42%	\$61.08 +/- 46%

¹⁵¹ MOSA, 2009. Summary Report on Estimated Costs to Develop and Operate new Regional Waste Disposal and Processing Facilities

¹⁵² NYC, 2006. Focused Verification and Validation of Advanced Solid Waste Management Conversion Technologies

¹⁵³ URS, 2005. Los Angeles County, Conversion Technology Evaluation Report

¹⁵⁴ MacViro, 2007. City of Ottawa REOI Report

¹⁵⁵ MacViro, 2007. County of Dufferin, RFP Process

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The reported operating and capital costs are not based on those incurred by actual operating facilities or guaranteed via any procurement process. In most cases this information was provided by technology vendors through REOI or RFQ processes, in which the vendors were not required to guarantee a price. It is not clear that reported capital costs address all capital and construction cost elements. Nor is it clear that reported operating costs address all real costs associated with such facilities.

7.1.1.3 Plasma Arc Gasification

Capital costs were estimated based on four project estimates found during the literature review.^{[156],[157],[158]} A summary of the reported capital and operating costs for plasma arc gasification facilities is presented in Table 7-4.

Table 7-4: Summary of Reported Capital and Operating Costs for Plasma Arc Gasification Facilities (2009\$ CDN)

	Capital Costs (Annual Design Tonne)	Operational Costs
Lowest Reported Cost	\$859	\$87.37
Highest Reported Cost	\$2,027 (200,000 tpy capacity)	\$213.97
Median Reported Cost	\$1,225 +/- 44%	\$119.69 +/- 55%

The reported operating and capital costs are not based on those incurred by actual operating facilities or guaranteed via any procurement process. In most cases this information was provided by technology vendors through REOI or RFQ processes, in which the vendors were not required to guarantee a price. It is not clear that reported capital costs address all capital and construction cost elements. Nor is it clear that reported operating costs address all real costs associated with such facilities.

7.1.1.4 Pyrolysis

Cost range information for pyrolysis was made available through data gathering processes without any requirement for financial guarantees, and thus should be considered to be less reliable. Capital costs and operating costs were estimated based on six project estimates found during the literature review.^{[159],[160],[161]} A summary of the reported capital and operating costs for pyrolysis facilities is presented in Table 7-5.

¹⁵⁶ MOSA, 2009. Summary Report on Estimated Costs to Develop and Operate new Regional Waste Disposal and Processing Facilities

¹⁵⁷ NYC. 2006. Focused Verification and Validation of Advanced Solid Waste Management Conversion Technologies

¹⁵⁸ URS. 2005. Los Angeles County, Conversion Technology Evaluation Report

¹⁵⁹ MOSA, 2009. Summary Report on Estimated Costs to Develop and Operate new Regional Waste Disposal and Processing Facilities

¹⁶⁰ NYC. 2006. Focused Verification and Validation of Advanced Solid Waste Management Conversion Technologies

¹⁶¹ URS. 2005. Los Angeles County, Conversion Technology Evaluation Report

Table 7-5: Summary of Reported Capital and Operating Costs for Pyrolysis Facilities (2009\$ CDN)

	Capital Costs (Annual Design Tonne)	Operational Costs
Lowest Reported Cost	\$161	\$29.76
Highest Reported Cost	\$926 (200,000 tpy capacity)	\$104.58
Median Reported Cost	\$539 +/- 43%	\$50.87 +/- 52%

The reported operating and capital costs are not based on those incurred by actual operating facilities or guaranteed via any procurement process. In most cases this information was provided by technology vendors through REOI or RFQ processes, in which the vendors were not required to guarantee a price. It is not clear that reported capital costs address all capital and construction cost elements. Nor is it clear that reported operating costs address all real costs associated with such facilities. There is some indication that the capital cost per annual design tonne for such facilities is more likely over \$1,500/annual design tonne.

7.1.1.5 Summary of Capital and Operating Costs

Table 7-6 summarizes the information that has been obtained regarding capital and operating cost ranges for the four more common WTE technologies. Generally as the complexity of the technology increases so too does the capital and operating costs.

Table 7-6: Summary of Reported Capital and Operating Costs for Common WTE Facilities (2009\$ CDN)

Conventional Combustion	
Median Capital Cost	▪ \$775/annual design tonne +/- 50%
Median Operating Cost	▪ \$65/tonne +/- 30%
Gasification	
Median Capital Cost	▪ \$800/annual design tonne +/- 40%
Median Operating Cost	▪ \$60/tonne +/- 45%
Plasma Arc	
Median Capital Cost	▪ \$1,300/annual design tonne +/- 45%
Median Operating Cost	▪ \$120/tonne +/- 55%
Pyrolysis	
Median Capital Cost	▪ \$161 to \$926/annual design tonne – data is not as reliable
Median Operating Cost	▪ \$50 to \$105/annual design tonne – data is not as reliable

7.1.2 Cost Differentials between Technologies

As indicated above, generally the reported median capital and operating costs per design tonne reflect the increased complexity of the technologies and the sensitivity of the systems to factors such as the variable nature of MSW. The primary features that result in increased capital and operating costs for these technologies include:

- **Pre-processing of MSW:** generally gasification and pyrolysis processes require a more homogenous waste stream, necessitating a front-end pre-processing system to remove inert materials, blend the MSW and shred/process the combustible fraction of the MSW to a more consistent particle size. This increases both the capital and operating costs for such facilities.
- **Energy Recovery:** generally gasification and pyrolysis processes have a higher parasitic plant load, consuming more electrical energy and/or fossil fuels to operate the facilities. This increases operational costs and decreases the proportion of energy recovered for sale.
- **Emissions Control:** generally gasification and pyrolysis processes include both controls to improve the quality of the intermediate energy product (e.g., syngas) involving various treatment systems, and at least some portion of the APC systems that would normally be used for conventional combustion facilities to control flue gas emissions when the intermediate energy product is combusted.
- **Reliability of the Technology:** as noted in Section 2.1.3, the complexity of gasification and pyrolysis systems is associated with decreased reliability. Scheduled and unscheduled downtime for high temperature gasification is reported as approximately 20%, higher than that for conventional combustion. While actual information on reliability for plasma gasification and pyrolysis is not readily available, it would be anticipated to be similar or worse than high temperature gasification. Some information indicates for example that the refractory for plasma gasifiers requires very frequent replacement, increasing downtime and costs. As a result, generally higher capital replacement costs and operating costs would be incurred in comparison with conventional WTE approaches.

7.1.3 Costs Associated with Emissions Control

Semi-dry APC systems with SNCR generally are the lowest cost emissions control systems for conventional WTE facilities (mass burn). However, some technical limitations associated with the semi-dry system with SNCR may make it less acceptable in some jurisdictions. Limitations include possible exceedances of emission limits in short periods with high HCl or SO₂ concentrations, the potential to produce large amounts of residue that has to be handled, and odours associated with the ammonia in the dry flue gas treatment (FGT) residue.

A report by Ramboll completed in July 2007^[162] analyzed the costs associated with various emissions control technologies (see Table 7-7). The report came to the following conclusions:

- The base-case (semi-dry FGT) has the lowest capital costs.

¹⁶² Ramboll, 2007. The Regions of Durham and York EfW Facility, Comparison of Flue Gas Treatment Systems.

- The wet FGT system with higher capital cost has the lowest operational costs, partly due to high efficiency of the used chemicals and partly due to the lack of dry FGT residues.
- The capital cost of the SCR process is around eight times more expensive than SNCR.
- The SCR uses around 30% less ammonia when reducing the NO_x content just below the emission limit, but the operational costs of SCR is nevertheless higher than SCNR as high pressure steam must be used to heat the flue gas an additional 25°C and spent catalyst must be disposed and replaced.

Table 7-7: Operational and Capital Costs for Different Emissions Control Systems

	Type of FGT System		Yearly Operational Costs (in 1,000 CAD 2007\$)		Capital Costs (in 1,000 CAD 2007\$)		Overall Costs (in 1,000 CAD 2007\$)	
	Acid Gas Treatment	De-NO _x Process	Acid Gas Treatment	De-NO _x Process	Acid Gas Treatment	De-NO _x Process	Total Cost Over 20 Years	Difference from Base Case
Base Case	Semi-dry	SNCR	2,516	90	11,000	1,000	56,928	–
S1	Semi-dry	SNCR + Stripper	2,156	98	11,000	2,200	58,281	1,353
S2	Semi-dry	SCR	2,156	180	11,000	7,000	64,728	7,800
S3	Wet	SNCR	1,887	90	21,000	2,200	61,546	4,618
S4	Wet	SNCR + Stripper	1,887	98	21,000	2,200	62,899	5,971
S5	Wet	SCR	1,887	180	21,000	7,000	69,346	12,418
S6	Semi-Wet	SNCR	2,198	90	14,000	1,000	60,763	3,835
S7	Semi-wet	SNCR + Stripper	2,198	98	14,000	2,200	62,116	5,188
S8	Semi-wet	SCR	2,198	180	14,000	7,000	68,563	11,635

As indicated in Table 7-4, the operational costs over 20 years are lower for wet emissions control systems, however there are significantly higher capital costs associated with this type of system.

7.2 Thermal Efficiency and Energy Recovery

Each of the WTE technologies discussed thus far has relative advantages and disadvantages associated with their operation.

This section of the report will discuss the thermal efficiency and energy recovery typical of mass burn incineration facilities (conventional combustion) and gasification facilities. There is insufficient information currently available to discuss the efficiency and energy recovery rates associated with pyrolysis and plasma arc gasification facilities.

7.2.1 Energy Recovery from Mass Burn Facilities

The combustion of waste is a heat generating process. Most of the energy produced during combustion is transferred to the flue gases which are cooled as they pass through the plant allowing for the capture of energy via a heat recovery boiler (which transfers the heat energy to water causing the production of steam or hot water).

Energy produced by such facilities can be used in the:

- Production and supply of heat (as steam or hot water)
- Production and supply of electricity (i.e., via a steam turbine), or,
- Production of heat and electricity (i.e., combined heat and power, CHP).

The energy produced can be used on-site and/or off-site. Heat and steam are commonly used for industrial processes or district heating systems while electricity is often supplied directly to an energy grid or used within the system.

Several factors influence the energy efficiency associated with mass burn incineration facilities.

These factors include:

- Characteristics of the waste being treated (chemical and physical characteristics – MJ/kg). Typical values of waste net calorific values are between 8 and 12.6 MJ/kg
- Plant design (increased steam parameters – boilers and heat transfer)
- Energy sale possibilities (heat and electricity or just electricity), and
- Local conditions (e.g., meteorological conditions – if the plant is located in a warm environment the use of district heating would not be practical).

The highest levels of waste energy utilization are normally obtained when the heat recovered can be supplied continuously as district heat (or process steam) or in combination with electricity generation. The use of district heat (or process steam), however, is highly dependent on the availability of a user for the energy (as well as local meteorological conditions).

The production of electricity alone is a common method that WTE facilities use to recover energy from the incineration process. Electricity only operations are less efficient than those that recover and use district heat (or process steam) but are less dependent on local conditions and therefore are widely employed.

Modern mass burn facilities that produce only electricity regularly recover and sell electricity in the range of 550 kWh/tonne of waste. Facilities that recover both heat and electricity can generate considerably more energy per tonne of waste treated. The WTE facility located in Brescia, Italy produces/markets 650 kWh and 500 kWh of electricity and heat respectively per tonne of waste treated. The WTE facility located in Malmo, Sweden (a much colder climate therefore increasing the beneficial uses of district heating) produces/markets 280 kWh and 2,580 kWh of electricity and heat respectively per tonne of waste treated. The Metro Vancouver WTE facility produces about 470 kWh

of electricity and 760 kWh of steam per tonne of waste (it should be noted that the Metro Vancouver facility was built in 1988, and higher efficiencies are now possible with BAT).^[163]

The following table (Table 7-8) provides ranges of potential efficiencies at incineration plants in a variety of situations. The actual figures at an individual plant will be site-specific. The purpose of the table, therefore, is to provide a means to compare what might be achievable under favourable circumstances. It should be noted that the reported efficiencies do not take into account boiler efficiencies (which exhibit typical losses in the order of 20%).^[164]

It is important to realize that direct comparison of WTE facilities with other power stations should be avoided. This is due to the fact that the conversion of steam into electricity at WTE facilities is limited by the composition of the waste (e.g., high chlorine content may cause corrosion in the boiler or economizer) and that when flue gas in is the range of approximately 250 – 400°C it cannot generally be used for generation of steam as this is considered to be the range in which de novo synthesis of dioxins/furans take place,^[165] discussed earlier in Section 3.1.1.

Table 7-8: Energy Potential Conversion Efficiencies for Different Types of Waste Incineration Plants^[166]

Plant Type	Reported Potential Thermal Efficiency %
Electricity Generation Only	17 – 30
Combined Heat and Power (CHP)	70 – 85
Heating Stations with Sales of Steam and/or Hot Water	80 – 90
Steam Sales to Large Chemical Plants	90 – 100
CHP and Heating Plants with Condensation of Humidity in Flue gas	85 – 95
CHP and Heating Plants with Condensation and Heat Pumps	90 – 100

NOTE:

The figures quoted in the above table are derived from addition of MWh of heat and MWh of electricity produced, divided by the energy output from the boiler. No detailed account is taken of other important factors such as: process energy demand (support fuels, electrical inputs) or displacement of electricity and heat generation.

A number of factors can be considered when attempting to increase the thermal efficiency of the waste incineration process. These include:

- Waste pre-treatment (homogenization and/or separation of non-suitable materials)
- Design of boilers for increased heat transfer

¹⁶³ AECOM. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

¹⁶⁴ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

¹⁶⁵ TWG. 2001. Draft of a German Report with basic information for a BREF-Documents “Waste Incineration”

¹⁶⁶ European Commission. 2006. Integrated Pollution Prevention and Control Reference Document on the Best Available Techniques for Waste Incineration

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- Combustion air pre-heating (can have a positive influence on overall energy efficiency in the case of electricity production)
- Use of water cooled grates
- Flue gas condensation
- Use of heat pumps
- Flue gas re-circulation
- Steam-water cycle improvements.

7.2.2 Energy Recovery from Gasification Facilities

All existing gasification technologies examined, have lower energy recovery efficiencies than those currently being achieved by modern mass burn incinerators.^[167] This is due to the fact that a mass burn process generally results in more complete combustion of the fuel compared to gasification and/or as the support fuel/electrical inputs for gasification tend to be higher.

The gasification process results in the production of syngas which can be used similarly to natural gas. Syngas can be used to fuel a conventional boiler (similar to a mass burn system) to produce steam and drive a turbine which results in the production of electricity, but it can also be used in reciprocating engines to produce electricity and heat, combined cycle gas turbine plants to produce electricity and heat, or fuel cells, or it can be converted into ethanol.

The efficiencies of the gasification process depend on how the syngas is used. When used to produce electricity using a steam boiler and turbine, efficiencies are in the range of 10% to 20%. When burned in reciprocating engines, efficiencies increase slightly to in the range of 13% to 28%, and in combined cycle gas turbines, they can be as high as 30%. It should be noted, that there are no known commercial scale applications of combined cycle gas turbines using syngas produced from MSW, therefore this number should be considered theoretical in nature. When used for district heating (CHP) over 90% efficiencies can be achieved.^[168]

Interstate Waste Technologies (who market the Thermoselect gasification technology in North America) report that the Thermoselect technology can produce 641 kWh of net electricity per tonne of waste treated.^[169] When the Thermoselect technology is combined with reciprocating engines, overall net efficiency is approximately 13% (exported power divided by thermal input).^[170]

7.3 European Union Energy Efficiency Equation Experience

In December 2008, the European Union's (EU) Waste Framework Directive (2008/98/EC) came into force. The Waste Framework Directive (WFD) provides an umbrella for all other European waste

¹⁶⁷ Fichtner Consulting Engineers Limited. 2004. The Viability of Advanced Thermal Treatment of MSW in the UK

¹⁶⁸ AECOM. 2009. Management of Municipal Solid Waste in Metro Vancouver – A Comparative Analysis of Options for Management of Waste After Recycling

¹⁶⁹ Alternative Resources, Inc. 2008. Evaluation of Municipal Solid Waste Conversion Technologies

¹⁷⁰ Fichtner Consulting Engineers Limited. 2004. The Viability of Advanced Thermal Treatment of MSW in the UK

legislation. The WFD includes an energy efficiency equation which will be adopted into legislation in the individual member states by December 31, 2010. The WFD lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving the efficiency of such use.

The WFD presents a five-step hierarchy of waste management options which must be applied by Member States when developing their national waste policies. The waste hierarchy given is as follows:

1. Waste prevention
2. Re-use
3. Recycling
4. Recovery (including energy recovery)
5. Safe landfill disposal, as a last resort.

The WFD considers energy-efficient waste incineration a recovery operation, provided that it complies with certain energy-efficiency criteria.^[171] In order to determine whether or not a WTE facility is deemed a recovery operation, the WFD presents an energy efficiency formula which calculates a facility's energy efficiency.

The energy efficiency formula is as follows:^[172]

$$\text{Energy efficiency} = (Ep - (Ef + Ei)) / (0.97 \times (Ew + Ef))$$

- *Ep* means annual energy produced as heat or electricity (GJ/year). It is calculated by applying an equivalence factor of 1MWh electricity produced being equivalent to 2.6 MWh of electricity imported from other sources onto the grid and by applying an equivalency factor of 1MWh of fuel replaced by heat produced being equivalent to 1.1 MW of imported fuel.
- *Ef* means annual energy input to the system from fuels contributing to the production of steam (GJ/year)
- *Ew* means annual energy contained in the treated waste calculated using the net calorific value of the waste (GJ/year)
- *Ei* means annual energy imported excluding *Ew* and *Ef* (GJ/year)
- 0.97 is a factor accounting for energy losses due to bottom ash and radiation.

Using this formula, an incineration facility is considered a recovery operation if it reaches an energy efficiency of 0.60 for installations in operation and permitted before January 1, 2009 and 0.65 for

¹⁷¹ European Parliament (November 11, 2008), *The Legislative Observatory Final Legislative Act*, Retrieved February 19, 2010, from <http://www.europarl.europa.eu/oeil/file.jsp?id=5303132>

¹⁷² Official Journal of the European Union (November 22, 2008), Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives, Retrieved February 19, 2010, from http://www.wastexchange.co.uk/documenti/europeanorm/DIR2008_98_EC.pdf

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installations permitted after December 31, 2008.^[173] Those WTE facilities that reach these criteria are considered R1 recovery operations.

The drivers behind the WFD and the R1 formula were many and to a certain degree contradicting, some are mentioned below:

- In the EU, when waste is co-incinerated in cement kilns, the process is defined as recovery, whereas incineration of MSW in dedicated WTE facilities is defined as disposal. The WTE industry found this definition unreasonable.
- Recovery of energy from waste is an important component in a European waste management business model. Energy is a precious resource and the WTE industry felt it should be credited this benefit. WTE also allows for material recovery, however material recovery is not accounted for by the energy efficiency equation.
- According to the EU transport regulation, trans-boundary transport of waste for recovery is allowed without any particular control, whereas trans-boundary transport of waste for disposal is subject to multiple restrictions and controls.

As a first step the produced energy is determined by considering produced electricity and thermal energy for commercial use. Two equivalency factors are applied: 2.6 as a factor if electricity is produced in lieu of electricity imported from other energy generating sources onto the grid and 1.1 if thermal energy is produced in lieu of imported fuel. The factor takes into account the efficiency of the energy production which is replaced by WTE production. In a second step the energy input from fuels and sources other than waste is subtracted ("Energy from fuels", "Other imported energy"). Energy input from fuels (e.g., gas firing for start-up operations; electricity supply from the grid) is deducted. The remaining figure is the energy produced only by waste input. In a third step the energy produced only by the waste input is divided by the energy content of the waste (the potential of energy contained in the waste, calculated from the lower calorific value) plus the energy input from fuels. Note: generally the energy content of the waste is determined through published values for specific material streams and/or fuel testing, but there are no specific requirements for fuels/material testing that must be met in application of the energy efficiency formula. In addition the denominator is multiplied by 0.97. This factor accounts for energy losses via bottom ash and radiation.

If a WTE facility does not meet the R1 criteria it is deemed a disposal facility and falls to the lowest level of the hierarchy.^[174]

As indicated in the Figure 7-3 below, WTE facilities generating a mix of both heat and power generally easily fulfill the efficiency formula having an R1 of between 0.6 and 0.8, and are defined as recovery. WTE facilities with optimized power production of over 700 kWh/tonne of waste will as well be able to fulfill the requirement for recovery whereas several facilities, especially older ones, might not be able to fulfill the requirement and will not succeed in being defined as recovery.

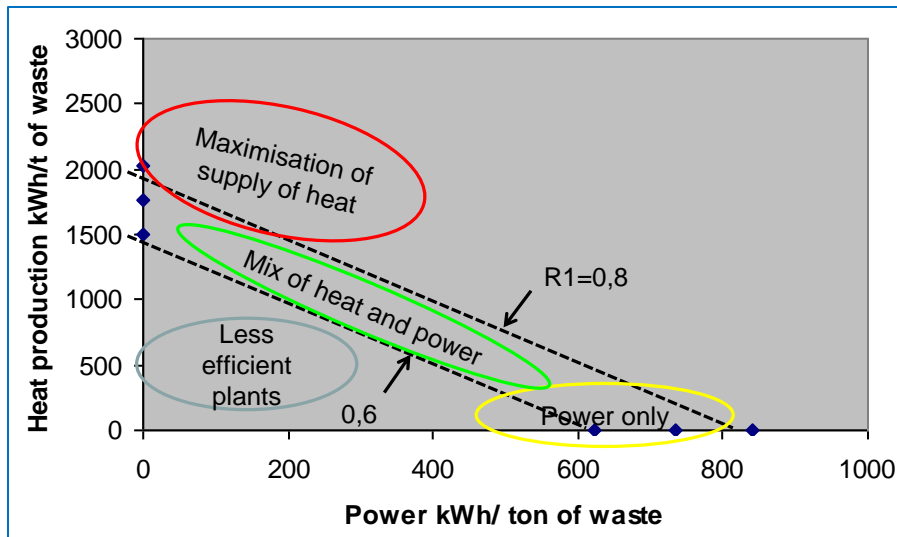
¹⁷³ The formula only applies to incineration facilities dedicated to the processing of municipal solid waste (reference 139)

¹⁷⁴ Institut für Ökologie und Politik GmbH (June 2006), *The Energy Efficiency Formula of Annex II of the Waste Framework Directive, A Critical Review*. Retrieved February 19, 2010, from http://www.eeb.org/activities/waste/waste_strategy/20060630-Okopol-Brief-on-MSWI-efficiency-formula-v5-final.pdf

It should be noted that the equation is not entirely clear and may be interpreted differently from one country to another. In addition, the impact of a facility's internal energy consumption is often discussed (e.g., if pre-treatment is required for the process it should then be calculated independently if pre-treatment is carried out at another location). This is of relevance for some mass burn facilities but even more so for fluidized bed incinerators and for the emerging technologies where the internal consumption of energy for waste pre-treatment is relatively high.

Figure 7-3: Relationship of Heat to Power Production for WTE Facilities

NOTE:



The dashed lines above represent an R1 of 0.6 and 0.8 respectively.

The EU Commission is in the process of further defining the use of the formula, as practical use of the formula showed that a transparent and harmonized way of calculating energy efficiency was necessary among the member states. The commission has engaged consultants, CEWEP, and other interest groups to evaluate and further define the use and the interpretation of the formula.

The Waste Framework Directive has to be implemented in all member states no later than December 31, 2010. For this purpose, the EU Commission will by the end of October 2010 publish European guidance for the use of the R1 energy efficiency formula for incineration facilities dedicated to the processing of MSW. The draft guidance is defining among others:

- The scope of the Energy Efficiency Formula
- The system boundaries
- The qualification procedure and monitoring of compliance.

Some countries in the EU have already adopted and implemented use of the formula. For example, the Netherlands has implemented the formula but takes the internal energy consumption of the facility into account. Five plants, representing approximately 70% of the country's capacity, are

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defined as recovery whereas the remaining facilities did not succeed in fulfilling the required efficiency and are therefore defined as waste disposal.

In Denmark the WFD has been adopted but without the formula. All WTE facilities in Denmark generate both heat and power and have an energy efficiency value of greater than 0.65. All plants will easily be defined as recovery according to the definition in the WFD. It is possible this value may be increased by government to drive continuous improvement in energy efficiency. The definition of recovery versus disposal and use of the equation is further complicated by the potential future imports of MSW, which are currently prohibited, into Denmark.

In Italy it is most likely that the input energy to the WTE facilities will be taken into account. Only energy that is actually sold (as heat and/or power) is allowed to be considered. The application of the formula is complicated by seasonal variations in consumption of energy where district heating is applied. Further, there is uncertainty in how to address facility consumptive use of power in the calculation. Principally this means that a WTE facility that is considered a recovery facility one year may be considered as a disposal facility in subsequent years should some or all of the energy not be sold.

In France a waste incineration tax is charged to plants defined as disposal facilities but not to plants determined to meet the recovery criteria. France recently started using the equation but is awaiting the published guidance later in 2010 for consistent application.

In the UK and in Scotland new WTE facilities have to prove they are able to achieve energy efficiency above 0.65 in order to obtain an operating permit. Similar to France, the UK and Scotland recently started using the formula, pending release of the EU guidance on application.

In summary, there is inconsistent application of the energy equation in the EU. The situation should be clarified somewhat with the release of additional guidance by the EU in the fall of 2010.

7.4 WTE Energy Recovery and Revenue Streams in BC

Direct revenue streams for WTE facilities include those from the sale of energy (including any combination of district heat generation and generation of electricity), from the sale of recovered materials (e.g., metals) and from tipping fees.

For every tonne of MSW consumed in a WTE facility, it is typically possible to generate up to 2 MWh of heat energy (as hot water or steam) and in the order of 0.5 to 0.8 MWh of electrical energy or any combination thereof depending on the design of the plant. The total amount of energy generated and marketed depends on the total available energy associated with the mass of MSW processed, and the ability to find a market for the energy.

Table 7-9 provides an overview of the potential energy generation and energy sales for a 100,000 tpy conventional (mass burn) WTE developed in a BC market, combusting post-diversion residual waste, if the sale of heat energy were to be limited by local market conditions. The composition of the post-diversion residual material assumes that a source separated organics diversion program is in place, diverting in the order of 60% or more of the 'wet' food materials from the waste stream.

Table 7-9: Potential Energy Generation and Energy Sales for a 100,000 tpy Conventional WTE Facility in a BC Market

Electricity Generation	Based on post source separated organics (SSO) waste composition and characteristics: <ul style="list-style-type: none"> ▪ Average Net Energy Production: 770 kWh/tonne ▪ Waste Energy Content: 13 MJ/kg ▪ Plant Heat Rate: 16.9 MJ/kWh
Combined Heat and Power (CHP)	CHP contingent upon development of proximate users of heat energy, that could be limited given local conditions
Auxiliary Fuel	Requires Natural Gas, for start up and temperature control
Bottom Ash Handling	Bottom ash quenched, quench water recycled Bottom ash screened and magnetically separated to remove ferrous and non-ferrous metals with 55% recovery rate
Power Island	One single casing steam turbine generator, mechanical draft cooling tower

Revenue streams for such a WTE Plant could generally include the following:

- Electricity Sales
- Sales of Ferrous and Non-Ferrous Metals, recovered from the bottom ash
- Tipping Fee revenue from commercializing plant capacity.

The value of these revenue streams is entirely contingent upon the market for the commodities noted, and in some cases it is difficult to determine with any degree of relative certainty at this time.

With regard to electricity sales, market prices are contingent upon the jurisdiction. For example, market prices for energy from waste have recently been established in Ontario of 8.5 cents per kWh. At that rate, electricity sales from a 100,000 tpy WTE plant could be in the order of \$6.5 million annually. However, it is likely that lower energy prices would prevail in BC based on the prevalence of renewable energy sources in the market. For BC residential customers, a two-step Conservation Rate is applied on an interim basis.^[175] As of April 1, 2010, the current cost of electricity in BC is 6.27 (Step 1) and 8.78 (Step 2) cents per kWh.

Should a proximate market for heat be developed (e.g., development of greenhouses), the potential for heat recovery for a 100,000 tpy conceptual WTE plant would vary between 46 million kWh (conservative based on high pressure steam, electricity production reduced to 88%) and 136 million kWh (hot water recovery based on BAT EU practice, electricity production reduced to 80% with 2 units of heat produced for each unit of electricity). For heating of greenhouses, the best option would be recovery of hot water that could be supplied and used in radiant heating systems. Heat recovery would decrease net electricity production and revenues, between 12.5 and 20%. The market would be contingent upon the energy requirements for greenhouses which vary, based on design (materials, construction method) and climate. Assuming that the heat sold replaces that which would

¹⁷⁵ BC Hydro. April 1, 2010, Electricity Rates. Website: http://www.bchydro.com/youraccount/content/electricity_rates.jsp.

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be otherwise generated by burning natural gas, and considering potential energy markets, the heat could be sold at approximately \$0.04/kWh. For a 100,000 tpy facility, annual revenues from the sale of heat could vary between \$1.8 and \$5.4 million.

Revenues earned from the sale of recovered materials, could include revenues from the sale of recovered metals (ferrous and non-ferrous), recovered reagents from the APC train (e.g., gypsum) and recovery of aggregate from bottom ash. Considering the current state of the industry in North America, it is reasonable to assume markets for recovered metals, but not necessarily for any other recovered materials. In regards to revenues from the sale of ferrous and non-ferrous metals recovered from the bottom ash of the WTE plant (assuming a 100,000 tpy capacity), approximately 9,000 tpy of metals could potentially be recovered (pending confirmation of the characteristics of the MSW stream that would be managed at the plant). Based on current North American metals markets, which are somewhat depressed compared to previous years, a conservative estimate for this material stream would be \$200/tonne or approximately \$1.8 million annually.

It is difficult to determine if or how much revenue would be generated through tipping fees for a WTE plant in BC. Current Metro Vancouver tipping fees at waste disposal sites are in the order of 82 to 86 \$/tonne.^[176] For a new WTE facility the ownership model (public or private) is anticipated to have a role in setting tipping rates.

As discussed above, the overall energy efficiency (and revenues from sale of energy) are potentially limited by the available markets for sale of heat energy, and other limitations including electricity pricing.

The Environmental Protection Division has an operational policy that addresses the review of SWMPs which include MSW as a feedstock for WTE facilities. This policy states that the ministry prefers WTE facilities that incorporate resource recovery (as part of a waste management hierarchy) and expects that energy recovery facilities would meet at least 60% efficiency based on a calculation similar to the EU energy efficiency equation. However, any new WTE facilities in BC may not be able to achieve an energy efficiency of 60% without further development of infrastructure such as district heating that would facilitate the use of heat generated by a WTE facility, recognizing that a high efficiency is difficult to reach through the production of electricity alone. The lessons learned in Europe as EU member states implement the energy efficiency equation during the last half of 2010 may provide guidance to the ministry about interpretation of the equation and how it may be further applied in a BC context.

¹⁷⁶ Metro Vancouver Disposal Facilities. Website:
<http://www.metrovancouver.org/services/solidwaste/disposal/Pages/disposalfacilities.aspx>

7.5 Summary – BAT for Energy Recovery

The following list outlines the BAT for energy recovery from WTE facilities^{[177] [178]}:

- Overall optimization of energy efficiency and energy recovery taking into account techno-economic feasibility and the availability of users for the energy to be recovered.
- Reduction of energy loss via the flue gases (i.e., reduce flue gas flow to recover more heat energy).
- The use of a boiler to transfer energy with a thermal conversion efficiency of at least 80%.
- Securing where possible, long-term heat/steam supply contracts to large heat/steam users to maximize the heat/steam usage.
- Locate in an area where heat and/or steam use can be maximized through any combination of:
 - Electricity generation with heat or steam supply (combined heat and power – CHP)
 - District heating
 - Process steam to industrial or other facilities
 - Heat/steam supply for use in cooling/air conditioning systems (through the use of absorption chillers, which use steam or hot water to drive a phase change in a medium to create a cooling effect).
- Where electricity is generated, optimization of steam parameters including consideration of the use of higher steam parameters to increase electricity generation.
- The selection of a turbine suited to the electricity and heat supply regime and high electrical efficiency.
- Where electricity generation is a priority over heat supply, the minimization of condenser pressure.
- General minimization of overall facility energy demand including consideration of the following:
 - Selecting techniques with lower energy demand over those with higher energy demand
 - Ordering APC components to avoid the requirement for flue gas reheating
 - If flue gas reheating is necessary, the use of heat exchanger systems to minimize energy demand.
- The location of a new facility so that the use of CHP and/or heat and/or steam can be maximized so as to generally exceed an overall total energy export level of 1.9 MWh/tonne of MSW based on an average net calorific value (NCV) of 2.9 MWh/tonne.
- Reduce the average installation electrical demand to be generally below 0.15 MWh/tonne of MSW processed based on an average NCV of 2.9 MWh/tonne.

¹⁷⁷ European Commission. 2006. Integrated Pollution Prevention and Control: Reference Document on the Best Available Techniques for Waste Incineration.

¹⁷⁸ Federal Environment Agency – Austria. 2002. State of the Art for Waste Incineration Plants.

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8 EMISSION MONITORING SYSTEMS

In order to determine compliance with facility emission permit limits, operators must undertake emission monitoring and report the results to regulatory authorities. Point source emissions monitoring is conducted either on continuous basis or periodic (non-continuous) basis.

Continuous monitoring measures parameters of concern using stationary monitoring equipment permanently installed at various locations within combustion, APC or discharge flue of the facility. Continuous monitors are typically used for operational control and occasionally for compliance measurements. The results from the continuous monitor are representative of the location on the system where they are installed, and therefore may not always represent the concentration in the discharge.

Periodic emission monitoring, also called stack sampling, is usually performed on a prescribed frequency, with the period specified (usually quarterly, annually or semi-annually) by the facility SWMP or permit in the case of WTE, and is therefore non-continuous. Periodic stack sampling is performed by a sampling crew of at least two people that extract a discrete sample from the stack for the facility. This method of determining discharge quality consists of obtaining samples of the emission stream according to approved protocols. The duration of the stack test is determined by the size of the stack, the number of prescribed sample points within the stack, the degree of difficulty in maintaining standard operating conditions during the test, and the number of replicate tests required by the test procedure.

Continuous emissions and periodic stack testing monitoring methods are discussed in additional detail below.

8.1 Continuous Emissions Monitoring Systems (CEMS)

Modern WTE monitoring systems ensure that air emissions resulting from plant operation fall within specified limits. Projects initiated within Canada are required to use Environment Canada or US Environmental Protection Agency (EPA) protocols and performance specifications listed in Appendix 7.1 of the BC *Stationary Air Emissions Testing* manual.^[179] New stationary continuous source testing methods can be approved if they meet the requirements of US EPA Method Validation Protocol Method 301.^[180] In conventional combustion facilities, Continuous Emissions Monitors Systems (CEMS) are installed to monitor the internal operations of the facility components to ensure the emissions leaving the facility are at appropriate levels.

The types of parameters that CEMS usually monitor and record include:

- The baghouse outlet for opacity, moisture, CO, TOC, O₂, NO_x, SO₂, HCl and HF. Opacity measurements would be used as the filter bag leak detection system

¹⁷⁹ British Columbia Field Sampling Manual Part B: Air and Air Emissions Testing. Stationary Air Emissions Testing. 2003.

¹⁸⁰ US EPA. CFR Promulgated Test Methods. Method 301 – Method Validation Protocol. Field Validation of Pollutant Measurement Methods from Various Waste Media.

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- The economizer outlet for O₂, SO₂ and CO
- Flue gas temperatures at the inlet of the boiler convection section and at the baghouse inlet
- The temperature and pressure of the feedwater and steam for each boiler
- The mass flow rate of steam at each boiler.

Often a long-term continuous sampling device can be installed to sample for dioxin/furan emissions over a fixed period of time, commonly two weeks or one month.^[181] In some countries, especially France and Belgium, intensive public concerns regarding dioxin emissions arose in many communities around 10 years ago as old WTE facilities were suspect for uncontrolled dioxin emissions. To prove that the WTE facilities were able to control dioxin emissions not only when the stack sampling was undertaken but on a continuous basis, initiatives were taken to develop and install continuous dioxin sampling devices. The continuous sampling equipment is in principle identical to the periodic sampling equipment but actually takes a sample from the stack over a period of 14 days or more. The probe is then sent for laboratory analysis. While the samples are taken on an on-going basis, this is not true continuous monitoring as the result is representative of an average concentration over the sampling period. Dioxin sampling is not regulated in the EU and thus there is no emission limit that is applicable for the long term sampling. However, some WTE plants mainly in Belgium and France, have voluntarily installed these continuous dioxin sampling devices.

In regards to particulate emission monitoring, progress has been made in regards to CEMS systems suitable for monitoring particulate. The use of CEMS to determine the concentration of particulate matter in the emission stream has yet to be widely adopted. Several different types of PM CEMS technologies (e.g., light scattering, Beta attenuation, etc.) are available, each with certain site-specific advantages. The USEPA recommends that proponents select and install a PM CEMS that is appropriate for the flue gas conditions at the source. Opacity is often used as a surrogate, but attempts to directly correlate opacity to PM emissions have not been reliable.^[182] The more commonly applied method of determining particulate matter concentrations utilizes the periodic stack sampling method EPA Method 5, as discussed in the next section.

Continuous particulate mass monitoring is required by the USEPA as part of the hazardous waste combustion MACT. The USEPA promulgated Performance Specification 11 (PS-11)^[183] in January 2004, in order to establish the initial installation and performance procedures that are required for evaluating the acceptability of a particulate matter (PM) continuous emission monitoring system. PS-11 outlines the procedures and acceptance criteria for installation, operation, calculations and reporting of data generated during the site-specific correlation of the PM CEMS response against manual gravimetric Reference Method measurements. Procedures for evaluating the ongoing performance of a PM CEMS are provided in Procedure 2 of Appendix F – Quality Assurance Requirements for Particulate Matter Continuous Emission Monitoring Systems Used at Stationary Sources.

¹⁸¹ Durham/York Residual Waste Study Environmental Assessment, November 27, 2009, Stantec Consulting Ltd

¹⁸² Status of Particulate Matter Continuous Emission Monitoring Systems, EPRI, Palo Alto, CA: 2001. 1004029.

¹⁸³ USEPA APPENDIX B OF PART 60 – PERFORMANCE SPECIFICATIONS PERFORMANCE SPECIFICATION 11 - Specifications and Test Procedures for Particulate Matter Continuous Emission Monitoring Systems at Stationary Sources, January 12, 2004.

Up until recently, although guidance was provided regarding PM CEMS by the USEPA it has not yet been widely used in the USA as a suitable monitoring approach for the purpose of demonstrating regulatory compliance because of measurement accuracy and repeatability issues. However, this has recently changed. The US EPA recently issued for public comment, 40 CFR Part 60 (new standards for incineration units), which includes requirements for example for new waste energy recovery units which would require units that have a design capacity greater than 250 MMBtu/hr, to include monitoring of PM emissions using a PM CEMS.^[184] For other incineration facilities, the use of PM CEMS would be optional as an alternative to periodic sampling.

The proposed new requirements for incineration units discuss the methods used to develop proposed new emissions limits, and discuss the use of averaging periods as they relate to CEMS or stack tests. For example, the proposed PM emission limits are based on data from infrequent (normally annual) stack tests and compliance would generally be demonstrated by stack tests. The use of PM CEMS for measurement and enforcement of the same emission limits must be carefully considered in relation to an appropriate averaging period for data reduction. Because historical PM CEMS data are unavailable for the solid waste incineration sector, EPA concluded that the use of a 24-hour block average was appropriate to address potential changes in PM emissions that cannot be accounted for with short term stack test data. The 24-hour block average would be calculated following procedures in EPA Method 19 of Appendix A-7 of 40 CFR part 60.^[185]

CEMS requirements vary between jurisdictions, with some common parameters being measured via CEMS but not all; and few jurisdictions have reviewed and assessed the potential requirement for mandatory CEMS for particulate. The following table presents an overview of the continuous emissions requirements as outlined in the current BC MSWI guidelines, Ontario Guideline A-7 (revised October 2010) and the EU Waste Incineration Directive.^[186]

Table 8-1: Continuous Emissions Monitoring in BC, Ontario and EU

Pollutant	BC 1991 MSWI Emission Criteria	Ontario Guideline A-7 (Parameters Considered for Continuous Monitoring)	EU Waste Incineration Directive
Temperature	X	X	X
Organic matter		X	
Carbon monoxide	X	X	X
Residual oxygen		X	X
Carbon dioxide		X	
Volumetric flow rate of the flue gas		X	
Hydrogen chloride	X	X	X
Sulphur dioxide		X	X

¹⁸⁴ ENVIRONMENTAL PROTECTION AGENCY, 40 CFR Part 60 EPA-HQ-OAR-2003-0119; FRL- RIN 2060-AO12 Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units, April 2010.

¹⁸⁵ Ibid.

¹⁸⁶ Ontario Ministry of the Environment. Guideline A-7: Air Pollution Control, Design and Operation Guidelines for Municipal Waste Thermal Treatment Facilities, October 2010.

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Pollutant	BC 1991 MSWI Emission Criteria	Ontario Guideline A-7 (Parameters Considered for Continuous Monitoring)	EU Waste Incineration Directive
Hydrogen fluoride		X	X
Nitrogen oxides		X	X
Opacity	X	X	
TOC			X
Total Dust/Particulate Matter		X	X

The Waste Incineration Directive also requires that O₂ concentration, pressure, temperature, and water vapour content of exhaust gas be continuously monitored. Periodic, instead of continuous, monitoring of HCl, HF, and SO₂ may be authorized if the operator can prove that the emissions of these pollutants can under no circumstance be higher than the prescribed emission limit values. The WID also requires at least two measurements per year of heavy metals, dioxins and furans (one measurement at least every three months for the first 12 months of operation). Further, if the operator can demonstrate that the emissions of heavy metals and dioxins/furans are always below 50% of the emission limit values, the operator only needs to test for heavy metals once every two years (instead of twice a year) and for dioxins/furans once a year (instead of twice a year). Some EU member nations impose additional requirements. For example, Germany requires that Hg be monitored continuously.

8.2 Periodic Emission Monitoring

Currently in BC, to determine if a discharge is in compliance with permit requirements, periodic non-continuous sampling may be required on a quarterly, semi-annually or annual basis. Field monitoring conducted for each survey must be conducted by certified stack test technicians as required by the BC *Stationary Air Emissions Testing* manual.^[187] This method of testing is also commonly called 'manual stack testing' and involves obtaining a representative sample of the emission from the flue over a period of time at a prescribed number of sample locations. Stack testing is conducted according to strict, approved protocols published in the BC Field Sampling Manual, the BC Air Analytical Manual, the US Environmental Protection Agency methods, or by other approved sampling and analytical methods.^{[188] [189]} The USEPA methods generally represent the approved period sampling methodologies for stationary sources, in many cases for specific industry sectors or specific emission sources.

The duration of a periodic stack test is linked with the diameter of the stack and therefore the number of sample locations on each traverse, the variability of the emission rate relative to standard

¹⁸⁷ British Columbia. Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples. 2003

¹⁸⁸ US Environmental Protection Agency 40 CFR Parts 60, 61 and 63

¹⁸⁹ British Columbia Environmental Laboratory Manual for the Analysis of Water, Wastewater, Sediment, Biological Materials and Discrete Ambient Air Samples. 2007

operating conditions during the test, and the number of replicate tests that are required to meet permit requirements. Typically, the test methodology will extract a sample from the discharge stream and collect the parameters of interest on a filter paper (for particulates) or in a reagent or resin (such as XAD-2 resin for organic constituents) for subsequent chemical analysis. Results are initially produced on a mass basis and are then converted to concentration values on the basis of the volumetric discharge rate. Therefore, the test results are representative of an average concentration for the duration of the sampling period. In BC a valid manual stack survey consists of three individual sample runs, and the result is then reported as the average of the triplicate tests. The discharge of particulate, speciated particulate, trace metals, speciated organics and other specific parameters are typically monitored using manual stack testing techniques.

It is important to note that the results produced by this testing method are representative of the operational performance and actual emissions during the duration of the test run.

Emission criteria must consider the methods available to determine compliance and base the limit on the period over which the sample is obtained.

8.3 Commonly Accepted Emission Monitoring Methods

Periodic stack testing requires the application of approved testing methods. Sampling methods have been developed for most all contaminants that may be encountered. The approved methods specify the locations and conditions under which testing can be considered representative of the emissions. The approved methods also define the reagents to be used in the sampling equipment and define how to handle the samples. The US EPA is one of the primary approving bodies for testing methods and their approved methods are adopted in Canada and in some EU countries. The province has in general, adopted the US EPA methods for application in BC. Continuous monitoring by CEMS also has prescribed methods for locating the monitors and for completing correlation tests to validate the CEMS data against periodic stack testing methods. The methods approved for use in BC are listed in Table 8.2 below.

Similar application of approved methods occurs in the EU. There, the European Committee for Standardization (CEN) is the body responsible for approving methods. The EU-directive 2000/76/EC Annex III states that, If CEN standards are not available, then International Standards Association (ISO) standard methods would apply. Similar to the EPA methods, CEN stipulates that continuous measurement techniques must pass the CAL2 test, as described in EN14181, where the correlation between the actual concentration and continuous monitor result is verified by annual reference test.

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Section 8: Emission Monitoring Systems

Table 8-2: Approved Emission Monitoring Methods

Contaminant	BC Approved Monitoring Methods	US EPA Proposed CIWSI Monitoring Methods	European Union Approved Monitoring Methods
Arsenic	EPA 108	–	EN14385
Cadmium	–	EPA 29	EN14385
Carbon Dioxide (CO ₂)	see Gas composition and molecular weight listing	–	US EPA Method 3A
Carbon Monoxide (CO)	EC c, EPA 10, EPA 10a, EPA 10b	EPA 10	EN14789
Continuous Emission Monitoring (certification/QA/QC)	EC d, EPA PS-1 to PS-7	–	EN14181
Gas composition and molecular weight (Orsat or fyrite)	EPA 3	–	
Gas composition and molecular weight (CO ₂ , O ₂ instrumental)	EPA 3a	–	
Gas composition and molecular weight (CO ₂ , O ₂ Orsat)	EPA 3b	–	
Hexavalent Chromium	EPA ALT 014, IC 306	–	EN 14385
Hydrogen Chloride (HCl) Halides and Halogens	EPA 26, EPA 26a EPA 26a is to be used when acid particulate matter is present in the emission	EPA 26a	EN1911
Lead (Pb)	EPA 12	EPA 29	EN14385
Mercury	EPA 101a	EPA 29, EPA30b	EN 13211
Metals (Ag, As, Cd, Cu, Mn, Ni, Pb, Sn, Ti, Zn)	EPA 29	–	EN14385
Moisture Content	EPA 4	–	En 14790
Nitrogen Oxides (NO _x)	EPA 7, EPA 7a, EPA 7c, EPA 7d, EPA 7e, EPA 20	EPA7E	EN14792
Opacity	EPA 9, EPA 9 alternative 1, MWLAP a, EPA 203 EPA 9 is the observation method; EPA 9 alternative 1 is the lidar method. EPA 203 is a proposed continuous method.	EPA 9	EN 13725
Organics (Total gaseous non-methane as carbon, grab)	EPA 25	–	
Organics (Speciation of hydrocarbons, grab)	EPA 18	–	EN13526 or VDI 3481, bl3 DIS 25140 (non methane)
Organics (polychlorinated biphenyls (PCBs) and other semi volatile organic compounds)	EC a	–	

Contaminant	BC Approved Monitoring Methods	US EPA Proposed CIWSI Monitoring Methods	European Union Approved Monitoring Methods
Organics (boiling point $\geq 100^{\circ}\text{C}$, semi-volatile organics (Semi-Vost), polychlorinated dibenzo-para-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs))	EC a, EPA 23	EPA 23	ISO 11338, part 1 En1948-1, modified
Organics (boiling point $\leq 100^{\circ}\text{C}$, volatile organics (VOST))	SW 0030	–	ISO 11338 (part 1+2), modified
Oxidants (ozone)	IC 411	–	
Oxygen (O_2)	See Gas composition and molecular weight listing	–	
Particulates	EC e, EPA 5, EPA 5d, EPA 5f	EPA 5, EPA 29	EN 14789
Particulates (Sizing)	EPA 201a	–	VDI 266, bl 1 ($>50 \text{ mg/Nm}^3$) EN13284-1 ($<50 \text{ mg/Nm}^3$)
Particulates (PM_{10})	EPA 201, EPA 201a	–	
Sampling site and traverse points	EC e, EPA 1	–	
Sampling site and traverse points (Stacks/ducts 4-12" diameter)	EPA 1a	–	
Sulphur dioxide (SO_2)	EPA 6, EPA 6a, EPA 6c	EPA 6, EPA6c	
Velocity and volumetric flow rate (Stacks/ducts $>12"$ diameter)	EC e, EPA 2	–	
Velocity and volumetric flow rate (Direct measurement)	EPA 2a, EPA 2d	–	ISO 10780
Velocity and volumetric flow rate (3-D probe)	EPA CTM 019	–	ISO 10780

It should be noted that if the above table is compared to emission limit parameters for WTE, monitoring methods are not noted for chromium, chlorophenols, chlorobenzene, polycyclicaromatic hydrocarbons, polychlorinated biphenyls, and total ACDD/F TEQ (Dioxins and Furans). Therefore, consideration should be given to research appropriate US EPA, Environment Canada or European Union Methods for adoption in the BC Field Sampling Manual.

8.4 Relationship between Monitoring Methods and Emission Limits

The setting of emission criteria must consider the monitoring method used to determine compliance and the period of time over which the sample is obtained. Emission limits based on periodic monitoring are typically lower than the emission limits based on CEMS. The reasons for this difference are described below.

In simple terms, periodic stack sampling generally involves sample runs for a minimum of 60 minutes for particulates or for dioxins, furans and other select air toxics a minimum of 240 minutes. A minimum of three sample runs constitutes a valid stack survey. Therefore, it can take between three and twelve hours to complete a single stack survey (not including time to set up and take down the equipment). During the test, the constituents of concern are collected continuously over the test period and the mass of the constituents collected is measured. The data is then reduced to generate a concentration value in a unit emission rate which is representative of the average concentration of the constituent over the sampling period.

Instantaneous fluctuations in the concentration of the constituents of concern in the emissions from incineration facilities occur as a result of a variety of factors, such as waste composition, moisture content, variations in feed rates, and the duration of the fluctuation is typically minutes or at most a few hours. Fluctuations in concentration during periodic monitoring test periods are averaged out and the average reported. Compliance is often determined by averaging the results of duplicate or triplicate tests, further normalizing the concentration in the emission.

Emission limits that are based on periodic sampling methods have a lower numerical value because the instantaneous fluctuations in the emission concentration are not identified individually but are averaged across the sampling period. The emission limits therefore correspond to the concentration that would be expected and achievable over the averaging period under normal facility operating conditions, including the fluctuations.

CEMS are by design continuous, with a high sampling frequency measured in seconds or minutes. CEMS will detect the instantaneous fluctuations in concentration and produces data over a short sampling interval, without averaging the results. CEMS provides a detailed glimpse of the emission quality and its variability over time. As a result, emission limits based on CEMS must take into account the expected fluctuations in emission quality and typically apply a much shorter averaging period (e.g., ½ hour) to accommodate the fluctuations. CEMS-based emission limits are set at a higher numerical value than periodic monitoring limits to accommodate the expected emissions fluctuations. Notwithstanding the higher numerical values, CEMS-based limits are equivalent to, or more protective than, the periodic sampling-based limit as they are generally applied over shorter averaging periods and as compliance with these limits can be more regularly demonstrated.

The US EPA establishes the CEMS-based limits by considering historical monitoring data from both periodic monitoring and CEMS and in the past has selected averaging periods between four hours and 24 hours based on statistical analysis of long-term CEMS data for a particular facility. Their default for setting CEMS-based limits is a 24-hour block average, calculated in accordance with EPA Method 19 of Appendix A-7 of 40 CFR Part 60.

8.5 Ambient Air Quality Monitoring

Ambient air quality monitoring stations are used to quantify concentrations of air contaminants in ambient air. The focus of ambient air monitoring is determining concentrations relative to ambient air quality objectives that have been established as being protective of human health and the environment. Ambient air quality monitoring does not measure emissions from any one source; rather it measures the combination of constituents in the atmosphere that may be present from any number of sources or locations. Point sources, fugitive emissions and even out-of-region emissions will be detected by ambient air quality monitoring. Ambient stations use a combination of continuous analyzers, typically for basic parameters and gas concentrations, and monitors that obtain a sample over an extended duration, for example total particulate and PM₁₀ and PM_{2.5}. Trends observed in air quality data are used to evaluate the effectiveness of reduction strategies for point source and non-point sources.

The Lower Fraser Valley Air Quality Monitoring Network is an excellent example of a regional ambient air quality monitoring. This network includes 27 long-term air quality monitoring stations operated by Metro Vancouver.^[190] Most of the stations collect air quality and weather data continuously. The six CACs reported continuously are: O₃, CO, SO₂, NO₂, PM₁₀, PM_{2.5}. Other pollutants that are less widely monitored include ammonia, VOCs, and Total Reduced Sulphur (TRS). Some stations collect non-continuous data for VOCs, particulate speciation and dichotomous particulates.^[191] In addition, Metro Vancouver deploys portable air quality stations and instruments to conduct special monitoring stations that focus on suspected problem areas in local communities.

Real-time ambient air quality monitoring data is also collected in the following BC communities:^[192]

- | | |
|-----------------------|--------------------------------------|
| ▪ Western Communities | ▪ Burns Lake |
| ▪ Victoria/Saanich | ▪ Terrace |
| ▪ Nanaimo/Parksville | ▪ Smithers |
| ▪ Campbell River | ▪ Fort St. John |
| ▪ Whistler | ▪ Fort Nelson |
| ▪ Williams Lake | ▪ Golden |
| ▪ Quesnel | ▪ Kamloops |
| ▪ Prince George | ▪ North, Central, and South Okanagan |

¹⁹⁰ Metro Vancouver Air Quality website: <http://www.metrovancouver.org/services/air/management/Pages/default.aspx>

¹⁹¹ Metro Vancouver. Technical Appendix Air Quality Data 2006. Accessible at: <http://www.bcairquality.com/readings/>

¹⁹² BC Air Quality Readings. Accessible at: <http://www.bcairquality.com/readings/>

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9 EMISSION LIMITS AND THEIR APPLICATION

9.1 Typical Regulatory Practices

This subsection contains an assessment of MSW-related emission limits from other jurisdictions. It indicates limits of all regulated substances plus determines which limits are dated, recent but derived from dated material, and recent. All limits have been classified as to whether they are representative of best achievable technology. Indications are made as to which technology is associated with the various limits. Most importantly, this section is intended to convey an understanding of not only the limits and appropriate control technologies that can meet these limits, but the rationale used to support setting these limits in other jurisdictions.

The key to examining the limits used in other jurisdictions for regulated substances is to understand not only the limits and appropriate control technologies that can meet these limits, but the rationale used to support setting these limits in other jurisdictions. In some cases, the limits can be risk-based with appropriate provisions for emissions to fall well within those that can cause an effect. In others, the limits are set based on MACT (i.e., BAT) to drive the use of best-practice control technologies, or are set at in-stack detection limits representing the limit of our capability to determine if a parameter is being emitted at all. Understanding the premise behind the regulatory practices, limits or standards set in other jurisdictions, will assist in the development of the supporting rationale for the updated provincial air emission criteria in BC.

Section 9 presents the regulatory approach applied in various jurisdictions which represent a range of jurisdictions in which WTE is applied. In preparation of this report, it was not intended to provide a summary of the regulatory approach applied in all jurisdictions in which WTE is applied, but instead to present information for a sampling of jurisdictions that generally fit the following requirements:

1. Jurisdictions located adjacent to BC (e.g., Alberta, Washington State, etc.) where the regulatory approach to emissions represents those that could affect connected airsheds.
2. Jurisdictions within Canada within which the Canada Wide Standards developed by the Canadian Council of the Ministers of the Environment (CCME) forms a foundation for the regulatory environment, where there have been appropriate modifications to reflect provincial specific issues, and where there has been more recent review of WTE approaches (e.g., Alberta, Ontario).
3. Other nations (e.g., USA, and various EU nations) where WTE is widely applied, where regulatory approaches have been relatively frequently updated over the past 20 years, and from which facility performance information and reasonable translations of the regulations and supporting documents are readily available.

There are a number of Asiatic nations (Japan, South Korea, China and others) where WTE has also been widely applied, and where some information is available regarding current approaches and technologies, however, sourcing facility performance data and/or reasonable translations of regulations and supporting documents that discuss the regulatory approach is very difficult. While

some research was undertaken, reliable consistent information from many other nations was not available to support this project.

9.1.1 Regulatory Environment in Canada

The Canadian Council of the Ministers of the Environment (CCME) has developed guidelines and Canada Wide Standards (CWS) that deal with the release of air emission from WTE facilities. It has also developed ambient air quality CWS for particulate matter and ozone. The following subsections discuss each.

9.1.1.1 CCME Guidelines

The Canadian Council of Ministers of the Environment (CCME) has developed federal guidelines which give a basis for acceptable levels of emissions for a number of substances of concern (total particulate matter, hydrogen chloride, carbon monoxide, sulfur dioxide, nitrogen oxides, cadmium and lead) that are released from WTE facilities. The 1989 CCME guidelines were developed because the CCME recognized the potential for significant growth in the area of MSW incineration in Canada and wanted to ensure that health and environmental concerns were addressed. Specific guidelines for each parameter are listed in Table 8-1.^[193]

Although the CCME has developed these guidelines, it has no authority to impose its guidelines on any jurisdiction in Canada. The guidelines, therefore, act more as a measure to which the provinces and territories can compare their own individual limits. Each province or territory decides on the degree to which it will incorporate the CCME suggested pollution guidelines in their own laws. Due to the CCME guidelines lack of authority, there is a large degree of variation of environmental standards across the country in terms of emissions from incineration facilities.

9.1.1.2 CCME Canada Wide Standards (CWS)

Canada-wide Standards (CWSs) are intergovernmental agreements developed under the Canadian Council of Ministers of the Environment (CCME) Canada-wide Environmental Standards Sub-Agreement, which operates under the broader CCME Canada-wide Accord on Environmental Harmonization. National ambient air quality objectives can be promulgated by Health Canada and/or by Environment Canada under the *Canadian Environmental Protection Act* (CEPA). CWSs address key environmental protection and health risk issues that require concerted action across Canada. CWSs represent co-operation toward a common goal and involve no delegation of authority by any federal, provincial or territorial Minister of Environment.

CWSs can include quantitative standards for protecting the environment and reducing risks to human health. The focus of the Canada-wide Environmental Standards Sub-Agreement is on standards that recommend concentrations of substances in the environment. The standards generally provide protection for human health and the environment, and are technologically and economically achievable.

¹⁹³ Canadian Council of Ministers of the Environment. Operating and Emissions Guidelines for MSW Incinerators Report CCME-TS/WM-TRE003, June 1989.

In addition to the 1989 CCME Guidelines, the CCME has developed Canada Wide Standards in regards to emissions of mercury and dioxins/furans from municipal waste incineration.^[194] In 2000, the CCME also developed ambient air quality CWS for particulate matter and ozone.^[195]

Mercury (Hg)

The standards for mercury emissions were endorsed in 2000 and address both existing and new facilities that incinerate waste. In their report, the CCME identified waste incineration as one of the three main sectors contributing to mercury emissions in Canada but stressed that these emissions are mainly associated with the incineration of sewage sludge and hazardous waste. The CCME set mercury emissions limits at 20 µg/Rm³.

Dioxins/Furans (PCDD/F)

The standards for dioxin and furan concentrations were endorsed in 2001. In their report, the CCME identified the incineration of municipal waste, sewage sludge, medical waste, and hazardous waste as major contributors to the emissions of dioxins and furans in Canada. The CCME set dioxin/furan emissions limits at 80 pg I-TEQ/Rm³.^[196]

The CCME also provides a number of recommendations regarding reduction of emissions of dioxins and furans from the incineration of municipal waste. Their recommendations included increasing the diversion of waste from disposal, removing materials from the waste stream that have a great potential to lead to increased emissions of dioxins and furans, combustion control strategies to optimize performance, and use of alternative disposal or management technologies.^[197]

In 2007, the CCME reviewed their CWS for dioxins/furans and determined that there is no need to update the emission limit. They reasoned that the current limit for dioxins/furans is still below limits put in place by other jurisdictions around the world such as the European Union (92 pg I-TEQ/Rm³).^[198]

Ambient Particulate Matter and Ozone

In addition to the guidelines for emission of total particulate matter from municipal solid waste incinerators set out in 1989^[199], the CCME also developed ambient air quality CWS for particulate matter (PM) and ozone in 2000.^[200] The CWS set an overall ambient target for PM_{2.5} for 2010 at 30 µg/Rm³ (24-hour averaging time based on the 98th percentile ambient measurement annually averaged over three consecutive years). The CWS does not set stack or industry sector specific targets.

¹⁹⁴ Canadian Council of Ministers of the Environment. Canada-Wide Standards for Mercury Emissions. June 2000

¹⁹⁵ Canadian Council of Ministers of the Environment Canada-Wide Standards for Particulate Matter (PM) and Ozone. 2000

¹⁹⁶ Canadian Council of Ministers of the Environment Canada-Wide Standards for Dioxins and Furans. 2001

¹⁹⁷ Canadian Council of Ministers of the Environment Canada-Wide Standards for Dioxins and Furans. 2001.

¹⁹⁸ Canadian Council of Ministers of the Environment (CCME). (2007). Review of Dioxins and Furans from Incineration In Support of a Canada-wide Standard Review

¹⁹⁹ Canadian Council of Ministers of the Environment. Operating & Emissions Guidelines for MSW Incinerators Report CCME-TS/WM-TRE003, June 1989.

²⁰⁰ Canadian Council of Ministers of the Environment Canada-Wide Standards for Particulate Matter (PM) and Ozone. 2000.

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The CWS did not provide an overall ambient target for PM₁₀ as the CCME considered the reduction in PM₁₀ to come along with a reduction in PM_{2.5}. Therefore the report does not discuss total particulate matter, or PM_{2.5}.

The CCME reviewed its CWS for particulate matter (PM) and ozone in 2005 and recommended keeping the 2000 targets.^[201]

9.1.1.3 CEAA

The federal requirements for an environmental assessment arise from the *Canadian Environmental Assessment Act* (CEAA) and its supporting regulations. CEAA requires the Government of Canada to consider the environmental effects of proposed projects before making a decision or exercising any regulatory power in relation to a project. Per section 5(1) of CEAA, the federal environmental assessment process is generally triggered if the Government of Canada:

- Is the proponent
- Provides funding, loan or other financial assistance that enables a project
- Sells or leases land to enable a project
- Issues a permit, licence, approval, or authorization that is identified in the Law List Regulations pursuant to CEAA.

If future WTE projects fall under the above triggers, a CEAA-compliant environmental impact assessment will be required.

9.1.1.4 Summary

Overall, the national guidelines set by the CCME are quite conservative in comparison to the laws and guidelines set by other countries on similar pollutants. However, because the CCME does not have the authority to enforce their standards and guidelines, it limits their ability to ensure that targets are being met. Responsibility for ensuring the environmental performance of WTE facilities rests with provincial and territorial governments.

Table 9-1 presents an overview of the CCME emissions guidelines and CWS applicable to municipal solid waste incinerators.

Table 9-1: CCME WTE Emissions Guidelines for Municipal Solid Waste Incinerators (1989)

Contaminant	Concentration Units	Canadian Council of Ministers of the Environment (CCME) Guidelines/CWS
Total Particulate Matter (TPM)	mg/Rm ³ @ 11% O ₂	20 ¹
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	260 ²
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	75 or 90% removal ¹
Nitrogen Oxides (NO _x) (as NO ₂)	mg/Rm ³ @ 11% O ₂	400 ²
Carbon Monoxide (CO)	mg/Rm ³ @ 11% O ₂	57 (114 for RDF Systems) ¹

²⁰¹ Joint Action Implementation Coordinating Committee (JAICC). (2005). An Update in Support of the Canada-wide Standards for Particulate Matter and Ozone

Contaminant	Concentration Units	Canadian Council of Ministers of the Environment (CCME) Guidelines/CWS
Cadmium (Cd)	µg/Rm ³ @ 11% O ₂	100 ²
Lead (Pb)	µg/Rm ³ @ 11% O ₂	50 ²
Mercury (Hg)	µg/Rm ³ @ 11% O ₂	20 ³
PCDD/F TEQ (Dioxins and Furans)	ng/Rm ³ @ 11% O ₂	0.08 ⁴
Opacity	%	5 ⁵

NOTES:

N. Def. = Not Defined

¹ CCME Operating and Emissions Guidelines for MSW Incinerators Report CCME-TS/WM-TRE003, June 1989. Table 4.2: Stack Discharge Limits (at 11% O₂)

² CCME Operating and Emissions Guidelines for MSW Incinerators Report CCME-TS/WM-TRE003, June 1989. Table 4.3: Anticipated Emissions from MSW Incinerators Operating Under Good

³ CCME Canada-Wide Standards for Mercury Emissions (2000)

⁴ CCME Canada-Wide Standards for Dioxins and Furans (2001)

⁵ CCME Operating and Emissions Guidelines for MSW Incinerators Report CCME-TS/WM-TRE003, June 1989. Section 4.3.2.

9.1.2 Regulatory Environment in British Columbia

This section summarizes the regulatory requirements that apply to existing and new WTE facilities in BC.

9.1.2.1 *Environmental Management Act*

The *Environmental Management Act* (EMA) is a relatively new piece of legislation in BC. It was brought into force on July 8, 2004 to replace the *Waste Management Act* and the (previous) *Environment Management Act*. It brings provisions from both *Acts* into one statute and covers a broad range of environmental management aspects including:

- Waste disposal (covering air emissions, effluent discharges and solid wastes)
- Hazardous waste management
- Municipal waste management
- Contaminated sites remediation
- Remediation of mineral exploration sites and mines.

Under sections 3(2) and 3(3), any introduction of waste into the environment requires authorization via permit or approval. Activities that necessitate a permit are prescribed through the *Waste Discharge Regulation* (WDR). In addition, emissions or discharges from industries that are not considered to pose a high risk for environmental damage have province-wide codes of practice established to govern operation.

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The WDR defines “prescribed” industries, trades, businesses, activities and operations for the purposes of regulation under EMA section 6(2) and 6(3). It also provides a process for registering under a Minister’s code of practice and a process for substituting requirements to a code of practice in order to protect the public or the environment if an applicant can prove that the intent of the code will be met.

The EMA and the WDR established a three-tiered approach for discharges to the environment by prescribed industries. Tier 1 industries, which would include the WTE sector, are considered to pose an elevated risk to the environment and public health and therefore require a permit to discharge to the environment or for the case of WTE facilities under a Solid Waste Management Plan (under Part 3 of EMA). Tier 2 industries pose a lower risk and discharges can be addressed by a Code of Practice or by a permit. Tier 3 industries are low risk and do not require a permit.

Following submission of the EMA permit application, Ministry staff review the technical assessment reports and application form information in order to draft recommendations for the Director of Waste Management. The applicant reviews the draft recommendations, at which point the Director makes a decision to either grant or deny a permit.

Should a permit be granted, the permit holder must pay an annual fee on the anniversary date of its issuance, or 30 days after the date an invoice has been issued for the amount owing. The annual permit fee is a combination of a base fee and a variable fee based on contaminants from authorized discharges identified in the permit.

Under the EMA, Part 3 (Municipal Waste Management), municipal Solid Waste Management Plans (SWMPs) are submitted for approval to the minister^[202]. Once the plan is approved by the minister, an operational certificate may be issued by the Director to the municipality or specific facility covered by the SWMP. A power or authority similar to a permit may be exercised by a director in reference to an operational certificate. SWMPs address the management of solid waste in landfills as well as WTE facilities. Once a SWMP containing specific emission limits for a WTE facility is approved by the Director, the facility would not require a permit from BCMOE.

9.1.2.2 Emission Criteria for Municipal Solid Waste Incineration

BC Ministry of Environment introduced Emission Criteria for Municipal Solid Waste Incinerators^[203] in 1991. A copy of the 1991 emissions criteria document can be found in Appendix B of this report. The respective incinerator stack emissions limits are summarized in Table 9-2 and apply to new and modified MSW incinerators with a capacity of greater than 400 kg/h (essentially equivalent to 9.6 tonnes per day) of waste. If the incinerator processing capacity is equal or less than 400 kg/h of waste, different emission limits and ambient air quality objectives apply (Table 8-3).

The criteria require continuous monitoring of combustion temperature, oxygen, CO, opacity, HCl, and emission control device inlet and outlet temperatures. Monthly source testing and annual performance reporting are also required.

²⁰² BC *Environmental Management Act*. Chapter 53. Part 3 – Municipal Waste Management. 2010.

²⁰³ BC Ministry of Environment. Emission Criteria for Municipal Solid Waste Incinerators. 1991.

The BC Emission Criteria for Municipal Solid Waste Incinerators also identify design and operation requirements for MSW and emission control systems to minimize emissions from an incinerator. Table 9-2 lists incinerator design and operation parameters applicable to all sizes of incinerators.

Information pertaining to the permitting of the Burnaby WTE Incinerator in comparison to BC Emission Criteria for Municipal Solid Waste Incinerators is provided in Section 9.1.3.2.

Table 9-2: BCMOE Emissions Criteria for MSW with a Processing Capacity Greater than 400 kg/h of Waste (1991)

Contaminant	Concentration Units	Emissions Criteria	Averaging Period	Monitoring Method
Total Particulate Matter (TPM)	mg/Rm ³ @ 11% O ₂	20	1	2
Carbon Monoxide (CO)	mg/Rm ³ @ 11% O ₂	55 ³	4-hour rolling average	Continuous monitoring
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	250	1	2
Nitrogen Oxides (NO _x as NO ₂)	mg/Rm ³ @ 11% O ₂	350	1	2
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	70	8-hour rolling average	Continuous monitoring
Hydrogen Fluoride (HF)	mg/Rm ³ @ 11% O ₂	3	1	2
Total Hydrocarbons (as CH ₄)	mg/Rm ³ @ 11% O ₂	40	1	2
Arsenic (As) ⁴	µg/Rm ³ @ 11% O ₂	4	1	2
Cadmium (Cd) ⁴	µg/Rm ³ @ 11% O ₂	100	1	2
Chromium (Cr) ⁴	µg/Rm ³ @ 11% O ₂	10	1	2
Lead (Pb) ⁴	µg/Rm ³ @ 11% O ₂	50	1	2
Mercury (Hg)	µg/Rm ³ @ 11% O ₂	200	1	2
Chlorophenols	µg/Rm ³ @ 11% O ₂	1	1	2
Chlorobenzenes	µg/Rm ³ @ 11% O ₂	1	1	2
Polycyclicaromatic Hydrocarbons	µg/Rm ³ @ 11% O ₂	5	1	2
Polychlorinated Biphenyls	µg/Rm ³ @ 11% O ₂	1	1	2
Total PCDD/F TEQ (Dioxins and Furans) ⁵	ng/Rm ³ @ 11% O ₂	0.5	1	2
Opacity	%	5	1hr avg, data every 10 sec	Continuous monitoring

NOTES:

BC Limits are based on 20°C.

¹ To be averaged over the approved sampling and monitoring method

² All sampling and monitoring methods, including continuous monitors, are to be approved by the Regional Manager.

³ For RDF systems the limit shall be 110 mg/m³

⁴ The concentration is total metal emitted as solid and vapour

⁵ Expressed as Toxicity Equivalents. The value shall be estimated from isomer specific test data and toxicity equivalency factors by following a procedure approved by the Minister

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BC has remote camps serving the resource industry. In many of these locations, domestic solid waste is incinerated in commercially available units with capacities less than 400 kg/h. Typically these are small units that operate intermittently and which have small diameter discharge stacks that may be difficult to conduct periodic or continuous source testing. For these facilities, the emission limits for particulate is less stringent than for larger facilities (180 mg/m³ for smaller facilities versus 20 mg/m³ for larger facilities) reflecting the absence of APC equipment to control particulate. The carbon monoxide limit is the same as 55 mg/m³ for large and small facilities where the fuel is MSW, but increases to 110 mg/m³ for small facilities burning RDF. This is intended to reflect less efficient combustion of RDF, which may include fuel with higher moisture content.

Under the BC Waste Discharge Regulation^[204], the emissions and ash from a commercially available auxiliary fuel fired refuse incinerator serving remote industrial, recreational, exploration or construction camp designed to accommodate fewer than 100 persons are exempt from the application of Environmental Management Act for waste disposal (Section 6(2) and 6(3)).^[205] In such instances, the emissions criteria defined in Table 8-3 are not applied.

The capacity limit of 400 kg/h (9.6 tonnes per day) has been a reasonable cut-off for the commercially available incinerators used in remote camps in BC. We noted that the US Environmental Protection Agency defines small as 250 tons per day or less and large facilities as greater than that. In Ontario, a simpler approval process applies to facilities that process less than 100 tonnes per day, however, the same air emissions criteria apply regardless of size for permanent facilities. There is some flexibility associated with temporary or research facilities. The BC Environmental Assessment Act trigger to conduct an Environmental Assessment is 250 tonnes per day. The concept of a low threshold in terms of facility size, as applied in BC and Ontario, is a reasonable one, affording a higher level of protection to the environment for all facilities that fall outside the scale for research or on-site materials management. Determining the appropriate cut-off capacity should be based on the regional context. In BC, small incinerators will in most all cases be associated with remote camps serving the resource sector, and not operating as commercial incineration facilities. It should be recognized that facilities below the capacity cut-off generally are too small for point source emission monitoring, so the limit needs to be set appropriately. While there is no direct connection between the facility size cut-off in the 1991 Criteria and the WDR exemption, the current 400 kg/h cutoff should be maintained in the BC context in the revised MSWI Criteria.

²⁰⁴ BC *Environmental Management Act*. Waste Discharge Regulation. 2008. Website:
http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/50_320_2004#section6

²⁰⁵ BC *Environmental Management Act*. May 5, 2010. Website:
http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/03053_02

Table 9-3: BCMOE Emissions Criteria for MSW with a Processing Capacity Equal to or Less than 400 kg/h of Waste (1991)

Contaminant	Concentration Units	Emissions Criteria	Averaging Period	Monitoring Method
Total Particulate Matter (TPM)	mg/Rm ³ @ 11% O ₂	180	1	2
Carbon Monoxide (CO)	mg/Rm ³ @ 11% O ₂	55 ³	4-hour rolling avg	Continuous
Carbon Monoxide (if burning RDF)	mg/Rm ³ @ 11% O ₂	110	4-hour rolling avg	Continuous
Sulphur Dioxide (SO ₂)	µg/Rm ³ @ 11% O ₂	450	1	2
Nitrogen Oxides (NO _x as NO ₂)	µg/Rm ³ @ 11% O ₂	400	1	2
Hydrogen Chloride (HCl)	µg/Rm ³ @ 11% O ₂	100	8-hour rolling avg	Continuous
Hydrogen Fluoride (HF)	mg/Rm ³ @ 11% O ₂	3	1	2
Opacity	%	10		

NOTES:

BC Limits are based on 20°C.

¹ To be averaged over the approved sampling and monitoring method

² All samples and monitoring methods, including continuous monitors, are to be approved by the Regional Manager

³ For RDF systems the limit shall be 110 mg/m³

Table 9-4: BCMOE Design and Operation Requirements for MSW and Emission Control Systems

Parameter	Incinerator Type Modular (Excess Air and Starved Air)	Incinerator Type	
		Mass Burn	RDF
Incinerator			
Minimum Incineration Temperature	1,000°C at fully mixed height	1,000°C determined by an overall design review	1,000°C
Minimum Residence Time	One second after final secondary air injection ports	1 second calculated from the point where most of the combustion has been completed and the incineration temperature fully developed	1 second calculated from point where most of the combustion has been completed and the incineration temperature fully developed
Primary Air (Underfire)	Utilize multi-port injection to minimize waste distribution difficulties	Use multiple plenums with individual air flow control	Use air distribution matched to waste distribution
Secondary Air (Overfire)	Up to 80% of total air required ¹	At least 40% of total air required	At least 40% of total air required
Overfire Air Injector Design	That required for penetration and coverage of furnace cross-section	That required for penetration and coverage of furnace cross-section	That required for penetration and coverage of furnace cross-section

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Parameter	Incinerator Type Modular (Excess Air and Starved Air)	Incinerator Type	
		Mass Burn	RDF
Auxiliary Burner Capacity	Secondary burner 60% of total rated heat capacity, and that required to meet start-up and part-load temperatures	60% of total output, and that required to meet start-up and part-load temperatures	60% of total output, and that required to meet start-up and part-load temperatures
Oxygen Level at the Incinerator Outlet	6 to 12%	6 to 12%	3 to 9%
Turndown Restrictions	80 to 110% of designed capacity	80 to 110% of designed capacity	80 to 110% of designed capacity
Maximum CO Level	55 mg/m ³ @ 11% O ₂ (4-h rolling average)	55 mg/m ³ @ 11% O ₂ (4-h rolling average)	110 mg/m ³ @ 11% O ₂ (4-h rolling average)
Emission Control Systems²			
Flue Gas Temperature at Inlet or Outlet of Emission Control Device ³	Not to exceed 140°C	Not to exceed 140°C	Not to exceed 140°C
Opacity ⁴	Less than 5%	Less than 5%	Less than 5%

NOTES:

¹ For excess Air type – as required by design.

² Applicable to incinerators equipped with such systems

³ The flue gas temperature at the inlet or outlet will depend on the type of emission control device in use

⁴ For incinerators with capacity or processing 400 kg/h or less of waste the opacity shall be less than 10%

9.1.2.3 BC Ambient Air Quality Objectives

The BC Ambient Air Quality Objectives (BC AAQO) have been derived from a variety of agencies on a provincial and national basis. It is the intention that the BC AAQO are at least consistent with, and potentially more stringent than, air quality objectives adopted on a national basis. As described above, national air quality objectives can be promulgated by either Health Canada or Environment Canada. It should be noted that the AAQO are non-statutory limits that are intended to be used as benchmarks to assess air quality and to guide decision making with respect to the management of air quality within an airshed.

The BC Ministry of Environment (2006), the federal government and Metro Vancouver established ambient air quality criteria for a number of air contaminants. The BC AAQO for particulate matter PM_{2.5} were adopted by the Ministry of Healthy Living and Sport (BC MHLS, 2009).^[206] These objectives are summarized in Table 8-5.

²⁰⁶ BC Ministry of Healthy Living and Sport. Air Quality Objectives for British Columbia and Canada. April, 2009
<http://www.env.gov.bc.ca/epd/bcairquality/regulatory/pm25-objective.html>

Historically, national air quality objectives^[207] have been defined as follows:

- The **Maximum Desirable Level** is the long-term goal for air quality and provides a basis for anti-degradation policy for unpolluted parts of the country, and for the continuing development of control technology.
- The **Maximum Acceptable Level** provides adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being.
- The **Maximum Tolerable Level** denotes time based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate action is required to protect the health of the general population.

The BC AAQO are denoted as Levels A, B, and C and generally defined as follows:

- **Level A** is set as the objective for new and proposed discharges and, within the limits of best practicable technology, to existing discharges by planned staged improvements for these operations.
- **Level B** is set as the intermediate objective for all existing discharges to meet within a period of time specified by the Director, and as an immediate objective for existing discharges which may be increasing in quantity or altered in quality as a result of process expansion or modification.
- **Level C** is set as the immediate objective for all existing chemical and petroleum industries to reach within a minimum technically feasible period of time.

Metro Vancouver adopted its own Ambient Air Quality Objectives as part of the Air Quality Management Plan (AQMP) in October, 2005. AAQO were set for carbon monoxide, nitrogen dioxide, sulphur dioxide, ozone, inhalable particulate matter (PM₁₀), and fine particulate matter (PM_{2.5}).^[208] In 2008, Metro Vancouver's objectives were equivalent or more stringent than both the CWS and BC objectives for these CACs.^[209] A provincial 24-hour AAQO for PM_{2.5} was established in 2009 and is numerically the same as Metro Vancouver's objective. However, whereas exceedance is prohibited under the Metro Vancouver objective, some exceedances are permissible under the BC objective each year. Metro Vancouver's annual objective is less stringent than the provincial annual target of 8 µg/m³ and an annual planned goal of 6 µg/m³.

²⁰⁷ Health Canada. National Ambient Air Quality Objectives. <http://www.hc-sc.gc.ca/ewh-semt/pubs/air/naago-onqaa/index-eng.php>

²⁰⁸ Greater Vancouver Regional District (GVRD). Air Quality Management Plan. September 2005
<http://www.metrovancouver.org/about/publications/Publications/AQMPSeptember2005.pdf>

²⁰⁹ Metro Vancouver. 2008 Lower Fraser Valley Air Quality Report. June, 2009
<http://www.metrovancouver.org/about/publications/Publications/LowerFraserValleyAmbientAirQuality-2008.pdf>

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Table 9-5: British Columbia, National and Metro Vancouver Ambient Air Quality Objectives

Contaminant	Averaging Period	BC Objectives ($\mu\text{g}/\text{m}^3$)			Canada Objectives ($\mu\text{g}/\text{m}^3$)			Metro Vancouver Objectives ($\mu\text{g}/\text{m}^3$)
		Level A	Level B	Level C	Maximum Desirable	Maximum Acceptable	Maximum Tolerable	Objective Level
Sulphur Dioxide (SO_2)	1-hour	450	900	900 – 1,300	450	900	NA	450
	3-hour	375	665	NA	NA			NA
	24-hour	160	260	360	150	300	800	125
	Annual	25	50	80	30	60	NA	30
Total Reduced Sulphur (TRS)	1-hour	7	28	NA	NA			7 ⁴
	24-hour	3	6	NA	NA			NA
Hydrogen Sulphide (H_2S)	1-hour	7.5 – 14	28 – 45	42 – 45	1	15	NA	NA
	24-hour	4	6 – 7.5	7.5 – 8	NA	5	NA	NA
Nitrogen Dioxide (NO_2)	1-hour	NA	NA	NA	NA	400	1,000	200
	24-hour	NA	NA	NA	NA	200	300	NA
	Annual	NA	NA	NA	60	100	NA	40
Carbon Monoxide (CO)	1-hour	14,300	28,000	35,000	15,000	35,000	NA	30,000
	8-hour	5,500	11,000	14,300	6,000	15,000	20,000	10,000
Ozone (O_3)	1-hour	NA			100	160	300	NA
	8-hour	NA			65 ppb ³			126
	24-hour	NA			30	50	NA	NA
	Annual	NA			NA	30	NA	NA
PM _{2.5}	24-hour	25 ¹			30 ²			25
	Annual	8			NA			12
PM ₁₀	24-hour	50			NA			50
	Annual	NA			NA			20

Contaminant	Averaging Period	BC Objectives ($\mu\text{g}/\text{m}^3$)			Canada Objectives ($\mu\text{g}/\text{m}^3$)			Metro Vancouver Objectives ($\mu\text{g}/\text{m}^3$)
		Level A	Level B	Level C	Maximum Desirable	Maximum Acceptable	Maximum Tolerable	Objective Level
Total Suspended Particulates (TSP)	24-hour	150	200	260	NA	120	400	NA
	Annual	60	70	75	60	70	NA	NA
Lead (Pb)	24-hour	4	4	6	NA			NA
	Annual	2	2	3	NA			NA
Formaldehyde (CH_2O)	1-hour	Action Level = 60			NA			NA
	24-hour	Action Level = 370			NA			NA

NOTES:

Sources: BC MHLS (2009, Internet Site), Health Canada (2007), Metro Vancouver (2008 Lower Fraser Valley Ambient Air Quality, 2006 Technical Appendix Air Quality Data, 2005 Air Quality Management Plan for Greater Vancouver).

NA = Not applicable

¹ Based on 98th percentile value for one year.

² The Canada-wide Standard is referenced to the 98th percentile value averaged over three consecutive years.

³ 8-hour daily maximum is based on fourth highest annual value, average over three consecutive years.

⁴ Metro Vancouver TRS desirable, acceptable and tolerable levels are 7, 14 and 1414 $\mu\text{g}/\text{m}^3$, respectively.

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9.1.2.4 BCMOE Best Achievable Technology Policy

In May 2008, the BC Ministry of Environment adopted an interim policy for “Determining Best Achievable Technology Standards”.^[210] The policy is intended to provide guidance to MOE staff when setting waste discharge standards, provincial targets, regulations and codes of practice, by using the best achievable technologies (BAT) appropriate for the sector. BAT is also to be used by staff in the setting of facility-specific permit or approval limits. The interim BAT policy is meant to encourage the scoping of all technology shown to be economically feasible through successful commercial application in a similar facility in the same industry. New and innovative technologies must also be examined. Generally, BAT will be applied to new facilities, facilities undergoing major modifications that will result in amendments to their permits and/or facilities located in sensitive environments.

The interim policy identifies seven steps to the determination of BAT to be used in the setting of standards and criteria for the province and for facilities. These steps include:

1. Identification of all potential technologies or options
2. Eliminating technically infeasible options
3. Consideration of the reliability of each option
4. Ranking of technically feasible options by control effectiveness
5. Evaluating the cost effectiveness of each option
6. Selection of the appropriate BAT for the specific application
7. Determine the appropriate waste discharge criteria or standard.

The interim BAT policy does not specify the appropriate technology for any given application, rather the approach is to determine what discharge quality is technically and economically possible and allow proponents to select equipment and processes that meet those criteria.

9.1.2.5 *British Columbia Environmental Assessment Act*

The British Columbia *Environmental Assessment Act* (BCEAA) governs the preliminary environmental approval process for large capital projects in BC and includes consideration of new projects, modifications to existing facilities, and dismantling and abandonment of facilities. BCEAA is administered by the British Columbia Environmental Assessment Office (BCEAO) and is intended to ensure that projects subject to the legislation meet the Province of British Columbia’s goals of environmental, economic, and social sustainability. BCEAA also provides a process to address issues and concerns raised by the public, First Nations, interested stakeholders and government agencies.

Future WTE facilities may require approval under the BCEAA if they meet the criteria set out in the Reviewable Projects Regulation^[211] under Part 4 (Energy Projects) and Part 6 (Waste Disposal Projects) of the regulation. BCEAA Reviewable Projects Regulations applicable to WTE projects are

²¹⁰ BCMOE Interim Policy: Determining Best Achievable Technology Standards, May 2008

²¹¹ *British Columbia Environmental Assessment Act*: Reviewable Projects Regulation. BC. Reg. 370/2002. Amended January 14, 2010

summarized in Table 9-6. The BC Environmental Assessment Office (EAO) has indicated that future WTE facilities will require BCEAA approval if they trigger one or both of the criteria defined under Part 4 and 6 of the Reviewable Projects Regulation.^[212]

Table 9-6: BCEAA Reviewable Projects Regulation Applicable to WTE Projects

Project Category	New Project	Modification of Existing Project
Part 4 – Power Plant	Criteria: (1) A new facility with a rated nameplate capacity of ≥ 50 MW of electricity that is (a) a hydroelectric power plant (b) a thermal electric power plant, or (c) another power plant	Criteria: (1) Modification of an existing facility that results in the facility having a rated nameplate capacity that has increased by ≥ 50 MW of electricity
Part 6 – Local Government Solid Waste Management	Criteria: (1) A new facility if (a) The board of a regional district has determined that the facility will be included in a solid waste management plan or a solid waste management plan amendment to be submitted to the minister responsible for the administration of the <i>Environmental Management Act</i> for approval as part of the Regional Solid Waste Management Planning Process, and (b) The facility is for the treatment or disposal of municipal solid waste by the operation of: (i) a landfill with a design capacity of $> 250\,000$ tonnes/year, or (ii) an incinerator with a design capacity of > 225 tonnes/day.	Criteria: (1) Modification of an existing facility if the board of a regional district has determined that the modification will be included in a solid waste management plan or a solid waste management plan amendment to be submitted to the minister responsible for the administration of the <i>Environmental Management Act</i> for approval as part of the Regional Solid Waste Management Planning Process, and the criteria in either (a) or (b) are met: (a) The modification of the existing facility if (i) the existing facility, were it a new facility, would meet the criteria described opposite in Column 2, section (1) (b) (i), (ii) the modification results in (A) an extension in the lifespan of the facility beyond that lifespan currently authorized in an approved solid waste management plan, or (B) an increase in the annual design capacity of the facility beyond that currently authorized in an approved solid waste management plan; (b) Does not meet the criteria described in Column 2, subsection (1) (b) (i) or (ii) for a new facility, but the modification results in an increase in the design capacity of the facility above the threshold under Column 2, subsection (1) (b) (i) or (ii).

²¹² Per. Comm. Chris Hamilton, EAO, and Ward Prystay, Stantec. February 26, 2010

9.1.3 Regulatory Environment in Metro Vancouver

9.1.3.1 Greater Vancouver Regional District Air Quality Management Bylaw No. 1082, 2008

The Greater Vancouver Regional District (GVRD, recently renamed to Metro Vancouver) has been authorized by the *Environmental Management Act* to regulate, control and prevent discharge of air contaminants. The Greater Vancouver Regional District Air Quality Management Bylaw No. 1082^[213] regulates the discharge of air contaminants within Metro Vancouver. The bylaw dictates air emissions from industries, trades, businesses, activities, operations or residences are required to obtain approval from the District Director whether or not they are permitted under the *Environmental Management Act*. Waste management facilities must fulfill the requirements defined by the District Director in order to obtain authorization to discharge air contaminants from the Provincial Government.

The Burnaby Incinerator operates under the Metro Vancouver Solid Waste Management Plan, and as such the above MV bylaw does not apply to the Burnaby Incinerator.

9.1.3.2 Metro Vancouver Solid Waste Management Plan

Specific objectives on reducing per capita garbage disposal in the Greater Regional Vancouver District (now Metro Vancouver) were set by the province of BC in 1995. The objectives were published in the 1995 Greater Waste Regional Solid Waste Management Plan^[214] report, stating per capita garbage disposal will be reduced by at least 30% in 1995 and 50% in 2000, while responsibly managing any residues. As part of the objectives, Appendix D of the report summarized long-term monitoring requirements and discharge limits for the Burnaby Incinerator disposal facility.

The Metro Vancouver Burnaby incinerator burns approximately 280,000 tonnes of garbage to produce 900,000 tonnes of steam which is used to generate electricity. The plant has three processing lines, each processing approximately 11.5 tonnes of garbage each hour. Generated heat and gases are passed into the boiler area, where they heat tubes filled with water. Gases subsequently pass into the flue gas cleaning system which consists of the lime and carbon injection reactor and fabric bags. The lime and carbon injection reactor captures acid gases and any traces of mercury. Fabric bags are used to remove acids and particulate matter before the cleaned gas is discharged through the 60 m high stack.

Table 9-7 compares the air discharge limits against actual Burnaby incinerator air emissions.^[215] The table also summarizes the long-term monitoring requirements as well as the monitoring techniques used at the facility.^[216, 217]

²¹³ Greater Vancouver Regional District Air Quality Management Bylaw No. 1082, 2008.
http://www.metrovancouver.org/boards/bylaws/Bylaws/RD_Bylaw_1082.pdf

²¹⁴ Greater Vancouver Regional Solid Waste Management Plan. July, 1995.

²¹⁵ AECOM. Management of Municipal Solid Waste in Metro Vancouver – A comparative Analysis of Options for Management of Waste After Recycling. June, 2009.

²¹⁶ Air-Tec Consulting Ltd. Metro Vancouver Waste-to-Energy Facility Compliance Testing Report. February 2010 Emission Survey. Feb. 2010.

²¹⁷ Air-Tec Consulting Ltd. GVRD Waste-to-Energy Facility Semi-Volatile Organics Testing Report. 2009 Emission Survey. Unit 3 Stack. November 7, 2009.

Table 9-7: Burnaby Incinerator ELVs and Actual Emissions (2007)

Contaminant	Concentration Units	Burnaby WTE ELV	Burnaby WTE (Actual Emissions) ⁽¹⁾	Averaging Period	Monitoring Technique
Total Particulate Matter (TPM)	mg/Rm ³	20	3.8	Manual stack testing	Primary: EPS 1/RM/8 Method E Supporting: EPA Method 5 ²
Sulphur Dioxide (SO ₂)	mg/Rm ³	200	85	24-hour average and Manual stack testing	Primary: CEMS EPS 1/PG/7 Supporting: EPA Method 6
Hydrogen Chloride (HCl)	mg/Rm ³	55	23.6	Manual stack testing	Primary: EPS 1/RM/1 Supporting: EPA Method 26, BC Method 7176106 and 7066101 ²
Hydrogen Fluoride (HF)	mg/Rm ³	3	0.1	Manual stack testing	Primary: EPS 1/RM/1 Supporting: EPA Method 26, BC Method 7176106 and 7066101 ²
Nitrogen Oxides (NO _x) (as NO ₂)	mg/Rm ³	350	265	24-hour average	CEMS: EPS 1/PG/7
Carbon Monoxide (CO)	mg/Rm ³	55	23	4-hour rolling average	CEMS: EPS 1/PG/7
Cadmium (Cd)	µg/Rm ³	100	0.6	Manual stack testing	Primary: EPA Method 29 ²
Lead (Pb)	µg/Rm ³	50	5.9		
Mercury (Hg)	µg/Rm ³	200	2		
Cd + Hg + Tl	µg/Rm ³	200	2		
Sum (As, Co, Ni, Se, Te)	µg/Rm ³	1000	8		
Sum (Sb, Pb, Cr, Cu, Mn, V, Zn)	µg/Rm ³	5000	69		
Total Hydrocarbons (as CH ₄)	mg/m ³	40	4.3	Manual stack testing	Primary: EPA Method 18 ²
PCDD/F TEQ (Dioxins and Furans)	ng/Rm ³	0.5	0.002	Manual stack testing	Primary: EPS 1/RM/2, 1/RM/3, 1/RM/23 Supporting: EPA Method 23 ³
PAH	µg/Rm ³	5	0.13	N/A	Primary: EPS 1/RM/2, 1/RM/3, 1/RM/23 Supporting: EPA Method 23 ³
Opacity	%	5	0.5	1-hour	EPS 1/PG/7

NOTES:

All contaminant concentrations are stated at standard conditions of 293 K, 101.3 kPa, corrected to 11% O₂ and dry basis unless otherwise noted.

¹ Actual Emissions for the Burnaby incinerator were extracted from the AECOM (June, 2009) report.

² Air-Tec Consulting Ltd. Metro Vancouver Waste-to-Energy Facility Compliance Testing Report. February 2010 Emission Survey. Feb. 2010.

³ Air-Tec Consulting Ltd. GVRD Waste-to-Energy Facility Semi-Volatile Organics Testing Report. 2009 Emission Survey. Unit 3 Stack. November 7, 2009.

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In general, the Burnaby incinerator permit requirements are in agreement with the provincial 1991 emissions criteria for MSW combustion (Table 8-2). The exceptions include permit limits SO₂ and HCl contaminants which are more stringent than the provincial criteria. Also, under the Burnaby permit the long-term monitoring requirements for HF call for manual stack testing, whereas provincial criteria require continuous monitoring and 8-hr rolling averaging.

Since the 1995 objectives have been met, Metro Vancouver has been working on revising the 1995 provincially mandated plan. The draft Integrated Solid Waste and Resource Management (ISWRM) report^[218] was released in November, 2009. The new target of the ISWRMP increases the regional diversion rate from an average of 55% to 70% by 2015. The plan also identifies aggressive waste reduction strategies to recover materials and energy from remaining waste through four goals:

Goal 1: Minimize waste generated

Goal 2: Maximize reuse, recycling and material recovery

Goal 3: Recover energy from the waste stream after material recycling

Goal 4: Dispose of all remaining waste in landfill, after material recycling and energy recovery.

The strategies identified to achieve the ISWRMP target under Goal 3 include:

- Use of WTE to provide electricity and district heating
- Recover energy from other solid waste management facilities
- Utilize non-recyclable material as fuel.

This includes the ongoing use of the Burnaby Incinerator as one of the approved disposal facilities, expansion of WTE utilization in the region (up to 500,000 tonnes per year of new WTE capacity), and development of new WTE capacity through new projects designed to maximize the environmental, financial, and social benefits.

9.1.3.3 Proposed Gold River Power (formerly Green Island) WTE Facility

The Gold River Power facility proposed by Covanta, will be capable of converting approximately 750,000 tonnes of post-recycled municipal solid waste per year to clean energy. This thermal power plant is proposed to be located at the former pulp mill site in Gold River, BC.

The proposed facility has an existing permit PA-17426, issued May 13, 2004 (last amended November 25, 2005), which authorizes the discharge of air emissions from a wood-fueled power boiler (Phase I Boiler) and a refuse derived fueled (RDF) modified recovery boiler (Phase II Boiler). Table 9-8 presents the ELVs identified in the existing permit for this facility.

²¹⁸ Integrated Solid Waste and Resource Management: A Draft Solid Waste Management Plan for the Greater Vancouver Regional District and Member Municipalities. November, 2009.

However, design of the facility (as well as ownership) has shifted to a design involving two new state-of-the-art boilers (No.1 and No. 2), each with independent Air Pollution Control (APC) equipment, and an application has been recently submitted to amend the existing air permit accordingly.

Combustion controls are proposed to maintain low levels of carbon monoxide and minimize products of incomplete combustion. Covanta's proprietary Very Low NO_x VLN™ system (patent pending) and a Selective Non-Catalytic Reduction (SNCR) system are proposed to achieve NO_x emissions levels that meet Provincial NO_x control criteria. The proposed APC approach would also include a scrubber, baghouse, carbon injection system and a continuous emission monitoring system. Lime injection and temperature control at the scrubber will control acid gases and carbon injection before the scrubber is intended to provide mercury and dioxin control.

The following table compares the authorized emissions from Phase I and Phase II Boilers under the existing permit with the proposed authorized emissions from the new high-efficiency boilers.

Table 9-8: Proposed Green Island Energy Emission Limit Values

Parameter	EXISTING Phase I Boiler (wood fueled)	EXISTING Phase II Boiler (RDF fueled)	PROPOSED Boilers Nos. 1 and 2
Max. Authorized Rate of Discharge	147 m ³ /s	220 m ³ /s	220 m ³ /s
Authorized Discharge Period	Continuous	Continuous	Continuous
Total Particulate Matter (1)	15 mg/m ³	15 mg/m ³	9.0 mg/m ³
Particulate matter less than 10 µm in diameter (PM ₁₀) (2)	No limit stipulated	No limit stipulated	23.0 mg/m ³
Particulate Matter less than 2.5 µm in diameter (PM _{2.5}) (2)	No limit stipulated	No limit stipulated	22.0 mg/m ³
Opacity	5%	5%	5%
Flue gas temperature (3)	No limit stipulated	190C	190C
Carbon Monoxide (CO)	No limit stipulated	110.0 mg/m ³ (4)	83.0 mg/m ³
Hydrogen Chloride (HCl)	No limit stipulated	70.0 mg/m ³	27.5 mg/m ³ (1hr) 23.8 mg/m ³ (24hr)
Hydrogen Fluoride (HF)	No limit stipulated	3.0 mg/m ³	1.8 mg/m ³ (1hr) 0.9 mg/m ³ (24hr)
Sulphur Dioxide (SO ₂)	No limit stipulated	200.0 mg/m ³ (5)	50.0 mg/m ³
Nitrogen Oxides (NO _x)	No limit stipulated	No limit stipulated	150.0 mg/m ³ (1hr) 123.0 mg/m ³ (24hr)
Total Hydrocarbons as CH ₄	No limit stipulated	40.0 mg/m ³	4.8 mg/m ³
Dioxins and Furans (I-TEQ)	No limit stipulated	8.0E-08 mg/m ³	8.14E-08 mg/m ³ (6)
Total Mercury (Hg)	No limit stipulated	0.02 mg/m ³	0.02 mg/m ³
Class I metals (Total of Cd, Hg, Tl)	No limit stipulated	0.2 mg/m ³	Note 7
Class II metals (Total of As, Co, Ni, Se, Te)	No limit stipulated	1.0 mg/m ³	Note 7

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Parameter	EXISTING Phase I Boiler (wood fueled)	EXISTING Phase II Boiler (RDF fueled)	PROPOSED Boilers Nos. 1 and 2
Class III metals (Total of Sb, Pb, Cr, Cu, Mn, V, Zn)	No limit stipulated	5.0 mg/m ³	Note 7
Polychlorinated biphenyls (PCBs)	No limit stipulated	No limit stipulated	0.0005 mg/m ³ ⁽⁸⁾
Chlorophenols	No limit stipulated	No limit stipulated	0.0005 mg/m ³ ⁽⁹⁾
Chlorobenzene	No limit stipulated	No limit stipulated	0.0005 mg/m ³ ⁽¹⁰⁾
Lead (Pb)	No limit stipulated	(7)	0.05 mg/m ³
Arsenic (As)	No limit stipulated	(7)	0.004 mg/m ³
Cadmium (Cd)	No limit stipulated	(7)	0.0072 mg/m ³
Chromium (Cr)	No limit stipulated	(7)	0.001 mg/m ³
Poly Aromatic Hydrocarbons (PAH)	No limit stipulated	0.005 mg/m ³	0.0025 mg/m ³ ⁽¹¹⁾

NOTES:

Concentrations are at the following standard conditions: dry gas, 293.15K, 101KPa, 11%O₂

¹ Total particulate matter concentrations referred to in PA-17426 constitute filterable particulate matter as determined by EPA Method 5.

² Includes filterable and condensable particulate matter as determined by US EPA test methods 5 and 202, excluding chlorides and ammonium.

³ Measured after baghouse.

⁴ 4-hour rolling average.

⁵ 24-hour rolling average.

⁶ CCME Standard (corrected to 20°C) is 8.14E-08 mg/m³.

⁷ Concentrations of groups of metals in existing PA-17426 (Class I, II and III) are proposed to be replaced by specific metal concentrations (Hg, Cd, As, Pb, and Cr).

⁸ Includes total of mono, di, tri, tetra penta, hexa, hepta, octa, nona, and deca chlorinated bi-phenols.

⁹ Includes di, tri, tetra, and penta chlorophenol.

¹⁰ Includes di, tri, tetra, penta and hexa chlorobenzene.

¹¹ Includes emissions for acenaphthylene, acenaphthene, fluorine, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(e)pyrene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, perylene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, benzo(g,h,i)perylene, and benzo(l)phenanthrene. Excludes naphthalene.

9.1.4 Regulatory Environment in Alberta

There are currently no regulatory requirements specific to WTE facilities in Alberta. At present, release of air contaminants is managed on a case-by-case basis through conditions outlined in permits authorized by Alberta Environment (AENV).^[219] The Enerkem Waste to Ethanol plant in Edmonton was approved on April 21, 2009, under the *Environmental Protection and Enhancement Act*.^[220] As part of its terms and conditions, the permit authorizes air emissions under the following conditions.

²¹⁹ Pers. Comm. Amit Banerjee, Designated Director under the *Environmental Protection and Enhancement Act* (AEnv) and Magda Kingsley, Stantec, February 29, 2010

²²⁰ Alberta Environment. *Environmental Protection and Enhancement Act* R.S.A. 200, c.E-12, as amended. Approval No 249118-00-00. April 21, 2009

- Air monitoring must comply with applicable AENV requirements outlined under:
 - The *Alberta Stack Sampling Code*, Alberta Environment, 1995, as amended
 - The *Methods Manual for Chemical Analysis of Atmospheric Pollutants*, Alberta Environment, 1993, as amended
 - The *Air Monitoring Directive*, Alberta Environment, 1989, as amended.
- Air emissions requirements must comply with the CCME *National Emission Guideline for Commercial/Industrial Boilers and Heaters*^[221] during the construction phase
- Air emissions during the operation phase shall not exceed the limits listed in Table 8-9. It is noteworthy that the emission limits in the permit are in units of kg/hr but with no linkage to emission volume, so a concentration limit is not established directly or indirectly.
- Ongoing monitoring and reporting is required as outlined in the Approval.

Table 9-9: Air Emissions Limits for the Enerkem Facility

Emission Source	Substance	Emissions Limit
Waste Heat Recovery Unit Stack	NO _x (expressed in NO ₂)	10 kg/hr
	SO ₂	1.3 kg/hr
Boiler Stack	NO _x (expressed in NO ₂)	0.9 kg/hr
All baghouse and dust collection systems	PM	0.20 g/kg

In practice, the kg/hr limits are the flow rate of the operation multiplied by the concentration of the contaminants. It is not possible to convert kg/hr emission limits into concentration numbers for comparison elsewhere in this report since the flow rate is not specified in the information Stantec was able to obtain.

9.1.5 Regulatory Environment in Ontario

Currently, the Ontario Ministry of the Environment applies two separate regulatory requirements to address air emissions from thermal treatment facilities: Ontario MOE Guideline A-7 *Air Pollution Control, Design and Operation Guidelines for Municipal Waste Thermal Treatment Facilities* and Ontario Regulation 419/05 with Point of Impingement (POI) guidelines and Ambient Air Quality Criteria (AAQC).

Ontario Guideline A-7 specifies a maximum allowable concentration of the critical contaminants in the exhaust flue gases from municipal waste thermal treatment facilities and is based on the “Maximum Achievable Control Technology (MACT)” principle, which is similar to the approach taken by a number

²²¹ Canadian Council of Ministers of the Environment. National Emission Guideline for Commercial/Industrial Boilers and Heaters. Initiative N306. N 1286. March, 1998

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of other jurisdictions. The MACT standards are based on emission levels already achieved by best-performing similar facilities.^[222]

Ontario Regulation 419/05 POI limits and AAQC are used to assess the potential for causing an adverse effect and general air quality at the WTE facility property line and beyond. These air standards were developed as a result of the well defined scientific evaluation of the likelihood of adverse health effects due to exposure of a human or ecosystem to a physical or a chemical agent. The POI standards are used by the MOE regularly to determine regulatory compliance of a facility and its emission sources for Certificate of Approval (Air) purposes.^[223]

The following subsections describe both Guideline A-7 and Regulation 419/05 in more depth.

9.1.5.1 Ontario Guideline A-7

Ontario MOE Guideline A-7 sets out minimum recommendations for pollution control systems and maximum allowable “in-stack” contaminant emission levels from municipal waste thermal treatment facilities in Ontario. In addition, the Guideline also sets out recommendations for acceptable design and operating parameters. The Guideline applies to all thermal treatment facilities processing municipal waste including manufacturing facilities, if they use MSW as an alternative fuel.

Guideline A-7 is applied through conditions on Certificates of Approval in accordance with the requirements of the *Environmental Protection Act*, Part V, Section 27, and Part II, Section 9. The EPA requires that a proponent of a municipal waste incinerator apply to the Ministry of Environment for approval to install and operate an incinerator. If the application is approved, the Ministry will issue a certificate of approval for the incinerator which will incorporate emission limits, and monitoring and operating requirements, based on the limits and criteria set out in Guideline A-7. The certificate may also incorporate other requirements specific to the location and the nature of the application for approval.

Emissions criteria specified in Guideline A-7 are relatively stringent. The emission limits for mercury and dioxin/furans are identical to the limits set by the Canadian Council of Ministers of the Environment (CCME) – Canada-Wide Standards for Mercury Emissions and Canada-wide Standard for Dioxins and Furans Emissions for MSW incinerators. The emissions limits are generally comparable (some lower and some higher, but within the same order of magnitude) with the current regulations governing such facilities in both the United States and Europe. Emission limits specified in Guideline A-7 are reviewed and updated by the Ministry to reflect technology improvements and new health and environmental information.

Guideline A-7 was most recently updated in October 2010 (after last being updated in 2004). The updates made to the Guideline include a reduction in the emission limits for particulate matter, cadmium, lead, nitrogen oxides, organic matter and also new emission limits for carbon monoxide and opacity from 2004 levels. The reduced emission limits were introduced to reflect requirements in

²²² Ontario Ministry of the Environment. Guideline A-7: Air Pollution Control, Design and Operation Guidelines for Municipal Waste Thermal Treatment Facilities. October 2010.

²²³ Ontario Ministry of the Environment. SUMMARY of O. REG. 419/05 Standards and Point of Impingement Guidelines and Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. December 2005

other jurisdictions as well as the capacity of current technologies. When draft revisions to the 2004 version of Guideline A-7 were first released in 2009, the Ministry proposed to also reduce the emission limit for dioxins and furans from 80 pg/Rm³ to 32 pg/Rm³. However, after considerable consultation the Ministry decided to keep the 2004 ELV for the following reasons:

- It is already the most stringent in the world;
- It is the same as the Canada Wide Standard Value;
- The CCME reviewed this limit in 2007 and found no reason to revise it; and finally,
- Releases to the environment at the level below 80 pg/Rm³ cannot be accurately measured.

In addition to new emission limits, the new 2010 Guideline also includes special considerations for experimental units, small units in remote locations in northern Ontario, and provides additional guidance on continuous or long-term monitoring requirements as well as handling of data obtained from these systems.

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Table 9-10: Emissions Requirements, Ontario Guideline A-7 (2004 and 2010)

Contaminant	Concentration Units	Ontario MOE A-7 OLD (February 2004)	Ontario MOE A-7 CURRENT (October 2010)	Comments
Particulate Matter (PM)	mg/Rm ³ @ 11% O ₂	17	14	Calculated as the arithmetic average of three stack tests conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system (2004). Results from compliance source testing or calculated as the rolling arithmetic average of four (4) hours of data before dilution with any other gaseous stream, measured by a continuous emission monitoring system that provides data at least once every fifteen minutes (2010).
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	56	56	Calculated as the arithmetic average of three stack tests conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system. (2004). Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes (2010).
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	27	27	Calculated as the arithmetic average of three stack tests conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system (2004). Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes (2010).
Nitrogen Oxides (NO _x) (as NO ₂)	mg/Rm ³ @ 11% O ₂	207	198	Calculated as the arithmetic average of three stack tests conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system (2004). Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes (2010).
Carbon Monoxide (CO)	mg/Rm ³ @ 11% O ₂	N.Def.	40	Calculated as the rolling arithmetic average of four (4) hours of data at the outlet of the piece of equipment where combustion of the gas stream resulting from thermal treatment of waste is completed but before dilution with any other gaseous stream, measured by a continuous emission monitoring system that provides data at least once every fifteen minutes (2010).

Contaminant	Concentration Units	Ontario MOE A-7 OLD (February 2004)	Ontario MOE A-7 CURRENT (October 2010)	Comments
Cadmium (Cd)	µg/Rm ³ @ 11% O ₂	14	7	Calculated as the arithmetic average of three stack tests conducted in accordance with standard methods (2004). Results from compliance source testing (2010).
Lead (Pb)	µg/Rm ³ @ 11% O ₂	142	60	Calculated as the arithmetic average of three stack tests conducted in accordance with standard methods (2004). Results from compliance source testing (2010).
Mercury (Hg)	µg/Rm ³ @ 11% O ₂	20	20	Calculated as the arithmetic average of three stack tests conducted in accordance with standard methods (2004). Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes (2010).
Cd + Tl	µg/Rm ³ @ 11% O ₂	N.Def.	N.Def.	
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	µg/Rm ³ @ 11% O ₂	N.Def.	N.Def.	
PCDD/F TEQ (Dioxins and Furans)	ng/Rm ³ @ 11% O ₂	0.08	0.08	Calculated as the arithmetic average of three stack tests conducted in accordance with standard methods (2004). Results from compliance source testing; results expressed as I-TEQ (2010).

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Contaminant	Concentration Units	Ontario MOE A-7 OLD (February 2004)	Ontario MOE A-7 CURRENT (October 2010)	Comments
Organic Matter (as Methane)	mg/Rm ³	65.6	33	Calculated as a 10 minute average at the outlet of the secondary chamber before dilution with any other gaseous stream, measured by a continuous emission monitoring system (2004). Results from compliance source testing or calculated as the rolling arithmetic average of 10 minutes of data at the outlet of the piece of equipment where combustion of the gas stream resulting from thermal treatment of waste is completed but before dilution with any other gaseous stream takes place, measured by a continuous emission monitoring system that provides data at least once every minute (2010).
Opacity		N.Def.	10%	Calculated as the rolling arithmetic average of six (6) minutes of data measured by a continuous emission monitoring system that provides data at least once every minute (2010).
			5%	Calculated as the rolling arithmetic average of two (2) hours of data measured by a continuous emission monitoring system that provides data at least once every fifteen minutes (2010).

NOTES:

Reference flue gas conditions are defined as 25°C, 101.3 kPa. 11% O₂ under dry conditions.

Guideline A-7 requires that within six months of an incineration facility starting up, stack emissions test results be submitted to the MOE to ensure the facility is in compliance with the emissions limits. Source testing must be performed under maximum operating feed and must be completed using the methods and procedures documented in the Ontario Source Testing Code (Procedure A-1-1). After the initial test, additional tests must be completed on an annual basis to ensure compliance. The guidelines also states that a report documenting the results of the test be submitted to the MOE within 90 days of the tests completion and also be made available to the public for review.

Guideline A-7 also outlines the proper design and operations of an incineration facility to ensure that good combustion conditions are met. Specifically the Guideline outlines nine different operational parameters that should be met by an incinerator. Table 8-11 outlines the parameters and what Guideline A-7 requires.

Table 9-11: Guideline A-7: Design and Operation Considerations for Municipal Waste Incinerators

Consideration	Description
Combustion Temperature	<p>The Ministry acknowledges that temperatures in the combustion chamber or zone of municipal waste incinerators and other combustion equipment will vary with the design.</p> <p>A minimum temperature of 1,000°C is considered adequate to ensure high-efficiency combustion and destruction of products from thermal treatment of municipal waste. The equipment that is used, at least in part, to destroy organic compounds, including products of incomplete combustion, and to meet the organic matter and the carbon monoxide limits, shall be capable of sustaining, on a continuous basis, a temperature that is 100°C degrees greater than the minimum required operating temperature. This capability to operate at a temperature of up to 1,100°C is expected to provide an adequate safety margin as the actual operating temperature should always be more than 1,000°C unless an alternative temperature is approved.</p> <p>An auxiliary burner is expected to be incorporated into the design to ensure that the minimum operating temperature is maintained:</p> <ul style="list-style-type: none"> ▪ At start-up before the commencement of the thermal treatment cycle, i.e., Before any waste is fed into the equipment ▪ During shutdown until all thermal treatment of waste has ceased ▪ At all times when waste is being thermally treated.

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Consideration	Description
Combustion Gas Residence Time	<p>The Ministry recognizes that there are municipal waste thermal treatment facilities in operation throughout the world with a wide range of combustion gas residence times in the portion of the facility that combusts gases from thermal treatment of waste. A minimum residence time of one second in the combustion zone at the minimum combustion temperature specified in this guideline is anticipated to be sufficient for providing high-efficiency destruction of the chemical species that may be present in the gas stream entering the combustion zone or equipment.</p> <p>It is acknowledged, however, that performance of a combustion system is dependent on the combination of the temperature and the residence time together with equipment design that may affect gas turbulence. Therefore a combustion temperature that is lower than 1,000°C may be acceptable if the residence time is increased accordingly. Additionally, certain combustion equipment used to burn materials/ by-products from thermal treatment may not be designed to achieve the combustion temperature specified in this guideline but its use in selected applications has proven to result in good combustion of the compounds present in those applications. It is the responsibility of the proponent to justify the temperature-residence time combination being proposed for an incineration or other combustion system.</p> <p>The residence time shall be calculated from the point where most of the combustion has been completed and the combustion temperature has fully developed. If air is introduced downstream of the burner flame front, residence time shall be calculated from the final air injection point to the location of the thermocouple that is used to verify combustion temperature. In some cases, such as large mass burn units, overall design review, including temperature profiles, may need to be carried out to determine the portion of the unit that is considered to be the combustion zone for the purposes of residence time calculations.</p> <p>If a proponent is of the opinion that residence time within a certain combustion device is not relevant for compliance with the in-stack contaminant concentration limits, the proponent is expected to provide a detailed rationale for the opinion, preferably with manufacturer's data, relevant test data and information on requirements in other jurisdictions for facilities similar to the one being proposed. An application for a Certificate of Approval for such a facility will be reviewed on a case by case basis.</p>
Combustion Air Distribution	<p>Combustion air systems shall be designed to control air distribution within the thermal treatment equipment and/or the device that combusts gases generated during thermal treatment of municipal waste. Ideally, control systems shall have the capability of adjusting the distribution of combustion air in order to provide adequate mixing of the gases and the desired level of residual oxygen in the exhaust gases under all loading conditions. The Ministry recognizes that these systems vary widely.</p>

Consideration	Description
Oxygen Availability	<p>Lack of sufficient oxygen during combustion of any combustible material, including gases generated during thermal treatment of municipal waste, is a contributing factor to the discharge of products of incomplete combustion. Components of thermal treatment facilities shall be designed and operated to ensure that there is sufficient residual oxygen in the flue gases from the component used for combustion of gases from thermal treatment of waste. Availability of oxygen and ability to control the amount of oxygen are intended to minimize the discharge of products of incomplete combustion at all times when waste is being thermally treated. A sufficient level of residual oxygen in the exhaust gases is critical with respect to meeting the organic matter and carbon monoxide limits set out.</p> <p>Thermal treatment facilities are typically expected to be designed and operated to provide an oxygen rich atmosphere in the combustion zone or dedicated piece of combustion equipment with residual oxygen level of at least 6% by volume on dry basis in the undiluted gases leaving the combustion zone. The Ministry acknowledges that the recommendation of 6% residual oxygen may be too conservative for some designs, such as those where the gases from the solid waste are a product of a carefully controlled gasification process, followed by elaborate cleaning and refining of the gases to the point of the gases becoming a gaseous fuel with consistent quality rather than being a complex mixture of products of incomplete combustion. In order to establish an appropriate oxygen level, there will be a need to balance between energy recovery, emissions of oxides of nitrogen and the system's ability to deal with variations in waste feed quality. The composition of waste can vary significantly depending on factors such as the extent and type of industrial activity, seasonal activities and level of recycling, and so will the gases from the thermal treatment of that waste. It is also noted that a proposal may involve use of "engineered fuel", solid or gaseous, made from municipal waste that meets certain specifications and is therefore expected to be of more consistent quality. In this case, the combustion process may not be subject to great challenges and an oxygen level below 6% may be acceptable.</p>
Gas-Phase Turbulence and Mixing	<p>The design and operation of a thermal treatment facility shall provide a high degree of gas-phase turbulence and mixing in the combustion zone. This can usually be achieved through appropriately located/directed air jets, changes of flue gas flow direction, baffling, and constriction of cross-sectional flue gas flow area.</p>
Range of Operation	<p>Municipal waste thermal treatment facilities shall be designed and operated to achieve the required temperature, residence time, oxygen availability and turbulence over the expected range of operation, taking into account feed rate variations, as well as ultimate analysis, heating value, ash and moisture content of the waste together with combustion air requirements and heat losses.</p>

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Consideration	Description
Continuous Operation of Air Pollution Control Systems	<p>Air pollution control systems for thermal treatment facilities are expected to be designed to operate on a continuous basis whenever there is waste being processed in the thermal treatment facility. The design of the system should consider:</p> <ul style="list-style-type: none">▪ Conditions that could lead to an unscheduled shutdown of the air pollution control system or the entire facility;▪ Means of ameliorating such conditions; and▪ Means for system venting when there is a need to bypass the air pollution control equipment. <p>Control systems at a thermal treatment facility shall be designed to ensure the shutdown of the thermal treatment facility immediately upon an unscheduled shutdown of the air pollution control system in a manner that will minimize air emissions, unless the system allows redirection of flue gases into equipment that operates and provides control that is equivalent to the control provided by the equipment that was shut down.</p> <p>The control system shall also be designed to record pertinent information for subsequent reporting to the Ministry's local district office and for an assessment of the reasons for the shutdown and potential measures to prevent a recurrence.</p>
Pressure Control and Emergency Exhaust	<p>Thermal treatment facilities shall be designed to operate under negative pressure during all phases of operation so that gaseous products from the thermal treatment of waste do not leak out of the thermal treatment facility. The requirement for negative pressure does not apply to equipment that may be designed to operate under pressure. A Certificate of Approval issued for the thermal treatment facility will include conditions relating to abnormal operating conditions, shut down and cessation of waste feed during abnormal operating conditions as well as use of the emergency exhaust.</p>

Consideration	Description
Ash Management and Organic Content of Ash	<p>Municipal waste thermal treatment facilities typically generate residues that are collected from various parts within the facility. One such residue, often referred to as bottom ash, is typically removed from the chamber, vessel or other equipment into which the municipal waste is introduced. Some designs offer a capability to vitrify (solidify into a glass-like substance) this residue. Residue can also be collected from equipment used for energy recovery from gases from thermal treatment and from air pollution control equipment (fly ash). Owners and operators of thermal treatment facilities are encouraged to consider beneficial use of any residues where possible.</p> <p>Under Regulation 347, fly ash from an incinerator's energy recovery and pollution control system must be handled separately from the bottom ash generated in the zone where municipal waste is incinerated. Similarly, for other types of thermal treatment facilities, the fly ash should be kept separate from the bottom ash or any other residue.</p> <p>Thermal treatment facility operators are expected to test the ash and other residues in accordance with the conditions included in a Certificate of Approval issued under Part V of the EPA (waste approval) before the ashes and/ or residues are transferred from the site of the thermal treatment facility.</p> <p>Testing of bottom ash involves determination of organic content in all cases to confirm that it meets the definition of incinerator ash set out in Regulation 347. The organic content in ash should be determined using Loss on Ignition testing on dry ash samples with ferrous metals absent or as otherwise required by conditions included in a Certificate of Approval. Owners and operators of municipal waste thermal treatment facilities are expected to develop a detailed protocol for sampling and analysis of residues that are to be tested. The protocol is expected to be periodically reviewed and amended as experience with the facility is gained and test results are available. The operation of a thermal treatment facility is expected to be controlled such that the organic content of the bottom ash is minimized to the greatest degree possible.</p> <p>In accordance with Regulation 347 incinerator ash (bottom ash), as defined, resulting from the incineration of waste that is neither hazardous waste nor liquid industrial waste is not a hazardous waste and may be disposed of at a site that is approved to receive solid non-hazardous waste. Owners and operators of thermal treatment facilities processing municipal waste are not required to carry out Toxicity Characteristic</p> <p>Leachate Procedure (TCLP) on the bottom ash that meets the definition of incinerator ash (i.e., has an organic content of less than 10%). Testing using TCLP, however, is required if the organic content exceeds 10% unless the bottom ash is to be disposed of at a waste disposal site approved to accept hazardous waste. In the absence of testing, the owners and operators must assume that the bottom ash is hazardous waste and handle it accordingly.</p> <p>Fly ash from thermal treatment of municipal waste, on the other hand, is assumed to be hazardous waste unless otherwise proven. Therefore, if an operator of a thermal treatment facility wishes to classify the fly ash, or any other residue aside from bottom ash, as non-hazardous, the ash or other residue must be tested to determine if it is leachate toxic. The Ministry's testing protocol, TCLP, is referenced in Regulation 347 while the sampling procedure and results evaluation procedure is in the Ministry's publication "Protocol for Sampling and Evaluating Fly Ash from Non-Hazardous Solid Waste Incineration Facilities" October 1990 as may be amended.</p>

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The Ontario MOE also encourages the installation of Continuous Emissions Monitoring Systems for the following parameters:

- Temperature
- Organic matter
- Carbon monoxide
- Residual oxygen
- Volumetric flow rate of the flue gas
- Hydrogen chloride
- Sulphur dioxide
- Nitrogen oxides
- Opacity
- Particulate matter.

Other parameters that may also be considered for continuous or long-term monitoring include:

- Carbon dioxide
- Hydrogen fluoride
- Mercury
- Dioxins and furans.

9.1.5.2 O. Reg. 419 Schedule 3 Standards

The MOE Standards Development Branch released a revised version of the *Summary of O. Reg. 419/05 Standards and Point of Impingement Guidelines (POI) and Ambient Air Quality Criteria (AAQCs)* in December 2005.

The regulation incorporates “effects-based” standards derived from AAQC with the appropriate averaging period (e.g., 24 hr, 1 hr, 10 minutes) to enable a more realistic assessment of environmental impacts. The “effect-based” standards are set to protect the most sensitive population, such as children and the elderly, recognizing that some contaminants move through the natural environment, persist for long period of time and/or accumulate in the food chain. Simultaneous exposure through more than one environmental pathway (air, water, food) is also taken into consideration. The effects considered may be based on health, odour, vegetation, soiling, visibility, corrosion or other effects.

The “effects-based” air standards, applicable to the new MSW thermal treatment facilities, are listed in Schedule 3 of the Regulation 419/05. Most of these 24-hour air standards are the same as the AAQCs values in the 2001 MOE document “*Summary of Point of Impingement Standards, Point of Impingement Guidelines, and Ambient Air Quality Criteria (AAQCs)*”. Therefore, the Schedule 3 Standards should be considered the ambient air quality objective set to avoid adverse health effects and to protect the ecosystem. For contaminants that are not listed in Schedule 3 of the Regulation, but are instead listed as a half-hour POI guideline or an AAQC, the exceedance of a POI guideline or of an AAQC is considered to cause the adverse effects.

All contaminants for which there has been a stack emission limit set out in Guideline A-7 (except dioxins and furans) have 24-hour average health-based Schedule 3 standards based on the most recent AAQCs developed via the Ministry's standard setting process. The AAQCs identify the limit for concentration in the air of the specific contaminants that would be emitted from an EFW stack, below which they would not be expected to cause any adverse effects. The AAQCs would be determined for a defined point or points set at a defined distance from a facility (usually between the facility and sensitive community receptors) at which the specific limit for air pollutants must be met.

For dioxins and furans, since there is no Schedule 3 standard, the 24-hour average concentration listed in the AAQC is used. The applicable POI Limits and AAQC for the contaminants that are also regulated by Guideline A-7, are summarized in Table 9-12.^[224]

Table 9-12: O. Reg. 419 Schedule 3 Standards and Ambient Air Quality Criteria (2005)

Contaminant	Concentration Units	MOE Reg. 419 Schedule 3 Standards (24-Hour Average)	MOE AAQC (24-Hour Average)
Total Particulate Matter (TPM)	µg/m ³	120	–
Sulphur Dioxide (SO ₂)	µg/m ³	275	–
Hydrogen Chloride (HCl)	µg/m ³	20	–
Nitrogen Oxides (NO _x) (as NO ₂)	µg/m ³	200	–
Carbon Monoxide (CO)	–	N. Def.	–
Cadmium (Cd)	µg/m ³	2	–
Lead (Pb)	µg/m ³	2	–
Mercury (Hg)	µg/m ³	2	–
PCDD/F TEQ (Dioxins and Furans)	pg TEQ/m ³	–	5

NOTES:

N. Def. = Not Defined

9.1.6 United States Environmental Protection Agency

In the United States, as of 2007, there were 87 WTE facilities operating in 25 states with an approximate capacity of 28.7 million tons per year.^[225] WTE facilities in the United States are regulated by the United States Environmental Protection Agency (US EPA). The US EPA has developed clear and relatively strict limits on the acceptable levels of emissions for many substances from WTE facilities. The emission guidelines are not directly enforceable by the US EPA but, rather, are implemented by State air pollution control agencies. In December 2005, the EPA adopted emission guidelines for large WTE units with a combustion capacity greater than 250 tons per day (sub part Cb of 40 CFR part 60). These adoptions became a final ruling on May 10, 2006. The emissions limitations apply to new MWC units and existing MWC units (compliance was required by December 2000).^[226]

²²⁴ MacViro Consultants and Jacques Whitford Limited. Durham/York Residual Waste Study Annex E-6: Supporting Technical Document on Generic Air Dispersion Modelling Report on Selection of Preferred Residuals Processing System\May 30, 2006

²²⁵ The 2007 IWSA Directory of Waste-to-Energy Plants. Ted Michaels. 2007

²²⁶ Environmental Protection Agency. 2006. 40 CFR Part 60 – Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Large Municipal Waste Combustors; Final Rule

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The emissions limitations set out in the emissions guidelines reflect the performance of maximum achievable control technology (MACT). The MACT standards require affected sources to meet specific emissions limits that are based on the emissions levels already achieved by the best-performing similar facilities. For existing facilities, the MACT is set based upon the best-performing 12% of similar facilities, for new sources, the MACT must equal the level of emissions currently achieved by the best-controlled similar source.^[227]

Table 9-13 summarizes the currently adopted emission limits for new and existing municipal waste combustors. In all cases the emission limits below are checked for compliance using manual stack test methods (where one stack sampling survey result is the average of three individual sample runs).

Table 9-13: US EPA Emissions Criteria for New and Existing Municipal Waste Combustors

Contaminant	Concentration Units	Large MWC ^{1, 2}	
		Existing Facilities	New Facilities
Total Particulate Matter (TPM)	mg/Rm ³ @ 11% O ₂	17.5	14.0
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	53.2 ⁴	55.0 ³
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	30.3 ⁵	26.1 ⁵
Nitrogen Oxides (NO _x) (as NO ₂)	mg/Rm ³ @ 11% O ₂	237 to no limit ⁷	197.5 ⁶
Carbon Monoxide (CO)	–	40 to 200 ⁸	41 to 200 ⁸
Cadmium (Cd)	µg/Rm ³ @ 11% O ₂	24.5	7.0
Lead (Pb)	µg/Rm ³ @ 11% O ₂	280.1	98.0
Mercury (Hg)	µg/Rm ³ @ 11% O ₂	35.0	35.0
PCDD/F (Dioxins and Furans)	ng (total mass basis) @ 11% O ₂	21.0 ⁹	9.1 ⁹
Opacity	%	10	10

NOTES:

N. Def. = Not Defined

All emission limits are measured at 11% O₂, 25°C and 101.3 kPa

¹ Large MWC unit has a capacity greater than 250 tons/d

² Units have been converted to Ontario MoE A-7 concentration units to allow direct comparison

³ or 80% reduction by weight or volume of potential SO₂ emissions, whichever is less stringent

⁴ or 75% reduction by weight or volume of potential SO₂ emissions, whichever is less stringent

⁵ or 95% reduction of potential HCl emissions by weight, whichever is less stringent

⁶ 180 ppmdv @ 7% O₂ for 1st year of operation, 150 ppmdv @ 7% O₂ after 1st year of operation

⁷ NO_x limit varies by combustor type: 210 ppmdv @ 7% O₂ for Mass Burn Rotary Waterwall, 180 ppmdv @ 7% O₂ for Fluidized Bed, 205 ppmdv @ 7% O₂ for Mass Burn Waterwall, 250 ppmdv @ 7% O₂ for Refuse-derived fuel, no limit for Mass Burn Refractory (after Apr. 28, 2009)

⁸ CO limit varies per technology: 40 mg/Rm³ @ 11% O₂ for Modular Starved-Air and Excess Air Unit; 200 mg/Rm³ @ 11% O₂ for Spreader Stoker Refuse-derived fuel

⁹ Limit not comparable to Canadian and European limits. Dioxins/furans on total mass basis measured as tetra- through octachlorinated dibenzo-p-dioxins and dibenzofurans. Not TEQ values

²²⁷ The University of Tennessee. 2009. EPA MACT Rules. Accessed March 12, 2010 from <http://epamact.utk.edu/>

It should be noted the EPA has released draft standards for emissions from commercial and industrial solid waste incineration units in April 2010 ^[228]. These standards are currently in the public domain for comment; it is too early to determine if they will be adopted as presented. Key features of the standards include the provision for continuous monitoring of total particulate, a reduction in the allowable concentration of particulate in the discharge and variability in the allowable concentration depending of the type of incineration facility. Detailed examination of the proposed standards was not possible under our schedule of this WTE Emissions assignment for BC MOE.

9.1.7 Regulatory Environment in the State of Oregon

Oregon Department of Environmental Quality established emission standards, design requirements and performance standards for all solid waste incinerators in order to minimize air contaminant emissions and provide adequate protection of public health as filed through April 15, 2010. Incinerator Regulations are summarized under the Oregon Administrative Rule (OAR) 340-230. ^[229] Air emissions from municipal waste combustors with a combustion capacity greater than 250 tons/day must meet the criteria outlined in Table 9-14 (OAR 340-230-300 through 340-230-0395). In addition, no owner or operator of the municipal waste combustor may cause or allow visible emissions of combustion ash from an ash conveying system in excess of 5% of the observed period.

Table 9-14: Oregon Administrative Rule 340-230-310 Incinerator Regulations – Emissions Limits (April 15, 2010)

Contaminant	Units	Before April 28, 2009	On or After April 28, 2009
Particulate Matter (PM)	mg/Rm ³ @ 11% O ₂	19	18
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	53 ¹	
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	30 ²	
Nitrogen Oxides (NO _x) (as NO ₂)	mg/Rm ³ @ 11% O ₂	270	
Carbon Monoxide (CO)	–	N. Def.	
Cadmium (Cd)	µg/m ³ @ 11% O ₂	28	14
Lead (Pb)	µg/m ³ @ 11% O ₂	308	140

²²⁸ Environmental Protection Agency 40 CFR Part 60 [EPA-HQ-OAR-2003-0119; FRL-RIN 2060-A012], Standards of Performance for New Stationary Sources and Emission Guidelines for Existing Sources: Commercial and Industrial Solid Waste Incineration Units.

²²⁹ Oregon Administrative Rules. Department of Environmental Quality. OAR 340-230. Incinerator Regulations. Filed through April 15, 2010. http://arcweb.sos.state.or.us/rules/OARs_300/OAR_340/340_230.html

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Contaminant	Units	Before April 28, 2009	On or After April 28, 2009
Mercury (Hg)	$\mu\text{g}/\text{m}^3$ @ 11% O ₂	56 ³	35 ³
PCDD/F (Dioxins and Furans)	ng/m^3 @ 11% O ₂	42 ⁴	25 ⁵
Opacity	%	10 ⁶	

NOTES:

N. Def. = Not Defined

All emission limits are converted to 11% O₂, 25°C and 101.3 kPa

¹ Or 25% of the potential SO₂ emission concentration (75% reduction by weight or volume), whichever is less stringent.

² Or 5% of the potential HCl emission concentration (95% reduction by weight or volume), whichever is less stringent.

³ Or 15% of the potential mercury emission concentration (85% reduction by weight), whichever is less stringent.

⁴ Total mass. Applies to municipal waste combustor units that employ electrostatic precipitator-based emission control system. If electrostatic precipitator-based emission controls are not employed, 30 ng per dry m³ (total mass) @ 7% O₂.

⁵ Total mass. Applies to municipal waste combustor units that employ electrostatic precipitator-based emission control system. If electrostatic precipitator-based emission controls are not employed, 15 ng per dry m³ (total mass) @ 7% O₂.

⁶ Opacity considered over a 6-minute average.

9.1.8 Regulatory Environment in the State of Washington

Within Washington State, standards for Energy Recovery and Incineration Facilities are defined under Washington Administrative Code (WAC) 173-350-240 effective 2003.^[230] These standards apply to incineration facilities designed to burn more than 12 tons/day of solid waste or RDF. Although there are no specific design standards, the facilities must meet the general performance requirements under WAC 173-350-040.^[231] The standards require facilities meet emission standards or ambient air quality standards at the property boundary in compliance with chapter 70.94 RCW (Revised Code of Washington), *Washington Clean Air Act*.^[232]

Emission standards, design requirements, and performance standards for solid waste incinerator facilities with a capacity of 12 tons/day or more are defined under WAC 173-434^[233] as promulgated under chapter 70.94 RCW. Table 9-15 summarizes the emission standards applicable to solid waste incinerator facilities. Design and operational requirements are summarized in Table 9-16.

Special emission standard provisions exist for combustor and incinerator units constructed prior to 1999 under WAC 173-400-050.^[234] These emissions standards are less stringent than the criteria summarized in Table 9-15.

²³⁰ Washington Administrative Code. Energy Recovery and Incineration Facilities, WAC 173-350-240.
<http://apps.leg.wa.gov/wac/default.aspx?cite=173-350-240>

²³¹ Washington Administrative Code. Performance Standards, WAC 173-350-040
<http://apps.leg.wa.gov/wac/default.aspx?cite=173-350-040>

²³² Revised Code of Washington. *Washington Clean Air Act*. Chapter 70.94 RCW.

²³³ Washington Administrative Code. Solid Waste Incinerator Facilities, WAC 173-434. <http://apps.leg.wa.gov/wac/default.aspx?cite=173-434>

²³⁴ Washington Administrative Code. Emission Standards for Combustion and Incineration Units, WAC 173-400-050
<http://apps.leg.wa.gov/WAC/default.aspx?cite=173-400-050>

Table 9-15: WAC 173-434-130 Emission Standards for Solid Waste Incinerator Facilities (2003)

Contaminant	Units	Small Facilities ¹	Large Facilities ²
Particulate Matter (PM)	mg/m ³ @ 11% O ₂	48	32
Sulphur Dioxide (SO ₂)	mg/m ³ @ 11% O ₂	92	
Hydrogen Chloride (HCl)	mg/m ³ @ 11% O ₂	52	
Opacity	%	5	

NOTES:

Units have been converted to 11%O₂ and 25°C to allow direct comparison

¹ Small facilities have a capacity less than 250 tons/day

² Large facilities have a capacity equal to or greater than 250 tons/day

³ For an hourly average

⁴ Except if uncontrolled emissions of SO₂ are reduced by at least 80% and a procedure acceptable to ecology or the authority for monitoring is developed

⁵ Except if uncontrolled emissions of HCl are reduced by at least 80% and a procedure acceptable to ecology or the authority for monitoring is developed

⁶ Opacity considered over a 6-minute average in any 6-minute period

Table 9-16: WAC 173-434-160 Design and Operation Requirements for Solid Waste Incinerator Facilities

Consideration	Description
Combustion	
Combustion zone temperature	Whenever solid waste is being burned, the temperature of the final combustion zone shall not be below 982°C (1,800°F) for a fifteen minute average or below 871°C (1,600°F) for any reading.
Combustion zone residence time	The minimum combustion chamber temperature must be maintained for at least one second (1.0 second) in a zone after the last over fire air has entered the combustion chamber. If over fire air is not used, the combustion chamber shall maintain the minimum combustion temperature or greater for at least one second with all combustion gases. Procedures for determining the residence time shall be a part of the new source review.
Excess air	The combustion gases leaving the final combustion zone must contain at least three percent oxygen measured on a wet basis.
Combustion air distribution and control	The air distribution shall be fully controllable where pressurized air is introduced and the air flow shall be monitored and recorded.
Combustion Air	
Combustion air	To minimize odour, fugitive emissions and to maintain a negative pressure in the tipping area, the combustion air shall be withdrawn from the tipping area, or shall utilize an equivalent means of odour and fugitive emission control acceptable to ecology or the authority.
Particulate Control Device Temperature	
Particle control device temperature	The inlet temperature of the primary particulate control device shall not exceed 177°C (350°F).

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Consideration	Description
Operation	
Operation	At all times, the owner or operator shall, to the extent practicable, maintain and operate any incinerator facility, including associated air pollution control equipment, in a manner consistent with good air pollution control practice. This may mean that if the emissions limits are being exceeded, no more waste should be fed into the incinerator until the problem is corrected. Determination of whether acceptable operating and maintenance procedures are being used will be based on information available to ecology or the authority which may include, but is not limited to, monitoring and recording results, opacity observations, review of operating and maintenance procedures, and inspection of the source.

9.1.9 European Union

Within the European Union, there are two directives that regulate the emissions from WTE facilities, namely:

- The Waste Incineration Directive (Directive 2000/76/EC)
- The Integrated Pollution Prevention and Control (IPPC) Directive (Directive 2008/1/EC).

The 2008 version of the IPPC Directive is a codified and slightly changed version of the original IPPC Directive (96/61/EC). Codification refers to the adoption of a directive such as the IPPC directive, into general law within the EU member states. Essentially, most of the provisions of the IPPC have been transposed into the laws put into force within the member states and were put into force many years ago. Both the WID and IPPC directives are addressed to the member states which are given a certain lead time to transpose them into their national legislation. The following sections describe each directive in more detail.

9.1.9.1 The Waste Incineration Directive (WID)

The Waste Incineration Directive (WID) was agreed to by the European Parliament and the Council of the European Union on December 4, 2000 and was officially published in the Journal of European Communities on December 28, 2000. The purpose of the WID is to prevent or limit the negative environmental effects associated with the incineration and co-incineration of waste materials, in particular emissions to air, soil, surface and ground water.

Through the WID, the European aims to “achieve a high level of environmental and human health protection by requiring the setting and maintaining of stringent operational conditions, technical requirements and emission limit values for plants incinerating and co-incinerating waste throughout the European Community.”^[235]

²³⁵ Department for Environment, Food and Rural Affairs. Environmental Permitting Guidance, The Directive on the Incineration of Waste for the Environmental Permitting (England and Wales) Regulations 2007, Updated October 2009

The WID applies to nearly all waste incineration and co-incineration plants. It goes beyond previous legislation such as the 1989 Municipal Waste Incineration (MWI) Directives (89/369/EEC and 89/429/EEC and also incorporates the Hazardous Waste Incineration Directive (94/67/EC) forming a single directive on waste incineration.

Facilities that fall under the directive include any incineration facility dedicated to the thermal treatment of waste including the oxidation of waste or by pyrolysis, gasification, or plasma processes insofar as the substances resulting from the treatment are subsequently incinerated. The WID requires that the local regulation authority ensures that the protection standards and requirements of the WID are met through the Environmental Permitting system.

The WID has specific and stringent requirements for waste incineration and co-incineration facilities including types of waste permitted; delivery and reception of waste; combustion furnaces, abatement facilities, residue handling, monitoring equipment and emission limit values. All requirements are laid out in the permit for the facility issued by the appropriate local authorities.

Proper facility operation is also described in the WID including combustion gas temperatures, flue gas residence times, the TOC content of residues, conditions when waste feed should be stopped, and energy recovery from the plant. It also allows some derogation from these requirements under some conditions.

The WID states that incinerators must be designed, equipped, built and operated such that the flue gas is raised to a temperature of 850°C for two (2) seconds (or in the case of hazardous waste with more than 1% halogenated substances be raised to 1,100°C). The WID also requires that these temperatures be met even under the most unfavourable operating conditions.

Table 9-17 presents some of the emissions limits set out in the Waste Incineration Directive. Generally compliance with these limits would be demonstrated through periodic stack testing, although for some parameters with half hourly emission limit values² compliance would be demonstrated through CEMS.

Table 9-17: Emissions Limits for WTE Facilities Set Out in EU Waste Incineration Directive

Contaminant	Concentration Units	EU Directive 2000/76/EC of the European Parliament and Council on the Incineration of Waste ¹
Total Particulate Matter (TPM)	mg/Rm ³ @ 11% O ₂	9.2 ²
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	45.8 ²
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	9.2 ²
Nitrogen Oxides (NO _x) (as NO ₂)	mg/Rm ³ @ 11% O ₂	183.2 ²
Carbon Monoxide (CO)	mg/Rm ³ @ 11% O ₂	45.8 ²
Cadmium (Cd)	µg/Rm ³ @ 11% O ₂	N. Def.
Lead (Pb)	µg/Rm ³ @ 11% O ₂	N. Def.
Mercury (Hg)	µg/Rm ³ @ 11% O ₂	45.8 ³

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Contaminant	Concentration Units	EU Directive 2000/76/EC of the European Parliament and Council on the Incineration of Waste ¹
Cd + Tl	µg/Rm ³ @ 11% O ₂	45.8 ³
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	µg/Rm ³ @ 11% O ₂	458.1 ³
PCDD/F TEQ (Dioxins and Furans)	ng/Rm ³ @ 11% O ₂	0.092

NOTES:

N. Def. = Not Defined

¹ Units have been converted to Ontario MOE A-7 concentration units to allow direct comparison

² Daily average value by periodic stack test. In addition, the Directive contains half-hourly emission limit values for the same pollutants

³ Average values over the sample period of a minimum of 30-minutes and a maximum of 8 h

9.1.9.2 The Integrated Pollution Prevention and Control (IPPC) Directive

The IPPC Directive is aimed at minimizing the emissions of pollutants from large industrial installations through the use of an environmental permit. Permits contain emission limit values (ELVs) and set conditions based on the application of best available technique (BAT). They also address energy efficiency, waste minimization, prevention of accidental emissions, and site restoration.^[236]

Specifically, the IPPC Directive applies to industrial and agricultural activities with a high pollution potential including energy industries, production and processing of metals, mineral industry, chemical industry, waste management, livestock farming, etc.^[237] For waste incineration plants treating municipal waste (household waste and similar commercial, industrial and institutional wastes) the IPPC directive applies if the facility capacity exceeds three tonnes per hour (72 tonnes per day).^[238]

For WTE facilities that are subject to the IPPC Directive (2008/1/EC), meeting the requirements of the WID Directive are not necessarily sufficient to meet IPPC requirements as they are broader and may involve more stringent emissions limits.

The IPPC Directive is based on several principles, namely: (1) an integrated approach, (2) best available techniques, (3) flexibility; and (4) public participation.

- The integrated approach means that the permits must take into account the whole environmental performance of the plant, covering e.g., emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure. The purpose of the Directive is to ensure a high level of protection of the environment taken as a whole.

²³⁶ [http://www.eef.org.uk/policy-media/policy-briefs/briefings/Integrated-Pollution-Prevention-Control-\(IPPC\).htm](http://www.eef.org.uk/policy-media/policy-briefs/briefings/Integrated-Pollution-Prevention-Control-(IPPC).htm)

²³⁷ http://europa.eu/legislation_summaries/environment/waste_management/l28045_en.htm

²³⁸ DIRECTIVE 2008/1/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 January 2008 concerning integrated pollution prevention and control. January 29, 2008

- The permit conditions including emission limit values (ELVs) must be based on Best Available Techniques (BAT), as defined in the IPPC Directive. To assist the licensing authorities and companies to determine BAT, the Commission organizes an exchange of information between experts from the EU Member States, industry and environmental organizations. This work is coordinated by the European IPPC Bureau of the Institute for Prospective Technological Studies at EU Joint Research Centre in Seville (Spain). This results in the adoption and publication by the Commission of the BAT Reference Documents (commonly referred to as BREFs). Executive summaries of the BREFs are also translated into the official EU languages.
- The BREF on Waste Incineration was issued in August 2006. It contains Chapter 5 – Best Available Techniques with 63 numbered recommendations called BATs. One of these, BAT 35 contains a table with 'operational emission levels for releases to air associated with the use of BAT'. The values in Table 9-18 are, of course, lower than the emission limit values in WID Directive 2000/76, but the BREF states specifically that the BAT emission levels are not the same as emission limit values.
- It is important to stress that the BREF on Waste Incineration does not prescribe the technology to be used at waste to energy facilities nor does the BREF prescribe one technology to be better than the other.

Table 9-18: Comparison of the Requirements of the WID and the BAT Listed in the WI BREF

Contaminant Emissions to Air (mg/Nm ³ unless stated)	WID		BREF/BAT	
	Daily Average ELV	Half Hourly (100%/97% of the time)	Daily Average (operational BAT range)	Half Hour Average (operational BAT range)
Total Particulate	10	30/10	1 – 5	1 – 20
HCl	10	60/10	1 – 8	1 – 50
SO ₂	50	200/50	1 – 40	1 – 150
NO _x (as NO ₂)	<200 to <500 (size/new/existing dependant)	400/200	40 – 100 (SCR) 120 – 180 (SNCR)	40 – 300 (SCR) 30 – 350 (SNCR)
VOC (as Total Organic Carbon)	10	20	1 – 10	1 – 20
CO	50	150 (10 min avg) (some alternatives)	5 – 30	5 – 100
Hg	0.05 (non-continuous sample)		0.001 – 0.02	
Cd/Tl	0.05 (non-continuous sample)		0.005 – 0.05 (non-continuous sample)	
PCDD/F	0.1 ng/m ³ (non-continuous sample)		0.01 – 0.1 ng/m ³ (non-continuous sample)	
Ammonia	Not included in WID		<10	1 – 10
N ₂ O			Information about control techniques is provided	
Benz(a)pyrene				
PAHs				
PCBs				

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The IPPC Directive contains elements of flexibility by allowing the licensing authorities in determining permit conditions, to take into account:

- The technical characteristics of the installation
- Its geographical location
- The local environmental conditions.

The Directive ensures that the public has a right to participate in the decision making process, and to be informed of its consequences, by having access to:

- Permit applications in order to give opinions
- Permits
- Results of the monitoring of releases
- The European Pollutant Emission Register (EPER). In EPER, emission data reported by Member States are made accessible in a public register, which is intended to provide environmental information on major industrial activities. EPER will be replaced by the European Pollutant Release and Transfer Register (E-PRTR) from 2007 reporting period onwards.

9.1.9.3 IED – Industrial Emissions Directive

The European Commission's proposal from December 21, 2007 merges the IPPC directive 96/61/EC, the Waste Incineration directive (WID) 2000/76/EC and some other directives including the Large Combustion Plants Directive 2001/80/EC. This will most likely not occur until 2013.^[239]

The new Directive will include pre-treatment of waste for incineration and for co-incineration as well as treatment of bottom ash and APC ashes. Through the IED, the European Commission aims to strengthen the concept of BAT by making the BREFs more prominent.

One of the problems heavily discussed among the waste to energy sector and the authority, is not to mix-up the emission limit values (ELV) with the BAT AEL (Associated Emission Levels) based on the ranges presented in the BREF and mentioned in the chapter above.

The draft article 16.2 states "the competent authority shall set emission limit values that do not exceed the emission levels associated with the best available techniques as described in the BAT reference document".

The draft article 15.2 says " ...the emission limit values and the equivalent parameters and technical measures ... shall be based on the best available techniques, without prescribing the use of any technique or specific technology."

The time table for the approval of the IED has been delayed and the second reading will go before the European Parliament plenary 18 May 2010.

²³⁹ http://europa.eu/legislation_summaries/environment/waste_management/l28045_en.htm

The review of the BREF on Waste Incineration is expected to take place during the period from 2012 – 2014. It is not yet known if this will result in a general lowering of the ELV or if the IED will result in lowering of the ELV for only some pollutants and discussions are going on among the commission, the national member states and the industry. The general opinion among the member states tends towards keeping the current ELV set out in the WID.

9.1.9.4 European Union Member States Regulatory Limits

Since the EU Directives are addressed to the Member States, countries that are members of the European Union have to transpose the directives. The WID is a 'minimum' directive which means that the Member States are free to set stricter regulatory limits.

In general all European countries, with few exceptions, have implemented the WID and the emission limits. Several have set lower limits as a result of local considerations. Germany and Norway (not an EU member country) have implemented a more stringent emission limit for mercury. For NO_x the Netherlands have specified a limit at 70 mg/Nm³ and Austria and Switzerland (not an EU member country) have specified a limit at 80 mg/Nm³.

Some member states have implemented lower emission values in certain areas, and some individual facilities may have more stringent emission limits in their approvals/permits. An example of how the WID and emissions have been applied in a member state (Germany) is outlined below.

In 2007, Germany had 72 operating WTE facilities that treated waste. Since 1985, waste incineration capacity in Germany has nearly doubled.^[240] Alike to other members of the EU, Germany requires that WTE facilities that operate within its boundaries, meet the emissions standards set out in the EU's Waste Incineration Directive. Germany paved the way for the EU WID. The German Ordinance on Waste Incineration and Co-Incineration (17.BImSchV) which was developed in 1990 set stringent limits on the emissions associated with WTE facilities. The 17.BImSchV sets out the requirements for construction, layout and operation of WTE facilities, and for emissions measurement and monitoring. It outlined a transitional period of six years for existing facilities while new facilities were required to comply with specific limits from the very beginning. Since 1996, all facilities have complied with the stringent emissions requirements.^[241] The limits set out in Germany's 17.BImSchV had a large influence on the emissions limits developed in the EU's WID (2000/76/EC).

In 2003, the 17.BImSchV was updated to incorporate the requirements outlined in the EU WID. Moreover, it contains emission limit values for some additional compounds and it also requires that Hg emissions be monitored continuously. The 17.BImSchV incorporates all the requirements outlined in the EU WID and must be adhered to by all operators of waste incineration facilities.^[242]

²⁴⁰ Germany Federal Environmental Agency, 2005

²⁴¹ Waste Incineration – A Potential Danger? Bidding Farewell to Dioxin Spouting. Federal Ministry of the Environment, Nature Conservation and Nuclear Safety, September 2005

²⁴² Ordinance on Waste Incineration and Co-Incineration – 17. BImSchV. August 2003

It should be noted that CEMS for mercury is an emerging approach for mercury emissions monitoring. As noted above, it is required in Germany. The new CISWI rules proposed in the US include proposed requirements for using Hg CEMS (performance specification 12A – Specifications and Test Procedures for Total Vapor Phase Mercury Continuous Emission Monitoring Systems in Stationary Sources) or an integrated sorbent trap Hg monitoring system.

9.2 Emission Limits for Criteria Air Contaminants and Hazardous Air Pollutants

This subsection identifies and evaluates regulatory emission limits for all air contaminants applicable to WTE scenarios. Table 9-19, provides a comparison of the maximum allowable concentration of various pollutants measured in the discharge under:

- CCME
- British Columbia Criteria for Municipal Solid Waste Incinerators (1991)
- Old Ontario MOE Guideline A-7 (2004)
- New Ontario MOE Guideline A-7 (2010)
- Oregon Incinerator Regulations (OAC 340-230-310)
- Washington Emission Standards for Combustion and Incineration Units (WAC 173-434-130)
- US EPA New Incinerator Limits (i.e., the current US National Standard)
- The European Union, New Incinerator Unit, Regulation (i.e., the current European Standard).

The US EPA and EU limits have been converted to equivalent units comparable to those set out in the CCME and Ontario guidelines. These differ slightly in regards to reference conditions, where the values identified reflect mass per reference cubic metres corrected to 11% oxygen and 0% moisture. Reference conditions: 25°C, 101.3 kPa, except for British Columbia which is based on 20°C.

The emission limits provided are actual values with inherent consideration of achievability. These limits are consistent with BC's Interim BAT policy.

The maximum allowable concentrations, otherwise known as maximum emissions limits values (ELVs) for various jurisdictions are linked to appropriate averaging periods and monitoring methodologies. The limits presented in Table 9-19 are checked for compliance with the methods deemed appropriate by the individual jurisdictions either based on manual stack testing or CEMS data depending on the parameter and applicable averaging periods. Table 9-19 makes note of the applicable averaging periods.

As discussed in Section 7, Table 9-20 illustrates the direct connection between the stated ELVs and the monitoring methodology. Specifically, where continuous emission monitoring instrumentation is considered to be representative of emission quality, the ELV is commonly linked to an average concentration calculated over some specified monitoring period. The ELV is also set considering normal fluctuations in operating conditions that may affect emission quality, and must be set such that the ELV is protective of human health and the environment in all cases. CEMs produce a significant

volume of data and permit the application of statistical methodologies in determining the appropriate ELV for any given parameter. Most commonly, simple averaging techniques are used, such as one half hour average or daily average. These are reflected for certain parameters in Table 9-20.

Where periodic 'stack' testing is conducted as the representative method for obtaining compliance data, the results are typically averaged over the number of replicate sample runs completed during the test. ELVs that are based on a single stack survey made up of three individual sampling runs. An average can be inferred; however, as it is common for replicate tests on larger stacks to take a day or more, and an average over the duration of the test can be calculated. Table 9-20 also indicates where periodic tests form the basis for the ELV.

Monitoring technology is always evolving and consideration should be given to new and innovative monitoring techniques where it can be shown these techniques are reliable and representative of emission quality. Where CEMs can be shown to be equivalent to a periodic monitoring in terms of quality of data, most regulatory agencies are specifying the CEMs could form the basis for the monitoring program. The EPA protocol, SP-11, provides the guidance for demonstrating equivalence between periodic stack sampling results and CEMS results.

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Table 9-19: Comparison of Maximum Allowable Concentration of Pollutants Defined by CCME, BC, Ontario, US, and Europe

Contaminant	Concentration Units	Canadian Council of Ministers of the Environment (CCME) Guidelines (1989)	BC	OLD ONTARIO	OREGON	WASHINGTON	NEW ONTARIO	US EPA 40 CFR Part 60 (May-10-06 Edition) Standards of Performance for Large Municipal Waste Combustors (New Facilities) ^(5,6)	EU Directive 2000/76/EC of the European Parliament And Council on the incineration of waste ⁽⁶⁾
			Emissions Criteria for Municipal Solid Waste Incinerators (1991)	MOE A-7 (February 2004)	OAR 340-230-310 Incinerator Regulations – Emissions Limits for New Facilities (April, 2010)	WAC 173-434-130 Emission Standards for Large Combustion and Incineration Units (2003)	Guideline A-7 (October 2010)		
Total Particulate Matter (TPM)	mg/Rm ³ @ 11% O ₂	20 ⁽¹⁾	20	17	18	32	14	14.0	9.22 ⁽¹²⁾
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	260 ⁽²⁾	250	56	53 ⁽¹⁷⁾	92 ⁽²²⁾	56	55.0 ⁽⁷⁾	45.82 ⁽¹²⁾
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	75 or 90% removal ⁽¹⁾	70	27	30 ⁽¹⁸⁾	52 ⁽²²⁾	27	26.1 ⁽⁸⁾	9.22 ⁽¹²⁾
Nitrogen Oxides (NO _x) (as NO ₂)	mg/Rm ³ @ 11% O ₂	400 ⁽²⁾	350	207	270	N. Def.	198	197.5 ⁽⁹⁾	183.22 ⁽¹²⁾
Carbon Monoxide (CO)	mg/Rm ³ @ 11% O ₂	57 (114 for RDF Systems) ⁽¹⁾	55 (14)	N. Def.	N. Def.	N. Def.	40	41 to 200 ⁽¹⁰⁾	45.82 ⁽¹²⁾
Cadmium (Cd)	µg/Rm ³ @ 11% O ₂	100 ⁽²⁾	100 ⁽¹⁵⁾	14	14	N. Def.	7	7.0	N. Def.
Lead (Pb)	µg/Rm ³ @ 11% O ₂	50 ⁽²⁾	50 ⁽¹⁵⁾	142	140	N. Def.	60	98.0	N. Def.
Mercury (Hg)	µg/Rm ³ @ 11% O ₂	20 ⁽³⁾	200 ⁽¹⁵⁾	20	35 ⁽¹⁹⁾	N. Def.	20	35.0	45.83 ⁽¹³⁾
Cd + Tl	µg/Rm ³ @ 11% O ₂	N. Def.	N. Def..	N. Def.	N. Def.	N. Def.	N. Def.	N. Def.	45.83 ⁽¹³⁾
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	µg/Rm ³ @ 11% O ₂	N. Def.	N. Def.	N. Def.	N. Def.	N. Def.	N. Def.	N. Def.	458.13 ⁽¹³⁾
PCDD/F TEQ (Dioxins and Furans)	ng/Rm ³ @ 11% O ₂	0.08 ⁽⁴⁾	0.5 ⁽¹⁶⁾	0.08	25 ⁽²⁰⁾	N. Def.	0.08	9.1 ⁽¹¹⁾	0.092
Organic Matter (as Methane)	mg/Rm ³	N. Def.	N. Def.	65.6	N. Def.	N. Def.	33	N. Def.	N. Def.
Opacity	%	5	5		10	5	5 (2 hour avg) and 10 (6 minute avg)	10	

NOTES:

- N. Def. = Not Defined
- Concentration Units: Mass per reference cubic metres corrected to 11% oxygen and 0% moisture. Reference conditions: 25°C, 101.3 kPA, except British Columbia which is based on 20°C
- (1) CCME Operating and Emissions Guidelines for MSW Incinerators Report CCME-TS/WM-TRE003, June 1989. Table 4.2: Stack Discharge Limits (at 11% O₂)
- (2) CCME Operating and Emissions Guidelines for MSW Incinerators Report CCME-TS/WM-TRE003, June 1989. Table 4.3: Anticipated Emissions from MSW Incinerators
- (3) CCME Canada-Wide Standards for Mercury Emissions (2000)
- (4) CCME Canada-Wide Standards for Dioxins and Furans (2001) - 2007 review determine no need to update
- (5) Large' = Large MWC units with an individual MWC capacity greater than 250 tons/d
- (6) Units have been converted to Ontario MOE A-7 concentration units to allow direct comparison
- (7) Or 80% reduction by weight or volume of potential SO₂ emissions, whichever is less stringent
- (8) Or 95% reduction of potential HCl emissions by weight, whichever is less stringent
- (9) 180 ppm_{dv} @ 7% O₂ for 1st year of operation, 150 ppm_{dv} @ 7% O₂ after 1st year of operation
- (10) CO limit varies per technology: 40 mg/Rm³ @11% O₂ for Modular Starved-Air & Excess Air Unit; 200 mg/Rm³ @11% O₂ for Spreader Stoker Refuse-derived fuel
- (11) Limit not comparable to Canadian and European limits. Dioxins/furans on total mass basis measured as tetra- through octachlorinated dibenzo-p-dioxins and dibenzofurans. Not TEQ values
- (12) Daily average value
- (13) Average values over the sample period of a minimum of 30-minutes and a maximum of 8 h
- (14) For RDF systems the limit shall be 110 mg/m³
- (15) The concentration is total metal emitted as solid and vapour
- (16) Expressed as Toxicity Equivalents. The value shall be estimated from isomer specific test data and toxicity equivalency factors by following a procedure approved by the ministry
- (17) Or 25% of the potential SO₂ emission concentration (75% reduction by weight or volume), whichever is less stringent.
- (18) Or 5% of the potential HCl emission concentration (95% reduction by weight or volume), whichever is less stringent.
- (19) Or 15% of the potential mercury emission concentration (85% reduction by weight), whichever is less stringent.
- (20) Total mass. Applies to municipal waste combustor units that employ electrostatic precipitator-based emission control system. If electrostatic precipitator-based emission controls are not employed, 15 ng per dry m³ (total mass) @ 7% O₂.

Table 9-20: Permitted Emission Limit Values from Various Existing and Proposed Facilities Worldwide

Component	Unit	Metro Vancouver WTE Facility (Canada)	Durham/York Facility Proposed ^[1] (Canada)	SEMASS Boiler No. 3 (US) ^[3]	Spittelau (Austria) ^[10]		Zisterdorf (Austria) ^[10]		SITA Isle of Man Incinerator ^[2]			Linz (Austria) ^[7]	I/S Reno-Nord WTE (Denmark) Facility ^[5]			SELCHP (England) ^[6]	TREA Breisgau (Germany) ^[8]			Coventry WTE Facility (UK) (2009 Permit) ^[9]			Lungsjoverket (Sweden) ^[11]	
					Half Hour Average	Periodic	Half Hour Average	Periodic	Half Hour Average	Daily Average	Periodic	Half Hour Average	Daily Average	Periodic	Daily Average	Daily Average	Periodic	Half Hour Average	Daily Average	Periodic	Half Hour Average	Daily Average	Hourly Average	8 Hour Average
Total Particulate Matter	mg/m ³	20	9.2	19.6	14.0		7.5		28.0	9.3		4.7	9.3		9.3	4.7		28.0	9.3	28.0	9.3			
CO	mg/m ³	55	45.8	124.9	93.2		46.6		93.2	46.6					46.6			93.2	46.6	93.2				
SO ₂	mg/m ³	200	35.6	55.0	37.3		18.6		186.3	46.6		37.3	18.6		46.6	9.3		186.3	46.6	186.3	46.6			
NO _x	mg/m ³	350	123.1	245.0	93.2		65.2		372.7	186.3		55.9			186.3	65.2		372.7	167.7	372.7	139.8			
HCl	mg/m ³	55	9.2	27.0	18.6		6.5		55.9	9.3		6.5	4.7		9.3	4.7		55.9	9.3	55.9	9.3			
HF	mg/m ³	3			0.7		0.3				1.9	0.28	0.9							1.9				
TOC	mg/m ³					18.6		7.5	18.6	9.3		7.5			9.3	4.7		18.6	9.3	18.6	9.3			
Methane	mg/m ³	40	49.8																					
As	mg/m ³	0.004																						
Cr	mg/m ³	0.01																						
Hg	mg/m ³	0.2	0.015	0.020		0.093		0.047			0.047			0.047		0.009				0.047				
Cd	mg/m ³	0.1	0.007	0.029		0.093		0.009																
Cd,Tl	mg/m ³		0.047								0.047			0.047			0.009			0.047				
Pb	mg/m ³	0.05	0.051	0.313																				
Sum of As, Ni, Co, Pb, Cr, Cu, V, Mn, Sb	mg/m ³		0.47								0.47			0.47			0.093			0.47				
Dioxins/Furans I-TEQ	ng/m ³	0.5	0.061	22.9 ^[4]				0.093			0.093			0.093			0.047			0.093		0.093		

NOTES:
 N. Def. = Not Defined
 Concentration Units: Mass per reference cubic metres corrected to 11% oxygen and 0% moisture. Reference conditions: 20°C, 101.3 kPa,
 (1) Submitted to the Regions of Durham York from Covanta Energy Corporation.
 (2) SITA Isle of Man Annual Public Report 2008.
 (3) SEMASS Resource Recovery Facility Technology Description and Performance History
 (4) ng/Ncm (tetra-octa) - not comparable to TEQ values (same conditions except 0 degrees C)
 (5) Jeff Harnly. Europe's Continued Progress with Waste to Energy. Xcel Energy. (periodic measurements over a period of a minimum of 30 minutes and a maximum of 8 hours except dioxins/furans which is over a minimum of 6 hours and a maximum of 8 hours)
 (6) Obtained from <http://www.selchp.com/emissions.asp>.
 (7) Federal Environment Agency. 2009. Presentation entitled "Waste Management in Austria, How to Avoid Wasting Waste".
 (8) Jeff Harnly. Europe's Continued Progree with Waste to Energy. Xcel Energy. (periodic measurements over a period of a minimum of 30 minutes and a maximum of 8 hours except dioxins/furans which is over a minimum of 6 hours and a maximum of 8 hours)
 (9) Environment Agency. 2009. The CSWDC Waste to Energy Plant Permit Number NP3739PD.
 (10) Federal Environment Agency - Austria. 2002. State of the Art for Waste Incineration Plants.
 (11) LJUNGSJÖVERKET - PHASE 2 Waste Incineration Plant. Volund Systems Waste and Energy Technologies.

Table 9-21: Overview of Key Jurisdictions Emission Criteria and Limits with Respect to Averaging Periods

Contaminant	Concentration Units	British Columbia Emission Criteria for Municipal Solid Waste Incineration (1991)			US EPA Emissions Criteria for Large Municipal Waste Combustors (May 10, 2006) (8)			European Union Waste Incineration Directive (2000)			Ontario MOE A-7 (October 2010)	
		Facilities Processing >400 kg/h	Average Period	Monitoring Method	New Large Facilities	Averaging Period	Monitoring Method	Daily Average (CEMS) (14)	Half Hourly (100%) (CEMS) (9)	Half Hourly (97%) (CEMS) (10)	In-Stack Emission Limit	Verification of Compliance (15) Period
Total Particulate Matter (TPM)	mg/Rm ³ @ 11% O ₂	20	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	14.2			9.3	28	9	13.0	Results from compliance source testing or calculated as the rolling arithmetic average of four (4) hours of data before dilution with any other gaseous stream, measured by a continuous emission monitoring system that provides data at least once every fifteen minutes.
Carbon Monoxide (CO)	mg/Rm ³ @ 11% O ₂	55	4-hour rolling average	Continuous Monitoring	42-203 (6)			46.6	93.2 or 139.8 (1)		37.3	Calculated as the rolling arithmetic average of four (4) hours of data at the outlet of the piece of equipment where combustion of the gas stream resulting from thermal treatment of waste is completed but before dilution with any other gaseous stream, measured by a continuous emission monitoring system that provides data at least once every fifteen minutes.
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	250	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	56 (3)			46.6	186	47	52.2	Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes.
Nitrogen Oxides (NO _x as NO ₂)	mg/Rm ³ @ 11% O ₂	350	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	201 (5)			186.3	373	186	184.5	Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes.
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	70	8-hour rolling average	Continuous Monitoring	26.5 (4)			9.3	56	9	25.2 (2)	Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes.
Hydrogen Fluoride (HF)	mg/Rm ³ @ 11% O ₂	3	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	N.D.			0.93 (12)	3.7 (12)	1.9 (12)	N.D.	
Total Hydrocarbons (as CH ₄)	mg/Rm ³ @ 11% O ₂	40	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	N.D.			N.D.	N.D.	N.D.	N.D.	
Organic Matter (as CH ₄)	mg/Rm ³ @ 11% O ₂	-	N.D.	N.D.	N.D.			N.D.	N.D.	N.D.	30.7	Results from compliance source testing or calculated as the rolling arithmetic average of 10 minutes of data at the outlet of the piece of equipment where combustion of the gas stream resulting from thermal treatment of waste is completed but before dilution with any other gaseous stream takes place, measured by a continuous emission monitoring system that provides data at least once every minute.
VOCs (as Total Organic Carbon)	mg/Rm ³ @ 11% O ₂	-	N.D.	N.D.	N.D.			9.3	19	9.3	N.D.	
Arsenic (As)	µg/Rm ³ @ 11% O ₂	4	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	N.D.			N.D.			N.D.	
Cadmium (Cd)	µg/Rm ³ @ 11% O ₂	100	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	7.1			N.D.			6.5	Calculated as the arithmetic average of three stack tests conducted in accordance with standard methods
Chromium (Cr)	µg/Rm ³ @ 11% O ₂	10	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	N.D.			N.D.			N.D.	
Lead (Pb)	µg/Rm ³ @ 11% O ₂	50	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	99.7			N.D.			55.9	Calculated as the arithmetic average of three stack tests conducted in accordance with standard methods

Contaminant	Concentration Units	British Columbia Emission Criteria for Municipal Solid Waste Incineration (1991)			US EPA Emissions Criteria for Large Municipal Waste Combustors (May 10, 2006) (8)			European Union Waste Incineration Directive (2000)	Ontario MOE A-7 (October 2010)	
Cadmium (Cd) and Thallium (Tl)	µg/Rm ³ @ 11% O ₂	-	N.D.	N.D.	N.D.			47 (non continuous - average over period of min. 30 minutes and max. 8 hours) (11) (13)	N.D.	
Mercury (Hg)	µg/Rm ³ @ 11% O ₂	200	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	35.6			47 (non continuous - average over period of min. 30 minutes and max. 8 hours) (11) (13)	18.6	Calculated as the arithmetic average of 24 hours of data measured by as CEMS that provides data every 15 minutes
Sum of Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V	µg/Rm ³ @ 11% O ₂	-	N.D.	N.D.	N.D.			470 (non continuous - average over period of min. 30 minutes and max. 8 hours) (11) (13)	N.D.	
Chlorophenols	µg/Rm ³ @ 11% O ₂	1	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	N.D.			N.D.	N.D.	
Chlorobenzenes	µg/Rm ³ @ 11% O ₂	1	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	N.D.			N.D.	N.D.	
Polycyclicaromatic Hydrocarbons	µg/Rm ³ @ 11% O ₂	5	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	N.D.			N.D.	N.D.	
Polychlorinated Biphenyls	µg/Rm ³ @ 11% O ₂	1	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	N.D.			N.D.	N.D.	
Total PCDD/F TEQ (Dioxins and Furans)	ng/Rm ³ @ 11% O ₂	0.5	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager	9.3 (7)			0.093 (non continuous - average over min. 6 hours and max. 8 hours) (11) (13)	0.075	Results from compliance source testing; results expressed as I-TEQ.
Opacity	%	5	1-hour average from data taken every 10 seconds	Continuous Monitoring	10			N.D.	10% and 5%	(10%) calculated as the rolling arithmetic average of six (6) minutes of data measured by a continuous emission monitoring system that provides data at least once every minute or (5%) calculated as the rolling arithmetic average of two (2) hours of data measured by a continuous emission monitoring system that provides data at least once every fifteen minutes

NOTES:

Concentration units: Mass per reference cubic metres corrected to 11% oxygen. Reference conditions: 20 deg. C, 101.3 kPa, dry gas

N.D. = Not Defined

(1)139.8 if 95% of all measurements determined as 10-minute average values or 93.2 determined as half-hourly values taken in any 24 hour period (exemptions may be authorized by the competent authority for incineration plants using fluidized bed technology, provided that the permit foresees an emission limit value for carbon monoxide (CO) of not more than 93.2 mg/m³ as an hourly average value.)

(2) Or an HCl removal efficiency of not less than 95%

(3) or 80% reduction by weight or volume of potential SO₂ emissions, whichever is less stringent

(4) or 95% reduction of potential HCl emissions by weight, whichever is less stringent

(5) 180 ppm_{dv} @ 7% O₂ for the 1st year of operation, 150 ppm_{dv} @ 7% O₂ after 1st year of operation

(6) CO limit varies per technology: 40 mg/Rm³ @ 11% O₂ for Modular Starved-Air and Excess Air Unit; 200 mg/Rm³ @ 11% O₂ for Spreader Stoker Refuse-derived fuel.

(7) Limit not comparable to Canadian or European limits. Dioxins/furans on a total mass basis measured as tetra- through octachlorinated dibenzo-p-dioxins and dibenzofurans. Not TEQ values.

(8) 'Large' = Large MWC units with an individual MWC capacity greater than 250 tons/day

(9) None of the half-hourly values exceeds any of the emission limit values set out.

(10) 97% of the half-hourly average values over a year do not exceed any of the emission limit values set out.

(11) At least two measurements per year; one measurement at least every three months shall however be carried out for the first 12 months of operation.

(12) The continuous measurements of HF may be omitted if treatment stages for HCl are used which ensure that the emission limit value for HCl is not being exceeded. In this case the emissions of HF shall be subject to periodic measurements as laid down in (11).

(13) The reduction in the frequency of the periodic measurements from twice a year to once every year may be authorized by the competent authority provided that the emissions are below 50% of the emission limit values.

(14) No more than five half-hourly average values in any day shall be discarded due to malfunction or maintenance of the CEMS. No more than ten daily average values per year shall be discarded due to malfunction or maintenance of the CEMS.

(15) Compliance source testing as set out in the facility's Certificate of Approval.

9.3 Application of Emission Limits in BC

9.3.1 Setting Objectives and Standards for Existing and New Facilities

As discussed in the sections above, the regulatory review process in BC includes a combination of processes that may be triggered according to size of the WTE facility. In BC, these limits are to be determined in accordance with the guidance provided by the province's interim Best Achievable Technology (BAT) policy. In brief summary, the BAT policy requires the setting of limits based on what is technically and economically feasible and in general accordance with accepted practice at other similar facilities. Governing the emissions to atmosphere, however, is the EMA and associated codes of practice, regulations and guidelines (used as the basis for setting permit limits or for WTE facilities limits within SWMPs). The regulatory framework in BC currently utilizes the 1991 British Columbia Criteria for Municipal Solid Waste Incinerators as well as the BC Air Quality Objectives (last amended in April 2009). Emission guidelines and air quality objectives are non-statutory limits that are used by the regulatory agencies to guide decisions with respect to allowable concentrations of air pollutants in the discharge and ambient air.

The current system has been in place for many years and in general is functioning satisfactorily. The MSW Criteria specify the general conditions for which these facilities must be operated, but it is the permit or the SWMP that determines the average and maximum permissible point source concentrations of contaminants that may be discharged. These point source limits are based on the various guidelines directly for point source emissions, and indirectly for impacts to ambient air quality.

9.3.2 Operational Variability

All industrial processes have some variability. Specifically with WTE combustion technology, variability is inherent in the process and in the incoming MSW material stream, and the control of the facility operating conditions is the mandate of the operators so that the emission quality (and other operational parameters) is met. Operators try to minimize the variability of the process to provide a higher quality operation, but some variability in the operation and emission quality is certain.

In the combustion sector, particularly for WTE, there is a difference between the absolute minimum concentrations of emission constituents that will be released from the facility during periods of normal operating conditions and those greater concentrations that can be 'reasonably' expected to be produced during brief periods of operational and/or material stream flux. Well designed, maintained and operated facilities are able to achieve the lower emission values a large proportion of the time, generally over 95% of the time, potentially approaching 97% or more. During periods of upset conditions, however, such as during some upset in combustion or in the treatment works, the concentration of emissions may increase over a short period of time until the issue is resolved and normal conditions return. The frequency and magnitude of this variance is facility-specific and is mitigated to the extent possible by the use of CEMs to constantly monitor operating conditions and in the design of the facility and air pollution control systems.

As a result, some jurisdictions have addressed the need to set regulatory emissions limits that reflect not only BAT but the expectations for performance under both normal and upset conditions, and monitoring methods, by applying averaging periods for the emissions of various parameters and expectations on how emissions would be monitored in order to demonstrate compliance.

9.3.3 Setting Emission Limits

The regulator desires to regulate the discharge such that:

- a) The emission to atmosphere in all cases does not cause a risk to human health and the environment.
- b) The emission limit imposes an obligation on the operator to achieve the lowest practical emission concentrations for the maximum period of time.
- c) The emission limit is set such that it is achievable by the operator, is reasonable in terms of cost to meet the limit and meets the protective requirements and is consistent with the available monitoring equipment and techniques for a specific parameter.

Best Available Control Technology (BACT) refers to the use of equipment, operational practice and treatment systems to produce an emission that represents the best of technology for the sector. BACT is always changing because of advancements in technology. There is sufficient comparable technology in the WTE sector, as evidenced in our report, to establish BACT-based limits for the WTE sector in BC. In depth studies of BACT for WTE in other jurisdictions undertaken in part to support the establishment of new regulatory limits, indicate that the quality of air emissions from this sector have continually improved over the past 20 years (i.e., lower concentrations are being realized).^[243]

In order to meet the three points above, consideration of a combination of factors, including: emission quality (concentration and/or mass loading to the environment); variability of the emission (frequency and magnitude of the variance); and, monitoring/testing technique limitations, is necessary in the setting of the regulatory limits. Setting a limit too high does not incent the operator to strive to improve emission quality to meet the “best achievable” quality. Setting a limit too low may not be consistently achievable by the operator on a time scale consistent with the operation of the facility. This is the essence of the problem posed with setting limits.

9.3.4 Proposed Approach

The proposed change in regulatory approach suggested as an outcome of the review of WTE technologies, emissions quality from operating WTE and regulatory approaches in other jurisdictions, is based on the consideration of emissions parameters considered suitable as an indicator of facility performance, averaging periods and establishment of monitoring expectations as part of the specified emission limits. BACT would form the basis for the emission limits, and the averaging periods for a specific test would relate to the application of the BACT limit.

²⁴³ Ministry of Housing, Spatial Planning and the Environment. 2002. Dutch Notes on BAT for the Incineration of Waste

In simple terms, we suggest that for any specific parameter, that a maximum concentration “not to be exceeded” be established, representing an emission quality that is consistent with BACT which is also protective of human health and the environment. Concentrations in excess of this amount would be considered non-compliant and would require the facility to undertake immediate mitigation to improve the quality of emission. This approach is consistent with the current method used by BC to regulate air emissions. The difference between the current and proposed approaches is the identification of appropriate values that are specific to averaging periods that reflect both reasonable expectations for performance and the methods that would normally be used to demonstrate compliance.

Two averaging periods would be applicable for most emission parameters, and would be consistent with the approach applied in many jurisdictions where there continues to be significant application of WTE as a means of managing waste:

- a) Application of ½ hour averaging periods for specific parameters that reflect the expectations of performance for a facility under all operating conditions (normal or upset). Such limits would apply only to those parameters that can be continuously monitored, and that should be continuously monitored in order to ensure that expectations for operating performance are achieved.
- b) Application of ‘daily’ averages for a broader range of parameters, that reflect the expectations of performance for a facility under normal operating conditions, as determined through CEM or the averaging of the results from stack (source) testing depending on the parameter.

With respect to policy and perception, we view the use of dual values as the most effective manner to regulate emissions to the most reasonably stringent degree. The maximum value (half-hourly) will be protective in all cases. The statistical or average value (daily) will be even lower in numerical value than the maximum value, illustrating and recognizing that the expected emission quality can be much better than the maximum value on an on-going basis. This approach encourages the industry to install BACT and encourages resolution of operational issues in a timely fashion in order to meet the lowest possible value on an ongoing basis.

The use of average emission concentrations over both short and longer averaging periods is consistent with the regulatory limits in other jurisdictions. As shown in Tables 9-19 and Table 9-20, European Union limits rely on continuous monitors for many parameters and establish the compliance limit on a one-half hour average. As discussed earlier, stack tests generally approximate ‘daily’ averages. In almost no cases are instantaneous values used for compliance.

It is possible to define emission limits in relation to BAT, relative to other jurisdictions and at concentrations protective of human health and the environment in all cases, as set out in Table 9-21, below. Maximum emission concentration limits suggested for application over ½ hourly or daily averaging periods are presented. The suggested averaging periods and the appropriate emission limits considering averaging are consistent with the approach applied in other jurisdictions, and in regards to the majority of parameters are lower than the current emissions limits in effect in BC as these lower limits can be reasonably achieved through BAT.

Waste to Energy

A Technical Review of Municipal Solid Waste Thermal Treatment Practices

Final Report

Section 9: Emission Limits and Their Application

The actual value that would be applied to a given WTE facility, through the application to amend a current permit (e.g., for an upgrade to a current plant) or for a newly proposed facility, would be both parameter and facility based, and should be linked to the ability to sample and monitor the emission and specific facility design. On the basis of current practice in the WTE sector, values for guidance are also provided.

In Table 9-22, where non-continuous measurements are indicated, the averaging period does not apply. Sampling periods are generally in the order of four to eight hours for such measurements and the ELV is reflective of the averaging of the replicate tests over the monitoring period.

It should be recognized that there are distinct differences in regulatory approaches used in jurisdictions where WTE is a common practice. The proposed measures indicated in Table 9-22 are intended to be generally consistent with the approach that has been applied in BC and reflective of the BACT approaches adopted in other jurisdictions. That being said, some discussion is required to reflect some of the key differences in monitoring approaches and the rationale for the choices recommended for BC.

Organic Matter

During the incineration of organic waste, a large number of chemical reactions take place, some of which may be incomplete, based on the efficiency of the combustion process. Emissions of organic parameters depend on the grate and furnace design, and the optimal provision of incineration air, control of temperature, residence time and the homogeneity of the waste stream. This leads to an extremely complex set of organic compounds that may be emitted in very trace amounts. A complete account of every organic substance is usually not available, however, incineration generally can provide for high destruction efficiencies for organic substances. Various jurisdictions have chosen alternative approaches to monitoring the destruction efficiency and quality of the combustion process. Nearly all jurisdictions set limits on CO emissions, as this is a leading indicator of incomplete combustion, and as a rule CO is usually monitored continuously. However, the point of the flue gas management process at which CO concentrations is monitored does vary; it is generally monitored in the 'combustion gases' within the stack in the EU, and in Ontario and the USA it is monitored at the outlet of the equipment where combustion of the gas stream is completed.

For the broad range of organic compounds that can be emitted, there is significant variation in approaches, however in most cases in addition to CO, some form of organic compounds are required to be monitored and reported. In the EU, total organic carbon (TOC) is monitored and reported as the primary determinant of the emissions of volatile organic carbon (VOCs) and non-methane volatile organic carbon (NMVOC) that make up the large part of the compounds that can be measured continuously as a 'group'. Often the regulatory documents for EU jurisdictions make various references to monitoring TOC, VOCs, NMVOC, C_xH_y and organic carbon, but they are all essentially referring to one group of organic compounds measured and reported as TOC. In many cases, in addition to TOC, emissions of individual organic parameters or groups such as PCBs and/or PAHs may be reported, but generally there is no specified ELV for these parameters.

BC has been the only jurisdiction where monitoring and reporting of total Hydrocarbons (as CH₄) has been required, although Ontario has used (and continues to use) a similar approach requiring the monitoring and reporting of organic matter (as CH₄), with the point of monitoring being at the outlet of the equipment where combustion of the gas stream takes place. The US is the only jurisdiction where specific monitoring and reporting of the group of organic compounds that can potentially be emitted, is generally not required either by the EPA or under State standards.

Since 1993, there have been shifts in the composition of the MSW stream. The potential for contamination of MSW with materials containing chlorophenols, chlorobenzenes and PCB's has been significantly reduced through regulation so that the potential presence of these parameters in non-hazardous MSW is extremely low. BC is the only jurisdiction where ELVs have been established and applied to chlorophenols, chlorobenzenes, polycyclic aromatic hydrocarbons and polychlorinated biphenyls, although as noted above, many facilities may voluntarily monitor and report on some or all of these parameters.

Generally, given that CEMs for TOC and CO is considered state of the art, and that both parameters are suitable for the application of both ½ hourly and daily limits, a move to the use of this approach (similar to the EU) is recommended for BC.

Trace Heavy Metals

The regulatory approach for heavy metals also varies significantly between jurisdictions. Generally, jurisdictions in North America, set ELVs for individual metals of specific concern, each generally reflective of a 'class' of metals which can be present in different waste sources and that have differences in their potential speciation and behavior in a WTE facility, requiring different management techniques for effective treatment in the flue gas. All jurisdictions use generally the same approach to regulate Mercury (Hg), setting stack ELVs specific to this heavy metal. It is reasonable to continue to do so in BC, setting the limit at the lowest ELV representative of BACT and achievable by modern plants.

All jurisdictions regulate emissions of Cadmium (Cd) and its compounds, although in the EU cadmium is grouped with Thallium (Tl) and an ELV has been established for this combined group of compounds. Cadmium can be present in electronic devices present in municipal waste. Thallium is generally not present in municipal waste it is generally only present in hazardous waste materials. For municipal waste WTE facilities, it generally does not appear reasonable to set an ELV for the group of Cd, Tl and their compounds, but rather to continue to regulate Cd, setting the limit at the lowest ELV representative of BACT and achievable by modern plants.

All jurisdictions regulate emissions of Lead (Pb) and its compounds, although in the EU, Lead is grouped with a number of similar (less-volatile) heavy metals (Antimony, Arsenic, Chromium, Cobalt, Copper, Manganese, Nickel and Vanadium). This group includes carcinogenic metals and metal compounds as well as metals with toxicity potential. Lead and this group of metals are generally bound in dust due to the vapour pressures of their compounds, as contained in the flue gas (mainly oxides and chlorides). BC was the only jurisdiction noted where individual ELVs were established for Arsenic and Chromium. To summarize, there appears to be a range of approaches that could be

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considered in BC, which in various jurisdictions is considered representative of BACT for Lead and similar heavy metals, including:

- Set an ELV and regulate only Lead emissions, as a leading indicator of the potential emissions of the group of similar heavy metals that have potential carcinogenic and/or toxic potential (similar to the Ontario and US approach).
- Set an ELV that is applicable to the group of similar heavy metals (similar to the EU approach), recognizing that this approach would require monitoring of a number of metal parameters that are currently not required to be monitored in BC, and also recognizing that the concentration of any individual heavy metal in the group could reach up to the ELV and theoretically could reach a higher value than current permitted in the Province.
- Set an ELV that is applicable to the group of current similar heavy metals (Lead, Arsenic, Chromium) that is currently required in the Province, setting the value at the sum total of the current permitted limits for these heavy metals (being 64 ug/Rm^3). This approach represents a 'hybrid' of the EU and current B.C. approaches to regulate these metals.
- Continue to set individual ELVs for each of the specific heavy metals (Lead, Arsenic, Chromium) as indicated in the 1991 Guidelines for BC.

The recommended approach that appears to best serve the Province would be a grouping of the three heavy metals (lead, arsenic and chromium), setting the ELV as the sum total of the ELVs of 64 ug/Rm^3 . Establishing an ELV based on the grouping of these three metals allows for heterogeneity in the fuel while maintaining stringent levels protective of human health and the environment.

Particulate and Opacity

The current approach used in North American jurisdictions to monitor and limit emissions of particulate and the opacity of the flue gas stream which is a more indirect determination of particulate emissions, is to apply an ELV at the stack for total particulate matter as determined through periodic stack testing, and to require the continuous monitoring of opacity in the flue gas. Opacity is not a good determinant of compliance with particulate limits; however it is a leading indicator of potential performance issues with the APC system, particularly performance of the bag-house or other devices used to manage particulate. While in North America, particulate emissions are monitored periodically, there are no requirements for CEMS; rather the use of continuous monitoring devices is optional. Generally, in North America CEMS for particulate are considered to be improved but still evolving to address performance issues experienced with older approaches. In the EU, opacity is not regulated through an ELV, rather emissions of total particulate are regulated based on ELVs with $\frac{1}{2}$ hourly and daily averages based on data gathered through continuous emissions monitoring. Use of CEMS for particulate is regarded as part of the application of BACT for WTE facilities.

It is recommended for BC to adopt a hybrid approach. CEMS for particulate would be required for new facilities. Where continuous monitoring systems for particulate are used, opacity monitoring may not be necessary as a compliance parameter unless the continuous monitoring system is not functioning. During this scenario, opacity monitoring can be used as a temporary surrogate until the continuous monitoring system for particulate is reinstated.

Table 9-22: Proposed Revisions to Emission Criteria for Municipal Solid Waste Incineration in British Columbia

Contaminant	Concentration Units	RECOMMENDED EMISSION LIMITS					CURRENT EMISSION LIMITS (1991)		
		C: Continuous P: Periodic ⁽¹⁾	Daily Average	Average Period and Monitoring Method	Half Hourly Average	Average Period and Monitoring Method	Facilities processing >400 kg/h	Average Period	Monitoring Method
Total Particulate Matter (TPM)	mg/Rm ³ @ 11% O ₂	C (P for existing facilities)	9	Existing facilities without CEMS may use the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods. This limit also applies to facilities with CEMS where periodic stack testing is conducted to validate the CEMS or in the event the CEMS is not functional.	9 ⁽²⁾ 28	1/2 hour average as determined by a continuous emissions monitoring system, achieved 97% of the operating period on a 12 month rolling average. 1/2 hour average as determined by a continuous emissions monitoring system, achieved 100% of the operating period on a 12 month rolling average.	20	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Carbon Monoxide (CO)	mg/Rm ³ @ 11% O ₂	C	50	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	100	1/2 hour average as determined by a continuous emissions monitoring system	55	4-hour rolling average	Continuous Monitoring
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	C	50	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	190	1/2 hour average as determined by a continuous emissions monitoring system	250	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Nitrogen Oxides (NO _x as NO ₂)	mg/Rm ³ @ 11% O ₂	C	190	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	350	1/2 hour average as determined by a continuous emissions monitoring system	350	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	C	10	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	60	1/2 hour average as determined by a continuous emissions monitoring system	70	8-hour rolling average	Continuous Monitoring
Hydrogen Fluoride (HF)	mg/Rm ³ @ 11% O ₂	P/C	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	4	1/2 hour average as determined by a continuous emissions monitoring system ⁽³⁾ .	3	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Total Hydrocarbons (expressed as equivalent CH ₄) ⁽⁴⁾	mg/Rm ³ @ 11% O ₂	N.D.	N.D.		N.D.		40	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Total Organic Carbon	mg/Rm ³ @ 11% O ₂	C	10	Calculated as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	20	1/2 hour average as determined by a continuous emissions monitoring system	N.D.		
Arsenic (As)	µg/Rm ³ @ 11% O ₂	P	See Pb, As and Cr grouping	Calculated as the sum of Pb, As and Cr, as determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.		4	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Cadmium (Cd)	µg/Rm ³ @ 11% O ₂	P	7	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.		100	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager

Contaminant	Concentration Units	RECOMMENDED EMISSION LIMITS					CURRENT EMISSION LIMITS (1991)		
		C: Continuous P: Periodic ⁽¹⁾	Daily Average	Average Period and Monitoring Method	Half Hourly Average	Average Period and Monitoring Method	Facilities processing >400 kg/h	Average Period	Monitoring Method
Chromium (Cr)	µg/Rm ³ @ 11% O ₂	P	See Pb, As and Cr grouping	Calculated as the sum of Pb, As and Cr, as determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.		10	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Lead (Pb)	µg/Rm ³ @ 11% O ₂	P	See Pb, As and Cr grouping	Calculated as the sum of Pb, As and Cr, as determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.		50	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Sum of Lead (Pb), Arsenic (As), Chromium (Cr)	µg/Rm ³ @ 11% O ₂	P	64	Calculated as the sum of Pb, As and Cr, as determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.		50	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Mercury (Hg)	µg/Rm ³ @ 11% O ₂	P or C ⁽⁴⁾	20	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	N.D.		200	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Chlorophenols ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.		1	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Chlorobenzenes ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.		1	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Polycyclicaromatic Hydrocarbons ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	5	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.		5	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Polychlorinated Biphenyls ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.		1	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Total Dioxins and Furans (as PCDD/F TEQ)	ng/Rm ³ @ 11% O ₂	P	0.08	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.		0.5	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Opacity ⁽⁶⁾	%	C (P optional for existing facilities)	N.D.		5	1/2-hour average from data taken every 10 seconds, measured by a CEMS	5	1-hour average from data taken every 10 seconds	Continuous Monitoring

NOTES:

Concentration units: Mass per reference cubic metres corrected to 11% oxygen. Reference conditions: 20°C, 101.3 kPa, dry gas

N.D. = Not Defined

⁽¹⁾ Where Periodic stack test measurements (P) are indicated, the daily averaging period applies. For Continuous monitoring (C), the 1/2 hour averaging period applies. P/C indicates both technologies are available; ELV will be linked to sampling method.

⁽²⁾ 97% of the half-hour average values over an annual rolling average will not exceed 9 mg/Rm³. 100% of the half-hour average values will not exceed 28 mg/Rm³.

⁽³⁾ This requirement may be omitted at the discretion of the Regional Manager should treatment stages for HCl demonstrate that the ELV for HCl is not exceeded.

⁽⁴⁾ Daily Average ELV for mercury applies regardless of monitoring method.

⁽⁵⁾ Proponents may be able to demonstrate that monitoring both Total Organic Carbon (TOC) and Total Dioxin and Furans could negate the need to monitor Chlorophenols, Chlorobenzenes, Polycyclic Aromatic Hydrocarbons and Polychlorinated Biphenyls.

⁽⁶⁾ Opacity will not be required for compliance purposes for facilities utilizing continuous particulate monitoring systems. Opacity monitoring is recommended for operational monitoring purposes. However, monitoring opacity can be used as a temporary surrogate for total particulate monitoring in the event a particulate monitoring system failure. Under these circumstances, the ELV of 5% opacity over a 1/2 hour averaging period should apply.

Table 9-23 summarizes the rationale for recommended values for the ½ hourly or daily averaging periods as set out in Table 9-22.

Table 9-23: Rationale for Recommended Values for the ½ Hourly or Daily Averaging Periods

Parameter	Rationale for Daily Average	Rationale for ½ Hourly Average
TPM	<p>The 1991 BC Criteria limit is 20 mg/Rm³ on a daily basis with compliance based on manual stack testing.</p> <p>The new proposed limit would be 10 mg/Rm³ on a daily basis using a CEM system. This is similar to the EU standard and is stricter than the EPA and Ontario standards.</p>	<p>The 1991 BC criteria limit is 20 mg/Rm³ with compliance based on manual stack testing, which typically occurs quarterly each year. The proposed limits are consistent with the EU ½ hourly averages which are coupled to CEM monitoring. Thus, compliance is determined every half hour.</p> <p>The limit of 9 mg/Rm³ is based on ½ hour averages throughout the year, to be achieved 97% of the time, as an annual rolling average. During rare occasions when upsets in the process or treatment systems cause the 9 mg/Rm³ limit to be exceeded the upper limit of 28 mg/Rm³ is never to be exceeded. Thus, even when emission control systems require service, the 28 mg/Rm³ limit would remain in effect.</p> <p>Comparing the 1991 and proposed emission limits for particulate is difficult because they are monitored in completely different ways. The use of a CEM ensures that emissions are maintained at low levels on a consistent basis, whereas limits based on manual stack sampling do not have such assurance. That said, it is reasonable to suggest that a course comparison of the 20 mg/m³ limit to the proposed limit of 9 mg/Rm³ is a reasonable benchmark comparison. Thus, the new proposed limit is considerably more stringent than the one set in 1991.</p>
CO	<p>The 1991 BC Criteria limit is 55 mg/Rm³ on a daily basis with compliance based on a CEM system.</p> <p>The new proposed limit would be 50 mg/Rm³ on a daily basis using a CEM system. This is similar to the Ontario, EPA and EU standards.</p>	<p>The 1991 BC Criteria limit is 55mg/Rm³ on a daily basis with compliance based on a CEM system.</p> <p>There would also be a new proposed limit of 100 mg/Rm³ on a ½ hourly basis using a CEM system. This would provide a stricter control on maximum allowable emissions. This is similar to the EU standard.</p>
SO ₂	<p>The 1991 BC Criteria limit is 250 mg/Rm³ on a daily basis with compliance based on a CEM system.</p> <p>The new proposed limit would be 50 mg/Rm³ on a daily basis using a CEM system. This is similar to the Ontario, EPA, and EU standards.</p>	<p>The 1991 BC Criteria limit is 250 mg/Rm³ on a daily basis with compliance based on a CEM system.</p> <p>There would also be a new proposed limit of 190 mg/Rm³ on a ½ hourly basis using a CEM system. This would provide a stricter control on maximum allowable emissions. This is similar to the EU standard.</p>

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Parameter	Rationale for Daily Average	Rationale for ½ Hourly Average
NO _x as NO ₂	<p>The 1991 BC Criteria limit is 350 mg/Rm³ on a daily basis with compliance based on a CEM system.</p> <p>The new proposed limit would be 190 mg/Rm³ on a daily basis using a CEM system. This is stricter than the Ontario and EPA standards and similar to the EU standard.</p>	<p>The 1991 BC Criteria limit is 350 mg/Rm³ on a daily basis with compliance based on a CEM system.</p> <p>There would also be a new proposed limit of 350 mg/Rm³ on a ½ hourly basis using a CEM system. This would provide a stricter control on maximum allowable emissions. This is stricter than the EU standard.</p>
HCl	<p>The 1991 BC Criteria limit is 70 mg/Rm³ on a daily basis with compliance based on manual stack testing.</p> <p>The new proposed limit would be 10 mg/Rm³ on a daily basis using a CEM system. This is stricter than the Ontario and EPA standards and similar to the EU standard.</p>	<p>The 1991 BC Criteria limit is 70 mg/Rm³ on a daily basis with compliance based on manual stack testing.</p> <p>There would also be a new proposed limit of 60 mg/Rm³ on a ½ hourly basis using a CEM system. This would provide a stricter control on maximum allowable emissions. This is similar to the EU standard.</p>
HF	<p>The 1991 BC Criteria limit is 3 mg/Rm³ on a daily basis with compliance based on manual stack testing.</p> <p>The new proposed limit would be 1 mg/Rm³ on a daily basis using a CEM system. This is similar to the EU standard.</p>	<p>The 1991 BC Criteria limit is 3 mg/Rm³ on a daily basis with compliance based on manual stack testing.</p> <p>There would also be a new proposed limit of 4 mg/Rm³ on a ½ hourly basis using a CEM system. This would provide a stricter control on maximum allowable emissions. This is similar to the EU standard.</p>
Organic Matter as CH ₄	<p>NA – the parameters, organic matter, total hydrocarbons, and TOC are all primarily indicators of combustion efficiency although they may be monitored at different points of the process. A stack emission limit is not recommended for Organic Matter as the most appropriate monitoring point is at the outlet of the point of the process where combustion of the gas stream is completed. A stack emission limit is only being recommended for TOC.</p>	<p>NA – no value proposed. While regulation of emissions of organic matter at the outlet of the equipment where combustion of the gas stream takes place is a means of monitoring combustion efficiency, monitoring of TOC as discussed below can be accomplished through the use of CEMs and is consistent with BACT in the EU.</p>
Total Hydrocarbons (as CH ₄)	<p>NA – see organic matter rationale – no value proposed. The 1991 BC Criteria limit is 40 mg/Rm³ on a daily basis with compliance based on manual stack testing.</p> <p>A regulatory limit for hydrocarbons is best addressed through limits on Volatile Organic Compounds (see VOCs below).</p>	<p>NA – no value proposed. A regulatory limit for hydrocarbons is best addressed through limits on Volatile Organic Compounds (see VOCs below).</p>
TOC	<p>Consistent (rounded) with EU daily average.</p>	<p>Consistent (rounded) with EU ½ hourly values achieved 100% of the time.</p>

Parameter	Rationale for Daily Average	Rationale for ½ Hourly Average
As	<p>The 1991 BC Criteria limit is 0.004 mg/Rm³ with compliance based on manual stack testing.</p> <p>The new proposed limit would be on a class basis for As/Cr/Pb which exhibit similar properties, the limit would be set at 0.064 mg/Rm³. This approach is similar to EU standard (EU class basis includes Sb, As, Pb, Cr, Co, Cu, Mn, Ni, and V); no other jurisdictions have set a standard for arsenic.</p>	NA
Cd	<p>The 1991 BC Criteria limit is 0.1 mg/Rm³ with compliance based on manual stack testing.</p> <p>New proposed limit would be 0.014 mg/Rm³ which is the same as the Ontario standard. This limit is stricter than the EPA standard; the EU sets a combined limit for cadmium and thallium.</p>	NA
Cr	<p>The 1991 BC Criteria limit is 0.01 mg/Rm³ with compliance based on manual stack testing.</p> <p>The new proposed limit would be class basis for As/Cr/Pb which exhibit similar properties, the limit would be set at 0.064 mg/Rm³. This approach is similar to EU standard (EU class basis includes Sb, As, Pb, Cr, Co, Cu, Mn, Ni, and V); no other jurisdictions have set a standard for chromium.</p>	NA
Pb	<p>The 1991 BC Criteria limit is 0.05 mg/Rm³ with compliance based on manual stack testing.</p> <p>The new proposed limit would be class basis for As/Cr/Pb which exhibit similar properties, the limit would be set at 0.064 mg/Rm³. This approach is similar to EU standard (EU class basis includes Sb, As, Pb, Cr, Co, Cu, Mn, Ni, and V); Ontario is the only other jurisdiction to set a proposed limit for lead this limit has yet to be included in a final authorization.</p>	NA
Mercury	<p>The 1991 BC Criteria limit is 0.2 mg/Rm³ with compliance based on manual stack testing.</p> <p>New proposed limit would be 0.02 mg/Rm³ is consistent with the CCME Canada Wide Standard and Ontario standard. The proposed limit is stricter than the EPA and EU standards.</p>	NA

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Parameter	Rationale for Daily Average	Rationale for ½ Hourly Average
Chlorophenols	The 1991 BC Criteria limit is 1 ug/Rm ³ with compliance based on manual stack testing. The new proposed limit remains the same, other jurisdictions (e.g., EPA, EU) do not have a set limit for chlorophenols.	NA
Chlorobenzenes	The 1991 BC Criteria limit is 1 ug/Rm ³ with compliance based on manual stack testing. The new proposed limit remains the same, other jurisdictions (e.g., EPA, EU) do not have a set limit for chlorobenzenes.	NA
PAHs	The 1991 BC Criteria limit is 5 ug/Rm ³ with compliance based on manual stack testing. The new proposed limit remains the same, other jurisdictions (e.g., EPA, EU) do not have a set limit for PAH's.	NA
PCBs	The 1991 BC Criteria limit is 1 ug/Rm ³ with compliance based on manual stack testing. The new proposed limit remains the same, other jurisdictions (e.g., EPA, EU) do not have a set limit for PCBs.	NA
Total PCDD/F TEQ	The 1991 BC Criteria limit is 0.5 ng/Rm ³ with compliance based on manual stack testing. New proposed limit would be 0.08 ng/Rm ³ is consistent with the CCME Canada Wide Standard and Ontario standard. The proposed limit is stricter than the EPA and EU standards.	NA
Opacity	NA	The 1991 BC Criteria limit is 5% on a 1 hour average with compliance based on CEM measurements every 10 seconds. The proposed limit is 5%, also based on CEM, on a 1/2 hour basis. This parameter would be a backup to particulate monitoring in the event that the CEM systems were unavailable. The proposed limit is consistent with Ontario and EPA standards.

Comparison to the Permitted Values and Monitoring Approach for the Burnaby WTE Facility

In order to demonstrate the viability of the proposed regulatory approach for WTE emissions in BC, it is reasonable to conduct a comparison to the extent possible to the current permitted limits and actual emissions data for the only operating WTE facility in the Province. Table 8-7 provides an overview of the permitted air emissions limits as applied to the WTE facility in Burnaby and actual emissions reported as of 2007.

Note: as a point of interest, application of the MACT approach as used in the USA, results in the setting of regulatory emissions limits based on the emissions from the top percentage of existing facilities. This approach could not be easily used in BC given that there is currently only one operating plant. However, comparison of the emissions from the Burnaby plant to the proposed emissions limits is reasonable.

Note, that the proposed ½ hour and 24 hour emissions limits are not directly comparable to the current permits and performance of the Burnaby WTE facility. The permitted discharge limits for the Burnaby plant are generally applied as a 'not to exceed' limit which is closer the proposed ½ hour limits for emissions (to be achieved 100% of the time). There are no comparable equivalents using the data provided in Table 8-7 to the proposed 24 hour limits, additional information regarding current emissions as measured by CEMS is required for comparison.

Comparing the permitted and actual values with the suggested ½ hourly averages for application in BC indicates that:

- The proposed ½ hourly limits are generally comparable to the discharge limits set out in the current permit, and are generally comparable to the ½ hour averages for the key parameters that are normally monitored by CEMS (acid gases, NO_x and CO). Actual 2007 emissions information indicates that the proposed ½ hourly limits can be achieved.
- It is uncertain based on the available data if, the proposed daily averages will be able to be achieved. Further discussion and review is needed to determine the particulars in this case, and to examine the differences in the design of this facility and waste stream managed, versus that of BAT facilities permitted in other jurisdictions.

In regards to the current monitoring requirements and averaging periods applied to the Burnaby incinerator, the recommended approach does diverge from that currently in place for the facility for some parameters as summarized in Table 9-24.

Table 9-24: Comparison of Actual and Proposed Daily and ½ Hourly Monitoring Requirements for the Burnaby Incinerator

Parameter	Comparison to Proposed Daily Average Requirements	Comparison to proposed ½ Hourly Average Requirements
TPM	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	New requirement for CEM with new lower ½ hourly average achieved 97% of the time over an operating year.
CO	New requirement.	Current limit applied over 4-hour rolling average of CEM. Reporting based on ½ hourly averages would be new.
SO ₂	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	New requirement. Would require CEM.
NO _x as NO ₂	Consistent with current approach which requires reporting based on 24-average of CEM.	New requirement.

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Parameter	Comparison to Proposed Daily Average Requirements	Comparison to proposed ½ Hourly Average Requirements
HCl	Consistent with current approach which requires reporting based on 24-average of CEM.	New requirement.
HF	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	New requirement. Would require CEM. May be omitted should treatment stages for HCl demonstrate that the ELV for HCl is not exceeded.
Organic Matter as CH ₄	NA	NA
TOC	New requirement.	New requirement. Would require CEM.
As	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	NA
Cd	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	NA
Cr	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	NA
Pb	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	NA
Mercury	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	NA
Chlorophenols	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	NA
Chlorobenzenes	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	NA
PAHs	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	NA
PCBs	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	NA
Total PCDD/F TEQ	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	NA
Opacity	NA	Consistent with current approach, CEM used to determine average over ½ hour averaging period.

Comparison to the Proposed Amendments to the ELVs for the Gold River Power Facility

It is also reasonable to conduct a comparison to the proposed permitted limits for the only other permitted WTE facility in the Province. The proposed amendments to the existing permit for this facility include suggested 1 hr and 24 hour limits for a number of parameters, and thus exhibit greater alignment with the proposed ½ hour and 24 hour emissions limits. Comparing the proposed values for the Gold River facility with the suggested ½ hourly and 24 hour averages for application in BC indicates that:

- The proposed ELV for total particulate matter for the Gold River plant of 15 is higher in value than the proposed ½ hourly limit. However, the proposed ELV appears like it would have to be achieved 100% of the time over the operating year, in comparison with the proposed value that would have to be achieved 97% of the time over the operating year. The proponent has also proposed ELVs for particulate less than 10 µm and less than 2.5 µm; however, the proposed limits in both cases are above the proposed daily and ½ hour averages for TPM in the proposed provincial limits.
- The proposed ELV for CO is higher than the daily average proposed for the province but less than the proposed ½ hour limit.
- The proposed ELV for SO₂ is just a little less than the daily average proposed for the province and is less than the proposed ½ hour limit.
- Hourly and daily averages are proposed for NO_x, HCl and HF emissions, with the proposed ELVs being somewhat less than the proposed ½ hourly and daily averages proposed for the province, with the exception of the daily average for HCl which is over twice the proposed provincial value. Follow-up would be required to determine why the proposed facility may not be able to meet the 10 mg/Rm³ daily average limit.
- Proposed Gold River ELVs for trace heavy metals are in all cases equal to or less than the existing values for BC, and would be in general there should be no issue in meeting the proposed daily average values for the individual and grouped metals.
- Proposed Gold River ELVs for the range of organic parameters are in most cases equal to or less than the proposed daily averages for BC, with the exception of dioxins and furans where the proposed ELV is slightly higher than the proposed daily average for the province.

Generally it would appear that the proposed revisions to the emissions criteria for MSW incineration in BC would be consistent with the proposed approach for the new Gold River Power WTE facility, however, some modifications may be necessary for the ELVs for a few parameters.

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Section 9: Emission Limits and Their Application

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10 MANAGEMENT OF WTE RESIDUES

By using thermal treatment (mass burn incineration or alternative approaches) to manage municipal solid waste, a large reduction in the original volume and mass of the waste is achieved.

Conventional mass burn combustion results in the production of solid residuals which need to be managed in an appropriate manner. Conventional WTE combustion residues include:

- **Bottom Ash** – composed of post-combustion solid waste including the ash, non-combustible residuals (such as metal, rock, concrete, some types of glass) and potentially residuals of incomplete combustion (carbon)
- **Fly Ash** – composed of particulate matter produced by waste incineration in the combustion chamber and removed from the emission stream by the air pollution control (APC) system. Dry particulate control systems such as baghouses and electrostatic precipitators collect fly ash which can be managed as a dry solid waste
- **APC residues** – composed of spent or waste by-products from the APC system, such as reagents used in acid gas scrubbing (typically lime), activated carbon (used in dioxin/furan and heavy metal removal) and scrubber sludge (if a wet acid gas control system is used). APC residues typically include the fly ash the APC system has removed and may be dry solid waste or contain some moisture from semi-dry or wet APC systems.

Historically, fly ash was collected separately from APC residues but in most modern WTE facilities, it is collected and mixed together with APC residues. These are both referred to collectively as APC residues in the remainder of this section.

This subsection of the report discusses the regulatory framework governing incinerator residue management in Europe and North America and the current and emerging management strategies being used worldwide to manage bottom ash and APC residues. First, however, the typical composition (and the factors affecting the composition) of bottom ash and APC residues are discussed in order to better understand each residue stream.

10.1 Composition of Residues

The following subsections discuss the typical composition of bottom ash and APC residues from municipal solid waste mass burn facilities, and the composition of residues from gasification facilities.

10.1.1 Bottom Ash

Bottom ash is the mineral material left after the combustion of the waste. Bottom ash from a MSW incineration facility is a heterogeneous mixture of slag, metals, ceramics, glass, unburned organic matter and other non-combustible inorganic materials. Bottom ash consists mainly of silicates, oxides and carbonates. Typically, bottom ash makes up approximately 20 – 25% by weight or 5 to 10% by

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volume of the original waste.^[244] At most incineration facilities, bottom ash is mechanically collected, cooled (sometimes water quenched then drained), and mechanically, magnetically or electrically screened to recover recyclable metals. The remaining residue is typically disposed of at a landfill. It may also be incorporated into an alternate beneficial use, such as a construction aggregate substitute, assuming it has the appropriate physical properties and chemical composition and that it meets regulatory requirements in the applicable jurisdiction.^[245]

Table 10-1 illustrates the typical composition of bottom ash produced by MSW mass burn incinerators. The composition of the bottom ash is directly dependant on the in-feed waste composition, as described in Section 9.1.3. While organic constituents are typically destroyed by the high temperature and extended residence time found in a WTE facility, inorganic constituents are not destroyed and typically are found in the bottom ash.

Table 10-1: Composition of Bottom Ash from MSW Incineration in Various Jurisdictions

Parameter	Units	Typical German Values ^[246]	Hyks and Astrup (2009) ^[247]	Worldwide Range Found in MSWI Bottom Ash ^[248]
TOC	% by mass	<0.1-<2.2	N. Def.	N. Def.
Loss on Ignition	% by mass	<3	N. Def.	N. Def.
PCDD/PCDF	ng I-TEQ/kg	<3.3-<15	N. Def.	N. Def..
Aluminum	mg/kg	N. Def.	N. Def.	22,000 – 73,000
Antimony	mg/kg	N. Def.	10 – 432	10 – 430
Arsenic	mg/kg	1 – 20	5 – 189	0.1 – 190
Barium	mg/kg	N. Def.	400 -3,720	400 -3,000
Cadmium	mg/kg	1 – 25	1.0 – 40	0.3 – 70
Calcium	mg/kg	N. Def.	N. Def.	370 – 123,000
Chlorine	mg/kg	N. Def.	1,420 – 8,400	800 – 4,200
Chromium	mg/kg	100 – 1,000	230 – 3,100	23 – 3,200
Copper	mg/kg	500 – 5,000	900 – 8,240	190 – 8,200
Iron	mg/kg	N. Def.	N. Def.	4,100 – 150,000
Lead	mg/kg	300 – 6,000	1,270 – 5,400	100 – 13,700
Magnesium	mg/kg	N. Def.	N. Def.	400 – 26,000
Manganese	mg/kg	N. Def.	N. Def.	80 – 2,400
Mercury	mg/kg	0.01 – 0.5	<0.01 – 7.8	0.02 – 8
Molybdenum	mg/kg	N. Def.	2.5 – 51	2 – 280

²⁴⁴ AECOM report, 2009

²⁴⁵ AECOM report, 2009

²⁴⁶ UBA. 2001. Draft of a German Report with basic information for a BREF-Documents "Waste Incineration". Umweltbundesamt

²⁴⁷ Hyks and Astrup. 2009. Influence of operational conditions, waste input and ageing on contaminant leaching from waste incinerator bottom ash: A full-scale study. In *Chemosphere* 76 (2009) 1178-1184

²⁴⁸ Sabbas, *et al.* 2003. Management of municipal waste incineration residues. In *Waste Management* 23 (2003) 61-88

Parameter	Units	Typical German Values ^[246]	Hyks and Astrup (2009) ^[247]	Worldwide Range Found in MSWI Bottom Ash ^[248]
Nickel	mg/kg	30 – 600	60 – 650	7 – 4,200
Potassium	mg/kg	N. Def.	N. Def.	750 – 16,000
Silicon	mg/kg	N. Def.	N. Def.	91,000 – 308,000
Sodium	mg/kg	N. Def.	N. Def.	2,800 – 42,000
Sulphur	mg/kg	N. Def.	1,300 – 11,080	1,000 – 5,000
Vanadium	mg/kg	N. Def.	36 – 122	20 – 120
Zinc	mg/kg	30 – 10,000	2,370 – 6,200	610 – 7,800

NOTES:

N. Def. – Not Defined

Bottom ash from typical mass-burn facilities combusting MSW is typically classified as a non-hazardous waste. The constituents in the ash, including those listed in Table 9-1, are typically not leachable using the standard test methods, indicating contaminants are not mobile and are chemically/mechanically bound in the ash matrix. As a result of this non-hazardous classification, the disposal of bottom ash in a landfill or subsequent beneficial use is facilitated.

Bottom ash may be also produced at facilities that incinerate or co-incinerate refuse derived fuels and the composition of the bottom ash will vary with the waste type. For example, facilities that burn wood waste derived from forest products processing residues, biosolids or land clearing wastes will have lower concentrations of constituents of concern (such as trace metals) in their bottom ash than typically found in MSW bottom ash. As a result of the variability, it is important for new mass burn facilities to anticipate the quality of the bottom ash and plan on management of the ash in accordance with the ash characteristics. Additional discussion on the classification of ash is provided in Section 9.2 below.

10.1.2 APC Residues

APC residues are the residues from the APC system and other parts of incinerators where flue gas passes (i.e., superheater, economizer). APC residues are usually a mixture of lime, fly ash and carbon and are normally removed from the emission gases by a fabric filter baghouse and/or electrostatic precipitator.

APC residues contain high levels of soluble salts, particularly chlorides, heavy metals such as cadmium, lead, copper and zinc, and trace levels of organic pollutants such as dioxins and furans. The high levels of soluble, and therefore leachable, chlorides primarily originate from polyvinyl chloride (PVC) found in municipal solid waste. The composition of fly ash and APC residue is directly related to the composition of the in-feed to the incinerator. Wastes with higher concentrations of trace metals and refractory organic compounds will produce fly ash with higher concentrations of

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these constituents of concern. Typically, APC residues make up approximately 2 – 4% by weight of the original waste.^[249]

Compared to bottom ash, APC residues are often classified and managed as hazardous wastes. APC residues typically contain elevated concentrations of heavy metals compared to bottom ash. Fly ash and APC residues are hazardous wastes because of mechanical and chemical behavior of the constituents in the emission. Fine particulate present in the flue gas has been found to form a nucleus on which volatilized metals evolved in the combustion zone condense^[250]. These have been found to be water soluble and therefore are more leachable than the heavy metals found in bottom ash. As with bottom ash, the composition of APC residues and of fly ash will vary depending on the composition of the waste in the incinerator in-feed.

The primary environmental concerns associated with APC residues are the leaching of:

- **Easily soluble salts such as Cl and Na.** Although these substances are not usually associated with toxicity to humans, they may have a negative effect on ecosystems and drinking water resources.
- **Heavy metals such as Cd, Cr, Cu, Hg, Ni, Pb, and Zn.** Heavy metals and trace elements can be present in concentrations high enough to be potentially harmful to humans and ecosystems.
- **Dioxins/Furans.** Although not usually highly leachable (due to low aqueous solubility), these substances are considered toxic.

All jurisdictions surveyed have the choice of either treating APC residues as hazardous waste, or applying treatment to render the fly-ash as non-hazardous and suitable for disposal in a sanitary landfill.

The following table (Table 10-2) presents the typical composition of APC residues resulting from the thermal treatment of MSW. The values were taken from three separate scientific studies.^{[251] [252]}

Table 10-2: Typical Composition of APC Residues Resulting from the Combustion of MSW

Parameter	Units	Burnaby MSW APC Residue Average (2004)	Quina (2005)	Hjelmar (1996b)	International Ash Working Group (IAWG) (1997)
Si	g/kg	25.9	45 – 83	57 – 98	36 – 120
Al	g/kg	13.8	12 – 40	17 – 46	12 – 83
Fe	g/kg	5.8	4 – 16	3.6 – 18	2.6 – 71
Ca	g/kg	258.8	92 – 361	170 – 290	110 – 350
Mg	g/kg	5.6	nd	7.1 – 12	5.1 – 14

²⁴⁹ Algonquin Power Energy from Waste Facility Fact Sheet, <http://www.peelregion.ca/pw/waste/facilities/algonquin-power.htm#ash>

²⁵⁰ Chiang, K.Y. Wang, K. S. , Lin, F. L, Toxicology Environmental Chemistry 64, 1997

²⁵¹ Evaluation of GVRD Municipal Incinerator Ash as a Supplementary Cementing Material in Concrete, AMEC, 2004

²⁵² Treatment and use of air pollution control residues from MSW incineration: An overview. Quina *et al.* 2007

Parameter	Units	Burnaby MSW APC Residue Average (2004)	Quina (2005)	Hjelmar (1996b)	International Ash Working Group (IAWG) (1997)
K	g/kg	23.1	23 – 30	27 – 40	5.9 – 40
Na	g/kg	29.6	22 – 33	12 – 19	7.6 – 29
Cl	g/kg	200.6	101 – 138	92 – 220	62 – 380
P	g/kg	3	nd	1.7 – 4.6	1.7 – 4.6
Mn	g/kg	0.3	nd	0.3 – 0.7	0.2 – 0.9
As	mg/kg	232	nd	40 – 260	18 – 530
Ba	mg/kg	392	nd	310 – 1,400	51 – 14,000
Cd	mg/kg	253	49 – 87	140 – 300	140 – 300
Co	mg/kg	20	nd	4 – 15	4 – 300
Cr	mg/kg	900	72 – 259	150 – 570	73 – 570
Cu	mg/kg	878	440 – 648	450 – 1,100	16 – 1,700
Hg	mg/kg	-	9 – 16	9.3 – 44	0.1 – 51
Mo	mg/kg	23.5	nd	9.3 – 20	9.3 – 29
Ni	mg/kg	43.7	45 – 132	20 – 63	19 – 710
Pb	mg/kg	4,417	1,495 – 2,453	4,000 – 6,500	2,500 – 10,000
Se	mg/kg	–	nd	8.2 – 16	0.7 – 29
Sn	mg/kg	750	nd	620 – 780	620 – 1,400
Zn	mg/kg	18,800	4,308 – 6,574	12,000 – 19,000	7,000 – 20,000
PAH	µg/kg	–	nd	18 – 5,600	30
PCB	µg/kg	–	nd	<40	nd
PCDD	µg/kg	–	nd	0.7 – 1,000	0.7 – 32
PCDF	µg/kg	–	nd	1.4 – 370	1.4 – 73
TCDD	eqv	–	nd	0.8 – 2	0.8 – 2
TOC	g/kg	–	10	6 – 9	6 – 9

NOTES:

– Not reported or not available at the time this report was prepared.

nd – Not detected

This table indicates that the composition of the fly ash/APC residue from the Metro Vancouver Burnaby Municipal Solid Waste Incinerator is generally similar to the APC residue composition at other facilities operating in the EU.

10.1.3 Factors Affecting Ash Composition

There are several factors that affect the physical and chemical characteristics of bottom ash and APC residues resulting from the thermal treatment of MSW. The following are considered to be the primary factors affecting the quality of ash produced by MSW WTE facilities:

- The composition of waste being incinerated will affect ash quality. MSW is heterogeneous, with specific composition varying by jurisdiction. General ranges of composition have been developed but actual composition is specific to the catchment or service area for the WTE facility. Waste diversion strategies specific to a region can reduce the concentration of recyclable materials such as paper, metals and plastic, leaving the MSW with higher proportions of non-recoverable wastes including metallic and organic wastes. Diversion and source removal of potentially harmful constituents from the MSW, such as batteries, lead-based products, household hazardous wastes and fluorescent lamp tubes, prior to combustion will have the benefit of improving the quality of the bottom ash and APC residues.
- Front-end processing of the waste will also affect ash composition. Typically, MSW is deposited in a large bunker at the facility where it can be homogenized manually before entering the in-feed system. Some facilities also conduct source separation at this stage. Removal of potentially harmful constituents and homogenization of the waste will improve the quality of bottom ash and APC residues.
- Type of APC system being used will have an effect on fly ash and APC residue quality and quantity.
- Operating conditions of the incinerator will affect the quality of bottom ash and the flue gas and subsequently the APC residues. The physical geometry of the combustion zone will affect the residence time at the temperature required for complete combustion and the velocity of the flue gas through the incinerator and APC works. Also, upset operating conditions, such as start-up or shut down, or failure of some portion of the incineration or APC system, will affect ash quality. Steady operating conditions will produce a better quality ash.

Each jurisdiction will have a slightly different composition of MSW being incinerated; therefore the range of ash composition provided above is illustrative of the types and magnitude of the constituents of concern that may be contained in the ash.

10.1.4 Gasification Residue Management

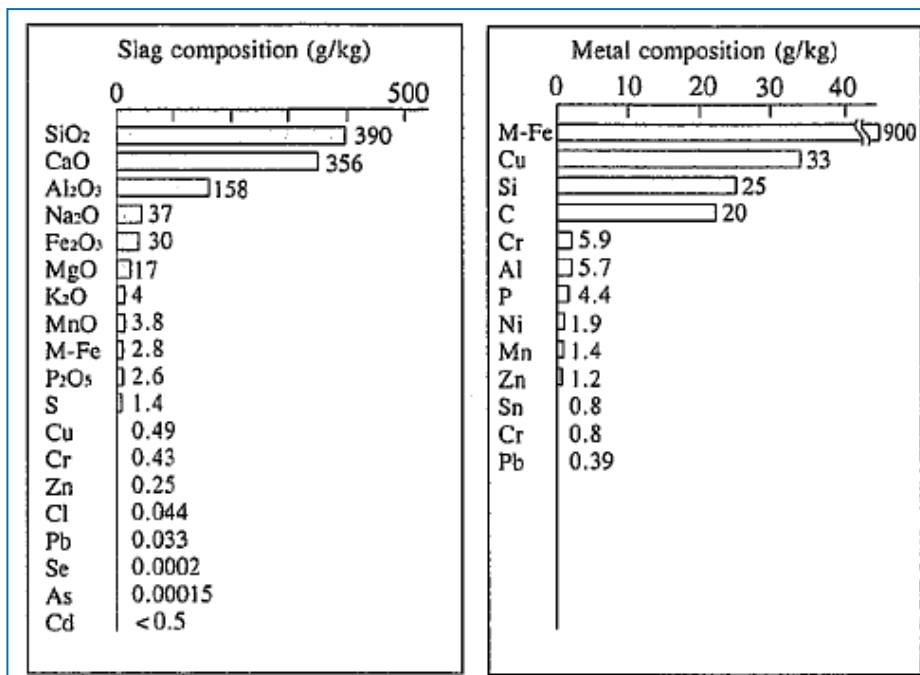
The types and composition of the solid residues produced by gasification facilities treating MSW depends on the particular gasification technology being considered as well as the composition of the waste being treated. The following paragraphs discuss the solid residues arising from the Nippon Steel “Direct Melting System” and the Thermoselect processes, as both processes have reasonable documentation on the solid residues produced. It should be noted that both of these technologies are considered high temperature gasifiers and produce residues which have different characteristics from those produced by other gasification technologies where high temperatures are not reached. Nippon Steel and Thermoselect are discussed because they are both more commercially proven

than other gasification approaches and as documentation was readily available that discussed solid residue management for these processes.

10.1.4.1 Nippon Steel “Direct Melting System”

The Nippon Steel “Direct Melting System” produces slag and metal (the metal is separated from the slag via a magnetic separator) from the melting furnace and produces fly ash from the combustion chamber, gas cooler and bagfilter/electrostatic precipitator. The slag and metal produced and recovered from the melting furnace are recycled (in Japan). The following figure (Figure 10-3) presents the composition of the slag and metal recovered from the melting furnace. It should be mentioned that the data presented comes from one of Nippon Steel’s demonstration facilities and the waste being treated was not MSW but a variety of different waste materials.^[253]

Figure 10-1: Composition of Slag and Metal from Nippon Steel “Direct Melting” Furnace



Taking advantage of its low impurity content and good homogeneity the slag is normally sold by facilities as a substitute for natural sand. It is used as fine aggregate for asphalt paving mixtures. The metal recovered from the melting furnace has a very high iron content and good homogeneity and is often sold to be used in construction machinery counterweights. The fly ash produced is treated chemically to render it harmless and is then disposed of via landfill.

²⁵³ Nippon Steel Technical Report No. 70. July 1996. Research and Development of Direct Melting Process for Municipal Solid Waste

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10.1.4.2 Thermoselect

The Thermoselect process produces a wider array of solid residues than does the Nippon Steel process. Approximately 22 – 30% (by weight) of the original materials are left over as solid residues following the Thermoselect process.^[254] In the Thermoselect process slag and metal is produced by the high temperature reactor. These materials are separated magnetically. Other solid residues result from synthesis gas cleaning and process water treatment. The following table (Table 10-3) illustrates the types of solid residues resulting from the Thermoselect process and how they are utilized or recycled.^[255]

Table 10-3: Residues from Thermoselect Process

Residue	% of Total Input (by weight)	Potential Usage
Mineral granulate	20 – 25%	Concrete, sand blasting, road construction
Metals	1 – 3%	Metal industry
Sulphur	0.2% – 0.3%	Chemical industry, sulphuric acid production
Salt Residues	1%	Chemical industry, additive for metal industry, aluminum recycling, filling materials in salt mines
Metal precipitation products of water purification (primarily Zn, some Pb, Cd, Hg)	0.2 – 0.3%	Zinc recycling

In addition to the solid residues listed in the table, additional residues would result if the syngas was combusted for electricity generation on site. These residues would include fly ash residues from the baghouse as well as residues associated with flue gas treatment (sodium sulphide). That said, the residual fly ash is often fed into the gasifier and recycled in that manner.^[256]

The following table (Table 10-4) shows the composition of mineral granulate that was produced by the Thermoselect process (Karlsruhe, Germany).^[257]

Table 10-4: Composition of Mineral Granulate Produced by Thermoselect Process (Karlsruhe, Germany)

Component	Unit	Composition
Water	% by weight	5 – 10
Bulk Density	Kg/m ³	Approximately 1,400
Ignition Loss	%TS	0.1
Carbon, total	%TS	<0.01

²⁵⁴ W.F.M Hesseling. 2002. Case Study ThermoSelect Facility Karlsruhe

²⁵⁵ Interstate Waste Technology. 2006. Thermoselect Technology an Overview. Presented to the Delaware Solid Waste Management Technical Working Group January 10, 2006

²⁵⁶ Thermoselect. 2005. Thermoselect Plant and Process Description

²⁵⁷ W.F.M Hesseling. 2002. Case Study ThermoSelect Facility Karlsruhe

Component	Unit	Composition
Al	%TS	3.4
Ca	%TS	8.9
Fe	%TS	9.3
Si	%TS	24.5
Cd	mg/kg TS	<6.0
Hg	mg/kg TS	<2.6
Sb	mg/kg TS	18
As	mg/kg TS	<3.7
Pb	mg/kg TS	202
Cr	mg/kg TS	2,670
Cu	mg/kg TS	2,240
Mn	mg/kg TS	1,470
Ni	mg/kg TS	265
Sn	mg/kg TS	93
Zn	mg/kg TS	890

10.2 Ash Management Regulations in Europe and North America

The regulatory environment and thus the methods of managing bottom ash and APC residues, varies across jurisdictions. The following subsections discuss the current regulatory framework in Europe and North America.

10.2.1.1 European Union

In the EU, there is no legislation that directly regulates the utilization of MSW incinerator bottom ash. That said much of the current legislation does provide guidance on the use of bottom ash from incinerators. APC residues on the other hand are classified as hazardous waste in the EU and management of this residue stream is directly regulated. The following sections discuss the EU regulations and how they impact the management of both bottom ash and fly ash.

EU Waste Incineration Directive (WID)

The following list outlines the guidance concerning the handling of bottom ash and APC residues as provided in the WID:

- Emphasis on the recycling of residues (on-site methods of recycling preferred but not required). Local regulatory authorities should require operators to keep records of such recycling and report in accordance with standard permit conditions.

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- Total organic carbon should be limited to 3% while loss on ignition should be approximately 5%.
- Fugitive dust releases from dusty wastes (including bottom ash) should be prevented by using best available technology equipment. Although containers are not needed in all circumstances (as damp storage may be sufficient for bottom ashes), new plants are expected to provide for ash storage within a building and in an area of controlled drainage.
- Bottom ash and APC residues (fly ash) should not be mixed together.
- Particular attention should be paid to APC residues which should be held in bags or bulk containers.
- Appropriate physical and chemical testing must be performed on all residues to determine the pollution potential of the residues prior to disposal or recycling. Analysis should be carried out to determine the total soluble fraction and the heavy metals content of this soluble fraction.

The process of revising the WID started in 2008 and the revisions may impact the allowable emissions levels from incinerators as well as the composition of residues. The revised directive is expected to be released in 2012. The new BREF for residue management is planned for 2010 – 2012.

EU Landfill Directive (LFD)

If the WTE residues are to be disposed via landfill, the management of these residues is governed by the direction found in the Landfill Directive (LFD). The LFD governs the landfilling of waste in Europe and was officially adopted in 1999. The LFD aims “to provide for measures, procedures and guidance to prevent or reduce as far as possible the negative effects on the environment...from the landfilling of waste.”^[258]

Further clarification to the LFD was given in 2002 by a Council Decision which set out waste acceptance criteria for waste that can be accepted at various types of landfills^[259]. The LFD distinguishes between the main classes of landfills:

- Landfills for inert waste
- Landfills for non-hazardous waste
- Landfills for hazardous waste
- Underground storage.

Each of the three types of landfills has waste acceptance criteria which set out the types of waste that the landfill can accept and the characteristics of that waste. The acceptance criteria include performing standard leachability tests to quantify mobile toxic constituents.

Fly ash and APC residues with heavy metals and dioxins/furans are classified as hazardous wastes and because of excessive leaching of salts; these residues are not accepted for disposal at hazardous waste landfills without pre-treatment. Consequently, they must either be placed in

²⁵⁸ EU landfill directive

²⁵⁹ Management of municipal solid waste incineration residues. Sabbas, *et al.* 2001

underground storage or stabilized prior to disposal at a hazardous waste landfill. The methods used to stabilize fly ash and APC residues are discussed further in this report.^[260]

Bottom ash does not contain the same concentrations of harmful substances and can therefore be disposed of at a non-hazardous waste landfill or used for an alternative beneficial use.

The LFD is a minimum directive, and EU member states are allowed to set stricter national criteria for waste acceptance at their own landfills.

Thematic Strategy on the Prevention and Recycling of Waste

The strategy on the prevention and recycling of waste was released in December 2005. “The aim of the strategy is to reduce the negative impact on the environment that is caused by waste throughout its life-span, from production to disposal, via recycling. This approach means that every item of waste is seen not only as a source of pollution to be reduced, but also as a potential resource to be exploited.”^[261]

Although no specific issues related to ash management are mentioned, an introduction of life-cycle thinking into waste management regulation may potentially have a large impact on the way residue management is evaluated and discussed in the EU.

EU Statutory Order on POP

The EU Statutory Order on Persistent Organic Pollutants^[262] (POPs) regulates the management of waste containing persistent organic compounds, including dioxins and furans (15 µg/kg), PCB, and a variety of organic pesticide products (each 50 mg/kg). This directive requires that waste containing POPs must be managed in such a way as to destroy or irreversibly transform the POPs by physico-chemical treatment, incineration on land or use as a fuel to generate energy. With respect to APC residue, physio-chemical pretreatment includes stabilization prior to disposal in a landfill.

10.2.1.2 European Union Member States

The following subsections outline the regulatory framework in place for the management of residues in various European Member States.

Netherlands

In the Netherlands, the management of waste is regulated through the framework of the Landelijk Afvalbeheer Plan (Federal Waste Management Plan) or simply LAP. The LAP sets out standards for the use of both APC residues and bottom ash as follows:

- Bottom ash and fly ash must be collected and managed separately. No mixing is permitted.

²⁶⁰ Air pollution control residues from waste incineration: Current UK situation and assessment of alternative technologies. Rani, *et al.* 2007

²⁶¹ http://europa.eu/legislation_summaries/environment/sustainable_development/l28168_en.htm

²⁶² Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC

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- Close to 100% must be utilized (a total utilization rate of 90% is considered the minimum standard for bottom ash + fly ash + APC residues).
- For bottom ash, utilization in large scale controlled embankments is considered the minimum option for utilization.

The Dutch Waste Incineration Directive also sets out compositional limits for bottom ash reflective of WTE facility performance, namely that the loss of ignition must be lower than 5%.

In the Netherlands, another piece of legislation called the Building Materials Decree (which came into force in 1998) sets the rules toward the environmentally safe utilization of building materials (such as incinerator bottom ash). The Decree stipulates the increase of 21 pollutants to a maximum of 1% over a 100 year period. As bottom ash is often used as a building material aggregate, it is subject to the Decree.

If bottom ash is to be used in accordance with the Decree, the following requirements must be met:

- The quantity of bottom ash used must be a minimum of 10,000 tonnes in foundations
- The quantity of bottom ash used must be a minimum of 100,000 tonnes in embankments
- A triple liner has to be used to cover the bottom ash
- Leaching quality of the bottom ash has to be monitored.

The limits set out in the EU LFD are implemented in Dutch legislation.^[263]

United Kingdom

In the UK, solid residues from municipal waste incinerators including bottom ash and air pollution control residues are considered controlled wastes. APC residues are classified as hazardous waste at the point they are generated at WTE facilities.

Ash residues are regulated by the UK's Environment Agency under the *Environmental Protection Act*. In the UK, solid residues are disposed of or recovered in a number of ways:

- Bottom ash is generally landfilled, used as landfill cover, or processed to produce an aggregate for use in highway sub-bases and embankments.
- APC residues are also landfilled or used in licensed waste treatment plants to neutralise and solidify other hazardous wastes.

Operators of landfills and treatment plants accepting air pollution control residues or bottom ash require a permit from the Environmental Agency (a waste management license). This permit must include conditions designed to protect the environment and human health.^{[264],[265]}

²⁶³ Management of APC residues from WTE Plants. ISWA. 2008

²⁶⁴ Solid Residues from Municipal Waste Incinerators in England and Wales. Environment Agency. May 2002

²⁶⁵ Management of Bottom Ash from WTE Plants. An overview of management options and treatment methods

Denmark

Being densely populated, Denmark seeks to avoid landfilling of wastes. Consequently, since 1997 landfilling of combustible wastes has been banned in favor of incineration. To further facilitate this, the Danish government has established a statutory order which allows the incinerator bottom ash to be utilized as a substitute construction material. Depending on the leaching properties, the ash is classified into three categories. Materials belonging to Category 1 may be utilized freely, while materials in Category 3 may only be utilized in certain projects. Category 2 is an intermediate class.

10.2.1.3 United States

In the United States, the management of residual ash from WTE facilities is regulated at both the federal and state level.

Federal

At the federal level, ash generated at WTE facilities is regulated under Subtitle C of the US *Resource Conservation and Recovery Act* (RCRA). Under Subtitle C, operators of WTE facilities must determine whether ash generated is hazardous based on the Toxicity Characteristic (TC) provision. Ash first becomes subject to this hazardous waste determination at the point that the ash leaves the “resource recovery facility”, defined as the combustion building (including connected APC equipment). Ash that falls under the regulation includes bottom ash, APC residues (fly ash) or any combination of the two (i.e., the common practice in the United States is to combine bottom ash and fly ash and dispose of the material as a combined ash stream).^[266]

The TC is one of four characteristics described in Subtitle C by which hazardous waste is identified. It is determined by either testing using the Toxicity Characteristic Leaching Procedure (TCLP) or by using knowledge of the combustion process to determine whether ash would exhibit the TC. Typically, ash that fails the TC, leaches lead or cadmium above levels of concern. In addition to the TCLP, alternative leaching procedures are sometimes used as specified by a state (e.g., California requires the California Waste Extraction Text) and some states may require total metal and organic analysis and fish bio assays.^{[267],[268]}

The following table (Table 10-5) presents a list of TC contaminants and their associated regulatory levels.

²⁶⁶ National Renewable Energy Laboratory. 1999. Beneficial Use and Recycling of Municipal Waste Combustion Residues – A Comprehensive Resource Document

²⁶⁷ Environmental Protection Agency. 2005. 40 CFR Part 270: Determination of Point at Which RCRA Subtitle C Jurisdiction Begins for Municipal Waste Combustion Ash at Waste-to-Energy Facilities

²⁶⁸ National Renewable Energy Laboratory. 1999. Beneficial Use and Recycling of Municipal Waste Combustion Residues – A Comprehensive Resource Document

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Table 10-5: List of Toxicity Characteristic Contaminants and Regulatory Levels²⁶⁹

Contaminant	Regulatory Level (mg/L)
Arsenic (As)	5.0
Barium (Ba)	100.0
Benzene	0.5
Cadmium (Cd)	1.0
Carbon Tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium (Cr)	5.0
o-Cresol	200.0
m-Cresol	200.0
p-Cresol	200.0
Cresol	200.0
2,4-D	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
2,4-Dinitrotoluene	0.13
Endrin	0.02
Heptachlor	0.008
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.5
Hexachloroethane	3.0
Lead (Pb)	5.0
Lindane	0.4
Mercury (Hg)	0.2
Methoxychlor	10.0
Methyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentachlorophenol	100.0
Pyridine	5.0
Selenium (Se)	1.0

²⁶⁹ Environment, Health, and Safety Online. 2009. The EPA TCLP: Toxicity Characteristic Leaching Procedure and Characteristic Wastes (D-codes). Accessed May 24, 2010 from <http://www.ehso.com/cssepa/TCLP.htm>

Contaminant	Regulatory Level (mg/L)
Silver (Ag)	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.5
2,4, 5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-TP (Silvex)	1.0
Vinyl Chloride	0.2

If the ash is determined to be hazardous waste, it must be handled in compliance with US EPA regulations for hazardous waste management (e.g., disposal via a hazardous waste landfill). Ash that is determined as being non-hazardous can be disposed of at a non-hazardous waste facility (e.g., a Subtitle D landfill) or it can be beneficially used.^[270]

Prior to 1994, it was generally accepted that the ash residue from municipal WTE facilities was exempt from Subtitle C of the RCRA. This changed, however, on May 2, 1994 after a Supreme Court decision stated that although WTE facilities could burn household waste alone or in combination with industrial and commercial wastes and would not be regulated under Subtitle C of the RCRA, the ash generated from these facilities is not exempt from the regulation.^[271]

The following sections describe the regulatory requirements concerning ash management in several US states.

Washington

The Washington State Department of Ecology adopted one of the more stringent regulatory programs for 'special incinerator ash' in 1990. The Washington Administrative Codes (WAC) contain special incinerator ash management and utilization standards (173-306-490). The codes impose numerous requirements and standards, including monitoring and sampling, disposal in specifically designed monofills with prohibition against co-disposal; ash management plans; siting, operational, treatment, closure and post-closure standards; ash utilization standards; and financial assurance.^[272]

The codes require that incinerator ash generators provide annual reports that include the amount of waste incinerated, the amount of bottom ash generated, and the amount of fly ash/scrubber residue generated, the disposal sites for the material, designation of test results (the results of testing bottom

²⁷⁰ Office of Solid Waste, US Environmental Protection Agency. 1995. Guidance for the Sampling and Analysis of Municipal Waste Combustion Ash for the Toxicity Characteristic

²⁷¹ Department of Environmental Protection, Florida, Solid Waste Section. 2001. Guidance for Preparing Municipal Waste-to-Energy Ash Beneficial Use Demonstrations

²⁷² Kim Maree Johannessen. 1996. The regulation of municipal waste incineration ash: A legal review and update. In *Journal of Hazardous Materials* 47 (1996) 383-393

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ash and fly ash/scrubber residues separately and combined) on representative samples taken each quarter of the year (this may be reduced after the first year of testing). The report must also provide results of testing bottom ash and fly ash separately for dioxins and dibenzofurans on a composite sample made from the eight quarterly samples as well as ambient lead and cadmium samples taken in the air and soil respectively at the property boundary.^[273]

The test results are subjected to the criteria of WAC 173-303-100 (Dangerous Waste Criteria). A waste is designated a dangerous waste if it meets one or more of the dangerous waste criteria listed as toxicity criteria or persistence criteria. Toxicity criteria are determined by either a book designation procedure (if enough information concerning the waste's composition is known) or biological testing methods (e.g., fish, rat bioassays). Persistence criteria are determined by either applying knowledge of the waste or by testing the waste according to WAC 173-303-110. Persistent constituents are substances which are either halogenated organic compounds (HOC) or polycyclic aromatic hydrocarbons (PAH). Depending on the concentration of the persistent substance present in the waste, the waste will be defined as either dangerous or not.^[274]

If ash is classified as a dangerous waste it must be disposed of at a facility which is operating either under a valid permit, or if the facility is located outside of this state, under interim status or a permit issued by United States EPA under 40 CFR Part 270, or under interim status or a permit issued by another state which has been authorized by United States EPA pursuant to 40 CFR Part 271.^[275] If ash is not classified as dangerous waste it must be disposed of at a site which holds a valid permit (ash monofills).

California

In California, regulations require that WTE ash be tested for toxicity prior to disposal. The state requires that for any substance that potentially fall under the RCRA, the use of a Waste Extraction Text (WET) be used for toxicity testing. The WET test is more stringent than the TCLP, and measures both soluble thresholds and total thresholds. The WET test dilutes the waste less, involves a longer extraction period (48 hours vs. 18 hours) and includes the analysis of more parameters of concern.^[276]

10.2.1.4 Canada

In Canada, the handling of residual ash is regulated by each province. The following sections describe the applicable regulations in Ontario and British Columbia.

Ontario

In Ontario, the handling of residues from incinerators that process MSW is governed by Ontario Regulation 347 under the *Environmental Protection Act*. Regulation 347 outlines several

²⁷³ WAC 173-306: Special incinerator ash management standards. 2000

²⁷⁴ WAC 173-303-100: Dangerous waste criteria

²⁷⁵ WAC 173-303-141: Treatment, storage, or disposal of dangerous waste. 2003

²⁷⁶ National Renewable Energy Laboratory. 1999. Beneficial Use and Recycling of Municipal Waste Combustion Residues – A Comprehensive Resource Document

requirements concerning the management of bottom ash and APC residues. The following is an overview of the requirements:

- Fly ash from an incinerator's energy recovery and pollution control system must be handled separately from the burning zone's bottom ash.
- Fly ash must be tested for leachate toxicity if the operator wants to classify the ash as non-hazardous. The testing protocol for leachate toxicity is contained in Ontario Regulation 347 while the sampling procedure and results evaluation procedure is in the ministry's policy publication "Protocol for Sampling and Evaluating Fly Ash from Non-Hazardous Solid Waste Incineration Facilities". Ontario requires application of the TCLP for leachate toxicity similar to the US EPA TL requirements.
- Incinerator operators shall analyze bottom and fly ashes sent to disposal for leachate toxicity and ultimate analysis during performance tests or at the direction of the Director of the Ministry's Environmental Assessment and Approvals Branch.
- Fly ash that is deemed hazardous must be disposed of at a landfill site that is capable of accepting fly ash (i.e., is permitted to accept the waste via a waste certificate of approval).
- Incinerators shall be operated such that the organic content of the bottom ash shall be minimized to the greatest degree possible. A maximum organic content of 5% is generally considered achievable by single chamber incinerators and 10% by multiple chamber incinerators.^[277]

British Columbia

Regulatory Framework

In British Columbia, the management of residual ash from the incineration of MSW is regulated by the British Columbia *Environmental Management Act*^[278] (EMA) and associated enabling Regulations, including the *Waste Discharge Regulation*, the *Contaminated Sites Regulation* and the *Hazardous Waste Regulation*. In general terms in British Columbia, the introduction of waste into the environment must be authorized by a permit issued under the EMA and Regulations. The incineration of municipal waste originating from residential, commercial, institutional, demolition, land clearing or construction sources is identified in Schedule 1 of the *Waste Discharge Regulation*. This means the activity requires authorization from BC MOE for the introduction of waste into the environment. If the waste discharge is governed by a Code of Practice approved by BC MOE, then the operation is exempt from obtaining a permit if the discharge is conducted in a manner consistent with the Code of Practice. For the municipal solid waste incineration sector, there is currently no Code of Practice in place. Requirements specific to the management of bottom ash or APC residues from a MSW incineration facility would be specified in the permit for the incineration facility and/or in the authorization for the landfill site. Solid Waste Management Plans (SWMP) are required for each

²⁷⁷ GUIDELINE A-7 Combustion and Air Pollution Control Requirements for New Municipal Waste Incinerators. Ontario Ministry of the Environment. 2004

²⁷⁸ BC *Environmental Management Act*, SBC 2003, October 23, 2003

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Regional District in the province. With respect to the operation of a municipally-owned and operated landfill, the authorization for an approved SWMP is typically in the form of an Operational Certificate (OC). The OC is issued by the Director of Waste Management and may contain conditions in the same manner as a permit. Specific requirements for the management of incinerator ash at a municipal landfill would be found in the Operational Certificate.

The *Hazardous Waste Regulation*^[279] (HWR) under the EMA specifies the requirements for the management of hazardous waste in BC. Wastes are classified as Hazardous Wastes in BC in several ways. The primary classification method is to determine if a waste is classified as a Dangerous Good by the Canadian *Transportation of Dangerous Goods Act*^[280], and if so it would be considered Hazardous Waste. Wastes may also qualify as hazardous wastes if they contain constituents that are considered hazardous or contain Specific Hazardous Wastes, such as asbestos and waste oil. The HWR contains a leachate extraction test to determine if the constituents of concern in the waste are leachable.

Classification of Residues

In BC, residuals such as bottom ash and fly ash produced by the incineration of MSW are characterized by subjecting the ash to the US EPA as Method 1311 Toxicity Characteristic Leaching Procedure (TCLP). TCLP is widely used across North America to determine if a material is leachable and therefore is classified as a hazardous waste.

Where constituents are found to be leachable by the TCLP in concentrations in excess of the Leachate Quality Standards specified in Table 1 of Schedule 4 of the HWR, the waste would be considered to be a leachable toxic waste and would be classified as a Hazardous Waste. Wastes classified as hazardous waste must be managed in accordance with the requirements of the HWR.

Typically, bottom ash has been found to be non-leachable and suitable for alternative, beneficial reuse, such as substitution aggregate in cement manufacture or road base material. Where reuse is not practical, bottom ash can be disposed of in a permitted landfill as waste without extraordinary precautions.

In contrast, APC residue and fly ash from incineration of MSW are typically found to be leachable by TCLP tests. Constituents of concern are typically trace metals entrained in the fly ash, and potentially include residual organic compounds not destroyed by the incineration process. APC or fly ash residues that are leachable must be either stabilized to reduce the leachability to the point at which it can be managed as a non-hazardous waste material, or disposed of at a secure landfill that is licensed to accept hazardous waste.

As described above, the constituents of concern in the fly ash will vary with the composition of the waste being incinerated. A homogeneous solid waste in-feed that has a low concentration of trace metals or hazardous organic compounds, such as wood waste and land clearing debris, is unlikely to produce a leachable fly ash.

²⁷⁹ BC Hazardous Waste Regulation, B.C. Reg. 63, April 1, 2009

²⁸⁰ Canadian *Transportation of Dangerous Goods Act* and Regulations, SOR/2008-34

Financial Security for Ash Disposal Sites

As discussed above, landfills operating in British Columbia are authorized under the EMA by the BC Ministry of Environment. These authorizations contain a variety of operational and monitoring conditions, established on a site-specific basis to ensure the protection of human health and the environment. One of the administrative requirements that can be included in a permit is the provision of financial security by the permit holder.

Financial security is a tool available to the ministry to manage the financial risks associated with the landfill site in the context of the license to operate and ultimately close the landfill. Typically, security is required by the ministry where a potential long-term liability exists with a facility and where adequate funds need to be available to the Province in the event of a default by the operator or to address the operator's inability to manage pollution originating at the landfill. The need for security is identified by the Director of Waste Management as defined by the EMA. Municipal governments are typically exempt from the requirement to post security, but private landfills and landfills managing hazardous waste are often required to post financial security.

Similar principles apply to the management of contaminated sites in BC. The BC Ministry of Environment document, *Protocol 8*^[281], *Security for Contaminated Sites*, provides a basis where the ministry considers the need for establishment of financial security. The requirements are summarized generally in this section and we refer the reader to the protocol(s) for specific details on their application.

The key guiding principles contained in the Protocol for determining the appropriate financial security include:

- Each site presents a unique set of circumstances that must be considered when determining security requirements
- Security is only required for sites that are considered high risk. *Protocol 12*^[282], *Site Risk Classification, Reclassification and Reporting* provides the guidance on the classification of a site as high risk. In brief summary, this determination has its basis in ecological and human health risk assessment, and considers the concentration of contaminants present at the site and the exposure pathway to receptors of concern. Where wastes and contaminants at a site pose a risk to human health or the environment, the requirement for posting financial security is considered appropriate.
- The requirement for security is the responsibility of the Director of Waste Management and any required security is subject to review. Security should be consistent with precedents set by the Ministry for other similar sites and be consistent, equitable and effective.

²⁸¹ Protocol 8 for Contaminated Sites, *Security for Contaminated Sites*, prepared pursuant to Section 64 of the *Environmental Management Act*, BC Ministry of Environment, November 19, 2007

²⁸² Protocol 12 for Contaminated Sites, *Site Risk Classification, Reclassification and Reporting*, prepared pursuant to Section 64 of the *Environmental Management Act*, BC Ministry of Environment, December 4, 2009

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Protocol 8 also includes a procedure for determining the value of financial security required. The basis for the security is the estimate of the potential remediation cost necessary to address future remediation of the high risk site, including capital costs, recurring costs, remediation schedule and discount rates for determining net present value. The required financial security is based on the least cost remedial alternative acceptable to the Director and is equal to 100% of the one-time remediation capital costs plus the value of the total management and monitoring cost over the entire planning and remediation period. The Director is to review the security requirements every one to five years.

Specific to the management of fly ash and bottom ash deposited in a permitted landfill facility, financial security may be required of an operator subject to the qualification criteria discussed above. Typically, bottom ash is not considered hazardous and as such is normally incorporated into the landfill without special precautions. Fly ash typically requires stabilization to reduce the leachability of contaminants and is considered to pose a higher risk than bottom ash. If the fly ash is suitably stabilized so it is no longer leachable, it would be deemed to pose no greater risk than the material contained in the landfill. The security required would therefore be consistent the security requirement for other landfills, if any. Unstabilized fly ash would be considered hazardous waste and would trigger a higher financial security for potential future remediation. There are few sites available in BC for the deposition of unstabilized fly ash, even in specifically designed monofill cells.

Given this high degree of variability of site conditions (size of landfill, quantity of ash in proportion to waste being deposited, environmental sensitivity of the site), and whether a site is classified as high risk, it is not possible to provide a single estimate of the value of financial security. Each site and each case must be evaluated, using the BCMOE Protocols, to determine the level of risk, the potential cost to mitigate or remediate the risk and who the responsible party will be. Unit costs for remediation will be higher for smaller landfills than for larger landfills, but the total cost will always be linked to the volume of material required to be remediated. Therefore, it is not technically unreasonable for the security requirement to be linked to volume of material deposited, but this approach may be logistically difficult to administer. Setting a financial security based on the ultimate capacity of the ash deposition site is more practical.

It is also difficult to differentiate between the risk posed by the ash in the landfill and the risk attributed to the other wastes contained therein. Where ash is managed in separate cells, it may be possible to apportion a remediation cost specific to the ash and separate from any financial security requirement for the landfill as a whole.

In summary, the requirement for a financial security must be considered on a case-by-case basis. It is reasonable for the landfill operator and WTE proponent to evaluate the potential risk posed by the deposition of ash in a landfill site and to justify the appropriate level of financial security that should be required by the Director, and have this requirement formally recognized by a legal instrument issued by the province, such as a permit, Solid Waste Management Plan.

10.3 Management of Bottom Ash and APC Residues

Bottom ash and APC residues can be managed in a variety of different ways but these can basically all be grouped into two main methods:

- Safe Disposal
- Alternative Uses (Recycling and Reuse).

Much investigation has been given to finding alternative uses for bottom ash and APC residues to divert these materials from landfill. Depending on the jurisdiction, bottom ash and APC residues are managed in different ways due to local regulations and/or access to appropriate technologies and markets in which to use the material.

10.3.1 Safe Disposal of Ash

There are several ways in which bottom ash and APC residues can be handled to ensure safe disposal.

Because bottom ash does not typically contain high concentrations of hazardous materials and is not typically leachable, it can usually meet regulatory requirements for disposal via a conventional sanitary landfill. Normally, bottom ash is 'aged' to ensure that it is highly stable (exhibited through a decrease in organic content, and fixing of metals) and less likely to leach its contents. Stabilization by ageing of bottom ash is achieved by simply storing the bottom ash for several weeks or months. For example in Germany, bottom ash is stored/aged for a minimum of three months while in the Netherlands it is stored for a minimum of six weeks.^[283]

APC residues typically contain high levels of leachable toxic substances which must be managed as hazardous waste^[284] at a suitably designed and authorized landfill. Pre-treatment of the APC residue may reduce the leachability and reduce the requirements on the landfill site.

Generally speaking, treatment options to ensure safe disposal for bottom and fly ash are based on one or more of the following principles:

- Physical or chemical separation
- Stabilization/solidification
- Thermal treatment.

Table 10-6 provides an overview of the current practices being used to handle ash residues from solid waste incinerators in order to make them suitable for utilization or safe for disposal.

²⁸³ Management of Bottom Ash from WTE Plants. An overview of management options and treatment methods

²⁸⁴ Characteristics, Treatment and Utilization of Residues from Municipal Waste Incineration. H.A. van der Sloot, *et al.* 2001

Table 10-6: Overview of Principles and Methods of Treatment of Ash Residues Resulting from the Thermal Treat of MSW^[285]

Treatment Principle	Examples of Processes and Unit Operations	Bottom Ash	Fly Ash
Separation	▪ Wash and extraction	1	1,2
	▪ Chemical precipitation		1,2
	▪ Crystallization/evaporation		
	▪ Ion exchange		
	▪ Density and particle size based separation	1	2
	▪ Distillation		2
	▪ Electrolysis		
	▪ Electrokinetic separation		
	▪ Magnetic separation	1	
	▪ Eddy-current separation	1	
Stabilization and/or Solidification	▪ Addition of hydraulic binders	1	1,3
	▪ Addition of pore-filling additives	1,2	1
	▪ Chemical stabilization	1	1
Thermal Treatment	▪ Sintering	1	1,3
	▪ Melting/vitrification	1,3	1,3

NOTES:

1 = Part of existing and proven treatment technology

2 = Have shown promising results, may be expected to be included in future treatment systems

3 = Currently under investigation or have been investigated and not found technically and/or economically feasible

10.3.2 Alternative Uses of Bottom Ash

Recent developments have focused on recycling and reusing bottom ash for construction purposes such as use in asphalt, cement bound materials, and pavement concrete. Bottom ash often shares similar physical and chemical characteristics to conventional aggregates used in construction and therefore may be suitable for substitution in some applications.

The main issues regarding the reuse and recycling of bottom ash are the release of harmful contaminants into the environment, and the requirement that the ash material meets specific technical material requirements to ensure that it has similar characteristics to the traditional materials being used for the same purpose.^[286]

²⁸⁵ Kosson, D.S. and van der Sloot, H.A. Integration of Testing Protocols for Evaluation of Contaminant Release from Monolithic and Granular Wastes. In: Waste Materials In Construction – Putting Theory into Practice. Studies in Environmental Science 71. Eds. J.J.J.M. Goumans, G.J. Senden, and H.A. van der Sloot. Elsevier Science Publishers, Amsterdam, 1997, 201-216

²⁸⁶ Characteristics, Treatment and Utilization of Residues from Municipal Waste Incineration. H.A. van der Sloot, *et al.* 2001

In Europe, bottom ash recycling is very common. Bottom ash has been used successfully in Europe as:

- Embankment fill
- Road base material
- Aggregate for asphalt
- Aggregate for concrete building blocks
- Daily cover material for landfills.

The following table (Table 10-7) illustrates how bottom ash is utilized in various countries worldwide and the percent of bottom ash generated in these jurisdictions which is landfilled.^[287]

Table 10-7: Quantity of Bottom Ash Produced and Utilized in Various Countries Worldwide

Country	Primary Type of Utilization	Bottom Ash Landfilled	
		Tonnes	Percent
Belgium	Construction Material	No Data	–
Czech Republic	Landfill construction	12,577	11%
Denmark	Primarily used as granular sub-base for car parking, bicycle paths and paved and un-paved roads, embankments and filler material for land reclamation. ^[288]	15,348	2%
France	Road construction	707,030	23%
Germany	Civil works, Sub-paving applications	868,200	28%
Italy	Civil works, based material for landfill	602,940	80%
Netherlands	Road construction and embankments	150,000	13%
Norway	Landfill construction	95,000	48%
Switzerland	Landfill	600,000	100%
Spain	Road construction	No data	–
Sweden	Civil works and landfill construction	No data	–
UK	Road construction, concrete aggregate	No data	–
USA	Road construction and landfill	No data	90%

Barriers to the utilization of bottom ash^[289] include:

- **Hazardous waste** – a small percentage of MSW bottom ash can be at risk of being classified as hazardous waste due to its high concentration of lead (>0.25%). This risk is directly related to lead concentration in the in-feed waste.
- **Competition from other recyclables** – in some cases there are other less polluted recyclables/materials which can be used for the same purpose.

²⁸⁷ Management of Bottom Ash from WTE Plants. An overview of management options and treatment methods

²⁸⁸ Thomas Astrup. Pretreatment and utilization of waste incineration bottom ashes: Danish experiences. 2007

²⁸⁹ Management of Bottom Ash from WTE Plants. An overview of management options and treatment methods

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- **Easy access to landfill** – cheap prices for landfill disposal discourages bottom ash utilization (e.g., Germany).
- **Easy access to natural resources** – abundance of cheap gravel and soil acts as a barrier to utilization (e.g., Switzerland) as an aggregate substitute.
- **Export** – possibilities of cheap disposal in landfills/mines of neighbouring countries can hinder usage.
- **Leaching of salts and trace metals** – potential for leaching must be addressed, often via stabilization.
- **Practical barriers** – if a contractor is not aware that bottom ash can be used it will be a barrier, limited amounts of bottom ash is a practical obstacle.
- **Regulatory barriers** – alternative uses of bottom ash are generally more difficult to permit in jurisdictions that are unfamiliar with such uses, and regulatory change may be necessary in order to permit such uses.

10.3.3 Treatment and Alternative Use of APC Residues

Table 10-8 presents an overview of the predominant management strategies currently being used for managing Fly Ash and/or APC residues in various countries around the world.

Table 10-8: Overview of Management Strategies Used for APC Residue in Various Countries^[290]

Country	Management Strategies of Fly Ash and APC Residue
United States	APC residues and bottom ash are mixed at most MSW incineration plants and disposed as a “combined ash”. The most frequent approach used is disposal in landfills which receive only incineration residues (ash monofills).
Canada	Bottom ash is typically non-hazardous and can have beneficial use or is deposited in a municipal landfill without extraordinary precautions. APC residues are disposed in a hazardous waste landfill after treatment or can be stabilized to reduce leachability and then landfilled.
Sweden	APC residues are disposed in secure landfills after treatment.
Denmark	APC residues and fly ash are classified as special hazardous waste and are currently exported. Significant efforts are being spent to develop treatment methods that can guarantee that APC residues can be landfilled in a sustainable way.
Germany	The APC residues are mainly disposed of in underground disposal sites, such as old salt mines.
Netherlands	Flue gas cleaning wastes are disposed temporarily in large sealed bags at a controlled landfill until better options are available. The utilization of APC residues is presently not considered. The re-use of the waste is subject to investigation.

²⁹⁰ Treatment and use of air pollution control residues from MSW incineration: An overview. Quina, *et al.* 2007

Country	Management Strategies of Fly Ash and APC Residue
France	After industrial solidification and stabilization processes based on the properties of hydraulic binders, the waste is stored in confined cavities in a specific landfill (French Class I and II). The high cost of this treatment is encouraging companies to search for alternatives to disposal.
Italy	Various technologies have been proposed, but the most widely adopted is solidification with a variety of hydraulic binders (such as cement and/or lime, blast furnace slag, etc.).
Portugal	APC residues are treated with hydraulic binders (solidification/stabilization method) and landfilled in specific sites (monofills).
Switzerland	APC residues are pre-treated before being landfilled. Some plants with wet flue gas treatment utilize the acid wastewater from the acid scrubber to extract soluble heavy metals, most notably zinc from the fly ash. The treated fly ash is then mixed into the bottom ash and landfilled together with the bottom ash. The filtrate is neutralised, precipitating the metals, and the sludge is dewatered and dried. If the sludge contains more than 15% Zn it may be recovered – but at a cost – in the metallurgical industry. Other plants apply a near neutral extraction and stabilize the remainder with cement. Export to Germany is also an option.
Japan	MSW fly ash and APC residues are considered as hazardous, and before landfill intermediate treatments must be performed, such as melting, solidification with cement, stabilization using chemical agents or extraction with acid or other solvents. Melted slag may be used in road construction and materials solidified or stabilized with cement are usually landfilled.

A large number of possible uses for APC residues have been investigated and these uses can be grouped into four main categories:

- Construction materials (cement, concrete, ceramics, glass and glass-ceramics)
- Geotechnical applications (road pavement, embankments)
- Agriculture (soil amendments)
- Miscellaneous (sorbent, sludge conditioning).^[291]

Of all the options listed, the one with the most promise appears to be the use of fly ash to produce ceramic or glass-ceramic materials.

APC residues have characteristics somewhat comparable with cement. APC residues have been suggested for use as a substitute cement in concrete for construction purposes. However this has proven to be quite technically difficult as it can negatively impact the strength development and settling times even when only 10 – 20% of the cement is substituted. Further the presence of aluminum in the fly ash can result in hydrogen generation which may lead to cracks and disintegration of concrete with APC residues.^[292]

²⁹¹ Ferreira *et al.* 2003. Possible applications for municipal solid waste fly ash. *Journal of Hazardous Materials*. 96 (203), 201-216

²⁹² Management of APC residues from WTE Plants. ISWA. 2008

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In addition to alternative uses, several components present in fly ash may be recovered and used again. The primary interest is centered on the recovery of salts, acid, gypsum, and metals.^[293]

- **Salts** – salt recovery directly from the residues is possible after water extraction. This has been considered in conjunction with several treatment technologies generating salt containing process water. This technique is in commercial use today.
- **Acid** – the solution from a first scrubber stage of a multi-stage APC setup is essentially concentrated hydrochloric acid. Techniques to recover this acid are in commercial use.
- **Gypsum** – production of gypsum can be achieved based on recovery of gypsum from the scrubber solution from alkaline scrubbers. This technique is in commercial use.
- **Metals** – metals can be recovered using extraction and thermal techniques. This technique is in commercial use.

Several different treatment options have been developed to make APC residues suitable for disposal or for other alternative uses. As discussed previously, these can be broken down into three main treatment types: separation, stabilization/solidification, and thermal treatment. In practice it may be useful to start the treatment with separation techniques (mainly washing or leaching with fluid solutions that are more aggressive than water) followed by thermal treatment or stabilization/solidification methods.

Separation methods are those that allow the removal or extraction of unwanted materials from the residue so that the residue is of higher quality and can be used for other purposes or the unwanted materials can be captured for other uses. Specific examples of separation techniques include washing processes, leaching (for heavy metal removal), electrochemical processes, and thermal treatment (evaporation). Some methodologies are very effective at removing the hazardous substances, and consequently non-hazardous materials can be obtained. Separation processes can also be used as the first step for further treatments. One study stated that the removal of soluble salts is crucial for sustainable treatment of APC Residue and if the APC residue is going to be used for another purpose.^[294]

Solidification/stabilization (S/S) processes are those that use additives or binders in order to physically and/or chemically immobilize hazardous components initially present in the waste. Solidification reduces the mobility of the contaminants found in the APC residue through encapsulation. Stabilization acts to convert the contaminants into less soluble or less toxic forms, with or without solidification. In practice, it is often useful to combine stabilization with solidification in order to further reduce the chances that hazardous materials can leach out of the APC residues. Cements and pozzolanic materials are the most common binders. In Europe, S/S methods are commonly used to treat APC residue due to the low cost of this approach and as this technology is

²⁹³ Management of APC residues from WTE Plants. ISWA. 2008

²⁹⁴ Quina, *et al.* Treatment and use of air pollution control residues from MSW incineration: An overview. Waste Management. 2008

well established. It appears that most of the current research regarding APC residue management involves investigation of solidification with binders, using in particular Portland cement.^[295]

Thermal methods are those that involve the use of high heat to induce physicochemical changes in the APC residues that reduces the volume and potential for leaching from the material while producing a stable and non-hazardous slag.^[296] The thermal option is highly effective at reducing the opportunities for the leaching of hazardous substances from the APC residues, reducing the volume of the material (therefore using less landfill space), and also destroying dioxins/furans which may be present in the residue. Thermal methods can be broken down into three main categories: sintering, vitrification, and melting (or fusion). The main drawback to the thermal treatment of APC residues is the high cost involved. Thermally treated fly ash results in the production of an environmentally stable material for which secondary applications can be found.

Generally speaking, lower costs are associated with the stabilization/solidification methods than with the separation or thermal treatment options.

10.3.4 Ash Management in Canada

In general, bottom ash is suitable for deposition in a permitted landfill or for selective beneficial use as a construction material. APC residue is generally not suitable for reuse given the concentration of hazardous constituents, the difficulty in stabilizing the ash for beneficial use, and the history of managing this ash as a hazardous waste. Typically, APC residue is stabilized then disposed in a designated monocell in a landfill.

As mentioned previously in this report, there are currently seven operating Canadian MSW thermal treatment facilities. Table 10-9 provides an overview of the generated quantity and the utilization/disposal of the bottom ash and fly ash/APC residues produced by these facilities as of 2006. Over 183,000 tonnes of bottom ash and over 26,000 tonnes of fly ash and APC residue were generated in 2006 from the four largest facilities. The average quantity of bottom ash at these facilities was 25% by weight of input material. Fly ash and APC residue combined represented 4% of the input waste. Information on the quantity of ash generated at two of the operating facilities was not available.

²⁹⁵ Quina, *et al.* Treatment and use of air pollution control residues from MSW incineration: An overview. Waste Management. 2008

²⁹⁶ Air pollution control residues from waste incineration: Current UK situation and assessment of alternative technologies. Rani, *et al.* 2007

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Table 10-9: Generated Quantity and Utilization/Disposal of MSW Bottom Ash and Fly Ash in Canada in 2006

Facility Name	Bottom Ash Produced (Tonnes) 2006	Bottom Ash Utilization/Disposal (%)	Fly Ash/APC Residue Produced (Tonnes) 2006	Fly Ash/APC Residue Management
Metro Vancouver Waste to Energy Facility	46,719	90% landfill cover 10% road base construction (mostly on site landfill some Metro Vancouver properties)	9,860	Stabilization (Wes-Prix process) thus enabling disposal in MSW landfill
Algonquin Power Peel Energy-From-Waste Facility	38,215	74% landfill cover, 24%landfill, 2 % aggregate use	5,647	Stabilized and disposed of at secure landfill in Quebec
L'incinérateur de la Ville de Quebec	86,300	100% Landfilled	10,290	Fly ash decontaminated on site to extract heavy metals and disposed with bottom ash
PEI Energy Systems EFW Facility	12,289	100% Landfilled	683	Hazardous Waste Disposal
Ville de Levis, Incinérateur	N/A	100% Landfilled	N/A	Fly ash decontaminated, Unknown disposal
MRC del Iles de la Madeleine	440	N/A	160	N/A
Wainwright Energy From Waste Facility	N/A	100% Landfill	N/A	N/A
Total	183,963		26,640	

Metro Vancouver WTE Facility

Metro Vancouver's WTE facility located in Burnaby has been in operation since 1988. The facility produces approximately 47,000 tonnes of bottom ash and almost 10,000 tonnes of fly ash each year. Bottom ash from the facility is passed through a resource recovery section to remove metallic residuals. The bottom ash is sampled and analyzed frequently and has consistently been classified as non-hazardous waste. This classification allows beneficial secondary use of the ash as well as allows the deposition of the ash in a municipal solid waste landfill.

Fly ash from the Metro Vancouver facility post- stabilization has been tested for leachability using the TCLP test method. A comparison of these results to a partial list of the HWR Leachate Quality Standards is summarized in Table 10-10 below.^[297] The test results are given in units of milligrams per litre, which is the concentration of the constituents in the liquid extract. The concentration of leachable lead in unstabilized fly ash causes it to be classified as hazardous waste. However, the

²⁹⁷ Pers Com, Mr. Chris Allan, Metro Vancouver, December 2010

leachable lead concentration in the stabilized fly ash is less than the HWR Standards. A reduction in the lead concentration in the MSW in-feed would result in lower lead concentrations in the unstabilized fly ash but such a targeted diversion strategy would be difficult to implement.

Table 10-10: TCLP Results for Metro Vancouver Burnaby MSW Stabilized Fly Ash and APC Residues and BC HWR Leachate Quality Standards (mg/L)

Parameter (in mg/L)	Stabilized Fly Ash TCLP result	BC HWR Leachate Quality Standards
Arsenic	<0.75	2.5
Barium	1.53	100
Boron	0.26	500
Cadmium	<0.05	0.5
Chromium	0.08	5
Lead	0.5	5
Mercury	<0.005	0.1
Silver	<0.5	5.0

Metro Vancouver MSW incinerator fly ash and APC residue is stabilized using the WES-PHix process, a patented stabilization process that reduces the mobility of heavy metals in the ash by creating an insoluble and highly stable metal phosphate mineral. Once treated, the ash is subjected to the Toxicity Characteristic Leaching Procedure (TCLP) test to verify stability in accordance with the HWR requirements. The treated fly ash is then disposed of at a permitted municipal landfill.

Other treatment methods have been examined for the Burnaby incinerator fly ash^[298] but for the most part have been discounted as a result of the chemical unsuitability of the ash for use as a concrete replacement or additive. Generally in comparison with other aggregate materials, fly ash contains elevated concentrations of chloride and hydroxide salts, potentially causing the release of ammonia during concrete batching or inducing accelerated corrosion in embedded reinforcing steel. It may be suitable as an additive in non-critical, non-reinforced concrete products.

Proposed Gold River Power (Formerly Green Island) WTE Facility

It is estimated that the maximum rate of ash discharged from the proposed Gold River Power facility will be 150,000 tonnes, while burning up to 750,000 tonnes of refuse per annum. No viable options are available in the vicinity of the site for beneficial reuse of the bottom ash at this time, and the primary management method would be landfill disposal. It is intended that fly ash/APC residue will be treated similar to the process used at the Burnaby incinerator, where phosphoric acid will be sprayed on the recovered fly ash to reduce pH and to stabilize and/or render heavy metals insoluble in water. This treatment method is intended to fix any potentially harmful elements in the fly ash such that TCLP testing would confirm that the material is non-hazardous and suitable for disposal in a

²⁹⁸ Ibid

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sanitary landfill. The treated fly ash/APC residue would be combined with the bottom ash from the facility and disposed in a purpose-built ash monofill designed and operated by Covanta.

An application for an authorization to dispose of ash at a monofill facility in the vicinity of the WTE facility was originally submitted on April 24, 2007 and is in the late stages of review by the Ministry. The original application is being amended to reflect the revised nature and volume of ash, as well as proposed leachate handling procedures.

Region of Peel WTE Facility

The Region of Peel uses a WTE facility as part of its integrated waste management system (the facility is privately owned by Algonquin Power). The facility was commissioned in 1992 and the Region is under contract to provide waste to the facility until 2012. The facility handles approximately half of the Region's MSW (approximately 160,000 tonnes annually). In a given year the facility generates approximately 8,000 tonnes of fly ash and about 40,000 tonnes of bottom ash.^[299]

Currently, the fly ash is stabilized on-site and is sent to a secure disposal site in Quebec. Historically, the bottom ash has been used as a landfill cover, has been sent to landfill for disposal and been used as an aggregate in building materials. In 2006, 74% of the bottom ash was used as landfill cover, 24% was sent directly to landfill and 2% was used as an aggregate supplement.^[300]

More recently, potential applications for the bottom ash have been investigated including its use in asphalt, brick, and concrete manufacturing. Currently, the Region of Peel has a supplier agreement with Greenpath Inc., a Mississauga company, to provide bottom ash for use as an aggregate substitute in the manufacture of paving stones and concrete blocks.^[301] The Region of Peel shipped 6,400 tonnes of bottom ash to Greenpath Inc. from April to September 2009.

Proposed Regions of Durham/York WTE Facility

The ash management system for the proposed Durham/York WTE facility project reflects current design for ash management systems in North America. For that reason, a detailed description of the proposed Ash management and treatment system is provided below, in order to provide a full overview of the potential expectations for ash management associated with new facility design.

For each combustion train, a complete residue conveying system will be furnished and installed. From the quench chamber following the stoker, a hydraulically driven ram will push the residue up an inclined draining/drying chute where a low amplitude electromagnetic vibrator mounted on the chute will vibrate the residue. This vibratory motion acts to separate excess water from the residue, which drains back into the quench bath (the quench bath will be designed such that it is capable of using wastewater from other facility operations). The bottom ash containing enough moisture to prevent dusting (15 to 25% by weight) will then fall to a heavy duty vibrating pan conveyor with integral grizzly scalper (coarse screening device) that services all of the boilers. The vibratory

²⁹⁹ GTAA Partners in Project Green – Algonquin Power – By-Product Synergies. 2009

³⁰⁰ 2007 GENIVAR report

³⁰¹ GTAA Partners in Project Green – Algonquin Power – By-Product Synergies. 2009

conveyor/grizzly scalper will remove large materials from the bottom ash before it is transferred by an enclosed inclined conveyor for transport to the residue storage building (the large materials will be collected and then transported independently via front-end loader to the residue storage building).

Within the residue storage building a magnetic drum and a vibratory screen will be used to separate ferrous material from the bottom ash, and an eddy current separator will be used to remove the non-ferrous metal from the bottom ash. After separation, each material will be directed into dedicated storage bunkers that will store four days worth of each material. A front end loader will stack and recast the materials. The front end loader will also load residue trucks inside the residue building that will take the residue to its final disposal location. Similar to waste delivery trucks the residue trucks will enter and exit through two motor operated doors, triggered automatically by inbound and outbound vehicles to open and close as required. To minimize any dust escaping to the environment during the conveying, separating, and truck loading process, the residue building will be totally enclosed and have a filtered ventilation system complete with a filtration unit (baghouse). The ventilation system will also draw air from the grizzly area and along the enclosed conveyor gallery. The residue storage building will not be connected to any other structure to prevent dust from infiltrating other parts of the Facility.

Following appropriate testing to ensure the material is not hazardous as defined and regulated by the Province, the bottom ash will be transported to a licensed landfill facility. At the time of this submission, it is anticipated that the bottom ash will be utilized as daily cover material. Covanta's Research and Development group are continually investigating new and more beneficial uses for this material.

Fly ash will be collected and managed separately from bottom ash.

The fly ash handling system for each combustion train will collect the fly ash from the convection pass, superheater, economizer and the APC system of that train. Fly ash will be collected via intermediate conveyors which will discharge into one of two redundant ash surge bins. The fly ash conveyors will be water and dust proof. Each ash surge bin will feed an ash conditioner/mixer (pugmill) that will combine and thoroughly mix the ash with Portland cement, pozzolan and water to fix any potentially harmful elements in the fly ash. The conditioned fly ash will then be discharged into the first of seven dedicated conditioned fly ash bunkers in the residue building.

Each bunker will hold three days worth of conditioned fly ash. To maintain a consistent and manageable product, the conditioned fly ash will be turned regularly. After three days, the fly ash will be transferred to the adjacent three-day storage bunker. This process will be repeated as required for a total curing period of up to 21 days (three days in each of the seven bunkers). After the fly ash has cured, it will be loaded into transportation vehicles by the front end loader. The conditioned fly ash will be kept separate from the bottom ash in the residue building.

In Ontario, fly ash is designated as hazardous and therefore must be managed in accordance with Ontario regulatory requirements.

10.4 Summary – BAT for Management of Residues

BAT for the management of residues from WTE facilities have been developed by various European Union Member States. The following list summarizes the generally accepted BAT principles:

- The separate management of bottom ash from fly ash and APC residues to avoid contamination of the bottom ash.
- Each type of ash should be assessed for potential for recovery either alone or in combination. It is important to assess the levels of contaminants in bottom ash and fly ash to assess whether separation or mixing is appropriate.
- Ferrous and non-ferrous metals should be recovered from the bottom ash to the extent practical and economically viable.
- If pre-dusting stages are used by the APC system, an assessment of the composition of the fly ash should be carried out to assess whether it may be recovered, either directly or after treatment, rather than disposed of at a secure landfill.
- The treatment of bottom ash (either on or off site) by a suitable combination of:
 - Dry bottom ash treatment with or without ageing
 - Wet bottom ash treatment with or without ageing
 - Thermal treatment, or
 - Screening and crushing.
- Treat APC residues to the extent required to meet the acceptance criteria for the waste management option selected for them (i.e., cement solidification, thermal treatment, acid extraction etc.).

In BC, BAT for the management of MSW incineration ash includes:

- Diversion of undesirable constituents in the MSW stream, such as metals removal wherever possible, to reduce the concentration of the constituents in the residuals.
- Aging of bottom ash to improve chemical stability prior to reuse.
- Reuse of bottom ash as a construction material substitute, such as a concrete or asphalt aggregate, road base material, or intermediate cover material at a landfill. Other possible beneficial reuses should be explored where practical.
- Subjecting APC residues to leachability (TCLP) tests to determine if the ash qualifies as hazardous waste. Ash that is classified as leachable can be managed as hazardous waste at a secure landfill. Stabilized ash that is rendered non-leachable can be re-classified as non-hazardous waste and can then be managed as solid waste. The *BC Hazardous Waste Regulation* specifies the test methods and limits for classifying residue as hazardous waste.
- Stabilization of APC residues from municipal solid waste incineration facilities to reduce leachability is an acceptable management option. Several proprietary stabilization processes have been developed and may be successfully applied to APC residue. It is important to test

the leachability of the stabilized waste using the TCLP test. Materials that contain concentrations less than the leachability standards provided in Table 1 of the HWR are not considered hazardous waste and can then be deposited in a suitably designed monofill at an authorized MSW landfill. Stabilized material that does not meet the HWR leachate standards must be managed as hazardous waste, which in BC requires out-of-province disposal.

- APC residues and fly ash from the incineration of biomass, wood and land clearing wastes and some RDF should also be subjected to the TCLP test. The absence of constituents of concern in these materials entering the thermal treatment facility results in the residue being more likely to pass the leachate criteria and be suitable for landfilling or reuse similar to bottom ash.

In practical terms, bottom ash from the Burnaby incinerator is deposited in a municipal landfill. Fly ash and APC residue is stabilized (as described above) then placed in a municipal landfill.

The separate management of bottom ash from fly ash and APC residues to avoid contamination of the bottom ash may not be a necessary approach in some contexts in BC. Generally, this would be a best practice approach for WTE facilities located in areas that have reasonable access to potential markets for reuse of the bottom ash, but this approach may be impractical for facilities in more isolated locations. Disposal of combined bottom ash and treated APC residue in a suitably designed secure facility and/or stabilization of the combined ash waste would be acceptable option where beneficial reuse of these residues is unfeasible.

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11 CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations reached following the review of technologies, BAT, BACT and the regulatory approaches in other jurisdictions, and considerations for regulatory change in BC can be summarized as follows:

Conclusions

1. Mass burn incineration continues to be the most common method of thermal treatment for WTE facilities. It is reasonable to anticipate that this technology would be proposed for new WTE facilities contemplated in BC.
2. Other thermal treatment technologies such as gasification, plasma gasification and pyrolysis have historically had certain limitations due to their complexity, difficulty in handling variations in the waste stream (which can be managed by waste pre-treatment), and lower net energy recovery (electricity and heat energy) once in-plant parasitic consumption is accounted for. These factors tend to make these other thermal treatment technologies less viable. However, the industry continues to evolve and facilities that treat a portion of the waste stream are being proposed, developed and commissioned. As more actual performance data is generated, it will be better understood if the limitations of these approaches can be resolved.
3. The 1991 BC Emission Criteria for Municipal Solid Waste Incinerators (1991 BC Criteria) cut off between small and large facilities of 400 kg/hour (equivalent to 9.6 tonnes per day) was put in place to differentiate between small facilities used for remote locations and/or on-site waste management and larger WTE facilities. In Europe WTE operations generally handle an average of 20 to 30 tonnes of MSW per hour (480 to 720 tonnes per day). To-date, various studies indicate that it is difficult for commercial WTE facilities to be economically viable at annual capacities less than 10 tonnes per hour (equivalent to 100,000 tonnes per year actual throughput), unless there is a local economic driver (e.g., high value local market for heat energy, high transportation costs and/or difficult logistics associated with other disposal options). In some jurisdictions (e.g., Ontario) differentiation between large and small facilities results in differentiation of approvals processes (large WTE requires full Environmental Assessment (EA) Screening, small WTE does not) however, in regards to air emissions the same criterion/limits apply regardless of size to all WTE applications except for very small scale research applications. Other jurisdictions (e.g., United States Environmental Protection Agency (US EPA)) apply different criterion/limits for smaller scale WTE approaches. For the purpose of regulating MSW incineration in the BC context, it seems reasonable that the cut-off of 400 kg/h between small and large facilities should be maintained.
4. The 1991 BC Criteria currently include the key substances of concern that would be released from the main stack (point source) of an existing or new WTE facility. The 1991 BC Criteria do not, however, provide limits for speciated total particulate matter in the 10 micron (PM₁₀) and 2.5 micron (PM_{2.5}) size fractions. This approach is consistent with emission limits observed in other jurisdictions evaluated in this report. The value of specifying limits for

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speciated particulate matter has not been demonstrated and thus limits for these parameters have not been identified in the proposed revisions.

5. The 1991 BC Criteria do not consider fugitive emissions including dust, odour, and Volatile Organic Compounds (VOCs).
6. The specification of temperature and retention time in the combustion zone varies between North America and the EU, although generally these jurisdictions define the combustion zone in a similar fashion (measured after the last point of air injection). In North America, a minimum temperature of 1,000°C with a retention time of 1 second is typical. In the EU, the specification is a minimum of 850°C with a retention time of 2 seconds. Operated correctly within the design criteria for the incinerator, both specifications should produce an acceptable quality of emission before entering the APC. Flexibility in specifying these operating parameters should be considered and the appropriate balance of temperature and retention time applied on a facility-specific basis.

In most jurisdictions, guidance on design and operation of WTE facilities is provided including recommendations related to combustion temperature and residence time, and also for other parameters such as combustion air distribution, oxygen availability, operation of APC systems and ash management. In these jurisdictions as in BC, the recommendations are not intended to restrict technology development or to dictate facility design or equipment selection. Alternative designs and operating conditions may be proposed for approval, and considered by the regulatory authority, provided that the systems are designed and operated such that the Emission Limit Values (ELVs) can be achieved. Proponents are expected to provide sufficient technical information to the regulatory authority to justify alternative design and operational parameters. Once approved, these parameters are reflected in the operational permit(s) and/or conditions set out for the facility.

7. The most common and effective air pollution systems applied to WTE facilities are dry/semi dry, wet and semi wet systems. Several types of “end of pipe” air pollution controls have been applied to WTE facilities. The selection of best technology (either BACT or BAT) depends on the nature of the waste, design of the combustion process, flue gas composition and fluctuation, energy supply, energy recovery and a number of other considerations.
8. Modern WTE facilities are capable of achieving substantial emission reduction through the use of emission control technology. Reductions in the contaminants of concern across the air pollution control system (APC) typically range from 90% up to 99.95% through the application of typical APC systems.
9. Management of NO_x can be accomplished through both Selective Non-Catalytic Reduction (SNCR) and Selective Catalytic Reduction (SCR) systems, with economics in the form of direct costs (including reagent and energy consumption) or financial incentives (e.g., tax regimes) playing a role in the decision regarding which system is selected and in how the system is operated. Lower NO_x emissions can regularly be achieved through SCR. With SNCR, the level of NO_x reduction achieved is often linked to immediate economic drivers since increasing quantities of ammonia injection (i.e., use of additional reagent) are required

to achieve lower emission levels. There is also a trade-off with SNCR, as the odour associated with ammonia slippage (stack ammonia releases due to excess ammonia not reacting with NO_x) must be considered.

10. Emission releases from WTE facilities have decreased substantially in the US between 1990 and 2005. SO_x and NO_x have been reduced by 88% and 24% respectively. The reductions have resulted from improvements in thermal treatment technology and operational control, improvements in waste diversion and source separation prior to thermal treatment, and improvements in the design and operation of the APC equipment.
11. The EU Energy Efficiency Equation will be adopted by EU member states by the end of 2010 as a means of differentiating between the energy recovery performance of WTE facilities. In general, the formula can be used for differentiating between energy recovery and disposal within a waste hierarchy. The application of the equation varies between the various EU member states. Further development and definition of the scope and application of the equations is expected. The ministry's Environmental Protection Division operational policy already states a preference for any MSW incineration facilities to meet energy recovery criteria (over disposal, determined using an approach similar the Equation). Therefore, it may be reasonable to modify the Equation to suit a BC context (i.e., modify the energy equivalency factors for electrical and thermal energy as appropriate) as part of future policy development in the Province. However, new WTE facilities in BC may not be able to achieve an energy efficiency of 60% without further development of infrastructure such as district heating that would facilitate the use of heat generated by a WTE facility, recognizing that a high efficiency is difficult to reach through the production of electricity alone.
12. In regards to the use of Refuse Derived Fuel (RDF) as substitute fuel in existing industrial or power generating facilities, the majority of jurisdictions examined in this study use a regulatory approach that combines some facets of the regulatory environment associated with WTE facilities (e.g., many of the same stack emissions limits, the same AAQO requirements) but also tailor these approaches in a more industry specific fashion. Generally, the approach applied to regulate use of RDF in other jurisdictions includes:
 - a) Ensuring that the composition of the RDF is similar in regards to fuel value and general chemical composition to the primary fuel source for the intended combustion facility (e.g., use of cellulosic waste materials in wood-fired boilers).
 - b) Requirement for RDF fuel analysis and comparison to current fuels to determine the potential shift in contaminant mass balance and thus facility emissions.
 - c) The requirement to complete test burns and stack testing to measure and validate predicted shifts in emission quality, if any.
 - d) Application of RDF quality standards, specific to parameters that cannot be reasonably managed in the proposed industrial application (e.g., avoidance of fuels with high PVC content if the control of acid gases is unfeasible).
 - e) Application of the same stack limits applied to WTE facilities, for parameters that are directly associated with fuel quality (e.g., heavy metals, persistent organic pollutants

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(POPs)) but not for emission parameters that are driven largely by the primary purpose and design of the facility (e.g., not including SO_x emissions for cement kilns as these emissions are largely driven by raw material quality).

13. In the EU, it is common for emission limits to be linked to monitoring techniques and corresponding averaging periods. Typically, one-half hour average limits are specified for parameters measured by continuous monitors, whereas daily average limits are specified for parameters measured by periodic monitoring. For some parameters, limits for both continuous and for periodic monitoring are specified. In the US, daily average emission limits are specified regardless of the monitoring method. The industry trend is towards increased use of continuous monitoring devices where they can be correlated as equivalent to periodic monitoring techniques.
14. In the EU, where one-half hour average limits and daily average limits are specified for a parameter, the one-half hour limit is numerically higher than the daily average limit. The dual limits acknowledge that the daily average takes into account the fluctuations in the emission over time, whereas the one-half hour limit more closely represents the maximum allowable discharge concentration over the shorter averaging period.
15. This report highlights the potential use of the dual standards for some parameters as applied in the EU. When comparing the emission limits proposed in this report to the 1991 BC Criteria, the potential monitoring methods applicable for each parameter must be considered. The proposed limits allow for continuous monitoring where appropriate and technically feasible and in general these values are greater than the daily average. The limits also allow for periodic monitoring for parameters that require stack testing and these proposed daily average limits are equal to, or more stringent than, the 1991 BC Criteria. New Ministry of Environment policy indicates that all WTE projects will be required to go through an Environmental Impact Assessment process. This is similar to the approach in jurisdictions such as Ontario, where all WTE projects (above a minimum size limit) are required to go through screening under the *Ontario Environmental Assessment Act*.
16. The BC Hazardous Waste Regulation specifies the methodology for testing leachability of a waste material and determining if it is classified as hazardous waste. Bottom ash, fly ash and APC residue should be subjected to the TCLP test and the ash should then be handled according to the classification.
17. Bottom ash is normally not classified as hazardous waste and it is acceptable practice to deposit bottom ash in a permitted sanitary landfill or for the ash to be utilized for a beneficial use, such as intermediate cover, concrete or asphalt aggregate substitution or road base material. Jurisdictions such as Ontario, recognize that bottom ash from facilities that process non-hazardous municipal waste and that has organic content of less than 10%, is a non-hazardous material and do not require that TCLP testing be carried out on such ash. Fly ash and air pollution control (APC) residue are more likely to contain leachable contaminants and be classified as hazardous waste. Fly ash and APC residue must be disposed of in a secure landfill authorized to receive this class of material. Alternatively, the fly ash/APC residue may be

pre-treated/stabilized to reduce leachability prior to deposition in a municipal sanitary landfill site. There is limited opportunity for beneficial use of fly ash and APC residues in BC, even when stabilized, at the present time.

18. The Waste to Energy sector continues to evolve with the advent of new incineration and new pollution control equipment technology and the further advances in municipal waste diversion and separation technologies. Regulatory agencies including Ontario Ministry of the Environment and the US EPA have either recently revised or are considering revisions to current regulations and criteria. The BC Ministry of Environment should take into account both the technical and regulatory advances underway in comparable jurisdictions when developing revised guidelines.

Recommendations

1. The 1991 BC Criteria for municipal solid waste incineration should be updated to reflect advancements in thermal treatment and pollution control technology and standards applied in other jurisdictions. A table summarizing the recommended emission limits is provided at the end of this section.
2. It is recommended that the Waste Discharge Regulation (WDR) exemption for remote incinerators to accommodate fewer than 100 persons (section 3(7)) remain in place for remote operations. If a facility is serving over 100 persons and is processing less than 400 kg/hr of municipal solid waste, site specific emission limits should be authorized by the Ministry. Facilities over the 400 kg/hr capacity limit should be required to meet new revised emission guidelines as set by the Ministry.
3. The design and operation requirements in the 1991 criteria should continue to apply including the recommended minimum incineration temperature of 1,000°C and minimum residence time of 1 second (after final secondary air injection ports). This requirement should be maintained as the default specification; however proponents should be provided an opportunity to seek an alternate temperature/retention time specification that would result in equivalent thermal destruction efficiencies without impacting emission quality. Flexibility in the application of the temperature and retention time specification is possible, as long as the quality of the emission is maintained for a specific facility. A minimum temperature of 850°C with a retention time of 2 seconds could be considered equivalent, depending on the proposed technology. Adjustments to the temperature profile and retention time for a proposed facility should be demonstrated as equivalent by a facility proponent at the application stage, and would be reflected in the approved operating conditions set out for the facility.
4. The potential for fugitive emissions from WTE facilities should be addressed through site specific design considerations such as maintaining appropriate areas of the facility (e.g., receiving and tipping floor) under negative pressure, using indoor facility air for combustion and specific measures for loading, transfer, storage, accidental loss of containment, as well as the handling of auxiliary fuels and reagents for the APC systems. Revisions to the 1991 BC Criteria should address fugitive emissions with references to Best Management Plans, meeting ambient objectives and/or odours at the fence-line or other enforceable criteria.

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5. The revised emission limits presented at the end of this section (also as Table 8-21) should be considered by the Ministry as proposed new emission criteria for WTE facilities in BC.
6. The recommended revised emission criteria generally reflect two approaches to setting in-stack emissions limits. The one-half hour limit is intended to be used where the facility uses continuous monitoring techniques. The one-half hour limit generally represents the maximum allowable concentration of a contaminant not to be exceeded at any time. The daily average limit applies when periodic stack sampling is used to characterize the emissions. The daily average limit should be considered to be the default limit where the facility must use periodic sampling to determine compliance or where continuous monitoring methods are not available or practical. Both the daily average and one-half hour limits should apply to parameters for which continuous monitoring is feasible and conducted, and where periodic stack sampling is required.
7. The recommended revised emission criteria for particulate adopts a hybrid approach to emission limit values from other jurisdictions. Where continuous monitoring systems are used, it is proposed that the concentration of total particulate be less than 9 mg/Rm^3 for 97% of the operating period on a 12 month rolling average, and less than 28 mg/Rm^3 for 100% of the operating period on a 12 month rolling average. Where continuous monitoring systems for particulate are used, opacity monitoring may not be necessary as a compliance parameter unless the continuous monitoring system is not functioning. During this scenario, opacity monitoring can be used as a temporary surrogate until the continuous monitoring system for particulate is reinstated.
8. The recommended revised emission criteria for metals lead (Pb), arsenic (As) and chromium (Cr) should be set as the sum of the three metals as determined by periodic sampling with the ELV being set at 64 ug/Rm^3 .
9. Where a non-MSW thermal treatment facility intends to substitute fuel with RDF, or C&D waste, the facility should be required to meet these revised WTE emission criteria for parameters that are directly associated with fuel quality, such as trace heavy metals and persistent organic pollutants. For particulate emissions, the facility could be required to meet new applicable guidelines (for biomass boilers the Ministry may set new limits of 35 mg/m^3 for facilities ranging in size from 3 to 39 MWh, and 20 mg/m^3 for facilities of 40 MWh and larger). The facility should still meet their permitted emission parameters that are established based on the primary purpose and design of the facility, such as SO_x , CO and NO_x . The range of permitted emission parameters that are established based on the primary purpose and design of the facility will vary as appropriate between specific types of existing industrial installations. This approach is permissive by allowing fuel substitution to occur but also protective by requiring compliance with the appropriate, more stringent, limits for potentially harmful contaminants related to the substituted fuel.
10. Generally, the approach applied to regulate use of RDF in BC should be similar to that used in other jurisdictions, including application of the following sequence of steps during the permitting process:

- a) Ensuring that the composition of the RDF is similar in regards to fuel value and general chemical composition to the primary fuel source for the intended combustion facility (e.g., use of cellulosic waste materials in wood-fired boilers).
- b) Requiring RDF fuel analysis and comparison to current fuels within the applications to use RDF, along with analysis that identifies the potential shift in contaminant mass balance and thus facility emissions.
- c) For use of dissimilar fuels and/or use of RDF where there is some potential for more significant shifts in emissions or concern regarding the degree of emissions shift demonstrated through desk top analysis, in addition to the fuel tests/analysis there should be a requirement to complete test burns and stack testing to measure and validate predicted shifts in emission quality.
- d) Development and application of RDF quality standards and specifications, specific to parameters that cannot be reasonably managed in the proposed industrial application (e.g., avoidance of fuels with high PVC content if the control of acid gases is unfeasible). This would include development of a definition for various fractions of sorted MSW and construction and demolition waste, for example defining what constitutes 'clean' versus 'contaminated' wood waste suitable for use as a substitute fuel for wood waste boilers.
- e) Application of the same stack limits applied to WTE facilities, for parameters that are directly associated with fuel quality (e.g., heavy metals, POPs) but not for emission parameters that are driven largely by the primary purpose and design of the facility (e.g., not including SO_x emissions for cement kilns as these emissions are largely driven by raw material quality). For those parameters that are driven largely by the primary purpose and design of the facility, facility specific ELVs will be determined and applied, potentially resulting in some adjustment to the ELVs for these parameters as set out in the operating permit.

The above represent preliminary recommendations. Further study is required to determine the appropriate RDF fuel quality specifications applicable in BC, and to determine the approach to stack emissions that would be most applicable to each of the major sectors (pulp mill boilers, lime kilns, cement kilns) that would represent industrial users of RDF in BC. The Province should consider development of specific regulatory instruments to address RDF composition (similar to other jurisdictions that regulate RDF composition for various applications) and use as a fuel alternative.

- 11. Dispersion modelling should be conducted to assess risks associated with the location and potential operation of a new WTE facility. Modelling results should show in all cases that AAQOs established or accepted by the Ministry would be not be exceeded with a wide margin of safety for all conceivable modes of operation including upsets.
- 12. Potential effluent discharges from a WTE facility originating from process wastewater (associated wet flue gas treatment), originating from bottom ash storage, or from other process wastewater streams (boiler feed water, sanitary wastewater, storm water (either

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Section 11: Conclusions and Recommendations

contaminated or clean) or used cooling water should be authorized as part of the Solid Waste Management Plan or under a waste discharge permit with limits determined on a site specific basis.

13. The current approach in BC used for leachability testing of bottom ash, fly ash and APC residues is consistent with other jurisdictions. Testing the leachability of the ash continues to be critical in the decision process for reuse and /or disposal of the bottom ash and APC residues. The TCLP leachate extraction test prescribed in the BC HWR is a suitable test method and widely accepted. Bottom ash found to be non-leachable is not hazardous waste and can have some beneficial use or can be deposited in a permitted landfill. APC residue from MSW treatment systems will likely be leachable and require stabilization prior to disposal in a landfill or should be managed as hazardous waste.
14. Separate handling of bottom ash and APC residues represents best practice in order to optimize recovery and/or beneficial use of bottom ash. New incineration technologies should be required to identify the characteristics of the facility residuals. If residuals are determined to have beneficial use characteristics the proponent should demonstrate the associated environmental benefits and liabilities. If beneficial reuse is not practical, consideration for comingling the ash for landfilling, with stabilization as may be necessary, may be permitted.
15. In the development of revised WTE guidelines, BC Ministry of Environment should take into account ongoing technical and regulatory advancements currently evolving in Ontario, the EU and USA.

Table 11-1: Proposed Revisions to Emission Criteria for Municipal Solid Waste Incineration in British Columbia

Contaminant	Concentration Units	RECOMMENDED EMISSION LIMITS				
		C: Continuous P: Periodic ⁽¹⁾	Daily Average	Average Period and Monitoring Method	Half Hourly Average	Average Period and Monitoring Method
Total Particulate Matter (TPM)	mg/Rm ³ @ 11% O ₂	C (P for existing facilities)	9	Existing facilities without CEMS may use the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	9 ⁽²⁾ 28	1/2 hour average as determined by a continuous emissions monitoring system, achieved 97% of the operating period on a 12 month rolling average. 1/2 hour average as determined by a continuous emissions monitoring system, achieved 100% of the operating period on a 12 month rolling average
Carbon Monoxide (CO)	mg/Rm ³ @ 11% O ₂	C	50	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	100	1/2 hour average as determined by a continuous emissions monitoring system
Sulphur Dioxide (SO ₂)	mg/Rm ³ @ 11% O ₂	C	50	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	190	1/2 hour average as determined by a continuous emissions monitoring system
Nitrogen Oxides (NO _x as NO ₂)	mg/Rm ³ @ 11% O ₂	C	190	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	350	1/2 hour average as determined by a continuous emissions monitoring system
Hydrogen Chloride (HCl)	mg/Rm ³ @ 11% O ₂	C	10	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	60	1/2 hour average as determined by a continuous emissions monitoring system
Hydrogen Fluoride (HF)	mg/Rm ³ @ 11% O ₂	P/C	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	4	1/2 hour average as determined by a continuous emissions monitoring system ⁽³⁾ .
Total Organic Carbon	mg/Rm ³ @ 11% O ₂	C	10	Calculated as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	20	1/2 hour average as determined by a continuous emissions monitoring system
Arsenic (As)	µg/Rm ³ @ 11% O ₂	P	See Pb, As and Cr group	Calculated as the sum of three metals determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Cadmium (Cd)	µg/Rm ³ @ 11% O ₂	P	7	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Chromium (Cr)	µg/Rm ³ @ 11% O ₂	P	See Pb, As and Cr group	Calculated as the sum of three metals determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Lead (Pb)	µg/Rm ³ @ 11% O ₂	P	See Pb, As and Cr group	Calculated as the sum of three metals determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Sum of Lead (Pb), Arsenic (As), Chromium (Cr)	µg/Rm ³ @ 11% O ₂	P	64	Calculated as the sum of three metals determined by arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Mercury (Hg)	µg/Rm ³ @ 11% O ₂	P or C ⁽⁴⁾	20	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods, or as the arithmetic average of 24 hours of data from a continuous emissions monitoring system.	N.D.	

Contaminant	Concentration Units	RECOMMENDED EMISSION LIMITS				
		C: Continuous P: Periodic ⁽¹⁾	Daily Average	Average Period and Monitoring Method	Half Hourly Average	Average Period and Monitoring Method
Chlorophenols ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Chlorobenzenes ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Polycyclic Aromatic Hydrocarbons ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	5	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Polychlorinated Biphenyls ⁽⁵⁾	µg/Rm ³ @ 11% O ₂	P	1	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Total Dioxins and Furans (as PCDD/F TEQ)	ng/Rm ³ @ 11% O ₂	P	0.08	Calculated as the arithmetic average of a minimum three individual stack tests per stack conducted in accordance with standard methods.	N.D.	
Opacity ⁽⁶⁾	%	C (P optional for existing facilities)	N.D.		5	½ hour average from data taken every 10 seconds, measured by a CEMS

NOTES:
Concentration units: Mass per reference cubic metres corrected to 11% oxygen. Reference conditions: 20°C, 101.3 kPa, dry gas
N.D. = Not Defined
⁽¹⁾ Where Periodic stack test measurements (P) are indicated, the daily averaging period applies. For Continuous monitoring (C), the 1/2 hour averaging period applies. P/C indicates both technologies are available; ELV will be linked to sampling method.
⁽²⁾ 97% of the half-hour average values over an annual rolling average will not exceed 9 mg/Rm³. 100% of the half-hour average values will not exceed 28 mg/Rm³.
⁽³⁾ This requirement may be omitted at the discretion of the Regional Manager should treatment stages for HCl demonstrate that the ELV for HCl is not exceeded.
⁽⁴⁾ Daily Average ELV for mercury applies regardless of monitoring method.
⁽⁵⁾ Proponents may be able to demonstrate that monitoring both Total Organic Carbon (TOC) and Total Dioxin and Furans could negate the need to monitor Chlorophenols, Chlorobenzenes, Polycyclic Aromatic Hydrocarbons and Polychlorinated Biphenyls.
⁽⁶⁾ Opacity will not be required for compliance purposes for facilities utilizing continuous particulate monitoring systems. Opacity monitoring is recommended for operational monitoring purposes. However, monitoring opacity can be used as a temporary surrogate for total particulate monitoring in the event a particulate monitoring system failure. Under these circumstances, the ELV of 5% opacity over a ½ hour averaging period should apply.

12 CLOSURE

This report has been prepared for the benefit of BC Ministry of Environment. The report may not be used by any other person or entity without the express written consent of BCMOE and Stantec. Any use of this report by a third party, or any reliance on decisions made based on it, are the responsibility of such third parties. Stantec accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

Some of the information presented in this report was provided through existing documents and interviews. Although attempts were made, whenever possible, to obtain additional sources of information, Stantec has assumed that the information provided is accurate.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. The conclusions and recommendations presented represent the best judgment of Stantec based on the data obtained during the assessment. Conclusions and recommendations presented in this report should not be construed as legal advice.

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Appendix A: Database of Current Technology Vendors and Thermal Treatment Technologies



APPENDIX A

Database of Current Technology Vendors and Thermal Treatment Technologies



Database of Current Technology Vendors

Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
Conventional Combustion						
Mass Burn Incineration	Advanced Alternative Energy (AAEC)	n/a	n/a	n/a	www.aaecorp.com/power.html	No reference facilities, claims to be able to treat waste and biomass
Mass Burn Incineration	ATCO Power	n/a	n/a	n/a	www.atcopower.com	No reference facilities, but actively investigating energy from waste
Mass Burn Incineration	Babcock & Wilcox Volund	1997	Billingham, UK	224,000 tpy	www.volund.dk	One of the 4 main suppliers of mass burn technology
Mass Burn Incineration	CNIM	n/a	Thiverval-Grignon-Plaisir, France	2 x 8 t/h + 1 x 14.7 t/h of household waste	www.CNIM.com	DBO
Modular Two Stage Combustion	Consutech Systems LLC	n/a	Iraq	5333 lbs/hr	http://www.consutech.com/	Design and manufacture incineration and APC equipment
Mass Burn Incineration	Covanta	1990	Huntsville, Alabama	625 tpd	www.covantaholding.com/	Operate 41 facilities in the US, 1 Burnaby - utilize Martin GmbH tech
Modular Two Stage Combustion	Enerwaste	2005	Egegik, Alaska	3.5 tpd	www.enerwaste.com	Also provide a MCS (mass burn type) for pre-processed garbage
Mass Burn Incineration	Fisia Babcock Environment GmbH	2005	Affaldscenter Århus, Denmark	17.5 tph	http://www.fisia-babcock.com/	One of the 4 main suppliers of mass burn technology
Mass Burn Incineration	JFE	2003	Hirano Plant, Japan	900 tpd	www.jfe-eng.co.jp/en	
Fluidized Bed Incineration	JFE	2006	Banpoo WTE Plant, Thailand	100 tpd	www.jfe-eng.co.jp/en	
Mass Burn Incineration	KAB TAKUMA GmbH	2003	Salzbergen, Germany	90,000 tpy	http://www.kab-takuma.com/	
Mass Burn Incineration	Martin GmbH	1999	Neunkirchen, Germany	408 tpd	http://www.martingmbh.de/index.php	One of the four main suppliers of mass burn technology
Mass Burn Incineration	Naanovo Energy Inc.	March 2010	The Gambia	n/a	www.naanovo.com	14 MW facility. Not sure as to the status.
Mass Burn Incineration	Seghers Keppel Technology Group	n/a	Beveren, Belgium	2 x 319 tpd	www.keppelseghers.com	
Mass Burn Incineration	Standardkessel Baumgarte	2007	MSZ 3 Moscow, Russia	330,000 tpy	http://www.standardkessel-baumgarte.com/	Five reference facilities located on their website.
	Steinmuller	n/a	n/a	n/a	http://www.steinmuller.co.za/default.asp?fid=0&sid=24&L=1	Mechanical engineers
Mass Burn Incineration	TPS Termiska	1992	Greve-in-Chianti, Italy	67,000 tpy	www.tps.se/subpage.aspx?MS=14839,15014	
Mass Burn Incineration	Veolia Environmental Services	2003	Hampshire, UK	90,000 tpy	www.VeoliaES.com	More than 80 plants worldwide
Mass Burn Incineration	Von Roll Nova	2007	Issy-les-Moulineaux (Paris), France	460,000 tpy	http://www.aee-vonrollnova.ch	One of the four main suppliers of mass burn technology
Mass Burn Incineration	Wheelabrator Technologies Inc.	1985	Baltimore	2,000 tpd	www.wheelabratortechnologies.com	Operates 21 facilities in the US
Mass Burn Incineration	Wulff Energy and Environmental Systems	n/a	n/a	n/a	http://www.wulff-hamburg.de	Boiler, combustion and drier technologies

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Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
Gasification						
Gasification	Ambient Eco Group	2002	n/a	75,000 to 250,000 tpy	-	
Gasification	City Clean 2000 Inc.	n/a	n/a	n/a	http://cityclean2000.com/	
Gasification	Coaltec Energy	n/a	Carterville, Illinois	Test Facility	www.coaltecenergy.com	
Gasification and Pyrolysis	Compact Power	2002	Bristol, UK	8,000 tpy	-	
Gasification	Ebara (two different technologies)	2002	Kawaguchi City Asahi Clean Centre, Japan	125,400 tpy	www.ebara.co.jp/en/	
Gasification	Emery Energy Company	n/a	Salt Lake City, Utah (Pilot Plant)	25 tpd	www.emeryenergy.com	
Gasification	Energos	1998	Ranheim, Norway	10,000 tpy	www.energ.co.uk/energy_from_waste	
Gasification	Energy Products of Idaho	1989	Tacoma, Washington	317 tpd	www.energyproducts.com	
Gasification	EnerTech Environmental	1997 – 2000 (Demonstration Facility)	Ube City, Japan	18 tpd	www.enertech.com	
Gasification	Envirotherm GmbH	2000	Schwarze Pumpe, Germany	300,000 tpy	http://envirotherm.de/	
Gasification	Eurotech	n/a	Quetzaltenango, Guatemala	n/a	www.eurotecguatemala.com/maineng.htm	
Gasification	Forevergreen Enterprises	Not yet constructed	DeKalb County	n/a	www.fgenterprises.net	
Gasification	Foster Wheeler	1998	Finland	80,000 tpy	www.fwc.com	
Gasification	Full Circle Energy	n/a	n/a	n/a	www.fullcircleanergy.net	
Gasification/Thermal Cracking	GEM America	2000	Tythegston Landfill Site, South Wales	36 tpd	www.gemamericainc.com	
Gasification	Global Energy Inc.	1992	Westfield Development Centre, UK	n/a	www.globalenergyinc.com	
Gasification	Global Energy Solutions Inc	n/a	Japan, Germany, Belgium, Korea, Malta, UK	1-25 tph	www.globalenergychicago.com	
Gasification	Global Warming Prevention Technologies Inc.	n/a	Anchoarge, Alaska; Kuala Lumpur, Malaysia	25 tpd	www.gwpt.com	
Gasification	Greey CTS Inc.	na/	Poland	35,000 tpy	-	
Gasification	Hitachi Zosen	1998	Gifu, Japan	30 tpd	-	
Gasification	ILS Partners	n/a	Germany	22 tpd	www.ils-partners.com	
Gasification	Interstate Waste Technologies (IWT) (uses Thermoselect)	1999	Chiba, Japan	93,000 tpy	www.iwtonline.com	
Gasification	ITI Energy Ltd.	n/a	South West England	72,000 tpy	http://www.iti-energy.com/	
Gasification	JFE	2003	Kakamigahara Plant, Japan	192 tpd	www.jfe-eng.co.jp/en	
Gasification	Karlsruhe Institute of Technology	1993 rotating grate gasifier; 2000 slagging gasifier	Schwarze Pumpe, Germany	700 tpd	www.fzk.de	
Gasification	Lurgi	1993 rotating grate gasifier; 2000 slagging gasifier	Schwarze Pumpe, Germany	700 tpd	www.lurgi.com	
Gasification	Nippon Steel	2002	Akita, Japan	400 tons per day	-	
Gasification	Ntech Environmental	1991	Chung Gung Municipality, Taiwan	27 tpd	www.ntech-environmental.com	
Gasification	OE Gasification	2007	Hapchon, South Korea	20 tpd (MSW)	-	
Gasification	PKA Umwelttechnik GmbH & Co	2001	Aalen, Germany	25,000 tpy	-	

Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
Gasification	Pyrolyzer	n/a	n/a	n/a	http://pyrolyzerllc.com/	
Gasification	SenreQ International	2002	Barrow, Alaska	27 tpd	-	
Gasification	Sierra Energy Corporation	n/a	n/a	n/a	http://www.sierraenergycorp.com/	
Gasification	SVZ	n/a	n/a	n/a	-	
Gasification	Rentech	1997	Burlington, Vermont	272 tpd	www.silvasgas.com	
Gasification	Terragon Environmental Technologies Inc.	n/a	n/a	Small-scale (Only for remote communities, outposts etc.)	www.terragon.net/MAGS.html	
Gasification	TGE Tech	2007	Tel Aviv	181 tpd	-	
Gasification	Thermogenics, Inc.	n/a	n/a	n/a	www.thermogenics.com	
Gasification	Thermoselect	1999 – 2004	Karlsruhe, Germany	250,000 tpy	www.thermoselect.com	
Gasification	Thide Environmental	2004	Arras, France	50,000 tpy	www.thide.com	
Gasification	Waste-to-Energy	Reference facilities do not process MSW (only biomass)	n/a	n/a	www.wastetoenergy.co.uk	
Gasification	Whitten Group International	1991	Taiwan	8,100 tpy	-	
Plasma Arc Gasificaion						
Plasma Arc Gasification	AdaptiveNRG	2005	Monterey, Mexico (portable)	33,000 tpy	www.adaptivenrg.com	
Plasma Arc Gasification	AlterNRG (Westinghouse Plasma Technology)	1999	Yoshi, Japan	n/a	www.alternrg.com	
Plasma Arc Gasification	EnviroArcTechnologies	Pilot Plant	Hofors, Sweden	.7 tph	www.enviroarc.com	
	Europlasma	n/a	n/a	n/a	http://www.europlasma.com/	Plasma torches
Plasma Arc Gasification	Geoplasma LLC	1999	Japan, Germany, Belgiu, Korea, Malta, UK	24 tpd	www.geoplasma.com	
Plasma Arc Gasification	Global Environmental Technologies of Ontario Inc.	n/a	n/a	n/a	-	
Plasma Arc Gasification	Green Power Systems	n/a	n/a	n/a	www.greenpowersystems.com	
Plasma Arc Gasification	Hitachi Metals	2003	Utashinai City, Japan	180 tpd	-	
Plasma Arc Gasification	Hi-Tech Enterprise Ltd	n/a	n/a	n/a	-	
Plasma Arc Gasification	InEnTech Chemical (Integrated Environmental Technologies)	n/a	Richland, Washington	22 tpd	www.inentec.com	
Plasma Arc Gasification	MPM Technologies Inc.	1987 – 1988	Libby, Montana (Pilot Plant)	45 tpd; 108 tpd (continuous feed)	www.mpmtech.com	
Plasma Arc Gasification	Peat International Inc	2007	Kaohsiung, Taiwan	9 tpd	www.peat.com	
Plasma Arc Gasification	Plasco Energy Group	2007	Ottawa, Canada	31,100 tpy	www.plasco.com	
Plasma Arc Gasification	Plasma Arc Technologies	n/a	n/a	n/a	www.plasmaarctech.com	
Plasma Arc Gasification	Plasma Environmental Technologies Inc.	No operating facilities.	n/a	n/a	www.plasmaenvironmental.com	
Plasma Arc Gasification	Plasma Waste Recycling	n/a	n/a	n/a	www.plasma-wr.com	
Plasma Arc Gasification	PyroGenesis Inc.	2000	Montreal, Quebec	10 tpd	-	
Plasma Arc Gasification	Recovered Energy Inc. (Westinghouse)	1999	Hitachi plant in Japan	3 tph	www.recoveredenergy.com	

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Plasma Arc Gasification	Rigel Resource Recovery and Conversion Company	2004	Eco-Valley Utashinai Plant, Japan	90,700 tpy	-	
Plasma Arc Gasification	Solena Group	n/a	Europe – no specifics given	n/a	www.solenagroup.com	
Plasma Arc Gasification	Startech Environmental Corporation	2001	Bristol, Connecticut	4.5 tpd (Demonstration Facility)	www.startech.net	
Plasma Arc Gasification	Sun Energy Group LLC	2011	New Orleans	n/a	www.sunenergygrp.com	
Plasma Arc Gasification	US Plasma	n/a	n/a	n/a	-	
Plasma Arc Gasification	Westinghouse Plasma/GeoPlasma	2002	Utashinai & Mihama Mikata, Japan	n/a	www.westinghouse-plasma.com	
Pyrolysis						
Pyrolysis	Balboa Pacific Corporation	n/a	n/a	n/a	www.balboa-pacific.com	
Pyrolysis and Gasification	Brightstar Environmental	2001	Australia	55,000 tpy	-	
Pyrolysis and Gasification	Compact Power	n/a	Avonmouth, UK	Clinical Waste	-	
Pyrolysis	Conrad Industries	1993	Centralia, Washington	Systems designed to process 21 to 65 tpd	www.conradind.com/to_tech_develop.asp	
Pyrolysis	Emerald Power Corporation	n/a	New York City	Commercial Scale Demo	-	
Pyrolysis	ENER-G (acquired Waste Gas Technology)	2002	Sarpsborg 1 Plant, Norway	75,000 tpy	www.energ.co.uk	
Pyrolysis	Entech Renewable Energy	2006	Korea	60 tpd (MSW)	http://www.entech.net.au/ws1/	
Pyrolysis	International Energy Solutions	2004	Romoland, California	16,500 tpy (MSW)	www.wastetopower.com	
Pyrolysis	JND Thermal Process	n/a	Hamburg, Germany	Test Facility	www.jnd.co.uk	
Pyrolysis	Mitsui Babcock	2000	Yame Seibu, Japan	219 tpd	www.doosanbabcock.com	
Pyrolysis	Mitsui R-21	2002	Toyohashi City, Japan	400 tpd	http://www.gec.jp/JSIM_DATA/WASTE/WASTE_3/html/Doc_436.html	
Pyrolysis	Nexus	n/a	France	10-100 tpd	-	
Pyrolysis	North American Power Co.	n/a	Las Vegas Nevada	10 to 68 tpd (Test Facility)	-	
Pyrolysis	Recycled Refuse International	No existing plant	n/a	n/a	www.rcrinternational.com	
Pyrolysis	Splainex Ecosystems Ltd.	n/a	n/a	n/a	www.splainex.com	
Pyrolysis	Takuma	2005	Kakegawa, Japan		www.takuma.co.jp/english/	
Pyrolysis	Technip / Waste Gen	1987	Burgau, Germany	36,200 tpy	www.wastegen.com/alternative.htm	
Pyrolysis amd Gasification	Techtrade	2002	Hamm, Germany	100,000 tpy	www.tech-trade.de/index.html	RDF
Pyrolysis	Thide/Hitachi	2003	Izumo, Japan	63,500 tpy	-	
Pyrolysis	TPF Group (Serpac Pyroflam)	2005	Keflavik, Iceland	41 tpd	www.tpf-bs.be	
Pyrolysis and Gasification	WasteGen (UK)	2000	Hamm, Germany	100,000 tpy	www.wastegen.com/wastegenuk.htm	

Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
Gasplasma						
Gasplasma	Advanced Plasma Power	n/a	Oxfordshire, Eng.	Small-scale Demonstration Plant	www.advancedplasmapower.com	
Thermal Cracking Technology						
Thermal Cracking Technology	GEM Waste to Energy Inc.	1998	Romsey, England	0.7 tph	www.gemcanadawaste.com/index2.html	
Thermal Oxidation						
Thermal Oxidation	Zeros Technology Holding	No existing plant			www.zerosinc.com	
Waste to Fuel						
Waste to Fuel	BioEngineering Resources (BRI)	2003	Fayetteville, Arkansas	1.3 tpd (Pilot Plant)	www.brienergy.com	
Waste to Fuel	BlueFire Ethanol Inc.	2002	Izumi, Japan		http://bluefireethanol.com/production_plant/	
Waste to Fuel	Changing World Technologies	1999	Philadelphia, PA	Test Facility	www.changingworldtech.com	
Waste to Fuel	Enerkem	2003	Sherbrooke, Quebec	5 tpd (MSW pellets)	www.enerkem.com	
Waste to Fuel	Enerkem (Novera)	To be constructed 2009	Edmonton, Alberta	100,000 tpy	www.enerkem.com	
Waste to Fuel	Genahol Inc.	2007	Lake County, Indiana	30 million gallons ethanol/year	Not constructed yet	
Waste to Fuel	Indiana Ethanol Power	2008	Lake County, Indiana	1,500 tons per day	Not constructed yet	
Waste to Fuel	Masada OxyNol	n/a	n/a	n/a	-	
Waste to Fuel	Power Ecalene Fuels	n/a	n/a	n/a	http://powerecalene.com	Converts syngas to alcohol
Waste to Fuel	Range Fuels Inc.	2008	Denver Colorado	5 oven dried tonnes	www.rangefuels.com	
Other Methodologies						
Kearns Disintegrator	Quantum Solutions Technology Ventures Inc.	1983	Cape Breton Isaldn, Nova Scotia	Prototype	www.gstv.ca/gstv-about.html	
Steam Reforming Plant	Elementa	2007	Sault Ste. Marie	n/a	http://www.elementagroup.com/	



Thermal Treatment Technologies Database

Thermal Treatment Technologies Database (MSW as a Feedstock)

Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
Conventional Combustion						
Mass Burn Incineration	Advanced Alternative Energy (AAEC)	n/a	n/a	n/a	www.aaecorp.com/power.html	No reference facilities, claims to be able to treat waste and biomass.
Mass Burn Incineration	ATCO Power	n/a	n/a	n/a	www.atcopower.com	No reference facilities, but actively investigating energy from waste.
Mass Burn Incineration	CNIM	n/a	Thiverval-Grignon-Plaisir, France	2 x 8 t/h + 1 x 14.7 t/h of household waste	www.CNIM.com	DBO.
Modular Two Stage Combustion	Consutech Systems LLC	n/a	Iraq	5333 lbs/hr	http://www.consutech.com/	Design and manufacture incineration and APC equipment.
Mass Burn Incineration	Covanta	1990	Huntsville, Alabama	625 tpd	www.covantaholding.com/	Operate 41 facilities in the US, 1 Burnaby - utilize Martin Gmbh tech.
Modular Two Stage Combustion	Enerwaste	2005	Egegik, Alaska	3.5 tpd	www.enerwaste.com	Also provide a MCS (mass burn type) for pre-processed garbage.
Mass Burn Incineration	Fisia Babcock Environment GmbH	2005	Affaldscenter Århus, Denmark	17.5 tph	http://www.fisia-babcock.com/	One of the 4 main suppliers of mass burn technology.
Mass Burn Incineration	JFE	2003	Hirano Plant, Japan	900 tpd	www.ife-eng.co.jp/en	
Fluidized Bed Incineration	JFE	2006	Banpoo WTE Plant, Thailand	100 tpd	www.ife-eng.co.jp/en	
Mass Burn Incineration	KAB TAKUMA GmbH	2003	Salzbergen, Germany	90.000 tpy	http://www.kab-takuma.com/	
Mass Burn Incineration	Martin GmbH	1999	Neunkirchen, Germany	408 tpd	http://www.martingmbh.de/index.php	One of the 4 main suppliers of mass burn technology.
Mass Burn Incineration	Naanovo Energy Inc.	March 2010	The Gambia	n/a	www.naanovo.com	14 MW facility. Not sure as to the status.
Mass Burn Incineration	Seghers Keppel Technology Group	n/a	Beveren, Belgium	2 x 319 tpd	www.keppelseghers.com	
Mass Burn Incineration	Standardkessel Baumgarte	2007	MSZ 3 Moscow, Russia	330,000 tpy	http://www.standardkessel-baumgarte.com/	5 reference facilities located on their website.
	Steinmuller	n/a	n/a	n/a	http://www.steinmuller.co.za/default.asp?fid=0&sid=24&L=1	Mecanical engineers.
Mass Burn Incineration	TPS Termiska	1992	Greve-in-Chianti, Italy	67,000 tpy	www.tps.se/subpage.aspx?MS=14839,15014	
Mass Burn Incineration	Veolia Environmental Services	2003	Hampshire, UK	90,000 tpy	www.VeoliaES.com	More than 80 plants worldwide.
Mass Burn Incineration	Von Roll Nova	2007	Issy-les-Moulineaux (Paris), France	460,000 tpy	http://www.aee-vonrollinova.ch	One of the 4 main suppliers of mass burn technology.
Mass Burn Incineration	Wheelabrator Technologies Inc.	1985	Baltimore	2,000 tpd	www.wheelabratortechnologies.com	Operates 21 facilities in the US..
Mass Burn Incineration	Wulff Energy and Environmental Systems	n/a	n/a	n/a	http://www.wulff-hamburg.de	Boiler, combustion and drier technologies.

Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
Gasification						
Gasification	Ambient Eco Group	2002	n/a	75,000 to 250,000 tpy		
Gasification	City Clean 2000 Inc.	n/a	n/a	n/a	http://cityclean2000.com/	
Gasification	Coaltec Energy	n/a	Carterville, Illinois	Test Facility	www.coaltecenergy.com	
Gasification and Pyrolysis	Compact Power	2002	Bristol, UK	8,000 tpy		
Gasification	Ebara (two different technologies)	2002	Kawaguchi City Asahi Clean Centre, Japan	125,400 tpy	www.ebara.co.jp/en/	
Gasification	Emery Energy Company	n/a	Salt Lake City, Utah (Pilot Plant)	25 tpd	www.emeryenergy.com	
Gasification	Energos	1998	Ranheim, Norway	10,000 tpy	www.enerq.co.uk/energy_from_waste	
Gasification	Energy Products of Idaho	1989	Tacoma, Washington	317 tpd	www.energyproducts.com	
Gasification	EnerTech Environmental	1997-2000 (Demonstration Facility)	Ube City, Japan	18 tpd	www.enertech.com	
Gasification	Envirotherm GmbH	2000	Schwarze Pumpe, Germany	300,000 tpy	http://envirotherm.de/	
Gasification	Eurotech	n/a	Quetzaltenango, Guatemala	n/a	www.eurotecguatemala.com/maineng.htm	
Gasification	Forevergreen Enterprises	Not yet constructed	DeKalb County	n/a	www.fqenterprises.net	
Gasification	Foster Wheeler	1998	Finland	80,000 tpy	www.fwc.com	
Gasification	Full Circle Energy	n/a	n/a	n/a	www.fullcircleenergy.net	
Gasification / Thermal Cracking	GEM America	2000	Tythegston Landfill Site, South Wales	36 tpd	www.gemamericainc.com	
Gasification	Global Energy Inc.	1992	Westfield Development Centre, UK	n/a	www.globalenergyinc.com	
Gasification	Global Energy Solutions Inc	n/a	Japan, Germany, Belgium, Korea, Malta, UK	1-25 tph	www.globalenergychicago.com	
Gasification	Global Warming Prevention Technologies Inc.	n/a	Anchoarge, Alaska; Kuala Lumpur, Malaysia	25 tpd	www.gwpt.com	
Gasification	Greey CTS Inc.	na/	Poland	35,000 tpy		
Gasification	Hitachi Zosen	1998	Gifu, Japan	30 tpd		
Gasification	ILS Partners	n/a	Germany	22 tpd	www.ils-partners.com	
Gasification	Interstate Waste Technologies (IWT) (uses Thermoselect)	1999	Chiba, Japan	93,000 tpy	www.iwtonline.com	
Gasification	ITI Energy Ltd.	n/a	South West England	72,000 tpy	http://www.iti-energy.com/	
Gasification	JFE	2003	Kakamigahara Plant, Japan	192 tpd	www.jfe-eng.co.jp/en	
Gasification	Karlsruhe Institute of Technology	1993 rotating grate gasifier; 2000 slagging	Schwarze Pumpe, Germany	700 tpd	www.fzk.de	
Gasification	Lurgi	1993 rotating grate gasifier; 2000 slagging	Schwarze Pumpe, Germany	700 tpd	www.lurgi.com	
Gasification	Nippon Steel	2002	Akita, Japan	400 tons per day		
Gasification	Ntech Environmental	1991	Chung Gung Municipality, Taiwan	27 tpd	www.ntech-environmental.com	
Gasification	OE Gasification	2007	Hapchon, South Korea	20 tpd (MSW)		
Gasification	PKA Umwelttechnik GmbH & Co	2001	Aalen, Germany	25,000 tpy		
Gasification	Pyrolyzer	n/a	n/a	n/a	http://pyrolyzerllc.com/	
Gasification	SenreQ International	2002	Barrow, Alaska	27 tpd		
Gasification	Sierra Energy Corporation	n/a	n/a	n/a	http://www.sierraenergycorp.com/	
Gasification	SVZ	n/a	n/a	n/a		
Gasification	Rentech	1997	Burlington, Vermont	272 tpd	www.silvasgas.com	
Gasification	Terragon Environmental Technologies Inc.	n/a	n/a	Small-scale (Only for remote communities, outposts etc.)	www.terragon.net/MAGS.html	
Gasification	TGE Tech	2007	Tel Aviv	181 tpd		
Gasification	Thermogenics, Inc.	n/a	n/a	n/a	www.thermogenics.com	
Gasification	Thermoselect	1999-2004	Karlsruhe, Germany	250,000 tpy	www.thermoselect.com	
Gasification	Thide Environmental	2004	Arras, France	50,000 tpy	www.thide.com	
Gasification	Waste-to-Energy	Reference facilities do not process MSW (only	n/a	n/a	www.wastetoenergy.co.uk	
Gasification	Whitten Group International	1991	Taiwan	8,100 tpy		

Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
Plasma Arc Gasificaiton						
Plasma Arc Gasification	AdaptiveNRG	2005	Monterey, Mexico (portable)	33,000 tpy	www.adaptivenrg.com	
Plasma Arc Gasification	AlterNRG (Westinghouse Plasma Technology)	1999	Yoshi, Japan	n/a	www.alternrg.com	
Plasma Arc Gasification	EnviroArcTechnologies	Pilot Plant	Hofors, Sweden	.7 tph	www.enviroarc.com	
	Europlasma	n/a	n/a	n/a	http://www.europlasma.com/	Plasma torches.
Plasma Arc Gasification	Geoplasma LLC	1999	Japan, Germany, Belgiu, Korea, Malta, UK	24 tpd	www.geoplasma.com	
Plasma Arc Gasification	Global Environmental Technologies of Ontario Inc.	n/a	n/a	n/a		
Plasma Arc Gasification	Green Power Systems	n/a	n/a	n/a	www.greenpowersystems.com	
Plasma Arc Gasification	Hitachi Metals	2003	Utashinai City, Japan	180 tpd		
Plasma Arc Gasification	Hi-Tech Enterprise Ltd	n/a	n/a	n/a		
Plasma Arc Gasification	InEnTech Chemical (Integrated Environmental Technologies)	n/a	Richland, Washington	22 tpd	www.inentec.com	
Plasma Arc Gasification	MPM Technologies Inc.	1987-1988	Libby, Montana (Pilot Plant)	45 tpd; 108 tpd (continuous feed)	www.mpmtech.com	
Plasma Arc Gasification	Peat International Inc	2007	Kaohsiung, Taiwan	9 tpd	www.peat.com	
Plasma Arc Gasification	Plasco Energy Group	2007	Ottawa, Canada	31,100 tpy	www.plasco.com	
Plasma Arc Gasification	Plasma Arc Technologies	n/a	n/a	n/a	www.plasmaarctech.com	
Plasma Arc Gasification	Plasma Environmental Technologies Inc.	No operating facilities.	n/a	n/a	www.plasmaenvironmental.com	
Plasma Arc Gasification	Plasma Waste Recycling	n/a	n/a	n/a	www.plasma-wr.com	
Plasma Arc Gasification	PyroGenesis Inc.	2000	Montreal, Quebec	10 tpd		
Plasma Arc Gasification	Recovered Energy Inc. (Westinghouse)	1999	Hitachi plant in Japan	3 tph	www.recoveredenergy.com	
Plasma Arc Gasification	Rigel Resource Recovery and Conversion Co	2004	Eco-Valley Utashinai Plant, Japan	90,700 tpy		
Plasma Arc Gasification	Solena Group	n/a	Europe - no specifics given	n/a	www.solenagroup.com	
Plasma Arc Gasification	Startech Environmental Corporation	2001	Bristol, Connecticut	4.5 tpd (Demonstration Facility)	www.startech.net	
Plasma Arc Gasification	Sun Energy Group LLC	2011	New Orleans	n/a	www.sunenergygrp.com	
Plasma Arc Gasification	US Plasma	n/a	n/a	n/a		
Plasma Arc Gasification	Westinghouse Plasma/GeoPlasma	2002	Utashinai & Mihama Mikata, Japan	n/a	www.westinghouse-plasma.com	
Pyrolysis						
Pyrolysis	Balboa Pacific Corporation	n/a	n/a	n/a	www.balboa-pacific.com	
Pyrolysis and Gasification	Brightstar Environmental	2001	Australia	55,000 tpy		
Pyrolysis and Gasification	Compact Power	n/a	Avonmouth, UK	Clinical Waste		
Pyrolysis	Conrad Industries	1993	Centralia, Washington	Systems designed to process 21 to 65 tpd	www.conradind.com/to_tech_develop.asp	
Pyrolysis	Emerald Power Corporation	n/a	New York City	Commercial Scale Demo		
Pyrolysis	ENER-G (acquired Waste Gas Technology)	2002	Sarpsborg 1 Plant, Norway	75,000 tpy	www.energ.co.uk	
Pyrolysis	Entech Renewable Energy	2006	Korea	60 tpd (MSW)	http://www.entech.net.au/ws1/	
Pyrolysis	International Energy Solutions	2004	Romoland, California	16,500 tpy (MSW)	www.wastetopower.com	
Pyrolysis	JND Thermal Process	n/a	Hamburg, Germany	Test Facility	www.jnd.co.uk	
Pyrolysis	Mitsui Babcock	2000	Yame Seibu, Japan	219 tpd	www.doosanbabcock.com	
Pyrolysis	Mitsui R-21	2002	Toyohashi City, Japan	400 tpd	http://www.gec.jp/JSIM_DATA/WASTE/WASTE_3/html/Doc_436.html	
Pyrolysis	Nexus	n/a	France	10-100 tpd		
Pyrolysis	North American Power Co.	n/a	Las Vegas Nevada	10 to 68 tpd (Test Facility)		
Pyrolysis	Recycled Refuse International	No existing plant.	n/a	n/a	www.rcrinternational.com	
Pyrolysis	Splainex Ecosystems Ltd.	n/a	n/a	n/a	www.splainex.com	
Pyrolysis	Takuma	2005	Kakegawa, Japan		www.takuma.co.jp/english/	
Pyrolysis	Technip / Waste Gen	1987	Burgau, Germany	36,200 tpy	www.wastegen.com/alternative.htm	
Pyrolysis amd Gasification	Techtrade	2002	Hamm, Germany	100,000 tpy	www.tech-trade.de/index.html	RDF.
Pyrolysis	Thide/Hitachi	2003	Izumo, Japan	63,500 tpy		
Pyrolysis	TPF Group (Serpac Pyroflam)	2005	Keflavik, Iceland	41 tpd	www.tpf-bs.be	
Pyrolysis and Gasification	WasteGen (UK)	2000	Hamm, Germany	100,000 tpy	www.wastegen.com/wastegenuk.htm	

Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
Gasplasma						
Gasplasma	Advanced Plasma Power	n/a	Oxfordshire, Eng.	Small-scale Demonstration Plant	www.advancedplasmapower.com	
Thermal Cracking Technology						
Thermal Cracking Technology	GEM Waste to Energy Inc.	1998	Romsey, England	0.7 tph	www.gemcanadawaste.com/index2.html	
Thermal Oxidation						
Thermal Oxidation	Zeros Technology Holding	No existing plant.			www.zerosinc.com	
Waste to Fuel						
Waste to Fuel	BioEngineering Resources (BRI)	2003	Fayetteville, Arkansas	1.3 tpd (Pilot Plant)	www.brienergy.com	
Waste to Fuel	BlueFire Ethanol Inc.	2002	Izumi, Japan		http://bluefireethanol.com/production_plant/	
Waste to Fuel	Changing World Technologies	1999	Philadelphia, PA	Test Facility	www.changingworldtech.com	
Waste to Fuel	Enerkem	2003	Sherbrooke, Quebec	5 tpd (MSW pellets)	www.enerkem.com	
Waste to Fuel	Enerkem (Novera)	To be constructed 2009	Edmonton, Alberta	100,000 tpy	www.enerkem.com	
Waste to Fuel	Genahol Inc.	2007	Lake County, Indiana	30 million gallons ethanol/year	Not constructed yet	
Waste to Fuel	Indiana Ethanol Power	2008	Lake County, Indiana	1,500 tons per day	Not constructed yet	
Waste to Fuel	Masada OxyNol	n/a	n/a	n/a		
Waste to Fuel	Power Ecalene Fuels	n/a	n/a	n/a	http://powerecalene.com	Converts syngas to alcohol.
Waste to Fuel	Range Fuels Inc.	2008	Denver Colorado	5 oven dried tonnes	www.rangefuels.com	
Other Methodologies						
Kearns Disintegrator	Quantum Solutions Technoogy Ventures Inc.	1983	Cape Breton Isaldn, Nova Scotia	Prototype	www.qstv.ca/qstv-about.html	
Steam Reforming Plant	Elementa	2007	Sault Ste. Marie	n/a	http://www.elementagroup.com/	

Waste to Energy

A Technical Review of Municipal Solid Waste Thermal Treatment Practices
Final Report

Appendix B: BC Emission Criteria for MSW Incinerators (June 1991)



APPENDIX B

BC Emission Criteria for MSW Incinerators (June 1991)

Emission Criteria for Municipal Solid Waste Incinerators (June 1991)

FOREWORD

The Emission Criteria for Municipal Solid Waste Incinerators have been developed in consultation with British Columbia stakeholders.

The Executive Committee of the Ministry of Environment approved the release of these criteria on June 17, 1991.

The Environmental Management Branch is responsible for the development of these criteria. The Branch intends to continue development work with British Columbia stakeholders in order that the emission criteria continue to be current and valid. All stakeholders are invited to submit their comments and recommendation for improvements to the Manager, Industry and Business Section.

1 Definitions

"Acid Gases" mean those gaseous contaminants, as listed in [Appendix A](#), which contribute towards the formation of acidic substances in the atmosphere.

"Chlorobenzenes (CBs)" mean those chlorinated benzene compounds listed in [Appendix A](#).

"Chlorophenols (CPs)" mean those chlorinated phenolic compounds listed in [Appendix A](#).

"Incinerator" means any device designed specifically for controlled combustion of wastes, alone or in conjunction with any auxiliary fossil fuel, for the primary purpose of reduction of the volume of the waste charged by destroying the combustible portion therein and/or to recover the available energy from the waste.

Note: Only those incinerators which are designed to burn wastes in a controlled manner, whether in a single-chamber or a multiple-chamber unit, and are capable of meeting the requirements of these Emission Criteria, with or without any emission control devices are to be considered.

"Municipal Solid Waste (MSW)" means municipal refuse which originates from residential, commercial, institutional and industrial sources and includes semi-solid sludges, household hazardous waste and any other substances which are typically disposed of in municipal-type landfills, but does not include biomedical waste.

"Polycyclicaromatic Hydrocarbons (PAHs)" mean those polycyclicaromatic hydrocarbon compounds listed in [Appendix A](#).

"Polychlorinated dibenzo-para-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)" mean those PCDD and PCDF compounds listed in [Appendix A](#).

"Refuse Derived Fuel (RDF)" means any fuel derived from municipal solid waste.

"Regional Manager" means the "manager" as well as the "district director" as interpreted in the current edition of the *Environmental Management Act*.

" Standard cubic metre (m³) of gas" means the volume of dry gas in cubic metres measured at a pressure of 101.3 kPa and a temperature of 20°C (293.15 K) .

"Toxicity Equivalency Factors (TEFs)" means those factors for Congeners of Concern in a Homologous Group for PCDDs and PCDFs.

2 Applicability

2.1 New or Modified Incinerators

These Emission Criteria are effective from the date of issuance and apply to all new incinerators designed and installed for burning MSW.

2.2 Existing Incinerators

Within five years or less after issuance of these Emission Criteria, the Environmental Management Branch will identify and implement measures for:

1. Phasing out of all older, uncontrolled single chamber incinerators used to burn MSW authorized under the current edition of the *Environmental Management Act* except for equipment which is classified and exempted in the current edition of the Waste Management Regulations of the *Environmental Management Act*; and
2. Modifications of all multiple-chamber, modular and mass burn incinerators used to burn MSW authorized by the current edition of the *Environmental Management Act* but not able to comply with these Emission Criteria.

2.3 Ambient Analysis and Site Specific Emission Limits

Notwithstanding the provisions of these Emission Criteria, no person shall operate a facility to cause emission of contaminants from an incinerator in quantities which may result in adverse impacts on the air quality in the vicinity of the site.

2.3.1 Ambient Air Quality Impact Analysis

An ambient air quality impact analysis shall be one of the major criteria for the selection of a site for an incineration facility. In general, the impacts of emissions from a proposed facility on the ambient air quality shall be determined for the contaminants listed in [Table 1](#) or [Section 3.2.1](#), as applicable to a particular facility. However, depending on the location of the proposed facility, the Regional Manager may require an air quality impact analysis only for certain contaminants selected from [Table 1](#) or [Section 3.2.1](#).

The ground level concentrations of the above contaminants shall be estimated for the worst case scenario by a dispersion model approved by the Regional Manager.

The impact analysis must show that predicted ground level concentrations do not exceed the ambient air quality criteria of the contaminants as stipulated by the Regional Manager.

2.3.2 Site Specific Emission Limits

Depending on the ambient air quality impact analysis results, the Regional Manager may require additional emission control measures for any facility to meet more stringent emission limits than those prescribed herein. The local government, such as a Regional District or Municipality, may also require more restrictive emission limits than those prescribed herein for any facility within its jurisdiction.

3 Emission Limits

3.1 Incinerators with Capacity of Processing over 400 kg/h of Waste

The stack emission limits for various contaminants listed in [Table 1](#) are applicable to the above size incinerators.

3.2 Incinerators with Capacity of Processing over 400kg/h or less of Waste

3.2.1 3.2.1 Emission Limits and Ambient Air Quality Criteria

1. Total particulates concentration in the incinerator stack discharge gas shall not exceed 180 mg/m³, averaged over the approved sampling period, corrected to 11% oxygen.
2. The carbon monoxide concentration in the incinerator stack discharge gas shall not exceed 55 mg/m³, corrected to 11% oxygen, on a 4-hour rolling average basis. In the case of an incinerator burning RDF, the carbon monoxide level in the stack discharge shall not exceed 110 mg/m³, corrected to 11% oxygen on a 4-hour rolling average basis.
3. The opacity of the incinerator stack discharge gas shall not exceed 10% at any time, as measured in accordance with a method approved by the Regional Manager.
4. The of the following gaseous contaminants in the ambient air at locations designated by the Regional Manager shall not exceed:
 - Hydrogen Chloride — 100 µg/m³ (0.5-h average) and 40 µg/m³ (24-h average);
 - Sulphur Dioxide — 450 µg/m³ (1-h average) and 160 µg/m³ (24-h average); and
 - Nitrogen Oxides (measured as Nitrogen Dioxide) — 400 µg/m³ (1-h average) and 200 µg/m³ (24-h average).
5. Depending on the site of the operation, the Regional Manager may at his discretion stipulate additional stack emission limits and/or ambient air quality criteria for any other contaminants.

3.2.2 Limits on Number of Incinerator Units

The installation and simultaneous operation of more than one small capacity (400 kg/h or less of waste processing) incinerator without any post-combustion emission control system at the same facility is not permitted.

3.2.3 Provisions for Emission Control System

Subsequent to the issuance of a Waste Management Permit, the Regional Manager reserves the right to require, at a later date, further control of emissions from an operating incinerator on the basis of an evaluation of the incinerator performance, monitoring data, and any other relevant information. It is recommended that provisions should be made for adequate space and other necessities at the initial design stage of the facility.

4 Incinerator and Emission Control System Design and Operation Requirements

To minimize emission of contaminants from an incinerator, the required design and operation parameters for the equipment as outlined below and summarized in [Table 2](#), shall be followed. The incinerator design and operation parameters listed in [Table 2](#) are applicable to all sizes of incinerators. The emission control system parameters will apply to all incinerators equipped with such systems.

These requirements are based on currently available information and may be revised at a future date, if deemed necessary. Any alternative system of different design, which is operated outside the required parameters, will be acceptable as long as it can be demonstrated that such a system can meet all other requirements of the Emission Criteria. These requirements do not preclude development of any new technology.

4.1 Minimum Incineration Temperature and Residence Time

The incinerator shall be designed, equipped and operated in such a manner that a minimum temperature of 1000°C is maintained in the final combustion zone, at the fully mixed height after the final introduction of combustion air.

The incinerator design must provide for a minimum residence time of 1 second for the combustion gases at 1000°C at the said location during normal operation.

The residence time is to be calculated from the point where most of the combustion has been completed and the incineration temperature fully developed.

In multi-chamber incinerators the residence time is calculated from the secondary burner(s) flame front or final secondary air injection point(s).

In an incinerator where the furnace is one continuous space, such as in spreader stoker and single chamber mass burning equipment, the location of the complete combustion and fully developed temperature shall be determined by an overall design review.

It is recommended that new incinerators be designed conservatively to provide the combustion gases a capability to attain at least 1.2 seconds of residence time at a temperature of 1000°C at the above location.

4.2 Primary Air

The incinerator shall be designed to ensure that an adequate quantity of primary combustion air is distributed properly inside the initial combustion zone to promote good contact between the waste and the air. The design features shall also include the capability to control and adjust both the air flow rate and its distribution to minimize quenching of the combustion reaction and entrainment of particles, as well as to compensate for irregular waste loading on the grate.

4.3 Secondary Air

The incinerator shall be designed for adequate air supply through properly located injection ports to provide sufficient turbulence and mixing of the reactants in the final combustion zone. The location and design of the air injection ports shall ensure good penetration and coverage of furnace cross-section under all flow conditions.

4.4 Auxiliary Burner(s)

The incinerator shall be equipped with auxiliary burner(s) of adequate heat capacity to be used during start-up, shutdown, upset conditions, when burning marginally combustible waste, and at any other time as necessary to maintain the minimum incineration temperature. The auxiliary burner(s) shall be designed such that the minimum combustion zone temperature of 1000°C can be maintained for at least 15 minutes without any waste feeding to the unit. The firing of the auxiliary burner(s) and the supply of combustion air shall be modulated automatically to maintain the required minimum combustion zone temperature.

4.5 Oxygen Level in Flue Gas

To maintain adequate availability of combustion air in the incinerator, the combustion air supply system shall be designed to maintain the oxygen content in the flue gas leaving the unit within the prescribed range.

4.6 Turndown Restrictions

The incinerator shall be designed to meet the minimum requirements of temperature, residence time, combustion air supply, and oxygen level in the flue gas over the recommended range of the waste feed load.

4.7 Maximum Carbon Monoxide Level in Flue Gas

The recommended maximum CO concentration of 55 mg/m³ corrected to 11% O₂ (4-h rolling average) in the incinerator flue gas shall be used as the operating target. Any excursion of CO concentration to twice the above specified level shall require adjustment of operating parameters until the normal combustion conditions are restored.

4.8 Emission Control Systems

The temperature of the flue gas at the outlet of the emission control equipment used for simultaneous removal of acid gases and particulates, or at the inlet of a separate particulates control device, shall not exceed 140°C.

This limit of 140°C temperature requirement does not preclude the use of alternate emission control systems, which may necessitate a higher flue gas discharge temperature, provided it can be demonstrated that the stipulated emission limits in [Table 1](#) can be achieved. To ensure that the particulates control device is operating efficiently, the opacity of the flue gas leaving the stack shall be maintained below the stipulated limit.

5 Monitoring Requirements

To ensure that the emissions of contaminants from an incinerator are within the stipulated limits, the following monitoring requirements are considered to be essential. Any additional monitoring may be required by the Regional Manager on a site specific basis.

5.1 Continuous Monitoring

5.1.1 Monitoring Instruments Specifications, Locations and Maintenance

The performance specifications of the above continuous monitors for both operating and emission parameters shall be subject to approval by the Regional Manager. The locations of the monitors and the procedures for calibration, operation and maintenance of these instruments must be approved by the Regional Manager.

A monthly availability factor of at least 95% for each continuous monitor, with the exception of the hydrogen chloride monitor, is considered essential for data evaluation. For the hydrogen chloride monitor, a monthly availability factor of at least 90% is considered essential.

The Regional Manager must be notified of any continuous monitor failure for a period which may result in non-attainment of the recommended availability factor.

5.1.2 Continuous Monitoring Parameters

The following operating and emission parameters, applicable to all incinerator sizes, shall be monitored continuously:

1. Combustion Temperature;
2. Oxygen; and
3. Carbon Monoxide.

Additional continuous monitoring of emission and operating parameters listed below shall be required for incinerators of over 400 kg/h capacities:

1. Opacity;
2. Hydrogen Chloride; and
3. Emission Control Device Inlet or Outlet Temperature.

The above additional parameters shall also be monitored continuously for an incinerator of 400 kg/h or less capacity if it is equipped with an emission control system.

5.1.2.1 Combustion Temperature

The temperature at the fully mixed height in the final combustion zone of the incinerator shall be measured and recorded continuously. Temperature sensors shall be located such that flames from the auxiliary burners do not impinge on the sensors.

With respect to the continuous measurement and recording of the combustion temperature, a suitable and approved alternate location downstream of the final combustion zone may be acceptable, provided:

1. It is demonstrated that the temperature in the final combustion zone cannot be measured continuously without damaging the temperature sensors; and
2. A correlation between the final combustion zone temperature and that at the approved location downstream is established to the satisfaction of the Regional Manager.

5.1.2.2 Oxygen and Carbon Monoxide

Oxygen and carbon monoxide concentrations in the incinerator flue gas shall be measured at the same location downstream of the incinerator, but upstream of the emission control devices and where no dilution of the flue gas will occur.

It is recommended that the incinerator be equipped with automatic control and suitable alarm systems, preferably both visual and audible, in conjunction with the monitors for temperature, oxygen and carbon monoxide. The alarms should be set to ensure that whenever the minimum incineration temperature

and/or oxygen level drops below, or the carbon monoxide level exceeds, that recommended in [Table 2](#), auxiliary burner(s) should be turned on and/or the waste feed be discontinued automatically, until the normal operating conditions are reestablished.

5.1.2.3 Opacity

The opacity monitor should be equipped with suitable alarms set at an opacity level approved by the Regional Manager.

An alarm for excessive opacity level should be investigated for poor combustion of waste and/or malfunction of the particulate control device, and appropriate measures should be taken to rectify the situation.

5.1.2.4 Hydrogen Chloride

The continuous monitor for hydrogen chloride emission should be equipped with suitable alarms set at a predetermined hydrogen chloride concentration level approved by the Regional Manager. This monitor should be linked with the emission control system for acid gases, and the system should be adjusted automatically to reduce the emission, when the preset hydrogen chloride level is exceeded.

Alternatively, at facilities where continuous monitoring of sulphur dioxide is performed, a similar alarm and acid gas emission control system adjustment could be used to maintain the hydrogen chloride emission below the prescribed limit.

5.1.2.5 Emission Control Device Inlet or Outlet Temperature

The location of the sensor for continuous measurement of temperature at the outlet or inlet of the emission control device, depending on the particular emission control system in use, should be approved by the Regional Manager.

5.2 Source Testing

Within 90 days of the start of full normal operation of the incinerator, source testing shall be conducted for: oxygen, carbon dioxide and the contaminants listed in [Table 1](#) or Section [3.2.1](#), as applicable to a particular facility. The Regional Manager may require source testing of additional contaminants on a site specific basis.

The Regional Manager must be notified in writing well in advance of the actual testing. All source testing procedures shall be approved by the Regional Manager. Any subsequent source testing requirements will be determined by the Regional Manager based on his review of the initial source test results, continuous monitoring data and/or any other information related to the incinerator operation.

5.3 Other Monitoring

The following additional monitoring requirements are listed in general terms to encompass all facilities irrespective of the incinerator capacity. The Regional Manager shall determine the applicable items on a case by case basis.

5.3.1 General

The incineration facility shall be inspected daily by trained personnel to investigate the status of various components, so that malfunctioning of any components is identified and corrective actions are taken immediately. Such inspection should include, but not be limited to: waste and other materials delivery and storage area for spills, equipment leaks, corrosion, hot spots, gauges, monitors and recorders, etc. Records of daily inspection shall include the following items and any others which are considered to be necessary:

1. Inspection time and date;
2. Descriptions of the items inspected;
3. Observations made for each item inspected;
4. Any test, maintenance repair or any other corrective measures taken during or after the inspection; and
5. Inspector's name, position and signature.

5.3.2 Hours of Operation, Waste, Ash and Residue Handling

Records of operation of the incinerator and its ancillary facilities in hours per day shall be maintained. Daily records shall be maintained, in terms of weight, of quantities of:

1. Waste shipments delivered and their sources of origin;
2. Waste feed rate to the incinerator on an hourly basis or per batch, if the operation is in batch mode, and the number of batches per day; and
3. Daily rates of bottom ash, fly ash and/or residue generation and treatment, if any, and disposal.

5.3.3 Auxiliary Burner Operation

Records shall be maintained of operation of auxiliary burner(s) and the rate of auxiliary fuel used in each burner on an hourly basis for a continuous operation or on an "as used" basis, with the duration of each period, when operated intermittently. If the auxiliary fuel used is oil, then its source, type and sulphur content shall also be recorded for each batch of oil supplied. In no event shall the sulphur content in the auxiliary fuel exceed the limit stipulated in the current edition of the Sulphur Content of Fuel Regulation of the *Environmental Management Act*.

5.3.4 Emission Control Device

Records shall be maintained for emission control devices for removal of acid gases and/or particulates as follows:

1. Hourly average temperature at the inlet or outlet of the device, as the case may be, in degrees C;
2. Frequency and duration of any period when the device is not fully operational, and appropriate description of each period of malfunction of any device, as well as of the rectifying measure taken in each case;
3. Hourly average pressure drop in kPa across the wet scrubber and/or fabric filter;
4. Reagent chemicals used in kg/h by chemical; and
5. The volume of water used, if any, in m³/h.

The following additional records on an hourly basis shall be maintained for any separate particulates emission control device:

For fabric filter:

1. Average pressure drop in kPa across each module; and
2. Number of compartments in use.

For electrostatic precipitator:

1. Number of fields in use;
2. Applied voltage per field;
3. Current flow per field in amperes; and
4. Sparking rate per field.

5.4 Emission Control Device By-Pass Conditions

Records of relevant operating conditions during any discharge of flue gases by-passing the emission control device and the duration of such discharge shall be maintained.

6 Reports

6.1 Monthly Reports

For records of monitoring of items under Sections 5.1, 5.3 and 5.4 above, monthly reports shall be submitted to the Regional Manager within 20 calendar days following the end of each month.

The report for item [Section 5.1](#) shall include the following:

1. Data from each continuous monitor shall be tabulated in the specified averaging period for each parameter with both the minimum and maximum values recorded for each parameter during the

corresponding averaging period. The monthly average, minimum and maximum values for each parameter shall also be reported. Prior to discarding this data the Regional Manager shall be contacted regarding archiving;

2. Performance specifications and calibration data for each monitor;
3. Percentage of availability of each monitor;
4. Percentage of data capture for each monitor for the contaminants, oxygen and carbon dioxide;
5. The number of exceedances above the specified limit for each gaseous parameter and opacity, and the number of occasions when such exceedances lasted more than 1 hour, or the stipulated rolling averaging period for any particular parameter, with appropriate comments about remedial measures taken in each case;
6. The number of occasions when the combustion temperature dropped below 1000°C, and for each occasion indicate the recorded minimum temperature reached, the duration of operation at sub-1000°C temperature, and the corrective measures taken; and
7. The number of occasions when the flue gas temperature at the inlet or outlet of the emission control device exceeded 140°C, and for each occasion indicate the recorded maximum temperature reached, the duration of operation above 140°C temperature, and the corrective measures taken.

The records of monitoring of items under Sections 5.3.1 to 5.3.4 and Section 5.4 inclusive shall be summarized for the whole month in appropriate formats and submitted to the Regional Manager.

6.2 Source Testing Report

A complete report for the Source Testing ([Section 5.2](#)) results, with the exception of trace organics, shall be submitted to the Regional Manager within 60 days of the completion of the actual testing. The results for trace organics shall be submitted to the Regional Manager within 90 days of the completion of actual testing.

6.3 Annual Performance Report

An annual report reviewing the performance of the incinerator shall be submitted to the Regional Manager within 90 days following the end of a calendar year. The report shall contain evaluation of at least the following aspects:

1. The quantities of waste shipments received from different sources and waste processed at the site;
2. An overview of the plant performance describing the incinerator availability and the duration and causes of any non-availability; the status of operation and maintenance of various equipment and their adequacies; plant output, if any energy recovery is practiced; the quantities of bottom ash, fly ash and/or residue generated and their disposal methods; general housekeeping practices;

incidence of any emergencies and the response measures implemented; incidence of emission control system by-passing; and

3. Operation, performance and maintenance of emission control devices and continuous monitoring systems.

7 Start-up, Shutdown and Upset Condition Periods, and Spill Management

The owner or operator of an incineration facility shall prepare a detailed operating plan and procedures for the incinerator start-up, shutdown and upset condition periods, and submit it to the Regional Manager for approval prior to the issuance of a Permit. Such plan and procedures must be developed following the recommendations outlined in Appendix B and consultation with the equipment manufacturers, as necessary, so that the essential safety procedures for operation of any equipment are not overlooked or compromised.

Spill protection and/or reporting for the site shall be handled in accordance with the current edition of the Special Waste Regulation and/or Spill Reporting Regulation of the *Environmental Management Act*.

8 General Requirements for the Facility

8.1

The waste unloading and storage area shall be enclosed in order to minimize odorous and fugitive emissions. The area shall be designed and maintained on negative draft and in such a manner that the air from this area is used as combustion air for the incinerator.

8.2

The waste storage area shall be of sufficient capacity to store the delivered waste in the event of a shutdown of the incinerator due to malfunctions of equipment, labour dispute or any other interruption of operation.

8.3

The vehicular traffic areas at the facility shall be paved to minimize fugitive dust emissions.

8.4

Daily clean-up at the facility must be practiced so that any spilled waste or any other material is collected on a regular basis.

8.5

A standby electrical power generator of sufficient capacity must be available at the site to supply necessary power to maintain full operation of the facility in the event of a failure of the general electric power supply system. The standby electric power supply must be provided until the general electric power supply is restored or the incinerator is shut down in a manner prescribed in [Section 7](#) and [Appendix B](#).

9 Requirement for Training of Incinerator Operator

All incineration facilities subject to these Emission Criteria must be operated by properly qualified personnel. Copies of certificates of the operating staff verifying the satisfactory completion of a training program shall be submitted to the Regional Manager.

All incinerator operators shall be trained by a recognized technical organization or an institution with capabilities to provide necessary training in the operating practices and procedures of all equipment. The content of the training program shall be submitted to the Regional Manager for approval. The training program shall include, but not be limited to, the following:

1. The basic principles of waste incineration and emission of contaminants there from;
2. Knowledge of the Waste Management Permit requirements;
3. The basic features and location of the incinerator, emission control system, and other equipment at the facility;
4. Proper operation, functioning and maintenance of all mechanical, emission control and monitoring equipment;
5. Detection of excessive emissions and procedures to be followed during such occasions; and
6. Response procedures and measures to be taken during emergency situations.

This requirement does not eliminate the need for any staff involved with the facility from obtaining any other licenses or certificates necessary to carry out other duties as may be required by any other agencies.

10 Wastewater Management

Any wastewater generated at the site from the waste handling, storage and incineration area, any emission control system, ash and/or residue quench and conveyance systems, sanitary effluent, and from any other sources shall be treated and disposed of in a manner approved by the Regional Manager.

11 Ash and Residue Management

To minimize fugitive emissions of ash and residue particles, adequate precautions shall be taken at the time of handling, conveyance and storage of these materials. Wind-sheltered, enclosed storage areas shall be provided for these materials. As some of these materials may be classified as special waste, the final disposal methods for these materials must be approved by the Regional Manager. The disposal methods shall be determined after testing these materials in accordance with the procedures outlined in the current edition of the Special Waste Regulation of the *Environmental Management Act*.

Table 1: Stack Emission Limits for Incinerators of Capacity Over 400 kg/h of Waste

(Concentrations corrected to 11% O₂)

Contaminant	Limit	Averaging Period	Monitoring Method
Total Particulate	20 mg/m ³	(1)	(2)
Carbon Monoxide	55 mg/m ³ (3)	4-hour rolling average	Continuous Monitoring
Sulphur Dioxide	250 mg/m ³	(1)	(2)
Nitrogen Oxides (NO _x as NO ₂)	350 mg/m ³	(1)	(2)
Hydrogen Chloride	70 mg/m ³	8-hour rolling average	Continuous Monitoring
Hydrogen Fluoride	3 mg/m ³	(1)	(2)
Total Hydrocarbons (as Methane CH ₄)	40 mg/m ³	(1)	(2)
Arsenic (4)	4 µg/m ³	(1)	(2)
Cadmium (4)	100 µg/m ³	(1)	(2)
Chromium (4)	10 µg/m ³	(1)	(2)
Lead (4)	50 µg/m ³	(1)	(2)
Mercury (4)	200 µg/m ³	(1)	(2)
Chlorophenols	1 µg/m ³	(1)	(2)
Chlorobenzenes	1 µg/m ³	(1)	(2)
Polycyclicaromatic Hydrocarbons	5 µg/m ³	(1)	(2)
Polychlorinated Biphenyls	1 µg/m ³	(1)	(2)
Total PCDDs & PCDFs (6)	0.5 ng/m ³	(1)	(2)
Opacity	5%	1-hour average from data taken every 10 seconds	Continuous Monitoring

(1) To be averaged over the approved sampling and monitoring method.

(2) All sampling and monitoring methods, including continuous monitors, are to be approved by the Regional Manager.

(3) For RDF systems the limit shall be 110 mg/m³.

(4) The concentration is total metal emitted as solid and vapour.

(5) For existing incinerators the limit shall be 200 µg/m³, for the initial 2 years after the issuance of these Emission Objectives.

(6) Expressed as Toxicity Equivalents. The value shall be estimated from isomer specific test data and toxicity equivalency factors by following a procedure approved by the ministry.

Table 2: Design and Operation Requirements for Municipal Solid Waste Incinerators and Emission Control Systems

Parameter	Incinerator Type Modular (Excess Air and Starved Air)	Incinerator Type Mass Burn	Incinerator Type RDF
Incinerator			
Minimum Incineration Temperature	1000 degrees C at fully mixed height	1000 degrees C determined by an overall design review	1000 degrees C
Minimum Residence Time	1 second after final secondary air injection ports	1 second calculated from the point where most of the combustion has been completed and the incineration temperature fully developed	1 second calculated from point where most of the combustion has been completed and the incineration temperature fully developed
Primary Air (Underfire)	Utilize multi-port injection to minimize waste distribution difficulties	Use multiple plenums with individual air flow control	Use air distribution matched to waste distribution
Secondary Air (Overfire)	Up to 80% of total air required (1)	At least 40% of total air required	At least 40% of total air required
Overfire Air Injector Design	That required for penetration and coverage of furnace cross-section	That required for penetration and coverage of furnace cross-section	That required for penetration and coverage of furnace cross-section
Auxiliary Burner Capacity	Secondary burner 60% of total rated heat capacity, and that required to meet start-up and part-load temperatures	60% of total output, and that required to meet start-up and part-load temperatures	60% of total output, and that required to meet start-up and part-load temperatures
Oxygen Level at the Incinerator Outlet	6 to 12%	6 to 12%	3 to 9%
Turndown Restrictions	80 to 110% of designed capacity	80 to 110% of designed capacity	80 to 110% of designed capacity
Maximum CO Level	55 mg/m ³ @ 11% O ₂ (4-h rolling average)	55 mg/m ³ @ 11% O ₂ (4-h rolling average)	110 mg/m ³ @ 11% O ₂ (4-h rolling average)
Emission Control Systems (2)			
Flue Gas Temperature at Inlet or Outlet of Emission Control Device (3)	Not to exceed 140 degrees C	Not to exceed 140 degrees C	Not to exceed 140 degrees C
Opacity (4)	Less than 5%	Less than 5%	Less than 5%

(1) For excess Air type — as required by design.

(2) Applicable to incinerators equipped with such systems.

(3) The flue gas temperature at the inlet or outlet will depend on the type of emission control device in use.

(4) For incinerators with capacity or processing 400 kg/h or less of waste the opacity shall be less than 10%.

12 Appendix A

Acid Gases:

- Hydrogen chloride
- Hydrogen fluoride
- Oxides of nitrogen
- Oxides of sulphur

Chlorobenzenes (CBs):

- Cl-2 benzene
- Cl-3 benzene
- Cl-4 Benzene
- Cl-5 benzene
- Cl-6 benzene

Chlorophenols (CPs):

- Cl-2 phenol
- Cl-3 phenol
- Cl-4 phenol
- Cl-5 phenol

Polycyclic Aromatic Hydrocarbons (PAHs):

- Acenaphthylene
- Acenaphthene
- Fluorene
- Phenanthrene
- Anthracene
- Fluoranthene
- Pyrene
- Chrysene
- Benzo [a] anthracene
- Benzo [e] pyrene
- Benzo [a] pyrene
- Benzo [b] fluoranthene
- Benzo [k] fluoranthene
- Perylene
- Indeno [1,2,3-cd] pyrene
- Dibenzo [a,h] anthracene
- Benzo [g,h,i] perylene
- Benzo [l] phenanthrene

Polychlorinated Biphenyls (PCBs):

Polychlorinated dibenzo-para-dioxins (PCDDS) and polychlorinated dibenzofurans (PCDFs) in the following homologue groups:

- T — tetra
- Pa — penta
- Hx — hexa
- Hp — hepta
- O — octa

Appendix B: Recommendations for an Operating Plan and Procedure for Incinerator Start-up, Shutdown, and Upset Condition Periods

1 Incinerator Start-up and Shutdown

Without limiting the scope of the plan, provisions for the following must be included in the detailed plan and procedures:

1.1 Combustion Temperature and Waste Feed

The systems for waste feed, combustion control, and continuous monitoring of combustion parameters must be integrated in such a manner that proper incinerator operating conditions are maintained automatically. In addition, the procedures outlined below must be adhered to under the following circumstances:

1.1.1 No waste shall be charged to the incinerator until the required minimum temperature in the final combustion zone is achieved and maintained for at least 15 minutes by using the auxiliary burner(s).

1.1.2 In the event of any unscheduled or scheduled shutdowns:

1. The waste feed to the incinerator shall be automatically discontinued; and
2. The minimum required temperature in the final combustion zone shall be maintained by using auxiliary burner(s): (a) until the carbon monoxide concentration in the stack gas can be maintained below the required level, and the combustion and burndown cycles of the remaining waste in the incinerator are complete; and (b) for a minimum of 15 minutes from the beginning of an unscheduled shutdown and when an emergency discharge of the flue gas directly to the atmosphere becomes necessary.

1.2 Continuous Monitoring and Emission Control Systems

The continuous monitoring systems for combustion and emission parameters and emission control systems must be in proper operating conditions: (a) prior to any waste charging to the system during

start-up; (b) during normal operation of the incinerator; and (c) until the burndown cycle is complete at the time of any planned shutdown.

The emission control systems shall not be by-passed at any time when the incinerator is in operation, except under the following circumstances, if necessary, and during start-up and shutdown:

1. When the temperature of the flue gas at the emission control device is below or above that specified by the manufacturer; and
2. During an emergency shut down, for example, due to fire hazard or failure of the induced draft fan.

2 Upset Condition Periods

Some variations in the incinerator operating parameters and in the emission control parameters are to be expected; however, during normal operation of the incinerator the specified average values of these parameters can be maintained. Common indications of upset conditions may include but not be limited to:

1. An operating parameter which varies consistently for any unusual duration; and
2. The development of a trend towards a higher or lower value, as the case may be, than that specified for any particular parameter.

The incinerator operators must be trained to recognize abnormal operations as well as to take corrective actions in a systematic manner. A suggested list of potential measures is provided below; however, these measures should be reviewed with the manufacturers' specifications for the particular equipment installed at the facility.

2.1 Continuous Monitoring Systems

All continuous monitors and recorders should be checked for their performance and calibration by zero and fullscale span as applicable.

2.1.1 Combustion Parameters

In the event of low combustion temperature, low oxygen level and/or high carbon monoxide level, the following checks should be made:

1. Auxiliary burner(s) operation, including the fuel and air supplies;
2. The waste feed system;
3. Combustion air supplies to the incinerator;
4. Visual inspection of the incinerator grates; and
5. Other ancillary equipment which could influence the incinerator performance.

2.1.2 Opacity and Emission Control Parameters

During any exceedances of the flue gas temperature at the inlet or outlet of emission control device, of opacity, and of hydrogen chloride the following checks should be necessary:

1. The normalcy of the incinerator operation;
2. The flue gas conditioning system, if any, upstream of the emission control device;
3. Particulates emission control device; and
4. Acid gas scrubbing system.

2.2 Emergency Shutdown

Emergency shutdown procedures should be followed if the malfunctioning of the incinerator or emission control system persists even after implementation of the corrective measures to rectify any upset conditions.



Combustion of Municipal Solid Waste

The purpose of this document is to summarize key information contained in the Ministry's guideline for emissions from Municipal Solid Waste (MSW) combustion.

The rationale behind the guideline is contained in a report that was developed by Stantec for the Ministry of Environment under contract.¹

What is the guideline for emissions from MSW combustion used for?

The guideline is intended to provide assistance for reviewing Solid Waste Management Plans submitted under the *Environmental Management Act*, assistance to directors for issuing Operational Certificates to local governments or to owners or operators of MSW combustion facilities covered by a Solid Waste Management Plan, and assistance to directors for issuing permits for MSW combustion facilities.²

Why combust MSW?

The practice of MSW combustion as a method of waste treatment is being considered by various local governments and private companies. It provides a means to reduce the volume of waste entering landfills, as well as a means to recover energy. The latter, known as Waste to Energy, is an allowable activity under the *Environmental Management Act*.

Who does the guideline for emissions from MSW combustion apply to?

The guideline is intended for facilities carrying out combustion of MSW³ that has not been processed into refuse derived fuel. The guideline applies to facilities that combust MSW both with and without energy recovery.

The conditions and limits within the guideline apply to mass burn facilities. If other treatment techniques including, but not limited to, gasification, plasma gasification or pyrolysis are contemplated, the same conditions and limits should be applied, as appropriate, along with other parameters that ensure effective operation of the technology.

What air emissions are produced during the combustion of MSW?

Combustion of MSW can be achieved using several technologies, with the most common method being mass burn. Typical air pollutants which may be released to the atmosphere during this process include: particulate matter, carbon monoxide, sulphur dioxide, nitrogen oxides, acidic compounds, metals and organic compounds.

What are the limitations of the guideline?

The guideline is limited to conditions that could be placed in an authorization. It does not take into account various factors that would be evaluated as part of an Environmental Impact Assessment, nor does

¹ "Waste to Energy: A Technical Review of Municipal Solid Waste Thermal Treatment Practices" available online at: <http://www.env.gov.bc.ca/epd/mun-waste/reports/pdf/BCMOE-WTE-Emissions-final.pdf>

² For more information on waste discharge authorizations, see: http://www.env.gov.bc.ca/epd/waste_discharge_auth/index.htm

³ Municipal Solid Waste is defined under Section 23 of the *Environmental Management Act* as (a) refuse that originates from residential, commercial, industrial, demolition, land clearing or construction sources, or (b) refuse specified by a director to be included in a waste management plan.

it limit any additional requirements that may be imposed for a specific facility.

If an impact assessment indicates a potential for continued adverse effects on the environment or human health, more stringent emission limits than the limits listed here may be deemed necessary.

What are the emission limits?

Emission limits for the combustion of MSW are outlined in Table 1. These limits include daily average and several ½ hour average limits.

New Facilities

All new facilities are expected to install operational and emission control technologies that will, at minimum, achieve the conditions required by the Ministry and the emission limits in Table 1.

Existing Facilities

Existing facilities that operate within BC are expected, within two years or less, to submit a plan to the Ministry for achieving the requirements set out in the guideline and a timeline for implementation of the plan. In addition, existing facilities that have been significantly modified⁴ may be required to upgrade control technologies to meet more stringent emission limits.

Why are the ½ hour and daily average limits different?

The ½ hour limits are numerically higher than the daily limits to represent maximum allowable discharge concentrations over shorter time periods, whereas the daily averages are lower to account for fluctuations over time.

Why are there two ½ hour particulate matter emission limits?

During normal operation, facilities are required to operate within the limit of

⁴ A facility has been significantly modified if it has undergone a physical or operational change resulting in an increase of 10% or more in the volume of discharge or the total amount of any contaminant released to the environment.

Note: This summary is solely for the convenience of the reader. The current guideline should be consulted for complete information.

9 mg/m³ which applies as a 97% rolling operating annual average. The limit of 28 mg/m³ is to be met at all times and is intended to ensure emissions are maintained at low levels even during extenuating circumstances, such as a temporary disruption in the emission control equipment.

What are the incineration process operating conditions?

Proper incineration process operating conditions are important to ensure adequate combustion and to minimize air emissions. Conditions that pertain to temperature and oxygen concentration are to be set and monitored. Other conditions such as residence time, primary and secondary combustion air supply, and auxiliary burner capacity are to be incorporated in the facility design.

What are the requirements for public access to monitoring data?

MSW combustion facilities should ensure the public have online access to continuous emission monitoring system (CEMS) data and an indication of when CEMS data are not available.

What are the requirements for best management plans?

MSW combustion facilities should provide a best management plan to the Ministry prior to the issuance of an authorization. This plan should be updated regularly and include odour management and waste management contingency considerations. The odour management section should be site specific and incorporate considerations such as neighbouring facilities and residents, ongoing complaint mitigation and design.

Will the guideline be amended?

As other jurisdictions update emission limits for MSW combustion facilities and technologies and techniques improve, the Ministry will update the guideline as appropriate, especially if new MSW combustion facilities are contemplated.

Table 1. Emission Limits for Municipal Solid Waste Combustion Facilities in British Columbia

Contaminant	Units	EMISSION LIMITS	
		Daily Average	CEMS ½ Hour Average
Total Particulate Matter (TPM)	mg/m ³ @ 11% O ₂	9	9 ⁽¹⁾ , 28
Carbon Monoxide (CO)	mg/m ³ @ 11% O ₂	50	100
Sulphur Dioxide (SO ₂)	mg/m ³ @ 11% O ₂	50	190
Nitrogen Oxides (NO _x as NO ₂)	mg/m ³ @ 11% O ₂	190	350
Hydrogen Chloride (HCl)	mg/m ³ @ 11% O ₂	10	60
Hydrogen Fluoride (HF)	mg/m ³ @ 11% O ₂	1	4 ⁽²⁾
Total Organic Carbon	mg/m ³ @ 11% O ₂	10	20
Cadmium (Cd)	µg/m ³ @ 11% O ₂	7	N/A
Mercury (Hg)	µg/m ³ @ 11% O ₂	20	N/A
Sum of Lead (Pb), Arsenic (As), Chromium (Cr)	µg/m ³ @ 11% O ₂	64	N/A
Chlorophenols ⁽³⁾	µg/m ³ @ 11% O ₂	1	N/A
Chlorobenzenes ⁽³⁾	µg/m ³ @ 11% O ₂	1	N/A
Polycyclic Aromatic Hydrocarbons ⁽³⁾	µg/m ³ @ 11% O ₂	5	N/A
Polychlorinated Biphenyls ⁽³⁾	µg/m ³ @ 11% O ₂	1	N/A
Total Dioxins and Furans (as PCDD/F TEQ)	ng/m ³ @ 11% O ₂	0.08	N/A
Opacity ⁽⁴⁾	%	N/A	5

NOTES:

Concentration units: Mass per reference cubic metre corrected to 11% oxygen. Reference conditions: 20°C, 101.3 kPa, dry gas
N/A = Not Applicable

⁽¹⁾ 97% of the ½ hour average values over an annual operating rolling average will not exceed 9 mg/Rm³. The 28 mg/Rm³ ½ hour average value is never to be exceeded.

⁽²⁾ This requirement may be omitted at the discretion of the director should treatment stages for HCl demonstrate that the emission limit for HCl is not exceeded.

⁽³⁾ Proponents may be able to demonstrate that monitoring both Total Organic Carbon and Total Dioxins and Furans could negate the need to monitor Chlorophenols, Chlorobenzenes, Polycyclic Aromatic Hydrocarbons and Polychlorinated Biphenyls.

⁽⁴⁾ Opacity will not be required for compliance purposes for facilities utilizing continuous particulate monitoring systems. Opacity monitoring is recommended for operational monitoring purposes. However, opacity monitoring can be used as a temporary surrogate for total particulate monitoring in the event of a particulate monitoring system failure. Under these circumstances, the emission limit of 5% opacity over a ½ hour averaging period should apply.

For more information contact the Environmental Standards Branch at: eqb@Victoria1.gov.bc.ca,
or, consult our website at <http://www.env.gov.bc.ca/epd/mun-waste/>.

Note: This summary is solely for the convenience of the reader. The current guideline should be consulted for complete information.

As of 2015-09-25, this is the most current version available. It is current for the period set out in the footer below. It is the first version and has not been amended.

Le texte figurant ci-dessous constitue la codification la plus récente en date du 2015-09-25. Son contenu était à jour pendant la période indiquée en bas de page. Il s'agit de la première version; elle n'a fait l'objet d'aucune modification.

THE ENVIRONMENT ACT
(C.C.S.M. c. E125)

Incinerators Regulation

Regulation 91/88 R
Registered January 29, 1988

Definitions

1 In this regulation,

"**domestic incinerator**" means an incinerator used for a single family residence or for a two-family residence in duplex or double house form, or for multiple-dwelling units in which the incinerator serves fewer than three apartments; (« incinérateur domestique »)

"**flue-fed incinerator**" means an incinerator provided with a flue which serves as a charging chute in addition to conducting the products of combustion to the atmosphere; (« incinérateur alimenté par carneau »)

"**incinerator**" means a device used for the process of burning waste and from which the products of combustion are conveyed to the atmosphere by passage through a stack; (« incinérateur »)

"**opacity**" means the degree to which emissions reduce the transmission of light and obscure the view of an object in the background; (« opacité »)

"**particulates**" means any material, except uncombined water, which exists in a finely divided form as a liquid or solid at standard conditions; (« macroparticules »)

LOI SUR L'ENVIRONNEMENT
(c. E125 de la C.P.L.M.)

Règlement sur les incinérateurs

Règlement 91/88 R
Date d'enregistrement : le 29 janvier 1988

Définitions

1 Les définitions qui suivent s'appliquent au présent règlement.

« **conditions normales** » Température de 20° Celsius (68° Fahrenheit) et pression de 760 mm Hg (29.92 po Hg). ("standard conditions")

« **fumée** » Petites particules portées par le gaz et découlant de la combustion, qui sont formées principalement mais non exclusivement de carbone et de cendres et qui, sous l'action d'un courant d'air, forment une volute visible. ("smoke")

« **incinérateur** » Dispositif servant à brûler les déchets et libérant les produits de la combustion dans l'atmosphère par le biais d'une cheminée. ("incinerator")

« **incinérateur alimenté par carneau** » Incinérateur doté d'un carneau qui sert de conduite de chargement en plus de libérer les produits de la combustion dans l'atmosphère. ("flue-fed incinerator")

« **incinérateur domestique** » Incinérateur utilisé dans les résidences unifamiliales, les résidences bifamiliales de type duplex ou maisons jumelées, ou dans les immeubles à logements multiples où l'incinérateur dessert moins de trois appartements. ("domestic incinerator")

"Ringelmann Number" means a value on the Ringelmann Smoke Chart for grading the density of smoke, published by the U.S. Bureau of Mines, or any other chart, recorder, indicator or device for the measurement of smoke density which is approved by the department as the equivalent of the said Ringelmann Smoke Chart; (« numéro Ringelmann »)

"smoke" means small gas-borne particles resulting from combustion and consisting predominantly but not exclusively of carbon and ash, which form a visible plume under draft; (« fumée »)

"standard condition" means a temperature of 20° Celsius (68° Fahrenheit) and a pressure of 760 mm Hg (29.92 in. Hg); (« conditions normales »)

"standard cubic foot" means the volume of one cubic foot of gas at standard conditions; (« pied cube normal »)

"standard cubic metre" means the volume of one cubic metre of gas at standard conditions. (« mètre cube normal »)

Registration

2 Prior to operating a new incinerator, a person shall register the incinerator with the department on a form approved by the department.

Standards

3(1) No person shall operate a new incinerator which emits more than 0.23 grams of particulates per standard cubic metre (0.10 grains per standard cubic foot) of dry flue gas corrected to 12% carbon dioxide by volume.

3(2) No person shall operate a new incinerator which emits smoke with an opacity equal to or greater than

(a) 40% (equivalent to number two on the Ringelmann Smoke Chart) at any time; or

(b) 20% (equivalent to number one on the Ringelmann Smoke Chart) for a period exceeding four minutes in any one hour.

« **macroparticules** » Toute matière, à l'exception de l'eau non combinée, qui, aux conditions normales, existe sous forme liquide ou solide très fine. ("particulates")

« **mètre cube normal** » Volume d'un mètre cube de gaz aux conditions normales. ("standard cubic metre")

« **numéro Ringelmann** » Valeur figurant sur la table de Ringelmann, qui sert à quantifier la densité de la fumée et qui est publiée par le « U.S. Bureau of Mines », ou toute autre table, ou tout appareil enregistreur, appareil indicateur ou dispositif de mesure de la densité de la fumée approuvé par le ministère comme étant équivalent à la table de Ringelmann. ("Ringelmann Number")

« **opacité** » Degré auquel les émissions réduisent la transmission de la lumière et voilent la vue d'un objet en arrière-plan. ("opacity")

« **pied cube normal** » Volume d'un pied cube de gaz dans des conditions normales. ("standard cubic foot")

Enregistrement

2 Avant d'exploiter un incinérateur, une personne est tenue de l'enregistrer auprès du ministère au moyen d'une formule approuvée par celui-ci.

Normes

3(1) Nul ne peut exploiter un incinérateur qui émet plus de 0,23 gramme de macroparticules par mètre cube normal (0,10 grain par pied cube normal) de gaz de fumée sec corrigé à 12 % d'anhydride de carbone par volume.

3(2) Nul ne peut exploiter un incinérateur qui émet de la fumée dont l'opacité est égale ou supérieure à :

a) 40 % (équivalent au numéro 2 de la table de Ringelmann) à quelque moment que ce soit;

b) 20 % (équivalent au numéro 1 de la table de Ringelmann) durant plus de quatre minutes pendant une période d'une heure.

Prohibitions

4(1) No person shall construct or install a domestic incinerator.

4(2) No person shall construct or install a flue-fed incinerator.

Requirements

5(1) The rated capacity and the type of waste material for which the incinerator is designed shall be displayed in a conspicuous location near the incinerator.

5(2) Detailed instructions for the operation of an incinerator shall be posted in a conspicuous location near the incinerator.

5(3) Sampling ports shall be suitably located in the stack or breeching of incinerators.

Measurement

6 The method for measurement of particulates and opacity of smoke from incinerators shall be as approved by the department.

Coming into force

7 This regulation comes into force on the later of

(a) the date *The Environment Act* c. 26 of *The Statutes of Manitoba 1987-88* comes into force; or

(b) the date this regulation is filed with the Registrar of Regulations.

Interdiction

4(1) Nul ne peut construire ni installer un incinérateur domestique.

4(2) Nul ne peut construire ni installer un incinérateur alimenté par carneau.

Affichage

5(1) La capacité nominale de l'incinérateur ainsi que le type de résidus pour lequel il est conçu doivent être affichés à un endroit bien en vue près de l'incinérateur.

5(2) Le mode de fonctionnement détaillé de l'incinérateur doit être affiché à un endroit bien en vue près de l'incinérateur.

5(3) Des orifices d'échantillonnage doivent être prévus à des endroits appropriés dans le corps ou la culotte de la cheminée des incinérateurs.

Méthode de mesurage

6 La méthode de mesurage des macroparticules et de l'opacité de la fumée émanant des incinérateurs doit être approuvée par le ministère.

Entrée en vigueur

7 Le présent règlement entre en vigueur à la dernière des dates suivantes :

a) la date d'entrée en vigueur de la *Loi sur l'environnement*, chapitre 26 des *Lois du Manitoba de 1987-1988*;

b) la date du dépôt du présent règlement auprès du registraire des règlements.

Solid Waste-Resource Management Regulations
made under Section 102 of the
Environment Act
S.N.S. 1994-95, c. 1
O.I.C. 96-79 (February 6, 1996), N.S. Reg. 25/96
as amended up to O.I.C. 2007-102 (February 22, 2007), N.S. Reg. 61/2007

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Citation

1 These regulations may be cited as the "Solid Waste-Resource Management Regulations".

Definitions

2 In these regulations,

- (a) "Act" means the *Environment Act*;
- (b) "Administrator" means a person designated by the Minister pursuant to Section 3 of these regulations and includes an acting Administrator;

- (c) “approved program” means a program approved by the Minister pursuant to Section 7 of these regulations;
- (d) “backyard composting” means composting at a residential dwelling unit of organic solid waste, including grass clippings, leaves or food waste, where
 - (i) the waste is generated by the residents of the dwelling unit or neighbouring dwelling units or both, and
 - (ii) not more than 10 m³ is processed annually;

Subclause 2(d)(ii) replaced: O.I.C. 2000-201, N.S. Reg. 63/2000.

- (e) “beverage” means any liquid that is a ready to serve drink, but does not include milk, milk products, soya milk or concentrates;
- (f) “beverage container” means a container of less than 5 litres which contains or has contained a beverage and was sealed by the manufacturer after the beverage was placed in it;
- (g) “Board” means the Resource Recovery Fund Board established pursuant to Section 5 of these regulations;
- (h) “compost” means a product of composting which is used or sold for use as a soil amendment, artificial topsoil or growing medium or for some other application to land;
- (i) “composting” means the biological decomposition of organic materials, substances or objects under controlled circumstances to a condition sufficiently stable for nuisance-free storage and safe use in land applications;
- (j) “construction and demolition debris” means materials which are normally used in the construction of buildings, structures, roadways, walls and other landscaping material, and includes, but is not limited to, soil, asphalt, brick, mortar, drywall, plaster, cellulose, fibreglass fibres, gyproc, lumber, wood, asphalt shingles, and metals;
- (k) “Department” means the Department of Environment;
- (l) “depot” means a place registered with the Board pursuant to Section 17 of these regulations and is operated for the collection of redeemable beverage containers, post-consumer paint products or other materials;

Clause 2(l) amended: O.I.C. 2002-94, N.S. Reg. 24/2002.

Clause 2(m) repealed: O.I.C. 2007-102, N.S. Reg. 61/2007.

- (n) “distributor” means one of the following:
 - (i) the last person in the Province to supply, sell or offer for sale, by wholesale or other means, a designated material to a retailer in the Province,

- (ii) the retailer of the designated material, if a designated material is not supplied, sold or offered for sale by a person in the Province to a retailer in the Province;

Clause 2(n) replaced: O.I.C. 2007-102, N.S. Reg. 61/2007.

- (o) “Fund” means the Resource Recovery Fund established pursuant to Section 98 of the Act,
- (p) “incinerator” means a facility designed or used for the primary purpose of destruction of municipal solid waste by combustion;
- (q) “landfill” means a facility for the disposal of municipal solid waste by placing it in or on land;
- (qa) “leaf and yard waste” means vegetative matter resulting from gardening, horticulture, landscaping or land clearing operations, including materials such as tree and shrub trimmings, plant remains, grass clippings, leaves, trees and stumps, but excludes construction and demolition debris or contaminated organic matter;

Clause 2(qa) added: O.I.C. 2000-201, N.S. Reg. 63/2000.

- (r) “liquor” means liquor as defined in the *Liquor Control Act*;
- (s) “litter” means any material left or abandoned in a place other than a receptacle or place intended or approved for receiving such material and “littering” has a corresponding meaning;

Clause 2(s) replaced: O.I.C. 96-827, N.S. Reg. 167/96.

- (t) “Minister” means the Minister of Environment;
- (u) “municipality” means a city, an incorporated town, a municipality of a county or district or a regional municipality;
- (v) “municipal solid waste” means garbage, refuse, sludge, rubbish, tailings, debris, litter and other discarded materials resulting from residential, commercial, institutional and industrial activities which are commonly accepted at a municipal solid waste management facility, but excludes wastes from industrial activities regulated by an approval issued under the Act;
- (w) “owner” of property includes a part owner, joint owner, tenant in common or joint tenant of the whole or any part of any land or building, and includes a trustee, an executor, a guardian, an agent, a mortgagee in possession or a person having the care, management, or control of any land or building in case of the absence or disability of the person having title to it, any person who occupies shores, beaches or shoals and, in the absence of proof to the contrary, includes the person assessed for the property;
- (x) “private event” means an event where more than 300 persons are in attendance at one location, but excludes an event held in a residential dwelling;
- (y) “redeemable beverage container” means a [beverage] container on which a deposit has been paid;

- (z) “redeemed beverage container” means an empty beverage container accepted by a depot for refund, or collected as part of a private or municipal collection program;

Original clause 2(aa) relettered (za): O.I.C. 2002-94, N.S. Reg. 24/2002; repealed: O.I.C. 2007-102, N.S. Reg. 61/2007.

(aa) “sale” or “supply” means the transfer of a property interest, including

- (i) gifts,
- (ii) exchange,
- (iii) barter, or

(iv) any transaction in the nature of a franchise, head, option or rental;

Clause 2(aa) added: O.I.C. 2002-94, N.S. Reg. 24/2002.

(ab) “yard waste” means vegetative matter resulting from gardening, horticulture, landscaping or land clearing operations, including materials such as tree and shrub trimmings, plant remains, grass clippings, leaves, trees and stumps, but excludes construction and demolition debris or contaminated organic matter;

(ac) “waste diversion” means waste reduction, reuse, recycling or composting.

[Note: the name of the Department in clauses (k) and (t) has been updated in accordance with Order in Council 2008-161 under the *Public Service Act*, R.S.N.S. 1989, c. 376, effective April 1, 2008.]

Administrator

3 (1) The Minister may appoint an Administrator to administer these regulations.

(2) The Minister may appoint the Board as Administrator to administer subsections 15(2), (3) and (4) and Sections 16, 17 and 18 of these regulations.

Division I - Solid Waste Reduction

Part I - Resource Recovery

Resource Recovery Fund

4 (1) Pursuant to Section 98 of the Act, the Resource Recovery Fund is established

- (a) to develop and implement industry stewardship programs;
- (b) to fund municipal or regional diversion programs;
- (c) to develop and operate a deposit-refund system for beverage containers;
- (d) to develop education and awareness of source reduction, reuse, recycling and composting; and
- (e) to promote the development of value-added manufacturing in the Province.

- (2) The Resource Recovery Fund established pursuant to Sections 5 and 8 of Chapter 12 of the Statutes of Nova Scotia 1989, the *Recycling Act*, and the Resource Recovery Fund Regulations made pursuant to the *Recycling Act* shall form part of the Fund described in subsection (1).

Resource Recovery Fund Board

- 5 (1) The Fund shall be administered by a board to be known as the Resource Recovery Fund Board.
- (2) The Board shall
- (a) undertake measures to implement the goals and objectives of the Fund as described in Section 4;
 - (b) enter into an agreement with the Minister to administer the Fund, which agreement shall include an outline of the respective duties, powers and responsibilities of the parties and confirm that Section 143 of the Act applies to members of the Board;
 - (c) prepare, negotiate and enforce agreements with a person respecting payments into the Fund;
 - (d) administer and operate a deposit-refund system for beverage containers; and
 - (e) perform such functions and exercise such powers as may be assigned or requested by the Minister or the Governor in Council.
- (3) Unless the Minister agrees otherwise in writing, the Board shall be duly incorporated as a not for profit organization under the laws of the Province.
- (4) The Minister shall be entitled to appoint 3 persons to the Board.
- (5) The Minister shall appoint one of the persons described in subsection (4) to be the Chair of the Board and determine the term of office of the Chair.
- (6) A Regional Waste Coordinator shall be appointed by the Board and be a member of the Board.
- (7) A representative of the Union of Nova Scotia Municipalities shall be appointed by the Board, as a member of the Board, from a nomination submitted by the Union of Nova Scotia Municipalities.

Payments into Fund

- 6 (1) Pursuant to Section 98 of the Act, the Fund shall consist of
- (a) money which comes from an agreement entered into between the Board and a person;
 - (b) revenues generated from the deposit-refund system on beverage containers;
 - (c) money acquired by the Board or the Province for the purposes of the Fund by way of gift, donation or bequest or derived from the disposition of any real property or other property given, donated or bequeathed to the Board for the purposes of the Fund;

- (d) interest accruing to the Fund; and
 - (e) money paid to the Fund under the Resource Recovery Fund Regulations made pursuant to Sections 5 and 8 of Chapter 12 of the Statutes of Nova Scotia 1989, the *Recycling Act*.
- (2) Pursuant to Section 98 of the Act, the Minister, following consultation with the Board, may pay into the Fund
- (a) money which comes from an agreement entered into between the Minister and a person;
 - (b) a surcharge on a designated material pursuant to subsection 100(2) and clause 102(1)(v) of the Act; and
 - (c) money that accrues from any financing arrangement or program of the Province, including financing arrangements or programs with other governments entered into for any of the purposes for which the Fund is established.

Approved programs

- 7 (1) Programs which are approved for financial assistance under these regulations are listed in Schedule “A”.
- (2) The Board or any person may submit a proposal to the Minister to
- (a) designate a program as an approved program; or
 - (b) alter or modify an approved program.

Expenditures from the Fund

- 8 (1) Subject to the provisions of these regulations, the terms of any agreement between the Minister and the Board, and in accordance with the *Finance Act*, the Board shall provide funding for municipal solid waste diversion by

[Note: the reference to the *Provincial Finance Act* has been updated in accordance with Section 82 of the *Finance Act*, S.N.S. 2010, c. 2.]

- (a) paying a minimum of 50% of the net revenues in the Fund to provide financial support, to be divided between or among municipalities or regions based on the solid waste diverted by the municipality or region;
- (b) paying out of the Fund money to provide financial assistance and incentives under an approved program;
- (c) paying out of the Fund any costs, charges, audit and other fees and expenses involved in the administration of the Fund;
- (d) investing money in the name of the Fund in any manner in which trustees are authorized by law to invest trust funds; and

- (e) doing any other matter or thing which relates to, or is incidental to, the purposes of the Fund.
- (2) (a) Funding shall be provided by the Board pursuant to clauses 8(1)(a) and (b) on the basis of an agreement executed between the Board, and a municipality, a region or a person.

(b) Clause (a) is subject to existing agreements signed by a municipality or a region and a person before the effective date of these regulations.
- (3) Copies of any agreement executed under clause 2(a) shall be filed with the Minister within 30 days of signing.

Accounts of Fund

- 9** (1) The Board shall cause to be kept proper books of accounts respecting
- (a) all sums of money received and expended by the Fund and the matters in respect of which the receipt and expenditure of money took place; and
 - (b) the assets and liabilities of the Fund.
- (2) The accounts of the Fund shall, from time to time, and at least annually, be audited by an auditor licensed under the *Public Accountants Act* and copies of the audit report shall be filed with the Minister within 30 days of preparation.

Action plan/annual report

- 10** (1) The Board shall submit annually an action plan to the Minister.
- (2) No later than 30 days following the end of each calendar year, or such other date agreed upon in writing by the Minister, the Board shall prepare and submit an annual report to the Minister which shall include the following information:
- (a) work of the Board during the year;
 - (b) progress made towards reaching the 50% solid waste diversion goal;
 - (c) a financial statement setting forth the assets and liabilities of the Fund and the receipts and expenditures of the Fund for the year;
 - (d) the status of all applications received during the year including applications approved, applications rejected and the reasons for any outstanding or rejected applications; and
 - (e) other information requested by the Minister.

Public documents

- 11** Subject to the *Freedom of Information and Protection of Privacy Act*, all reports, agreements, action plans, annual reports and other documents filed by the Board with the Minister are public documents.

Part II - Industry Stewardship

Designated materials

11A The materials listed in Column 1 of Schedule “B” are prescribed as designated materials for Part IX of the Act.
Section 11A added: O.I.C. 2007-102, N.S. Reg. 61/2007.

Industry stewardship agreements

12 (1) (a) The Board may negotiate an agreement with manufacturers, distributors, retailers and others respecting a designated material banned from landfills and incinerators, covered in Schedule “B”, on or before the date the ban comes into effect.

Clause 12(1)(a) amended: O.I.C. 96-107, N.S. Reg. 34/96.

(b) An agreement described in clause (a) may include, but not be limited to, details respecting an industry stewardship program.

Clause 12(1)(b) amended: O.I.C. 96-107, N.S. Reg. 34/96.

(2) (a) The Minister shall provide the Board with a list of designated materials for industry stewardship programs pursuant to subsection 100(1) of the Act.

(b) For designated materials covered in clause (a), the Minister, after consultation with the Board, shall establish a date when an agreement shall be negotiated.

(c) For designated materials covered in clause (a), the Board shall negotiate an agreement with manufacturers, distributors, retailers and others respecting the designated material, on or before the date established pursuant to clause (b).

(d) An agreement described in clause (c) shall include, but not be limited to, details respecting an industry stewardship program.

Surcharges

13 Subject to the approval of the Governor in Council, the Minister may establish a surcharge applicable to a designated material.

Beverage container programs

14 (1) All beverage containers sold in the Province shall be either refillable or recyclable as determined by the Administrator.

(2) All beverage containers shall be subject to a deposit-refund system as described in these regulations.

(3) No person shall sell, manufacture, distribute, offer to sell or permit to be sold in the Province a beverage in a container that is subject to the deposit and refund system which is not clearly labelled with the words “RETURN FOR REFUND” or words to like effect.

(4) (a) No later than 3 months after the effective date of these regulations, the Board shall collect and submit to the Minister

- (i) baseline figures for 1994 respecting the proportion of refillable and non-refillable beverage containers by product type sold for consumption in the Province; and
 - (ii) current figures in 1995 to a date determined by the Board.
- (b) Unless the Minister agrees otherwise in writing, no distributor shall decrease the proportion of refillable containers of any given type for a beverage sold for consumption in the Province below the proportions established in the 1994 baseline figures.
 - (c) The Board shall report annually to the Minister respecting the proportion of refillable and non-refillable containers sold for consumption in the Province.
- (5) In Sections 14 to 18,
- (a) “distributor” means a distributor of beverage containers;
 - (b) “retailer” means a person who sells or offers for sale a beverage in a beverage container to the public
 - (i) for consumption off the premises, or
 - (ii) by a coin-operated vending machine.

Subsection 14(5) added: O.I.C. 2007-102, N.S. Reg. 61/2007.

Deposits and refunds

15 (1) The minimum cash deposit on a redeemable beverage container is

- (a) for a refillable or non-refillable beverage container other than a beverage container for liquor, an amount that, when added to any applicable federal and Provincial sales tax on that amount, equals \$0.10;
- (b) for a refillable liquor container of less than 1.0 L, an amount that, when added to any applicable federal and Provincial sales tax on that amount, equals \$0.10;
- (c) for a refillable liquor container greater than or equal to 1.0 L, an amount that, when added to any applicable federal and Provincial sales tax on that amount, equals \$0.20 cents;
- (d) for a non-refillable liquor container less than or equal to 500 ml, an amount that, when added to any applicable federal and Provincial sales tax on that amount, equals \$0.10;
- (e) for a non-refillable liquor container greater than 500 ml, an amount that, when added to any applicable federal and Provincial sales tax on that amount, equals \$0.20.

Subsection 15(1) replaced: O.I.C. 2000-287, N.S. Reg. 100/2000.

- (2) A retailer shall collect from the purchaser the cash deposit prescribed in subsection (1) for each beverage sold to the purchaser in a redeemable beverage container and shall show the amount of the ~~such~~ deposit on a cash receipt.

(3) Upon receipt of a beverage container, a depot operator shall immediately provide a minimum cash refund of,

(a) for a refillable beverage container, an amount, including the applicable federal and Provincial sales tax, that equals 100% of the full cash deposit;

(b) for a non-refillable beverage container, an amount, including federal and Provincial sales tax, that equals 50% of the full cash deposit.

Subsection 15(3) replaced: O.I.C. 2000-287, N.S. Reg. 100/2000.

(4) Where the amount of the cash deposit or cash refund is more than the minimum amount prescribed in subsection (1) or (3), the cash deposit or the cash refund shall be inclusive of any applicable federal and Provincial sales tax.

Subsection 15(4) replaced: O.I.C. 2000-287, N.S. Reg. 100/2000.

(5) Within 30 days of collection of redeemable beverage containers by the Board or its agent from a depot operator, the Board or its agent shall reimburse the depot operator the minimum cash refund prescribed in Schedule "C" plus a handling fee determined by the Board.

(6) Unless otherwise agreed to by the Board, the Minister and the Nova Scotia Liquor Commission, subsection (5) does not apply to a beverage container for liquor.

Distributor registration/operation

16 (1) A distributor of beverage containers in the Province shall register with the Board within 60 days of the effective date of these regulations.

(2) No distributor shall sell or offer for sale a beverage container in the Province unless that person is registered with the Board under subsection (1).

(3) A distributor of beverage containers shall register with the Board all beverage containers distributed and shall designate each container registered by beverage product, container size and container type.

(4) No person shall sell or offer for sale a beverage in a beverage container which is not registered with the Board under subsection (3).

(5) On or before the 20th day of each month, a distributor shall file with the Board a return, in a form approved by the Board, reporting

(a) all units sold during the immediately preceding calendar month; and

(b) the remittance due by the distributor by type and tax status of beverage container as described in subsection (5B),

and shall remit to the Board any cash deposits collected pursuant to these regulations during that immediately preceding calendar month.

Subsection 16(5) replaced: O.I.C. 2000-287, N.S. Reg. 100/2000.

(5A) Despite subsection (5), at the request of the Board, a distributor shall file with the Board a return covering such period as the Board may determine, in a form approved by the Board, reporting

(a) all units sold; and

(b) the remittance due by the distributor by type and tax status of beverage container, as described in subsection (5B),

and shall remit to the Board any cash deposits collected pursuant to these regulations during that period.

Subsection 16(5A) added: O.I.C. 2000-287, N.S. Reg. 100/2000.

(5B) Where reporting the tax status of beverage containers in a return required pursuant to subsection (5) or (5A), the distributor shall list taxable units sold and zero-rated units sold, as defined in the *Excise Tax Act* (Canada).

Subsection 16(5B) added: O.I.C. 2000-287, N.S. Reg. 100/2000.

(6) A distributor may arrange for a person outside of the Province to act as their agent to collect and submit to the Board any cash deposit required under these regulations.

(7) In the event of any default of payment by an agent under subsection (5), the distributor is responsible to pay the cash deposit money to the Board.

(8) Unless otherwise agreed to by the Board, the Minister and the Nova Scotia Liquor Commission, subsections (1) to (7) do not apply to a distributor who distributes only beverage containers for liquor.

Depot registration/operation

17 (1) Within 60 days of the effective date of these regulations, no person shall be eligible to receive payment for collection of beverage containers or other materials by the Board or its agent unless the person is registered with the Board and has supplied information as required by the Board.

(2) Subject to subsection (3), a container collection depot which, at the effective date of these regulations, is registered with the Registrar of Joint Stock Companies to operate a container collection depot shall automatically be registered as a container collection depot under these regulations if an application, together with proof of registration as a collection depot with the Registrar, is submitted to the Board within 60 days of the effective date of these regulations.

(3) The status of a container collection depot under subsection (2) shall be revoked within 1 year of the effective date of these regulations if the collection depot fails to comply with standards established by the Board.

(4) The Board shall develop and publish standards under subsection (3) on or before February 28, 1996.

(5) The Board may establish rules and standards governing the operation of a depot.

- (6) No depot operator shall fail to accept any redeemable beverage container provided the container is intact and it is in reasonably clean condition.

Notice to consumers

18 A retailer shall clearly display a notice indicating

- (a) the deposit which will be charged for each type of beverage container;
- (b) the refund available on a returned beverage container;
- (c) the location of the nearest depot where a beverage container can be redeemed for refund; and
- (d) the hours of operation of the depot,

at a retail premises where beverages are sold in redeemable beverage containers.

Used tire management program

18A (1) For the purpose of this Section,

- (a) “motor vehicle” means a motor vehicle as defined under the *Motor Vehicle Act*;
- (b) “new tire” means a tire which is provided
 - (i) with a motor vehicle, a vehicle or a trailer, or
 - (ii) separately for use on or with a motor vehicle, a vehicle or a trailer,but does not include a retreaded tire, a used tire, or a tire with a rim size greater than 622.3 mm (24.5 inches);
- (c) “retreaded tire” means a tire to which a new tread has been affixed to extend the usable life of the tire;

Clause 18A(1)(d) repealed: O.I.C. 2002-94, N.S. Reg. 24/2002.

- (e) “tire” means a tire which is air filled or designed to be air filled and is designed for use on the wheel of a motor vehicle, a vehicle or a trailer;
- (f) “tire retailer” means a person, including a vehicle dealer or vehicle lessor, who supplies new tires in the Province to an end user;
- (g) “used tire” means a tire no longer suited for its original purpose because of wear and tear or damage;
- (h) “vehicle” means every device in, upon or by which any person or property is or may be transported or drawn upon a public highway or private road, but does not include

- (i) a motorized wheelchair,
- (ii) a device moved by human power, including a bicycle,
- (iii) an off-highway vehicle as defined under the *Off-highway Vehicles Act*, or
- (iv) a farm implement or farm machinery which is exempt under clause 25(1)(d) of the *Revenue Act* and which is not used on a public highway.

Subsection 18A(2) repealed: O.I.C. 2007-102, N.S. Reg. 61/2007.

- (3) (a) A tire is considered to be a new tire from the time of its manufacture until immediately after it is first supplied by a tire retailer.
- (b) Every tire retailer who uses or consumes in Nova Scotia a new tire that the tire retailer has acquired shall be deemed to have supplied the tire to another person.
- (4) The Minister may appoint an Administrator under this Section.
- (5) No tire retailer shall supply a new tire in the Province on or after January 2, 1997, unless that tire retailer is registered with an Administrator.
- (6) (a) No tire retailer shall supply a new tire in the Province on or after January 2, 1997, unless that tire retailer has entered into an industry stewardship agreement with an Administrator.
- (b) For the purpose of clause (a), a tire retailer may designate a person, including a manufacturer or distributor of new tires who is in agreement, to act as their agent in connection with an industry stewardship agreement with an Administrator.
- (c) In the event of a breach or default by an agent under clause (b), the tire retailer is responsible to comply with an industry stewardship agreement entered into with an Administrator.
- (7) No person shall falsify, render misleading, unlawfully alter or fail to provide any report or record required by the Minister or an Administrator from a tire retailer or an agent of a tire retailer.

Section 18A added: O.I.C. 96-827, N.S. Reg. 167/96.

Consumer paint product stewardship program

18B (1) For the purpose of Sections 18B to 18I,

- (a) “Administrator” means a person designated by the Minister pursuant to Section 18C and includes an acting Administrator;
- (b) “brand owner” means
 - (i) a person who is the owner or licensee of the intellectual property rights of a consumer paint product sold, offered for sale, or otherwise distributed in the Province, or

- (ii) a manufacturer or distributor of a consumer paint product sold, offered for sale, or otherwise distributed in the Province;
- (c) “consumer paint product” means a latex, oil or solvent-based architectural coating, including stain and paint for commercial and industrial use, but does not include a specially formulated industrial, automotive or marine coating;
- (d) “consumer paint product stewardship program” means a program that
 - (i) establishes a process for the collection, handling, transportation and final treatment of a post-consumer paint product regardless of who is the original brand owner of the consumer paint product, and
 - (ii) incorporates the principles of a pollution prevention hierarchy by moving progressively from disposal to reduction, reuse and recycling and recovery of post-consumer paint products;
- (e) “industry stewardship agreement” means an agreement between the Board and a brand owner that sets out the terms of a consumer paint product stewardship program;
- (f) “post-consumer paint product” means a consumer paint product and its container that are no longer used or required by a consumer;
- (g) “retailer” means a person who sells or offers for sale or otherwise distributes a consumer paint product in the Province;
- (h) “return collection facility” means a place operated by a brand owner for the collection of a post-consumer paint product.

Subsection 18B(2) repealed: O.I.C. 2007-102, N.S. Reg. 61/2007.

Section 18B added: O.I.C. 2002-94, N.S. Reg. 24/2002.

18C The Minister may appoint an Administrator for the purposes of a consumer paint product stewardship program.

Section 18C added: O.I.C. 2002-94, N.S. Reg. 24/2002.

18D (1) On or after 90 days after the effective date of Sections 18B to 18I, no brand owner of a consumer paint product shall sell, offer for sale or otherwise distribute a consumer paint product in the Province unless

- (a) the brand owner is registered with the Board;
- (b) the brand owner either
 - (i) operates a consumer paint product stewardship program, or
 - (ii) has entered into an industry stewardship agreement with the Board for the Board to operate a consumer paint product stewardship program on the brand owner’s behalf; and

(c) the consumer paint product stewardship program referred to in clause (b) is authorized by the Minister pursuant to clause 18E(2)(a).

(2) On or after 90 days after the effective date of Sections 18B to 18I, no retailer shall sell, offer for sale or otherwise distribute a consumer paint product in the Province unless the brand owner from whom the product was acquired is registered pursuant to clause (1)(a).

Section 18D added: O.I.C. 2002-94, N.S. Reg. 24/2002.

18E (1) A brand owner shall submit a proposal for a consumer paint product stewardship program to the Minister for authorization.

(2) Upon receipt of a proposal for a consumer paint product stewardship program pursuant to subsection (1), the Minister shall

(a) authorize the program with or without terms or conditions;

(b) refuse to authorize the program and provide reasons, in writing, for the refusal; or

(c) request any additional information that the Minister considers necessary.

(3) Despite subsection (1), a brand owner may enter into an industry stewardship agreement with the Board for the Board to submit a proposal for a consumer paint product stewardship program to the Minister on the brand owner's behalf.

(4) A brand owner or the Board, as the case may be, shall operate a consumer paint product stewardship program in accordance with the terms and conditions of the authorization made pursuant to clause (2)(a).

Section 18E added: O.I.C. 2002-94, N.S. Reg. 24/2002.

18F (1) Every brand owner shall, on or before June 30 in each year or on some other date agreed upon in writing by the Administrator, provide the Administrator with an annual report on their consumer paint product stewardship program during the previous fiscal year including, but not limited to, information respecting

(a) the total amount of consumer paint products sold and post-consumer paint products collected;

(b) the total amount of post-consumer paint products processed or in storage;

(c) the percentage of post-consumer paint products that were treated or contained, reduced, reused, recycled or recovered;

(d) efforts taken through consumer paint product marketing strategies to reduce post-consumer paint products and packaging waste;

- (e) the types of processes used to reduce, reuse, recycle or recover post- consumer paint products, including but not limited to details of efforts to incorporate the priorities of a pollution prevention hierarchy by moving progressively from disposal to reduction, reuse, recycling and recovery of post-consumer paint products;
- (f) the location of return collection facilities or depots;
- (g) the location of any long-term containment or final treatment and processing facilities for post-consumer paint products;
- (h) the types of educational information and programs provided;
- (i) the process of internal accountability used to monitor environmental effectiveness; and
- (j) any other information requested by the Administrator,

and the annual report shall be accompanied by copies of the annual financial statements prepared by an independent auditor of the revenues received and the expenditures incurred.

- (2) Despite subsection (1), a brand owner may enter into an industry stewardship agreement with the Board for the Board to submit the annual report and financial statements to the Administrator on behalf of the brand owner.
- (3) On receipt of the annual report submitted pursuant to this Section, an Administrator may require the brand owner or the Board, as the case may be, to
 - (a) amend the authorized consumer paint product stewardship program; or
 - (b) submit a proposal for a new consumer paint product stewardship program to the Minister for authorization pursuant to clause 18E(2)(a).

Section 18F added: O.I.C. 2002-94, N.S. Reg. 24/2002.

18G (1) Every brand owner shall, as a component of their consumer paint product stewardship program,

- (a) either
 - (i) provide a return collection facility at the premises of each retailer of the brand owner's consumer paint products, or
 - (ii) enter into an industry stewardship agreement with the Board to operate depots to collect post-consumer paint products generated from the brand owner's consumer paint products; and
- (b) implement an education and awareness program for consumers of consumer paint products that includes information respecting
 - (i) the consumer paint product stewardship program,

- (ii) consumer access to return collection facilities, and
- (iii) the environmental and economic benefits of participating in the consumer paint product stewardship program;
- (c) confirm that the post-consumer paint products generated from the brand owner's consumer paint products are recycled or reused to the maximum extent possible; and
- (d) ensure that 70% of the reusable and recyclable portion of the post-consumer paint products collected at the return collection facility is reused or recycled.
- (2) Despite clauses (1)(b) to (d), a brand owner may enter into an industry stewardship agreement with the Board that requires the Board to implement a component of the consumer paint product stewardship program on the brand owner's behalf.
- (3) Every retailer shall provide, either at the point of display or at the point of sale, a place for the display of information supplied pursuant to clause (1)(b).

Section 18G added: O.I.C. 2002-94, N.S. Reg. 24/2002.

18H (1) The owner of a return collection facility shall accept a post-consumer paint product, regardless of the identity of the brand owner of the consumer paint product from which it was generated.

- (2) The owner of a depot shall comply with the rules and standards, including those respecting record production, set forth by the Board.
- (3) The owner of a return collection facility or a depot shall
 - (a) operate the facility or depot during regular business hours;
 - (b) accept from any person any quantity of post-consumer paint products that does not exceed the maximum allowable per person daily quantity as authorized by an Administrator; and
 - (c) not charge a fee for accepting post-consumer paint products in accordance with clause (b).

Section 18H added: O.I.C. 2002-94, N.S. Reg. 24/2002.

18I No person shall falsify, render misleading, unlawfully alter or fail to provide any information, report or record required in accordance with Sections 18B to 18H.

Section 18I added: O.I.C. 2002-94, N.S. Reg. 24/2002.

Electronic Products Stewardship Program

18J (1) In Sections 18J to 18Q,

- (a) "brand owner" means one of the following:

- (i) a person who is the owner or licensee of the intellectual property rights to an electronic product sold, offered for sale or otherwise distributed in or into the Province,
- (ii) a manufacturer or distributor of an electronic product sold, offered for sale or otherwise distributed in or into the Province;
- (b) “electronic product” means an electrical device or electronic equipment that is a designated material;
- (c) “electronic product stewardship program” means a program that
 - (i) establishes a process for the collection, transportation, reuse and recycling of electronic products and, if no further options exist, the disposal of any residual electronic product components, and
 - (ii) incorporates the principles of a pollution prevention hierarchy by replacing disposal with reuse and recycling of electronic products;
- (d) “return collection facility” means a place operated by or on behalf of a brand owner for collecting electronic products.

Section 18J added: O.I.C. 2007-102, N.S. Reg. 61/2007.

18K The Minister may appoint an administrator to administer an electronic product stewardship program.

Section 18K added: O.I.C. 2007-102, N.S. Reg. 61/2007.

18L (1) Every brand owner shall ensure that a brand name, image or logo is clearly affixed in plain view on the electronic product.

(2) After the implementation date specified in Schedule “B” for that product, a brand owner of an electronic product shall not sell, offer for sale or otherwise distribute an electronic product in or into the Province unless the brand owner operates an electronic product stewardship program that is authorized by the Minister in accordance with criteria outlined by the Minister.

(3) A brand owner may designate a third party to operate an electronic product stewardship program on its behalf.

(4) After the implementation date specified in Schedule “B” for that product, a retailer shall not sell, offer for sale or otherwise distribute an electronic product in or into the Province unless the brand owner operates an electronic product stewardship program that is authorized by the Minister.

(5) The Minister may cease the sale of any electronic products belonging to a brand owner who is not complying with the Act and these regulations.

Section 18L added: O.I.C. 2007-102, N.S. Reg. 61/2007.

18M (1) A brand owner shall submit an electronic product stewardship program to the Minister for authorization 6 months before the earliest implementation date specified in Schedule “B” for an electronic product accepted by the program.

- (2) Upon receipt of a proposal for an electronic product stewardship program, the Minister shall
- (a) authorize the program with or without terms and conditions;
 - (b) refuse to authorize the program and provide reasons, in writing, for the refusal; or
 - (c) request any additional information that the Minister considers necessary to decide whether to authorize the program.

- (3) A brand owner shall operate their electronic product stewardship program in accordance with the terms and conditions of the authorization made pursuant to clause (2)(a).

Section 18M added: O.I.C. 2007-102, N.S. Reg. 61/2007.

18N (1) An electronic product stewardship program shall include:

- (a) an agreement with the Board for managing the electronic products and receiving them at return collection facilities under contract with the Board;
- (b) an education and awareness program for consumers of electronic products that includes information about all of the following:
 - (i) the electronic product stewardship program, specifying products accepted by the program;
 - (ii) how and when consumers can access return collection facilities,
 - (iii) the environmental benefits of participating in the electronic product stewardship program;
- (c) a list of return collection facilities and their operating hours;
- (d) a description of the proposed methods to be used to reuse and recycle electronic products and their components.

- (2) A retailer shall provide all education and awareness program information required under clause 18N(1)(b) at the point of display or sale.

Section 18N added: O.I.C. 2007-102, N.S. Reg. 61/2007.

18O (1) A brand owner who operates an electronic product stewardship program shall, on or before June 30 of each year or on or before the date set by the Administrator of the electronic product stewardship program, inform the Administrator in writing of the total quantity of electronic products collected.

- (2) A brand owner who operates an electronic product stewardship program shall, upon request in writing from the Minister, provide the Minister with any information about their electronic product stewardship program, including any of the following:

- (a) the types of processes used to reuse and recycle the electronic products and their components;

- (b) the location of return collection facilities for electronic products;
- (c) the location of any long-term containment or final treatment and processing facilities for electronic products;
- (d) records showing that the program adheres to established vendor qualification standards or information demonstrating that the electronic products collected were managed in a manner that employs environmental and human health and safety standards meeting or exceeding applicable federal, Provincial, and local regulations;
- (e) efforts made to improve the environmental design of the brand owner's electronic products.

- (3) On receipt of the information submitted pursuant to subsection 18(O)(2), the Minister may require a brand owner to submit a revised proposal for an electronic product stewardship program to the Minister for authorization.

Section 18O added: O.I.C. 2007-102, N.S. Reg. 61/2007.

18P The operator of a return collection facility that collects electronic products shall not charge a fee for accepting the electronic products.

Section 18P added: O.I.C. 2007-102, N.S. Reg. 61/2007.

18Q A person shall not submit any information, report or record required by Sections 18M to 18O that is false or misleading

Section 18Q added: O.I.C. 2007-102, N.S. Reg. 61/2007.

Part III - Litter Abatement

Prohibition against littering

19 No person shall release or cause litter to be released into the environment unless

- (a) the litter is placed in a litter receptacle;
- (b) the litter is disposed of at a disposal site for municipal solid waste or an area designated by a municipality having jurisdiction for the disposal of litter; or
- (c) the litter is deposited in a location designated for that purpose by a municipality having jurisdiction during special clean-up days.

Littering from buildings/structures

20 (1) No owner, operator or person in care, management or control of a commercial outlet, service outlet, plant, building, facility or thing shall permit the release of litter from the commercial outlet, service outlet, plant, building, facility or thing into the environment.

(2) A person described in subsection (1) shall clean up any litter discharged or released into the environment.

Construction sites

21 (1) No owner, operator, contractor or person in care, management or control of the construction, repair or demolition of a plant, building, facility, or thing shall permit the release of litter from the plant, building, facility, or thing into the environment.

(2) A person described in subsection (1) shall clean up any discharged litter released into the environment.

Convenience stores, fast food and vending outlets

22 (1) An owner, operator, or person in care, management or control of a business or operation

(a) where food or beverages are sold in cartons, containers, foils or papers and

(b) where cartons, utensils, containers, foils or paper are discarded in the vicinity by the patrons of the business or operation,

shall provide receptacles for litter and receptacles for recyclable materials in appropriate and easily accessible locations, and shall service, maintain and empty the receptacles.

(2) An owner, operator, or person in care, management or control of a business or operation shall keep the property and all public or private lands, streets, lanes, passageways, beaches or docks within 15 m of any boundary of their property free of all litter unless the landowner or operator denies access to their lands for this purpose.

(3) A person described in subsections (1) and (2) shall ensure that the discarded materials are collected and disposed of as prescribed in these regulations.

Public and private events

23 (1) A person who organizes or is responsible for a public or private event shall

(a) provide an adequate number of receptacles for litter and receptacles for recyclable materials in appropriate and easily accessible locations; and

(b) service, maintain and empty the receptacles as required.

(2) Every person who organizes or is responsible for a public or private event shall ensure that the property where the event takes place and all public or private lands, streets, lanes, passageways, beaches or docks within 15 m of the boundary of the property are free from all litter within 24 hours after the conclusion of the event, unless the land owner or operator denies access to their lands for this purpose.

Flyers/advertisements

24 (1) No person, including a sponsor, organizer, or promoter of an event or thing, shall attach or cause to have attached a flyer, brochure, advertisement or other literature on a utility pole, structure, fence, or other thing,

(a) without the prior approval of the owner of the utility pole, structure, fence, or other thing; and

(b) without the prior approval of the municipality, city or town where the utility pole, structure, fence, or other thing is located.

- (2) Subject to subsection (1), no person, including a sponsor, organizer or promoter of an event or thing, who attaches or causes to be attached a flyer, brochure, advertisement or other literature on a utility pole, structure, fence, or thing shall
- (a) fail to put the posting date on the flyer, brochure, advertisement or literature;
 - (b) fail to remove the same within 30 days after the event; or
 - (c) fail to dispose of the same as prescribed in these regulations.
- (3) No person, including a sponsor, organizer or promoter of an event or thing, shall distribute or cause to have distributed a flyer, brochure, advertisement or other literature by placing the same on a parked vehicle.

Structures/vehicles on ice

25 No owner, operator or user of a structure, vehicle or thing on the ice surface of a watercourse, shall

- (a) abandon the structure, vehicle or thing unless it is made of snow or ice; or
- (b) fail to remove and properly dispose of the structure, vehicle or thing before the ice surface of the watercourse melts.

Part IV - Composting

Application

26 Part IV does not apply to

- (a) backyard composting;
- (b) generally accepted farming practices; and
- (c) the composting of leaf and yard waste where not more than 100 m³ is processed annually.

Section 26 replaced: O.I.C. 2000-201, N.S. Reg. 63/2000.

Regulated activities

27 No person shall construct, operate, expand or modify a facility which can process compost without obtaining an approval from the Minister.

Section 27 amended: O.I.C. 2000-201, N.S. Reg. 63/2000.

Approval application information

28 In addition to the information required under the Approvals Procedure Regulation*, a person who wishes to obtain an approval to construct, operate, expand or modify a facility for composting shall supply the Minister with the following information:

[*Effective January 22, 2013, the *Approvals Procedure Regulations* are replaced by the *Approval and Notification Procedures Regulations*, N.S. Reg. 17/2013 (O.I.C. 2013-18 dated January 22, 2013).]

- (a) a description of the odour control system, when necessary;
- (b) a description of the storm and runoff management system;
- (c) moisture control;
- (d) the type and source of waste received and processed;
- (e) programs to deal with unauthorized materials; and
- (f) other information requested by the Administrator.

Requirements

29 The owner, operator or person who has care, management or control of a facility for composting, shall ensure that

- (a) a facility for composting is maintained in a clean and orderly condition; and
- (b) when a facility for composting ceases operation, a person described in clause (a) shall remove all residuals, unprocessed waste, compost product and recyclable material from the property and recycle or dispose of it in accordance with the directions of the Minister.

Division II - Disposal of Municipal Solid Waste

Bans

- 30** (1) No person shall dispose of a designated material listed in Column 1 of Schedule “B” in a site for the disposal of municipal solid waste on, from and after the date prescribed in Column 2 of Schedule “B”.
- (2) No person, including a municipality, shall accept for disposal a designated material which is banned in Schedule “B”.
- (3) Each municipality shall provide a plan to the Administrator to ensure that the bans described in Schedule “B” are implemented.

Regulated activities

- 31** (1) No person shall own, construct, manage, operate, alter or modify a landfill without obtaining approval from the Minister.
- (2) (a) No person shall own, construct, manage, operate, alter or modify a disposal site for construction and demolition debris without obtaining approval from the Minister.
- (b) Clause (a) does not apply to rock (excluding rock containing a sulphide bearing material), aggregate, soil, bricks mortar, concrete, asphalt pavement, porcelain or ceramic materials, trees, brush, limbs, stumps, root balls, organic mat, and milled wood that is free of adhesives, coatings or preservatives.

- (3) No person shall own, construct, manage, operate, alter or modify an incinerator for the disposal of municipal solid waste without obtaining approval from the Minister.
- (4) No person shall own, construct, manage, operate, alter or modify the operation of an ash disposal site without obtaining approval from the Minister.

Approval application information

32 (1) In addition to the information required under the Approvals Procedure Regulations*, a person who wishes to obtain an approval to operate a landfill or incinerator for the disposal of municipal solid waste shall supply the Minister with the following information:

[*Effective January 22, 2013, the *Approvals Procedure Regulations* are replaced by the *Approval and Notification Procedures Regulations*, N.S. Reg. 17/2013 (O.I.C. 2013-18 dated January 22, 2013).]

- (a) complete construction drawings and specifications showing details including
 - (i) a site plan indicating the relation of the landfill or incinerator to any well, watercourse, road or other significant natural and man-made features within 1 km of the landfill or incinerator,
 - (ii) the entrances and exists to the landfill or incinerator, and
 - (iii) all other structures and works to be constructed, installed or used in the operation of the landfill or incinerator;
 - (b) a description of the waste material which is to be received at the landfill or incinerator;
 - (c) the life expectancy of the landfill or incinerator;
 - (d) monitoring programs, including groundwater and surface water monitoring studies, to be established at the landfill or incinerator;
 - (e) a detailed operation manual outlining how the applicant intends to operate the landfill or incinerator; and
 - (f) other information requested by the Administrator.
- (2) An approval may contain requirements for the implementation and operation of a waste reduction, reuse, recycling and composting program.

Additional information - landfill

33 In addition to the information required under Section 32, a person who wishes to obtain an approval to operate a landfill for municipal solid waste shall supply the Minister with the following information:

- (a) a description of liner and subdrainage systems;
- (b) a description of leachate collection and treatment systems;

- (c) a description of gas collection and treatment systems; and
- (d) other information requested by the Administrator.

Additional information - incinerator

34 In addition to the information required under Section 32, a person who wishes to obtain an approval to operate an incinerator for municipal solid waste shall supply the Minister with the following information:

- (a) a description of all liquid, solid, and gaseous emissions discharged from the incinerator;
- (b) a description of all solid and liquid wastes requiring disposal and the methods proposed to dispose of these wastes;
- (c) a description of the air pollution control system to be used;
- (d) a description of the ambient air monitoring program including monitoring protocols;
- (e) a description how the incinerator will generate energy;
- (f) an assessment of how the incinerator will not reduce or take away opportunities for recycling, composting or other reprocessing of waste-resource materials; and
- (g) other information requested by the Administrator.

Records and reports

- 35** (1) An owner, operator or manager of a landfill or incinerator shall keep books, records and accounts of the operations including, but not limited to, daily quantities of all waste received, disposed, stored and diverted, daily tipping fees, and other data as may be required.
- (2) An owner, operator or manager of a landfill or incinerator shall submit to the Administrator on a bi-annual basis, or more often if required by the Administrator, data pertaining to the quantities and types of materials received at the landfill or incinerator, material recovery facilities, and material storage and transfer facilities.

Open burning ban

36 On, from and after April 1, 1996, no person shall permit, carry out or be responsible for open burning of municipal solid waste which shall include open burning in an uncontrolled teepee, pit and silo burner.

Incineration

- 37** Subject to Section 38, no person shall own, operate or manage the operation of an incinerator for municipal solid waste which does not adhere to
- (a) national standards described in a publication prepared by the Canadian Council of Ministers of the Environment entitled "Operating and Emission Guidelines for Municipal Solid Waste Incinerators", Report CCME-TS-WM-TRE003, June 1989; or

- (b) standards prescribed by the Minister.

Minimum standards for stack emissions

- 38** (1) No person shall own, operate, or manage the operation of an incinerator for municipal solid waste that releases a contaminant listed in Column I of Schedule “D” in excess of the amounts prescribed in Column II of Schedule “D”.
- (2) Test methods shall be as prescribed in Column III of Schedule “D” or as agreed to in writing by the Administrator.

Division III - Regional Solid Waste-Resource Management Plans Regional Requirements

Establishment of regions

- 39** (1) For the purposes of Part IX of the Act and these regulations and to encourage regional cooperation, there are hereby established 7 administrative regions in the Province, hereafter referred to as a “region” or “regions”, identified as follows:
- (a) Region 1 to be known as the Cape Breton Region, comprised of the counties of Cape Breton, Inverness, Victoria and Richmond;
 - (b) Region 2, to be known as the Eastern Region, comprised of the counties of Antigonish, Pictou and Guysborough;
 - (c) Region 3, to be known as the Northern Region, comprised of the counties of Colchester and Cumberland and the District of East Hants;
 - (d) Region 4, to be known as the Halifax Region, comprised of the County of Halifax;
 - (e) Region 5, to be known as the Valley Region, to be comprised of the counties of Annapolis and Kings;
 - (f) Region 6, to be known as the South Shore Region, to be comprised of the counties of Lunenburg and Queens and the District of West Hants; and
 - (g) Region 7, to be known as the Western Region, to be comprised of the counties of Digby, Shelburne and Yarmouth.
- (2) The municipalities may agree to make variations in the composition of the regions described in subsection (1), where the Administrator is of the opinion that the proposed variation will not affect the viability of the region.
- (3) Each region described in subsection (1), or as varied pursuant to subsection (2), shall include all municipalities within the boundaries of the region.

- (4) Pursuant to Section 93 of the Act, each region described in subsection (1), or as varied pursuant to subsection (2), shall achieve a minimum of 50% solid-waste diversion by the year 2000.
- (5) All diversion activities, whether or not conducted by the municipal unit or region shall be used to determine whether the goal described in subsection (4) is achieved.

Role of the regions

40 (1) The municipalities in each region shall

- (a) prepare and submit to the Administrator a regional solid waste-resource management plan on or before March 1, 1997, unless the Minister agrees in writing to an extension of time;
 - (b) implement the regional solid waste-resource management plan within the time frames approved by the Administrator in the plan; and
 - (c) prepare and submit to the Administrator reports about the progress achieved towards 50% solid waste diversion, including providing information about how much solid waste is being disposed and diverted from disposal.
- (2) The Administrator shall review and, if deemed acceptable, approve the regional solid waste-resource management plans submitted.

Contents of plan

41 A regional solid waste-resource management plan shall include, but is not limited to, the following information:

- (a) a description of the roles and responsibilities of each municipality;
- (b) a public awareness program;
- (c) a program to increase the diversion of household waste dangerous goods;
- (d) source reduction, reuse, recycling and composting programs;
- (e) a proposal for identifying markets for diverted materials;
- (f) a schedule and estimate of costs to implement each component of the plan;
- (g) a method for monitoring the progress towards implementation of the plan;
- (h) administrative agreements and a description of fair and equitable cost sharing arrangements made between the municipalities; and
- (i) other information requested by the Administrator.

Division IV - Financial Assistance

Plans, studies and audits that qualify for assistance

42 A plan, study or audit which may qualify for financial assistance under these regulations includes:

- (a) a regional solid waste-resource management plan;
- (b) an audit or closure study of an existing solid waste-resource management facility;
- (c) a waste diversion study, including a recycling study, a composting study or a waste reduction study;
- (d) a waste disposal study; or
- (e) any combination or part of the foregoing.

Proposals

43 A proposal for a plan, study or audit described in Section 42 shall contain a detailed description of

- (a) the methodology, including a schedule of the plan, study or audit;
- (b) the relevance and compatibility of the plan, study or audit with the applicable regional solid waste-resource management plan;
- (c) the costs of the plan, study or audit; and
- (d) other information requested by the Administrator.

Review of application

44 After reviewing an application for financial assistance, the Administrator may

- (a) approve the application in whole or part;
- (b) reject the application; or
- (c) request more information.

Technical steering committee

45 (1) Where the Administrator considers it appropriate, a technical steering committee shall be established to guide the plan, study or audit described in Section 42 and to provide recommendations to the applicant on parts of the plan, study or audit that require direction.

(2) Where the Administrator considers it appropriate, the technical steering committee may include technical representation from a municipality, the Department, and other regulatory or funding agencies.

Payment of assistance

- 46** (1) Where the Minister has approved an application for financial assistance respecting a study or audit, the Administrator may, prior to the completion of the project, advance progress payments to the applicant in amounts which shall not exceed 50% of the approved financial assistance.
- (2) Any request for a progress payment under subsection (1) shall be accompanied by appropriate invoices to justify the expenditures claimed.
- (3) Upon completion of the project, the Administrator shall pay the remainder of the approved financial assistance to the applicant provided
- (a) the applicant has completed the plan, study or audit to the satisfaction of the Administrator; and
- (b) appropriate invoices have been submitted to the Administrator to justify the expenditures claimed.

Effective date

- 47** These regulations shall come into force on, from and after February 6, 1996.

Schedule “A” - Approved Programs

1. Municipal waste diversion programs, including source reduction, reuse, recycling and composting programs.
2. Municipal household hazardous waste programs.
3. Municipal waste management education programs.
4. Market development, manufacturing and processing of recycled materials.

Schedule “B” - Materials Banned from Landfills and Incinerators

Column 1: Designated Material	Column 2: Implementation Date
Beverage containers	April 1, 1996
Corrugated cardboard	April 1, 1996
Newsprint	April 1, 1996
Used tires	April 1, 1996
Lead-acid (automotive) batteries	April 1, 1996
Leaf and yard waste	June 1, 1996
Post-consumer paint products, formerly known as waste paint	April 1, 1997
Ethylene glycol (automotive antifreeze)	April 1, 1997

Compostable organic material	June 1, 1997
Steel/tin food containers	April 1, 1998
Glass food containers	April 1, 1998
Low-density polyethylene bags and packaging	April 1, 1998
High-density polyethylene bags and packaging	April 1, 1998
Televisions	February 1, 2008
Desktop, laptop and notebook computers, including CPU's, keyboards, mice, cables and other components in the computer	February 1, 2008
Computer monitors	February 1, 2008
Computer printers, including printers that have scanning or fax capabilities or both	February 1, 2008
Computer scanners	February 1, 2009
Audio and video playback and recording systems	February 1, 2009
Telephones and fax machines	February 1, 2009
Cell phones and other wireless devices	February 1, 2009

Schedule "B" amended: O.I.C. 2002-94, N.S. Reg. 24/2002; O.I.C. 2007-102, N.S. Reg. 61/2007.

Schedule "C" repealed: O.I.C. 2000-287, N.S. Reg. 100/2000.

Schedule "D" - Stack Discharge Limits (at 11% oxygen)

Contaminant	Limit	Test Method
Particulate matter	20 mg/Rm ³	Environment Canada's EPS 1/RM/8 (December 1993 or as amended and adopted)
Hydrogen chloride	75 mg/Rm ³ (50 ppm _{dv}) or 90% removal	Environment Canada's EPS 1/RM/1 (June 1989 or as amended and adopted)
Carbon monoxide	57mg/Rm ³ (50 ppm _{dv})	Environment Canada's EPS 1/RM/4 (July 1990 or as amended and adopted)
Total polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans	0.5 ng/Rm ³ (toxic equivalency factor, new international method)	Environment Canada's EPS 1/RM/2 (June 1989 or as amended and adopted)
Rm ³ :Reference cubic meter (i.e. the volume of gas at 25°C and 101.3 kPa) ppm _{dv} :parts per million dry volume		

Schedule "D" replaced: O.I.C. 96-827, N.S. Reg. 167/96.

Environmental Guideline for the Burning and Incineration of Solid Waste



Department of Environment
Government of Nunavut

GUIDELINE: BURNING AND INCINERATION OF SOLID WASTE

Original: October 2010

Revised: January 2012

This Guideline has been prepared by the Department of Environment's Environmental Protection Division and approved by the Minister of Environment under the authority of Section 2.2 of the *Environmental Protection Act*.

This Guideline is not an official statement of the law and is provided for guidance only. Its intent is to increase the awareness and understanding of the risks, hazards and best management practices associated with the burning and incineration of solid waste. This Guideline does not replace the need for the owner or person in charge, management or control of a solid waste to comply with all applicable legislation and to consult with Nunavut's Department of Environment, other regulatory authorities and qualified persons with expertise in the management of solid waste.

Copies of this Guideline are available upon request from:

Department of Environment

Government of Nunavut

P.O. Box 1000, Station 1360, Iqaluit, NU, X0A 0H0

Electronic version of the Guideline is available at <http://env.gov.nu.ca/programareas/environmentprotection>

Cover Photos: Nunavut Department of Environment (left and bottom right), Aboriginal Affairs and Northern Development Canada (top right)

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Introduction

People living and working in Nunavut often have limited options available for cost effective and environmentally sound management of household and other solid waste. The widespread presence of permafrost, lack of adequate cover material and remote locations make open burning and incineration a common and widespread practice to reduce the volume of solid waste and make it less of an attractant to wildlife. A wide variety of combustion methods are used ranging from open burning on the ground to high temperature dual-chamber commercial incinerators. Generally, high temperature incinerators are more expensive to purchase and operate and cause less pollution than do the less expensive and lower temperature methods. However, high temperature incinerators can safely dispose of a wider variety of waste than can the lower temperature open burning methods.

The Guideline for the Burning and Incineration of Solid Waste (the Guideline) is not intended to promote or endorse the burning and incineration of solid waste. It is intended to be a resource for traditional, field and commercial camp operators, communities and others considering burning and incineration as an element of their solid waste management program. It examines waste burning and incineration methods that are used in Nunavut, their hazards and risks and outlines best management practices that can reduce impacts on the environment, reduce human-wildlife interactions and ensure worker and public health and safety. This Guideline does not address incineration of biomedical waste, hazardous waste and sewage sludge. The management of these wastes requires specific equipment, operational controls and training that are beyond the scope of the current document.

The *Environmental Protection Act* enables the Government of Nunavut to implement measures to preserve, protect and enhance the quality of the environment. Section 2.2 of the *Act* provides the Minister with authority to develop, coordinate, and administer the Guideline.

The Guideline is not an official statement of the law. For further information and guidance, the owner or person in charge, management or control of a solid waste is encouraged to review all applicable legislation and consult the Department of Environment, other regulatory agencies or qualified persons with expertise in the management of solid waste.

1.1 Definitions

<i>Biomedical Waste</i>	Any solid or liquid waste which may present a threat of infection to humans including non-liquid tissue, body parts, blood or blood products and body fluids, laboratory and veterinary waste which contains human disease-causing agents, and discarded sharps (i.e. syringes, needles, scalpel blades).
<i>Bottom Ash</i>	The coarse non-combustible and unburned material which remains at the burn site after burning is complete. This includes materials remaining in the burn chamber, exhaust piping and pollution control devices where such devices are used.
<i>Burn Box</i>	A large metal box used to burn solid waste. Combustion air is usually supplied passively through vents or holes cut above the bottom of the box. An exhaust pipe or stack may or may not be attached.

<i>Commercial Camp</i>	A temporary, seasonal or multi-year facility with a capacity greater than 15 people and which has been established for research, commercial or industrial purposes. A commercial camp does not include a traditional camp or field camp.
<i>Commissioner's Land</i>	Lands that have been transferred by Order-in-Council to the Government of Nunavut. This includes roadways and land subject to block land transfers. Most Commissioner's Land is located within municipalities.
<i>Contaminant</i>	Any noise, heat, vibration or substance and includes such other substance as the Minister may prescribe that, where discharged into the environment, (a) endangers the health, safety or welfare of persons, (b) interferes or is likely to interfere with the normal enjoyment of life or property, (c) endangers the health of animal life, or (d) causes or is likely to cause damage to plant life or to property.
<i>Determined Effort</i>	The ongoing review of opportunities for reductions and the implementation of changes or emission control upgrades that are technically and economically feasible and which result in on-going reductions in emissions. Determined efforts include the development and implementation of waste management planning which is focussed on pollution prevention.
<i>De Novo Synthesis</i>	The creation of complex molecules from simple molecules.
<i>Environment</i>	The components of the Earth and includes (a) air, land and water, (b) all layers of the atmosphere, (c) all organic and inorganic matter and living organisms, and (d) the interacting natural systems that include components referred to in paragraphs (a) to (c) above.
<i>Field Camp</i>	A temporary, seasonal or multi-year facility consisting of tents or other similar temporary structures with a capacity of 15 people or less and which has been established for research, commercial or industrial purposes. A field camp does not include a traditional camp or commercial camp.
<i>Fly Ash</i>	Unburned material that is emitted into the air in the form of smoke or fine particulate matter during the burning process.
<i>Hazardous Waste</i>	A contaminant that is a dangerous good and is no longer wanted or is unusable for its original intended purpose and is intended for storage, recycling, treatment or disposal.
<i>Incineration</i>	A treatment technology involving the destruction of waste by controlled burning at high temperatures.

<i>Incinerator</i>	A device or structure intended primarily to incinerate waste for the purpose of reducing its volume, destroying a hazardous substance in the waste or destroying an infectious substance in the waste. An incinerator has means to control the burning and ventilation processes.
<i>Inspector</i>	A person appointed under subsection 3(2) of the <i>Environmental Protection Act</i> and includes the Chief Environmental Protection Officer.
<i>Modified Burn Barrel</i>	A metal drum used to burn waste that has been affixed with devices or features which provide limited increased heat generation, heat retention and holding time.
<i>Open Burning</i>	Burning of waste with limited or no control of the burn process. For clarity, open burning includes burning on the open ground or using a burn box or unmodified or modified burn barrel.
<i>Qualified Person</i>	A person who has an appropriate level of knowledge and experience in all relevant aspects of waste management.
<i>Responsible Party</i>	The owner or person in charge, management or control of the waste.
<i>Smoke</i>	The gases, particulate matter and all other products of combustion emitted into the atmosphere when a substance or material is burned including dust, sparks, ash, soot, cinders and fumes.
<i>Solid Waste</i>	Unwanted solid materials discarded from a household (i.e. single or multiple residential dwellings, other similar permanent or temporary dwellings), institutional (i.e. schools, government facilities, hospitals and health centres), commercial (i.e. stores, restaurants) or industrial (i.e. mineral, oil and gas exploration and development) facility. For clarity, solid waste does not include biomedical waste, hazardous waste or sewage sludge.
<i>Traditional Camp</i>	A temporary or seasonal camp used primarily for camping, hunting, fishing or other traditional or cultural activities. A traditional camp does not include a field camp or commercial camp.
<i>Unmodified Burn Barrel</i>	A metal drum used to burn waste that has not been affixed with devices or features which provide for enhanced heat generation, heat retention and holding time.
<i>Untreated Wood</i>	Wood that has not been chemically impregnated, painted or similarly modified to improve resistance to insects or weathering.
<i>Waste Audit</i>	An inventory or study of the amount and type of waste that is produced at a location.

1.2 Roles and Responsibilities

1.2.1 Department of Environment

The Environmental Protection Division is the key environmental agency responsible for ensuring the proper management and disposal of solid waste and other contaminants on Commissioner's Land. Authority is derived from the *Environmental Protection Act*, which prohibits the discharge of contaminants to the environment and enables the Minister to undertake actions to ensure appropriate management measures are in place. Although programs and services are applied primarily to activities taking place on Commissioner's and municipal lands and to Government of Nunavut undertakings, the *Environmental Protection Act* may be applied to the whole of the territory where other controlling legislation, standards and guidelines do not exist. A complete listing of relevant legislation and guidelines can be obtained by contacting the Department of Environment or by visiting the web site at:

<http://env.gov.nu.ca/programareas/environmentprotection>.

The Wildlife Management Division is responsible for managing wildlife in Nunavut. Section 90 of the *Wildlife Act* prohibits the intentional feeding of wildlife and the placement of any food or garbage where there is a reasonable likelihood that it would attract wildlife. Once wildlife has been 'conditioned' to obtaining food associated with human activities, it can become dangerous and often will have to be destroyed. Further information on ways to reduce contact between wildlife and humans can be obtained by contacting the local Conservation Officer or by visiting the web site at:

<http://env.gov.nu.ca/programareas/wildlife>.

The Department of Environment will provide advice and guidance on the burning and incineration of solid waste. However, it remains the responsibility of the owner or person in charge, management or control of the solid waste to ensure continued compliance with all applicable statutes, regulations, standards, guidelines and local by-laws.

1.2.2 Generators of Solid Waste

The generator, or responsible party, is the owner or person in charge, management or control of the solid waste at the time it is produced or of the facility that produces the waste. The responsible party must ensure the waste is properly and safely managed from the time it is generated to its final disposal. This is referred to as managing the waste from cradle-to-grave.

Contractors may manage solid waste on behalf of the responsible party. However, the responsible party remains liable for ensuring the method of management complies with all applicable statutes, regulations, standards, guidelines and local by-laws. If the contractor does not comply with the requirements of the *Environmental Protection Act* or *Wildlife Act* and is charged with a violation while managing the waste, the responsible party may also be charged.

1.2.3 Other Regulatory Agencies

Other regulatory agencies may have to be consulted regarding the burning and incineration of solid waste as there may be other environmental or public and worker health and safety issues to consider.

Workers' Safety and Compensation Commission

The Workers' Safety and Compensation Commission is responsible for promoting and regulating worker and workplace health and safety in Nunavut. The Commission derives its authority from the *Workers' Compensation Act* and *Safety Act* which require an employer to maintain a safe workplace and ensure the safety and well being of workers.

Department of Community and Government Services

The Department of Community and Government Services is responsible under the *Commissioners' Lands Act* for the issuance of land leases, reserves, licenses and permits on Commissioner's Lands. The Department, in cooperation with communities, is also responsible for the planning and funding of municipal solid waste and sewage disposal facilities in most Nunavut communities.

The Office of the Fire Marshal is responsible for delivering fire and life safety programs including reviewing plans to ensure incinerators and other heating devices comply with all legislation, codes and standards. The Office of the Fire Marshal derives its authority from the *Fire Prevention Act*, *National Fire Code* and *National Building Code*.

Department of Health and Social Services

Activities related to the burning and incineration of solid waste may have an impact on public health. The Office of the Chief Medical Officer of Health and Regional Environmental Health Officers should be consulted regarding legislated requirements under the *Public Health Act*.

Environment Canada

Environment Canada is responsible for administering the *Canadian Environmental Protection Act* (CEPA) and Canada's Toxic Substances Management Policy. Many pollutants that are released into the atmosphere from the incomplete combustion of unsegregated, or mixed, solid waste are listed as Toxic Substances in Schedule I of CEPA, or are targeted for phase-out through the Toxic Substances Management Policy. Environment Canada is also responsible for administering the pollution prevention provisions of the federal *Fisheries Act* and for regulating the international and interprovincial movement of solid and liquid hazardous waste under the *Interprovincial Movement of Hazardous Waste Regulations* and *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*.

The Air Quality Research Division of Environment Canada is responsible for conducting research into atmospheric releases of chemicals in commercial use in Canada, measuring exhaust emissions from stationary and mobile sources and undertaking ambient air quality monitoring in partnership with provinces and territories.

Aboriginal Affairs and Northern Development Canada

Aboriginal Affairs and Northern Development Canada is responsible under the *Territorial Lands Act* and *Nunavut Waters and Nunavut Surface Rights Tribunal Act* for the management of federal lands and waters, including the impact solid waste may have on the quality of these lands and waters.

Local Municipal Governments

The role of municipal governments is important in the proper local management of solid waste. Under the Nunavut Land Claims Agreement, municipalities are entitled to control their own municipal disposal sites. Local environmental and safety standards are determined, in part, by how the land is designated under municipal government development plans (i.e. land use zoning). Solid waste may be deposited into municipal landfill sites only with the consent of the local government. The local fire department may also be called upon if a fire or other public safety issue is identified.

Co-management Boards and Agencies

Co-management boards and agencies established under the Nunavut Land Claims Agreement have broad authority for land use planning, environmental impact assessment and the administration of land and water. Activities involving the burning and incineration of solid waste may be controlled through the setting of terms and conditions in plans, permits and licenses issued by the Nunavut Water Board and other co-management boards and agencies.

Waste Burning and Incineration

2.1 The Combustion Process

The combustion, or burning, of solid waste proceeds through a series of stages. Water is first driven from the unburned waste by heat produced from material burning nearby or from an auxiliary burner. As the waste heats up, carbon and other substances are released and converted into burnable gases. This is referred to as gasification. These gases are then able to mix with oxygen. If the temperature inside the burn chamber is high enough and maintained for a long enough period of time, the hot gases are completely converted into water vapour and carbon dioxide, which is then released into the air. If the temperature inside the burn chamber is not high enough and the burn time is too short, complete conversion of the burnable gases does not occur and visible smoke is released into the air. Another result of burning at low temperatures is the creation of pollutants that were not originally present in the waste. This process is known as *de novo* synthesis. Dioxins, furans and other complex chemical pollutants can be formed through this process.

Ash produced from combustion takes the form of either fly ash or bottom ash. Fly ash is the fine particles carried away in the form of smoke while bottom ash is the coarse non-combustible and unburned material that remains after the burn is complete. The type and amount of pollutants in the fly and bottom ash depend upon what waste is burned and completeness of the combustion process.

The completeness of combustion is determined by all of the following factors:

Temperature

The temperature generated is a function of the heating value of the waste and auxiliary fuel, incinerator or burn unit design, air supply and combustion control. Complete combustion requires high temperatures. Generally, temperatures that exceed 650°C with a holding time of 1-2 seconds will cause complete combustion of most food and other common household waste. Segregation of waste is required when using methods that don't routinely achieve these temperatures. Dual chamber incinerators, which are designed to burn complex mixtures of waste, hazardous waste and biomedical waste, must provide a temperature higher than 1000°C and a holding time of at least one second to ensure complete combustion and minimize dioxin and furan emissions. When these high temperatures and holding times are achieved, waste will be completely burned and ash, smoke and pollutant concentrations will be minimized.

Because exhaust gas temperatures vary from ambient to greater than 1000°C each time a batch waste incinerator is used, optional air pollution control systems with evaporative cooling towers and scrubbers are seldom recommended. However, it may be necessary to employ these systems with large continuous feed incinerators if additional cleaning of exhaust gas is required by regulatory authorities.

Holding Time

Complete combustion takes time. Holding time, otherwise known as retention or residence time, is the length of time available to ensure the complete mixing of air and fuel, and thus the complete burning of waste. Low temperatures, low heating values of the waste and reduced turbulence require that the holding time be increased to complete the combustion process.

Turbulence

The turbulent mixing of burnable gases with sufficient oxygen is needed to promote good contact between the burning waste and incoming air. This will help in achieving the high temperatures at which waste can be completely burned. The amount of mixing is influenced by the shape and size of the burn chamber and how the air is injected. Passive under-fire ventilation achieved during open burning does not result in sufficient turbulence for the burning of a wide variety of waste. Also, it is important not to overfill the burn chamber as airflow may be blocked and the amount of turbulence further reduced. The more advanced incineration designs provide effective turbulence through the forced introduction of air directly into hot zones.

Composition of the Waste

The heating value, wetness and chemical properties of the waste affect the combustion process and the pollutants that are contained in the resulting smoke and ash. The higher the burn temperature, holding time and turbulence that are achieved, the less effect the composition of the waste has on completeness of the burn.

2.2 Pollutants of Concern

Extreme care must be exercised when burning or incinerating solid waste. Open burning and the improper incineration of solid waste can result in environmental, health and safety hazards from the pollutants found in smoke and exhaust gases and in the bottom ash. These pollutants may either be found in the original waste itself, or may be created through *de novo* synthesis if sufficient temperature, holding time and turbulence is not achieved in the burn chamber.

Many different types of pollutants can be released during burning and incineration. A few of these pollutants include acid gases, trace metals, fine particulates, volatile organic compounds and semi-volatile organic compounds. Acid gases such as hydrogen chloride and sulphur oxides result from burning waste that has high levels of chlorine and sulphur (i.e. plastics). Mercury, lead and cadmium are examples of trace metals found in both fly and bottom ash when batteries, used lubricating oil and other metal-containing wastes are burned. Fine particulates are the very small particles found in smoke created by incomplete combustion and can cause respiratory irritation in humans and wildlife.

Dioxins and furans are pollutants that have drawn much attention in recent years because they have been linked to certain types of cancers, liver problems, impairment of the immune, endocrine and reproductive systems and effects on the fetal nervous system. These pollutants persist in the environment for long periods of time, bioaccumulate in plants and animals, result predominantly from human activity and have been identified for 'virtual elimination' in Canada under the federal Toxic Substances Management Policy. The incineration of solid waste accounts for almost 25% of the dioxin and furan emissions in Canada each year. They are formed in trace amounts by *de novo* synthesis during the low temperature burning of waste containing organic compounds and chlorine (i.e. chlorinated plastic, PVC pipe, marine driftwood).

The most effective way to reduce or minimize the release of pollutants is to segregate the waste before burning and achieve sufficiently high temperature, holding time and turbulence in the burn chamber. Open burning produces more smoke and pollutants, including dioxins and furans, than does an incinerator capable of achieving complete combustion.

2.3 Burning and Incineration Methods

The burning and incineration method used is a major factor in determining what type of waste can be safely and effectively disposed of. The methods commonly used in Nunavut include open burning on the ground, unmodified burn barrels and various mechanical incineration systems. Other useful methods include the use of burn boxes and modified burn barrels. Each method is discussed separately in the following sections.

2.3.1 Open Burning

Open burning means the burning of waste where limited or no control of the combustion process can be exercised by the operator. This method includes burning solid waste directly on the open ground or in burn boxes or burn barrels and often does not achieve the temperatures or holding time needed for complete combustion of the waste to occur. This results in the formation of potentially hazardous pollutants and ash, which are likely to impact nearby land and water. Food waste that is not completely burned through open burning can also be a powerful attractant for animals.

The various open burning methods can also present a risk of uncontrolled vegetation and tundra fires through the release of hot sparks or embers. The level of fire risk depends upon the type of open burning used, its location, the skill of the operator and the environmental conditions that exist at the time (i.e. dryness of the surrounding vegetation, wind).

The open burning of solid waste remains a common practice in Nunavut. It is the policy of the Department of Environment to eliminate or minimize open burning of mixed solid waste to the extent practicable and to encourage more acceptable methods of disposal and incineration.

Open Burning on the Ground

Open burning on the ground involves burning solid waste that has been piled directly on the surface of the ground or placed in a small open pit. Many large and small communities and camp operators in Nunavut continue to practice open burning on the ground as a means of reducing the volume of solid waste that must ultimately be disposed of. In general, open burning on the ground results in the incomplete combustion of waste and the release of various harmful pollutants to the air, can cause vegetation or tundra fires through the uncontrolled release of hot sparks and embers, and is actively discouraged by the Nunavut Department of Environment as a method for disposing of unsegregated or mixed solid waste.



Figure 1 – Open Burning on the Ground
Photo courtesy of Aboriginal Affairs and Northern Development Canada

Burn Boxes

There are two basic types of burn boxes. The *enclosed burn box* is constructed using heavy sheets of steel or other metal while the *open burn box* is constructed using expanded metal grating. The latter type is commonly referred to as a *burn cage*. These devices are not commercially-available in Nunavut, but can be constructed using locally available materials. For example, the enclosed metal burn box shown in Figure 2 is made from a dump truck bed and steel plating.



Figure 2 – Enclosed Metal Burn Box
Photo courtesy of Alaska Department of Environmental Conservation

Burn boxes are considered a modification of open burning. Combustion air is provided passively using a natural draft making electricity unnecessary. Burn boxes are single chambered units. Waste is raised off the bottom of the box by placing it on grates inside the unit. Unburned bottom ash falls through the grate during burning making removal easier once a sufficient amount has accumulated. Combustion air in enclosed burn boxes is typically provided by cutting holes near the bottom of the box allowing for better mixing with the burning waste.

Open burn boxes, or burn cages, are an improvement over enclosed burn boxes as the waste is exposed to natural drafts through the metal grating on all surfaces including the bottom. This enables air to better mix with burning waste and promotes more efficient combustion throughout the burning period. Both types of burn boxes are constructed with hinged tops to enable easier loading and cleaning.

Unlike open burning on the ground, burn boxes help to contain the burning waste within a specific location reducing the risk of fire spreading to other disposal areas or surrounding tundra, while still enabling moderate amounts of solid waste to be burned.

Burn Barrels

There are two basic types of burn barrels – the unmodified burn barrel and modified burn barrel.



Figure 3 – Open Metal Burn Box
Photo courtesy of Alaska Department of Environmental Conservation

The *unmodified burn barrel* is normally a 45 gallon, or 205 litre, metal fuel or oil drum with the top removed. These devices typically operate at a low temperature resulting in incomplete combustion of the waste and production of large volumes of smoke and fly ash.

A *modified burn barrel* is a 45 gallon metal fuel or oil drum that has been affixed with devices or features which result in higher burn temperatures, better mixing of the air and a longer holding time. These modifications include a 'metal mesh basket' insert or grate designed to suspend the burning waste. Evenly spaced vents or holes cut above the bottom of the barrel supply combustion air. These features provide for enhanced passive under-fire ventilation and promote better contact between the waste being burned and incoming air. The basket insert is topped with a hinged lid and a chimney port for attachment of an exhaust pipe or stack. The lid helps to increase heat retention and holding time inside the barrel while also allowing for easier loading and mixing of the waste. The removable mesh basket enables access to the unburned bottom ash.

Modified burn barrels can be built using commonly available materials. They can either be pre-built locally or transported to the site for assembly. Detailed construction plans are provided in Appendix 2.

Although modified burn barrels are designed to create an advantage over open burning on the ground, burn boxes and unmodified burn barrels through achieving higher burn temperatures and increased turbulence and holding time, incomplete combustion of waste and the release of pollutants to the atmosphere are still likely. In fact, emissions testing by Environment Canada on a modified burn barrel in April 2011 suggest that these devices do not provide any improvement over open burning on the ground in terms of emissions quality, particularly if wet food waste is added to the waste mixture. Other common problems include easily overfilling the unit and loading waste that should not be burned (refer to section 3.2). Wet or frozen masses of waste are particularly difficult to burn and the resulting partly burned food waste may still attract animals. The proper operation of modified burn barrels is critical to achieving the most efficient burn possible. Basic operating instructions are provided in section 4.1.



Figure 4 – Modified Burn Barrel

Burn barrels are capable of burning only small volumes of solid waste. Like burn boxes, they reduce the risk of fire spreading to vegetation and tundra by containing the burning waste to a specific location.

2.3.2 Incineration

Solid waste incinerators are engineered systems that are capable of routinely achieving burn temperatures in excess of 1000°C and a holding time of at least one second. Properly designed and operated incinerators are able to effectively and safely destroy a wide range of waste. Only incinerators designed for burning mixed municipal solid waste are discussed in the guideline. The incineration of

hazardous and biomedical waste and sewage sludge requires specific equipment, operational controls and training that are beyond the scope of the current document.

There are four basic types of incinerators. They vary based upon the number of burn chambers they have, the amount of air provided to each chamber and how waste is fed into the primary burn chamber.

<i>Dual-Chamber Starved Air System</i>	The primary burn chamber receives less air than is needed to achieve full combustion. Gases from this incomplete combustion then pass into a second burn chamber where sufficient air is injected and complete combustion is achieved.
<i>Single Chamber Excess Air System</i>	More than a sufficient amount of air (as much as 50% more than the amount of air needed) is injected into the single burn chamber to achieve complete combustion of the waste.
<i>Continuous Feed Incinerator</i>	An incineration process that is in a continuous burn cycle. A continuous feed incinerator operates without interruption throughout the operating hours of the facility by having waste continually added to the primary burn chamber.
<i>Batch Feed Incinerator</i>	An incineration process that is not in a continuous or mass burning cycle. A batch feed incinerator is charged with a discrete quantity or single load of waste at the beginning of the burn cycle.

Batch feed dual-chamber controlled air incinerators currently operate at several remote industrial locations in northern Canada and Alaska. Although they are generally considered to have the highest qualities of all the incinerators and open burning methods mentioned, they must be designed for the type and quantity of waste to be burned. Too little heat and holding time will not allow waste to burn properly; too much heat will damage the incinerator.

Figure 5 illustrates the design of a typical batch feed dual-chamber controlled air incinerator. The main features of this type of incinerator are:

- Batch operation allows greater control of temperature and air throughout the burn process.
- Air turbulence can be reduced in the primary chamber so fewer particulates are released into the air from the stack.
- Although a wide range of wastes can be destroyed, waste may have to be segregated and remixed in order to achieve a uniform heating value close to the design point of the incinerator.
- Externally supplied fuel and electricity are needed for the burners and forced air ventilation.
- A properly operating dual-chamber controlled air system will reduce problems with animal attraction as the production of bottom and fly ash and smoke is minimized.

Section 2.3.2 is intended to provide the reader with a brief introduction to incinerators. It is not intended to provide information suitable for the design, selection or operation of an incineration system. Any person considering the purchase of an incineration system should first consult the system's manufacturer or other qualified persons with expertise in the incineration of solid waste.

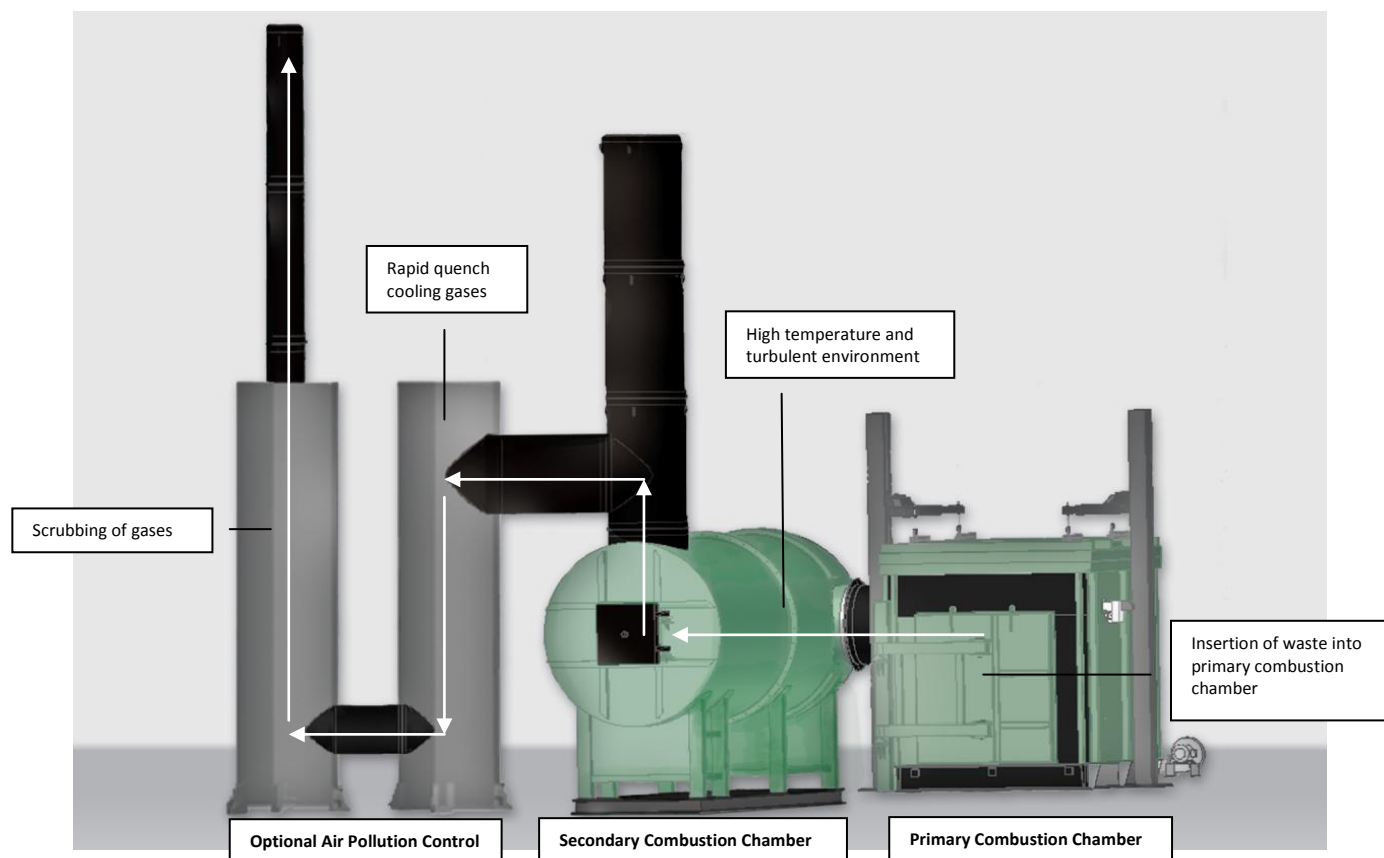


Figure 5 – Typical Batch Feed Dual-Chamber Controlled Air Incinerator with Optional Air Pollution Controls
 Illustration courtesy of Eco Waste Solutions

2.4 Environmental Standards

2.4.1 Air Emissions

Air emission standards establish limits on the amount of contaminants that can be released into the atmosphere. These standards are expressed as a concentration in the exhaust gases leaving the stack and are capable of being achieved using generally available incineration technology and waste diversion practices. The following emission standards¹ apply to existing, new or expanding solid waste incinerators operating in Nunavut and have been adopted from the Canadian Council of Ministers of the Environment (CCME) Canada-Wide Standards for Dioxins and Furans and Mercury Emissions, respectively. Similar standards for the open burning of solid waste have not been established.

¹ Stack concentrations are always corrected to 11% oxygen content for reporting purposes.

Table 1. Air Emission Standards for Solid Waste Incinerators

Parameter	Numeric Standard	Explanation
Dioxins and Furans	80 pg I-TEQ/cubic metre	Unit of measure is picograms of International Toxicity Equivalents per cubic metre of air
Mercury	20 µg/Rcubic metre	Unit of measure is micrograms per Reference cubic metre (the volume of gas adjusted to 25°C and 101.3 kilopascals)

Opacity is the degree to which the exhaust gases reduce the transmission of light and obscure the view of any object in the background. It is expressed as a percentage representing the extent to which an object viewed through the gases is obscured. Although not an emission standard, opacity provides an indication of the general performance of the incinerator during normal operation². Opacity in the incinerator stack should not exceed 5%. While it is not anticipated that opacity levels would exceed 1% to 2% under normal operation, values greater than 5% indicate the incinerator is not performing properly and additional performance evaluation and adjustment is required.

**Figure 6 - Examples of Smoke Opacity Ratings**

The opacity ratings are estimates and are provided for illustrative purposes only

Centre and right photos courtesy of GNWT Department of Environment and Natural Resources

2.4.2 Bottom Ash

The *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* establishes criteria for determining whether process residuals³ are suitable for disposal in landfill sites in Nunavut. For the purpose of this Guideline, process residuals include bottom ash from industrial and commercial incinerators. The Toxicity Characteristic Leaching Procedure Test method 1311 (US EPA) is the preferred method to analyze the residuals as this test is designed to simulate the processes a material would be subjected to if placed in a landfill.

Refer to the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* for additional information on the management of process residuals.

² The time during which optimum designed temperature is maintained in the burn chamber, and excludes 'startup' and 'cool down' operations.

³ Process residuals are the solid, semi-solid or sludge waste resulting from industrial operations.

Best Management Practices

Best management practices are methods and techniques that have been shown to be effective in preventing or reducing pollution. They include policies, prohibitions of practices, maintenance and monitoring procedures and other practices adopted by the responsible party. Implementing best management practices together with using best available technology is an effective means of reducing costs, reducing pollution and reducing a parties' legal liabilities.

3.1 Waste Management Planning

The generator of a waste is responsible for its safe management from cradle-to-grave. Using raw materials efficiently and reducing the amount of waste generated is the most important step in waste management planning. For example, through improved waste management planning, it may be possible to reduce or eliminate the need to burn or incinerate waste altogether. Undertaking a waste audit will help to identify the type and amount of waste being generated, the costs of current management options and examine opportunities for better managing the waste. This information will also enable the generator to implement a waste management regime that is tailored to its own unique needs, location and circumstances.

Even with improved waste reduction measures in place there will be waste generated. Waste by its nature is usually a mixture of different unwanted materials. The segregation and diversion of different types of waste is an effective way to reduce the amount of waste requiring costly handling, storage, treatment and disposal. Segregation also enables the reuse of certain types of waste for a different purpose. Reuse activities may be undertaken either on-site or off-site.

Treatment and disposal is the last step in effective waste management and should be undertaken only after all other practical reduction and reuse options have been examined. A wide variety of treatment and disposal options exist and each must be examined before deciding on a final method, regardless of whether waste is to be treated and disposed of on-site or off-site. If burning and incineration is the method of choice, equipment must be designed and sized accordingly to accommodate the type and quantity of waste being produced. As described in the following section, open burning is capable of safely destroying a limited number of types of waste. While incinerators are capable of safely destroying a wider range of waste, many types of waste must still be diverted. Because of this, on-site segregation remains a critical component of any waste management plan.

Overall, the following principles should be used to guide responsible solid waste management planning:

- Know your waste by conducting a waste audit.
- Reduce the amount of solid waste produced by implementing strategic purchasing policies that focus on the substitution or reduction of purchased products as well as product design, composition and durability.
- Reuse waste where different purposes can be identified.
- Segregate and divert mixed waste streams enabling waste to be reused or recycled, thereby reducing the amount of waste to be disposed of.
- All practical disposal methods should be examined. Burning and incineration of waste should be considered only where other practical methods do not exist.

- If burning and incineration is used, the equipment chosen should be designed and sized to accommodate the waste produced, minimize fire hazard and result in the complete combustion of the waste.

3.2 Wastes That Can be Burned or Incinerated

Complete combustion converts waste into inert bottom ash with minimal creation of smoke, fly ash and hazardous gases. Several factors influence this process including the heating value, wetness and chemical composition of the waste itself, operating conditions in the burn chamber (i.e. temperature, holding time and turbulence) and operator skill.

The method used is important in determining what can safely be burned. Certain wastes can only be incinerated using equipment that has been specifically designed and equipped with sufficient air pollution controls and that achieve specific air emission standards. For example, waste containing chlorinated compounds (i.e. chlorinated solvents and plastics, PVC piping, wood treated with pentachlorophenol or PCB-amended paint, marine driftwood) must be separated from other waste as their burning will result in the *de novo* creation and emission of various dioxin and furan compounds. Waste containing mercury (i.e. batteries, thermostats and fluorescent light bulbs) and other heavy metals (i.e. lead acid batteries, wood treated with lead paint) should not be burned as the mercury and heavy metals will not be destroyed. Other waste that should not be burned unless using specially designed incinerators include used lubricating oil, hydrocarbon contaminated soil, biomedical waste, sewage sludge or any other waste specifically prohibited by the Department of Environment.

Table 2 provides a listing of common wastes that can be burned and those that require special consideration and treatment. Note that open burning and incineration are identified as separate columns in the table and that different restrictions apply depending upon which method is used. In general, more restrictions apply to the various methods of open burning because of the incomplete combustion achieved. Fewer restrictions apply to incineration because of the operator's ability to control the combustion process.

Non-combustible materials such as metal and glass do not burn and will rob heat away from waste that can be destroyed by burning. Combustible waste should always be separated from non-combustible waste before being loaded into the burn chamber.

3.3 Keeping Waste Dry

Typical mixed garbage has a moisture content of less than 20% while the moisture content of food wastes can range up to 80%. Anything that can be done to reduce the moisture of waste burned will decrease the amount of smoke produced and increase the completeness of combustion. Waste should be covered or stored inside sheds or other secure buildings to keep rain and snow out of the waste. This will also lessen the opportunity for wildlife to access the waste. If wet waste must be burned, the wet waste should be mixed or layered with dry waste to reduce the overall moisture content of the waste burned. Mixing or layering waste in this manner is particularly important when loading wet solid waste into a burn box or modified burn barrel.

Table 2. Waste That Can be Burned or Incinerated

Waste Type	Method	
	Open Burning ⁴	Dual-Chamber Incinerator
Paper products	✓	✓
Paperboard packing including boxboard and cardboard	✓	✓
Untreated wood including lumber and plywood	✓	✓
Food waste		✓
Food packaging		✓
Natural fiber textiles	✓	✓
Plastic and Styrofoam except plastic containing chlorine ⁵		✓
Painted wood except wood painted with lead or PCB-amended paint		✓
Wood treated with creosote or tar oil		✓
Hydrocarbon spill absorbents		✓
Animal carcasses except those affected by disease-causing agents		✓

The following waste requires special consideration. It is not to be burned or incinerated unless the equipment used has sufficient air pollution controls, meets specific air emission standards and has been specifically designed to safely incinerate the waste product.

Hydrocarbon contaminated soil
 Radioactive waste including smoke detectors
 Organic compounds containing chlorine including plastics, solvents, PVC piping and marine driftwood
 Pesticides
 Items containing mercury, lead or other heavy metals including paint, computer equipment and fluorescent bulbs
 Batteries
 Explosives
 Pressurized cans, cylinders or other containers that may explode when heated
 Synthetic fiber textiles
 Biomedical waste and animal carcasses affected by disease-causing agents
 Wood treated with pentachlorophenol, inorganic preservatives, lead paint or PCB-amended paint
 Sewage sludge
 Rubber tires
 Used lubricating oil
 Waste fuel except limited quantities used solely as a starting fuel
 Construction and demolition waste including roofing materials, electrical wire and insulation

3.4 Locating the Facility

Distance from sensitive areas (i.e. camp, work site, drinking water supply) and prevailing wind direction are important factors to consider when locating any facility that burns waste. The facility should be kept

⁴ Includes open burning on the ground and the use of burn boxes, unmodified burn barrels and modified burn barrels.

⁵ Chlorinated plastic materials are identified by the number "3" associated with the mobius loop symbol.



at least 100 metres from any surface water body. Although the objective is to minimize pollutants being released to the air, the site should be selected so that any resulting emissions are adequately dispersed. This includes locating the structure or facility away from areas or features that may trap smoke close to the ground (i.e. located in a valley). Avoid burning waste if people will be living or working within the plume of smoke. The facility should be located on stable and level ground. A gravel, rocky outcrop or other area free of combustible materials and vegetation should be chosen to avoid accidentally starting a vegetation or tundra fire.

3.5 Maximizing Combustion Efficiency

More smoke and other pollutants are released into the air during the 'start-up' and 'cool down' phases of the burn cycle than during the 'full burn phase' when high temperatures are maintained. Low temperature smoldering fires should be avoided. Burn only dry feedstock and periodically add additional waste to the fire in order to maintain high burn temperatures until all waste has been destroyed. If waste is to be open burned on the ground, the use of deep or steep-walled 'pits' should be avoided as this will prevent the necessary turbulent mixing of oxygen with the burnable gases.

Desired operating temperature should be achieved as quickly as possible when operating any burning or incineration device. A rapid 'start-up' can be achieved by first loosely loading dry paper, paperboard packing and untreated wood into the bottom of the device. Dry, loosely loaded material will ignite more quickly and burn more evenly than a wet, tightly packed load. Wet waste should only be added after the fire is actively burning. Overfilling the burn chamber will prevent the turbulent mixing of burnable gases and oxygen, and should be avoided.

Modern batch feed incinerators are designed with primary and auxiliary burners to achieve and maintain the necessary high burn temperatures. Additional waste should only be added to these incinerators once the 'cool down' phase has been completed and it is safe to do so.

3.6 Ash Management

The management of bottom ash and other unburned residue is an integral part of sound waste management and the ash will need to be disposed of. Extreme care must be exercised when handling ash because of its physical (i.e. glass, nails) and chemical hazards. Use closed or covered containers when moving or transporting bottom ash from the burning device or incinerator to the approved disposal site. This will minimize physical contact with the ash and the release of fine ash particles to the environment.

Avoid handling bottom ash until it is completely cool. Hot ash and embers can cause painful skin burns and should never be buried or landfilled as they could cause unburned waste in the disposal area to catch fire.

Bottom ash from the open burning of paper, paperboard packing, untreated wood waste and natural fiber textiles is suitable for burial in a designated pit or municipal landfill. Because incinerators can be used to destroy a wide variety of waste and the subsequent ash may contain a wide variety of toxic residues, bottom ash from an incinerator is suitable for burial only where it meets the criteria set out in Table 1 of the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities*. Waste originating from outside a municipality and meeting the criteria may be deposited in municipal landfills only with the consent of the local government. Any bottom ash

not meeting the criteria set out in the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* is considered to be a hazardous waste. This ash is not suitable for landfilling and its management must comply with the *Environmental Guideline for the General Management of Hazardous Waste*.

3.7 Monitoring and Record Keeping

Burn boxes, burn barrels and incinerators should be inspected for signs of damage, corrosion or other physical defects before each burn cycle. Repairs must be completed before the equipment is used again to ensure the health and safety of the operator, nearby people and the environment.

The various open burning methods tend to produce large quantities of smoke. Burning dry waste, high burn temperatures and sufficient air mixing with the burnable gases will reduce, but not eliminate, the amount of smoke and other pollutants that are generated. Large quantities of dark smoke indicate problems and inefficiencies with the combustion process and the generation of pollutants. Keep records of when, how much and what waste was burned, how the waste was loaded into the burning device or incinerator, the amount of smoke and bottom ash generated, how the fire was started and any other information that would help remind the operator of what worked well, and what didn't. These records would also assist the operator, Department of Environment and other regulatory agencies if complaints of nuisance smoke were to be received.

The operation of incinerators should be monitored using on-line instruments capable of continuously measuring the combustion process and stack emissions. The most basic measurement associated with the combustion process is temperature in both the primary and secondary burn chambers. Temperature readings outside of the normal range can warn the operator that the system is not working properly. In-stack monitoring provides the operator with additional information on the combustion process and on pollutants that may be released to the environment. A continuous opacity or particulate monitor should be installed in the incinerator stack to monitor emissions quantity. Additional combustion chamber and in-stack sampling and monitoring may be required depending upon the type and quantity of waste being incinerated. Each process and in-stack monitor should be equipped with visible and audible alarms to warn operators of poor incinerator operation. Refer to section 4.2 for additional information on incinerator monitoring requirements.

Written records should be kept by incinerator operators of what waste is burned, when and how much. Other record keeping requirements for incinerators may include:

- Operating data including readings from the process and emissions monitoring instruments.
- Weather conditions (i.e. air temperature and wind speed) at the time the incinerator is being operated.
- Repairs and maintenance performed on the incinerator and monitoring instruments.
- Major changes in operation.
- Quantity, condition and disposal location of the collected bottom ash.
- Operator training.

Records should be maintained on-site throughout the operational life of the facility and be made available to Inspectors and other regulatory officials upon request.

3.8 Operator Training

The cornerstone of ensuring proper and safe operation of any equipment is adequate operator training. Facility owners must ensure qualified operators are available and have been properly trained to operate the equipment under both normal and emergency conditions. This will help to ensure the continued operation and maintenance of the equipment and facility, protection of the environment and the continued health and safety of the operator and nearby people. In particular, operators of incinerators should be trained in the following areas:

- Physical and mechanical features of the equipment and facility.
- Operation and trouble-shooting procedures.
- Environmental and safety concerns related to operation of the facility.
- Spill and fire emergency response procedures.
- Emergency and accident reporting procedures including use of the NWT/Nunavut 24-Hour Spill Report Line at (867) 920-8130.

Every incinerator manufacturer has its own approach to designing and building incinerators. Operators should be qualified and trained to safely operate the specific make and model of incinerator they are expected to operate.

The Application of Open Burning and Incineration

The Department of Environment does not promote or endorse the burning and incineration of solid waste. This method of waste management should be implemented only after the owner or operator has made all reasonable and determined efforts to implement sound waste management planning and practices. Opportunities to reduce or eliminate the need for burning and incineration through changes in purchasing practices, reuse, recycling, segregation and diversion, and other changes or emission control upgrades that would result in emission reductions, must be reviewed periodically and implemented where practical. Refer to section 3 for additional information on best management practices.

This section provides guidance on the application of open burning and incineration of solid waste. In addition to the guidance and direction provided through the Guideline, the burning and incineration of solid waste may also be controlled through permits and licenses issued by Nunavut's co-management boards, Aboriginal Affairs and Northern Development Canada and other regulatory agencies. These permits and licenses must be complied with at all times.

4.1 Open Burning

Open burning is the burning of solid waste where limited or no control over the combustion process can be exercised by the operator. For the purposes of the Guideline, open burning includes burning waste that has been piled on the surface of the ground or placed in small open pits, or the use of a burn box, unmodified burn barrel or modified burn barrel. Open burning does not include the destruction of waste using a commercial or manufactured incinerator.

The open burning of unsegregated, or mixed, solid waste must not occur under any circumstances. Today's household, institutional, commercial and industrial garbage contains many materials which, when burned at low temperature, can result in the release of high levels of particulates, acid gases, heavy metals, carbon monoxide, dioxins, furans and other chemicals, some of which may cause cancer. The only solid wastes that may be disposed of through open burning are paper products, paperboard packing, untreated wood waste and natural fiber textiles (i.e. cotton, wool). Refer to section 3.2 for further information on what waste can and cannot be burned.

The open burning of solid waste remains a hazardous practice from a fire prevention and environmental management perspective. **Open burning on the ground** should not take place within a municipality without first obtaining authority to do so from the local community government. It should never occur at a municipal or industrial landfill because of the proximity of other combustible wastes within the working landfill. Where permission has been obtained and paper, paperboard packing, untreated wood waste and natural fiber textiles are open burned on the ground or in a small open pit, the activity must be attended and carefully monitored by a responsible adult at all times.

The preferred alternative to open burning on the ground is the use of an **enclosed burn box or burn cage**. These devices should be used when burning a moderate to large quantity of paper, paperboard packing, untreated wood waste and natural fiber textiles. They are designed to contain the waste while it is burning and reduce the likelihood of sparks or burning embers igniting adjacent vegetation and other combustible materials. When using a burn box or cage at a municipal or industrial landfill, extreme caution must be taken to ensure other areas of the working landfill are not ignited. Their

proper operation includes loading the device with dry waste to about half its capacity before igniting the fire. Additional or wet waste can be added in small batches so as not to dampen the fire once the fire has developed into a good flame and it is safe to do so.

The following general conditions should be met whenever open burning on the ground or burning using an enclosed burn box or burn cage takes place:

- Only paper, paperboard packing, untreated wood waste and natural fiber textiles are burned.
- The waste is burned in a controlled manner and at a site which is separate from combustible vegetation and other materials.
- Burning takes place only on days when winds are light and blowing away from people.
- Waste is burned in manageable volumes so the fire does not get out of control.
- The fire is started, attended and monitored at all times by authorized and qualified personnel.
- The waste is kept dry or covered to the extent practicable prior to burning.
- Where applicable, authority is first obtained from the municipality or other regulatory agencies.

Modified or unmodified burn barrels should only be used to burn small quantities of paper, paperboard packing, untreated wood waste and natural fiber textiles at remote locations such as traditional camps and field camps. Food and food packaging waste, which make up a significant portion of kitchen garbage produced at these camps, should not be burned. These wastes should be segregated daily and stored in wildlife-proof containers for frequent removal to an approved disposal site.

It is important that burn barrels are properly constructed and operated to ensure safety of the operator and the environment. Appendix 2 provides detailed construction drawings for a modified burn barrel. The Department of Environment will consider other designs if they provide an equivalent level of environmental protection.

Below are some easy-to-do actions to ensure unmodified and modified burn barrels are operated safely and waste is burned to the greatest extent possible⁶.

When locating and constructing a burn barrel:

- Locate the burn barrel in a place predominantly downwind of the camp site or burn only on days when the wind is light and blowing away from the camp.
- Ensure the burn barrel is located on gravel, rocky outcrop or other area free of combustible materials and vegetation to avoid accidentally starting a tundra fire.
- Ensure the detailed plans provided in Appendix 2 are carefully followed when constructing a modified burn barrel. The 'exhaust gas to combustion air' ratio is particularly important to achieving the maximum burn rate. A 2:1 ratio of exhaust stack to air intake area consisting of a 6-inch exhaust port and three 2-inch air intake holes positioned equidistantly around the bottom of the barrel a few inches up from the base is preferred.

⁶ Testing of a modified burn barrel was performed by Environment Canada's Air Quality Research Division in April 2011 at the request of Nunavut's Department of Environment. Ten trial burns were completed prior to emissions testing in order to optimize and standardize barrel design and operational procedures. Following the trial burns, four test runs were performed and air emission samples collected for analysis. Results of the emission testing program will be available from Nunavut's Department of Environment. This list of recommended practices reflects the operational observations and measurements made during the testing program.

When operating a burn barrel:

- Inspect the barrel for any signs of leakage, corrosion or other physical defects before each burn cycle. Any necessary repairs must be completed before the equipment is used.
- Burn only dry waste. If wet waste must be burned, mix or batch the waste with other waste that has a low moisture content and high heating value (i.e. dry wood). This will help ensure the slow-burning wet waste is completely burned.
- Burn only paper, paperboard packing, untreated wood waste and natural fiber textiles. Food and food packaging waste should not be burned. Burning non-combustible waste (i.e. metal and glass) will rob the fire of valuable heat and should also be avoided. Food and food packaging, non-combustible and other waste that cannot be burned should be segregated and removed from the site for disposal on a regular basis.
- Do not overfill or densely pack waste into the burn barrel as air will be prevented from properly mixing with the waste. This will result in a smouldering, low temperature burn and smoke.
- Layering wet or slow burning waste with dry fast burning waste will help ensure more complete combustion of all waste.
- The burn barrel should not be used unless a responsible adult is available to monitor and watch over it until the fire has completely cooled.
- When using a modified burn barrel, the exhaust port on the 'metal basket insert' should be aligned between two of the 2-inch air intake holes in order to avoid short-circuiting of the combustion air directly through to the stack. Also, the spark arrest screen should be cleaned following each burn to ensure the stack does not become blocked with soot and other debris. If the barrel lid begins to 'puff' during a burn, inspect the screen to ensure it is not obstructing the flow of exhaust gases.

Care must be taken by the operator at all times to avoid skin contact with hot surfaces and avoid breathing smoke and other exhaust gases.

Written records of open burning should be kept by the operator. These record what was burned, when and how much, how waste was loaded into the device, how the fire was started, its location, weather conditions at the time and any other information that may help remind the operator of what worked well, and what didn't. These records are to be made available for review upon request by an Inspector.

Bottom ash from the open burning of paper, paperboard packing, untreated wood waste and natural fiber textiles is suitable for burial in a designated pit or municipal landfill site. Consent to use a municipal landfill should first be obtained from the local government. Bottom ash must be completely cooled before it can be safely handled and disposed of. Refer to section 3.6 for further information.

4.2 Incineration

Incinerators differ from the simpler methods of open burning as the operator has a higher degree of control over the burning process. The resulting higher temperatures, longer holding times and greater turbulence lead to more complete combustion of the waste. Although a wider range of wastes can be destroyed using high temperature single or dual-chambered incinerators, determined efforts should still be taken to reduce the quantity and type of waste generated and to implement other changes which would result in reductions in air emissions. Refer to section 3 for further information proper waste management practices and a listing of what waste can and cannot be incinerated.

The incinerator manufacturer's operating instructions must be followed at all times to ensure designed temperature, holding time and turbulence conditions are achieved and to avoid damage to the facility. When operating during winter months, additional care must be taken because cold air introduced into the primary and secondary chambers may make it difficult for normal operating temperatures to be achieved. Operators must be properly trained and qualified to operate the equipment under both normal and emergency conditions. Owners are strongly encouraged to consult system manufacturers or other qualified persons with expertise before purchasing an incinerator. Additional guidance on the selection of incinerator technologies and their operational requirements can be obtained by referring to Environment Canada's *Technical Document for Batch Waste Incineration*.

The installation and operation of monitoring and control systems is critical for the proper and safe operation of any incinerator. The design, installation, certification and operation of continuous emissions monitoring systems (CEMS) should comply with the principles described in Environment Canada's *Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation*. While the document is written for power generation facilities, the principles apply equally well to other types of facilities and continuous emissions monitoring systems. For incinerators operating in Nunavut, key operational parameters must be monitored at all times using on-line instruments capable of continuously measuring the combustion process and stack emissions quality. These instruments should be equipped with visible and audible alarms and be on-line whenever the incinerator is in operation, including 'start-up' and 'cool down' phases. Table 3 lists the monitoring and control system requirements.

Table 3. Incinerator Monitoring and Control System Requirements

System Description	Quantity of Waste to be Burned ⁷	
	Less than 26 Tonnes per Year	Greater than 26 Tonnes per Year
Weight and composition of feedstock waste on a batch basis	✓	✓
Temperature in the primary and secondary combustion chambers	✓	✓
Opacity in the stack ⁸	✓	✓
Initial Certificate of Operation ⁹		✓

While not a specific requirement of the Guideline, additional one-time or continuous emissions monitoring may be required depending upon the type and quantity of waste to be incinerated. Examples include monitoring oxygen and carbon monoxide in the undiluted gases exiting the combustion chamber, such as a secondary chamber of a conventional dual-stage incinerator. Annual or periodic stack sampling for hydrogen chloride, dioxins and furans may also be required where the feedstock includes a significant quantity of organic materials that contain chlorine (i.e. chlorinated solvents and plastics, PVC piping, marine driftwood). The reader is encouraged to contact Nunavut's Department of Environment for guidance on additional emissions monitoring requirements.

⁷ The CCME Canada-Wide Standard for Dioxins and Furans Emissions from Waste Incinerators and Coastal Pulp and Paper Boilers (2001) established a criterion of 26 tonnes per year to distinguish between a 'small facility' and 'large facility' incinerator.

⁸ An acceptable alternative to monitoring opacity is to continuously monitor particulate matter in the stack.

⁹ An initial Certificate of Operation includes satisfactory confirmation based on manufacturers' or third-party testing and certification that the unit is capable of complying with the requirements contained in the Guideline when operated in accordance with the manufacturer's recommendations and with minimal requirement for operator attention. The Certificate is to be provided to the Nunavut Department of Environment before the incinerator is placed into routine operational service.

Monitoring and control data should be recorded each time a burn cycle is completed. Records are to be maintained for the operational life of the incinerator and made available for review upon request by an Inspector. Refer to section 3.7 for additional information on monitoring and record keeping.

Bottom ash and other solid residue collected from the incinerator is suitable for burial where it meets the criteria set out in Table 1 of the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* or in accordance with land use permits and water licenses issued by Nunavut's co-management boards and Aboriginal Affairs and Northern Development Canada. Where bottom ash meets the criteria and is to be disposed of into a municipal landfill, the quantity transported off-site must be recorded and the consent of the local municipal government first be obtained. Bottom ash not meeting the criteria set out in the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* is considered to be a hazardous waste and must be managed in accordance with the *Environmental Guideline for the General Management of Hazardous Waste*.

Conclusion

This is a general introduction to the practice of burning and incinerating solid waste. It is not intended to promote or endorse the practice but to provide the reader with information on the risks, hazards and best management practices associated with this activity. It also provides specific guidance on the application of burning and incinerating solid waste should this practice be undertaken by municipalities and operators of traditional, field and commercial camps.

Familiarity with the Guideline does not replace the need for the owner or person in charge, management or control of the solid waste to comply with all applicable federal and territorial legislation and municipal by-laws. The burning and incineration of solid waste may be controlled through permits and licenses issued by Nunavut's co-management boards, Aboriginal Affairs and Northern Development Canada and other regulatory agencies. These permits and licenses must be complied with at all times.

For additional information on the management of solid waste, or to obtain a complete listing of available guidelines, contact the Department of Environment at:

Environmental Protection Division
Department of Environment
Government of Nunavut
Inuksugait Plaza, Box 1000, Station 1360
Iqaluit, Nunavut, X0A 0H0

Phone: (867) 975-7729

Fax: (867) 975-7739

Email: EnvironmentalProtection@gov.nu.ca

Website: <http://env.gov.nu.ca/programareas/environmentprotection>

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<http://env.gov.nu.ca/node/82#Guideline Documents>

APPENDICES

APPENDIX 1 - ENVIRONMENTAL PROTECTION ACT

The following are excerpts from the *Environmental Protection Act*

1. "Contaminant" means any noise, heat, vibration or substance and includes such other substance as the Minister may prescribe that, where discharged into the environment,
 - (a) endangers the health, safety or welfare of persons,
 - (b) interferes or is likely to interfere with normal enjoyment of life or property,
 - (c) endangers the health of animal life, or
 - (d) causes or is likely to cause damage to plant life or to property;

"Discharge" includes, but not so as to limit the meaning, any pumping, pouring, throwing, dumping, emitting, burning, spraying, spreading, leaking, spilling, or escaping;

"Environment" means the components of the Earth and includes

- (a) air, land and water,
- (b) all layers of the atmosphere,
- (c) all organic and inorganic matter and living organisms, and
- (d) the interacting natural systems that include components referred to in paragraphs (a) to (c).

"Inspector" means a person appointed under subsection 3(2) and includes the Chief Environmental Protection Officer.

- 2.2 The Minister may
 - (a) establish, operate and maintain stations to monitor the quality of the environment in the Territories;
 - (b) conduct research studies, conferences and training programs relating to contaminants and to the preservation, protection or enhancement of the environment;
 - (c) develop, co-ordinate and administer policies, standards, guidelines and codes of practice relating to the preservation, protection or enhancement of the environment;
 - (d) collect, publish and distribute information relating to contaminants and to the preservation, protection or enhancement of the environment:
3.
 - (1) The Minister shall appoint a Chief Environmental Protection Officer who shall administer and enforce this Act and the regulations.
 - (2) The Chief Environmental Protection Officer may appoint inspectors and shall specify in the appointment the powers that may be exercised and the duties that may be performed by the inspector under this Act and regulations.
5.
 - (1) Subject to subsection (3), no person shall discharge or permit the discharge of a contaminant into the environment.
 - (3) Subsection (1) does not apply where the person who discharged the contaminant or permitted the discharge of the contaminant establishes that
 - (a) the discharge is authorized by this Act or the regulations or by an order issued under this Act or the regulations;
 - (b) the contaminant has been used solely for domestic purposes and was discharged from within a dwelling house;
 - (c) the contaminant was discharged from the exhaust system of a vehicle;

- (d) the discharge of the contaminant resulted from the burning of leaves, foliage, wood, crops or stubble for domestic or agricultural purposes;
- (e) the discharge of the contaminant resulted from burning for land clearing or land grading;
- (f) the discharge of the contaminant resulted from a fire set by a public official for habitat management of silviculture purposes;
- (g) the contaminant was discharged for the purposes of combating a forest fire;
- (h) the contaminant is a soil particle or grit discharged in the course of agriculture or horticulture; or
- (i) the contaminant is a pesticide classified and labelled as "domestic" under the *Pest Control Products Regulations* (Canada).

(4) The exceptions set out in subsection (3) do not apply where a person discharges a contaminant that the inspector has reasonable grounds to believe is not usually associated with a discharge from the excepted activity.

- 5.1. Where a discharge of a contaminant into the environment in contravention of this Act or the regulations or the provisions of a permit or license issued under this Act or the regulations occurs or a reasonable likelihood of such a discharge exists, every person causing or contributing to the discharge or increasing the likelihood of such a discharge, and the owner or the person in charge, management or control of the contaminant before its discharge or likely discharge, shall immediately:
- (a) subject to any regulations, report the discharge or likely discharge to the person or office designated by the regulations;
 - (b) take all reasonable measures consistent with public safety to stop the discharge, repair any damage caused by the discharge and prevent or eliminate any danger to life, health, property or the environment that results or may be reasonably expected to result from the discharge or likely discharge; and
 - (c) make a reasonable effort to notify every member of the public who may be adversely affected by the discharge or likely discharge.
6. (1) Where an inspector believes on reasonable grounds that a discharge of a contaminant in contravention of this Act or the regulations or a provision of a permit or license issued under this Act or the regulations has occurred or is occurring, the inspector may issue an order requiring any person causing or contributing to the discharge or the owner or the person in charge, management or control of the contaminant to stop the discharge by the date named in the order.
7. (1) Notwithstanding section 6, where a person discharges or permits the discharge of a contaminant into the environment, an inspector may order that person to repair or remedy any injury or damage to the environment that results from the discharge.
- (2) Where a person fails or neglects to repair or remedy any injury or damage to the environment in accordance with an order made under subsection (1) or where immediate remedial measures are required to protect the environment, the Chief Environmental Protection Officer may cause to be carried out the measures that he or she considers necessary to repair or remedy an injury or damage to the environment that results from any discharge.

APPENDIX 2 – MODIFIED BURN BARREL DESIGN AND SPECIFICATIONS

A modified burn barrel is typically constructed from a 45 gallon metal fuel or oil drum. The modifications result in greater heat generation and retention, better mixing of the waste with incoming air and longer holding time inside the barrel. Together, these modifications result in more complete combustion of the solid waste than does open burning on the ground or in a pit.

Placing a metal screen over the top of the exhaust pipe may be required to prevent sparks and hot ash from escaping. Care should be taken to ensure the screen does not become blocked with soot.



A stove pipe attached to the top of the barrel allows smoke to escape and creates an effective draft.

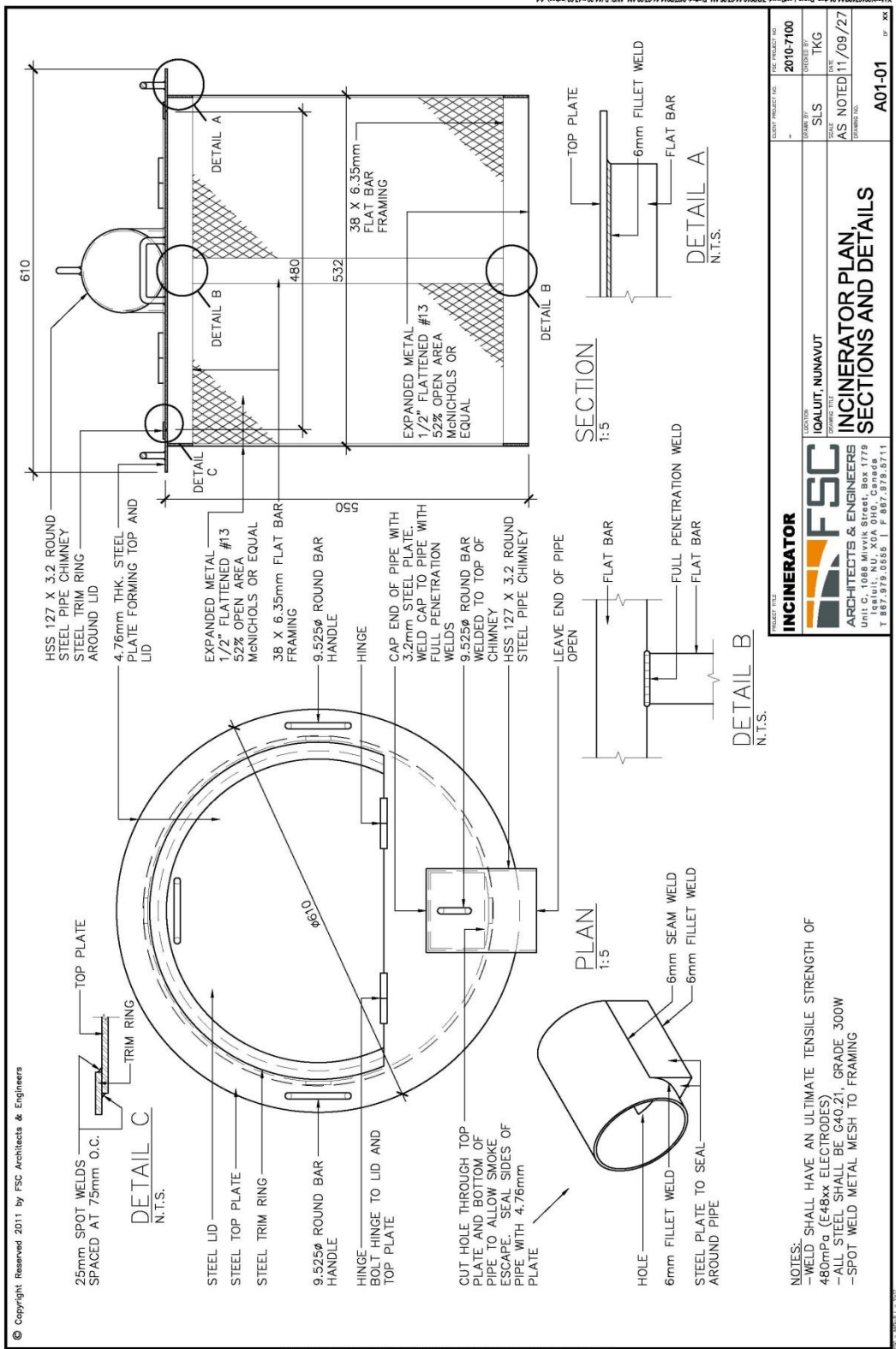
Evenly spaced vents or holes cut above the bottom of the barrel enable fresh air to mix with waste inside the metal basket.



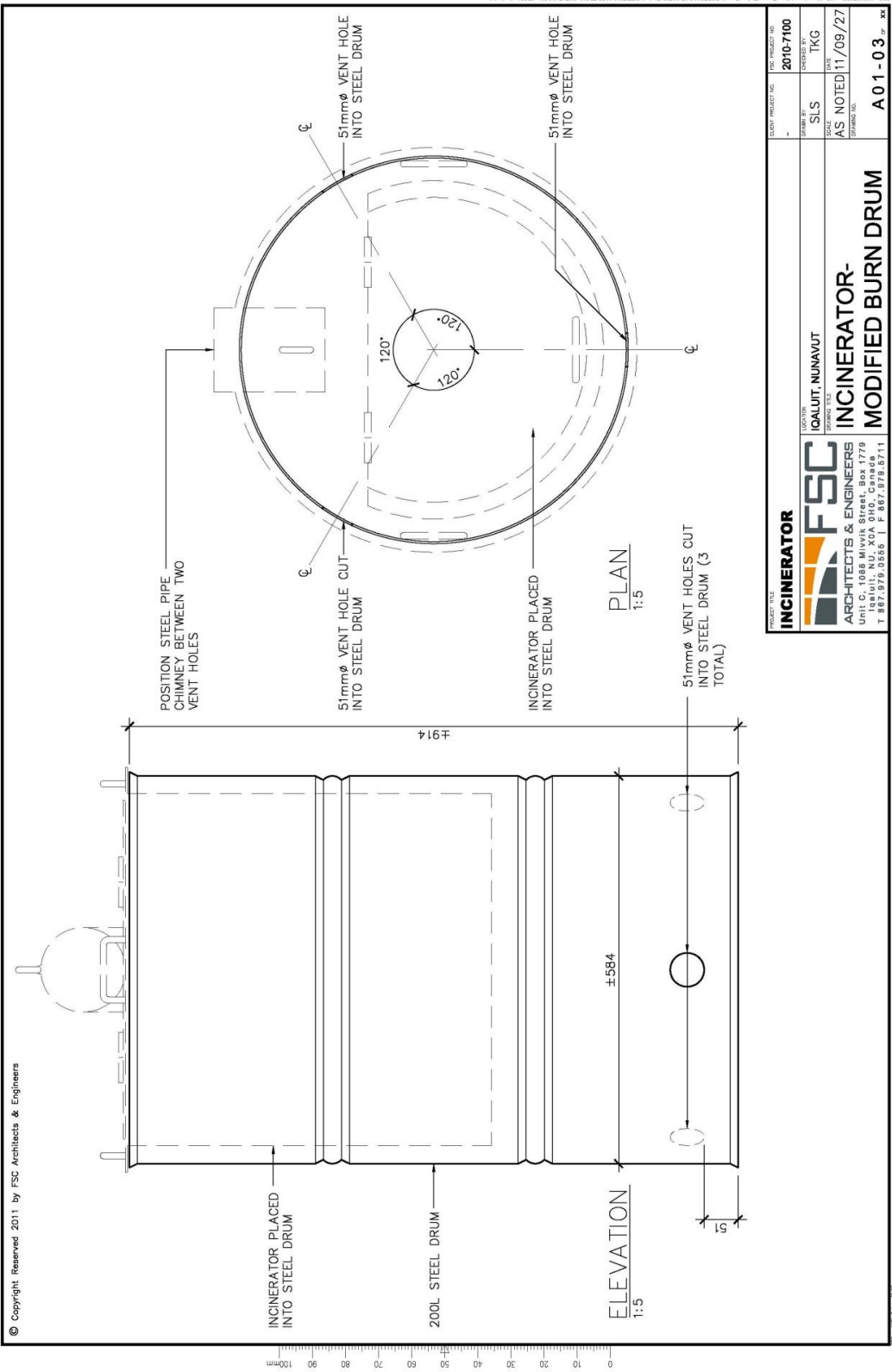
A hinged top helps to capture heat and enables easy loading and mixing of waste.



A metal basket or grate suspends the burning waste and enables mixing with the incoming air. The removable basket also enables access to any unburned ash that may collect in the bottom of the barrel.







GUIDELINE A-8

Guideline for the Implementation of Canada-wide Standards for Emissions of Mercury and of Dioxins and Furans

and

Monitoring and Reporting Requirements

for

Municipal Waste Incinerators

Biomedical Waste Incinerators

Sewage Sludge Incinerators

Hazardous Waste Incinerators

Steel Manufacturing Electric Arc Furnaces

Iron Sintering Plants

Legislative Authority:

Environmental Protection Act, Part V, Section 27, and Part II, Section 9
Ontario Regulation 347, General – Waste Management Regulation
Ontario Regulation 346, General – Air Pollution

Responsible Director:

Director, Standards Development Branch

August 19, 2004

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SYNOPSIS

This guideline establishes the formal adoption by Ontario of the Canada-wide Standards for emissions of mercury and of dioxins and furans from municipal waste, biomedical waste, sewage sludge and hazardous waste incineration systems in Ontario. This guideline also establishes the formal adoption by Ontario of the Canada-wide Standards for dioxin and furan emissions from steel manufacturing electric arc furnaces and iron sintering plants in Ontario.

The Canadian Council of Ministers of the Environment (CCME) announced Canada-wide Standards for emissions of mercury from incineration systems on June 6, 2000 and of dioxins and furans on May 1, 2001. These Canada-wide Standards have been adopted by Ontario and are reflected in this guideline and in an updated Guideline A-7. The CCME also announced Canada-wide Standards for emissions of dioxin and furan from steel manufacturing electric arc furnaces and iron sintering plants on May 1, 2003.

This guideline applies to new and existing incinerators. Effective August 1, 2001, all new incinerators must demonstrate compliance with the mercury the dioxin and furan limits within six (6) months of start-up. New steel manufacturing electric arc furnaces and iron sintering plants must comply with the dioxin and furan limits as of May 1, 2003. Existing incinerator, steel manufacturing electric arc furnaces and iron sintering plants will be required to demonstrate compliance through the inclusion of conditions in instruments such as Certificates of Approval at such time as these instruments take effect and prior to the end (December 31) of the years listed as "Compliance Date" for the applicable limits for existing plants.

1.0 INTRODUCTION

This guideline establishes Ontario specific limits for emissions of mercury and of dioxins and furans applicable to four types of waste incinerators through adoption of the June 6, 2000 and May 1, 2001 Canada-wide Standards (www.ccme.ca). These limits will be applied by the ministry when reviewing “Applications for Approval” for new incinerators, upgraded (expanded or modified) incinerators, and for other modifications to existing incinerators as necessary.

This guideline also establishes Ontario dioxin and furan emission limits for steel manufacturing electric arc furnaces and iron sintering plants through adoption of these Canada-wide Standards on May 1, 2003. These limits will be applied by the ministry when reviewing “Applications for Approval” for new steel manufacturing electric arc furnaces and iron sintering plants, upgraded (expanded or modified) steel manufacturing electric arc furnaces and iron sintering plants (May 1, 2003), or for other modifications to existing steel manufacturing electric arc furnaces and iron sintering plants as appropriate.

A waste incinerator will be considered to be upgraded (expanded or modified) if, as a result of changes, the approved or rated waste throughput increases, the approved or rated heat input to the unit increases by any amount or if the emissions are predicted to substantially increase for any other reason in relation to changes proposed in an application made by the plant owner/operator. A steel manufacturing electric arc furnace will be considered to be upgraded (expanded or modified) if there is a complete replacement of the EAF or of the gas conditioning system, or if there is a cumulative 25 percent or more increase in the hourly steel production from the maximum hourly steel production rate achieved in the 5 years prior to May 1, 2003 through physical modifications to the EAF facility. An iron sintering plant will be considered to be upgraded (expanded or modified) if there is a complete replacement of the sintering machine or of the gas conditioning system, or if there is a cumulative 25 percent or more increase in the hourly sintering capacity from the sintering capacity existing as of May 1, 2003 achieved through physical modifications to the iron sintering plant.

This guideline supplements the requirements of Regulation 346 (RRO 1990), General – Air Pollution, including compliance with the point of impingement standards prescribed in Schedule 1 to that regulation. This guideline complements Guideline A-7 which applies to new municipal waste incinerators and Guideline A-1 which applies to all biomedical waste incinerators operating in the Province of Ontario as of December 6, 2003 (one year after O. Reg. 323/02 took effect).

2.0 GUIDELINE LIMITS

2.1 Mercury

New, upgraded and existing waste incinerators, with the exception of existing “small” biomedical waste incinerators, shall meet the in-stack emission limits for mercury as set out in Table 1, below:

TABLE 1: MERCURY EMISSION LIMITS				
Incinerator Type	Emission Limit	Compliance Date		Comments
		New or upgraded	Existing	
Municipal Waste	20 µg/Rm ³ **	June 7, 2000	2006	calculated as the arithmetic average of 3 stack tests
Biomedical Waste *	20 µg/Rm ³	June 7, 2000	2006	calculated as the arithmetic average of 3 stack tests
Hazardous Waste	50 µg/Rm ³	June 7, 2000	2003	calculated as the arithmetic average of 3 stack tests
Sewage Sludge	70 µg/Rm ³	June 7, 2000	2005	calculated as the arithmetic average of 3 stack tests

* Variation from the Canada-wide Standard for mercury, which differentiates between “Large” and “Small” units using a throughput capacity of 120 tonnes per year as the boundary between these two sizes and allows for the use of “determined efforts” to meet the CWS (see section 2.3).

** µg/Rm³ means micrograms per reference cubic metre at 25°C and 101.3 kilopascals pressure. Concentrations are also to be corrected to 11 percent oxygen and zero percent moisture (dry) for reporting and compliance purposes.

2.2 Dioxins and Furans

New, upgraded and existing waste incinerators, with the exception of existing “small” biomedical waste incinerators, shall meet the in-stack emission limits for dioxins and furans as set out in Table 2, below:

TABLE 2: DIOXIN AND FURAN EMISSION LIMITS				
Facility Type	Emission Limit	Compliance Date		Comments
		New or upgraded	Existing	
Municipal Waste Incinerator	80 pg I-TEQ/Rm ³ **	May 2, 2001	2006	calculated as the arithmetic average of 3 stack tests
Biomedical Waste Incinerator *	80 pg I-TEQ/Rm ³	May 2, 2001	2006	calculated as the arithmetic average of 3 stack tests
Hazardous Waste Incinerator	80 pg I-TEQ/Rm ³	May 2, 2001	2006	calculated as the arithmetic average of 3 stack tests
Sewage Sludge Incinerator	80 pg I-TEQ/Rm ³ 100 pg I-TEQ/Rm ³	May 2, 2001 NA	NA 2005	calculated as the arithmetic average of 3 stack tests
Steel Manufacturing Electric Arc Furnace	150 pg I-TEQ/Rm ³ 100 pg I-TEQ/Rm ³	NA May 1, 2003	2006 2010	calculated as the arithmetic average of 3 stack tests
Iron Sintering Plant	1350 pg I-TEQ/Rm ³ 500 pg I-TEQ/Rm ³ 200 pg I-TEQ/Rm ³	NA NA May 1, 2003	2002 2005 2010	calculated as the arithmetic average of 3 stack tests

* Variation from the Canada-wide Standard for dioxins and furans, which differentiates between “Large” and “Small” units using a throughput capacity of 26 tonnes per year as the boundary between these two sizes and allows for the use of “determined efforts” to meet the CWS (see section 2.3).

** pg I-TEQ/Rm³ means picograms of toxicity equivalents (calculated using the toxicity equivalence factors recommended by the North Atlantic Treaty Organizations’s Committee on Challenges to Modern Society [NATO/CCMS] in 1989 and adopted by Canada in 1990) to 2,3,7,8 tetrachloro dibenzo-*p*-dioxin per reference cubic metre at 25°C and 101.3 kilopascals pressure. Concentrations are also to be corrected to 11 percent oxygen and zero percent moisture (dry) for reporting and compliance purposes for incinerators. Concentrations are also to be corrected to zero percent moisture (dry), but do not need to be corrected for oxygen for reporting and compliance purposes for EAF and iron sintering plants.

2.3 Guideline Limits for Small Biomedical Waste Incinerators

Since the Canada-wide Standards for mercury and for dioxins and furans were published, Ontario has developed a revised Guideline A-1 for biomedical waste incinerators (October 2002). The requirements of that document supercede the provisions of the Canada-wide Standards and require biomedical waste incinerators of any size to meet the same emission limits for mercury and for dioxins and furans as those set for “large” units under the Canada-wide Standards.

2.4 Guideline A-7: Combustion and Air Pollution Control Requirements for New Municipal Waste Incinerators

Guideline A-7 has been amended (October 2002) to incorporate the new dioxin and furan emission limit of 80 pg I-TEQ/Rm³ as well as the new mercury emission limit of 20 µg/Rm³ incorporated in September 2000.

3.0 COMPLIANCE TESTING

Within six months of start-up, all new or upgraded incinerator units, regardless of size, shall determine and demonstrate compliance with the limits set out in Tables 1 and 2 through source emissions testing, performed under maximum operating feed rates in accordance with the methods and procedures documented in the Ontario Source Testing Code. Thereafter, testing shall be performed once in each calendar year (annually), no less than six months apart.

Existing incinerators shall determine compliance with the limits set out in Tables 1 and 2 and existing steel manufacturing electric arc furnaces and iron sintering plants shall determine compliance with the limits set out in Table 2 through source emissions testing, performed under maximum operating feed rates in accordance with the methods and procedures documented in the Ontario Source Testing Code, within 6 months after the compliance date set out in Tables 1 and 2 as required by the appropriate legal instrument utilized to ensure compliance. Thereafter, testing shall be performed once in each calendar year (annually).

Additional source emissions testing may be required by the Director if recurring mercury or dioxin and furan emission problems occur with an operating incinerator, steel manufacturing electric arc furnace or iron sintering plant either in the context of reviewing and evaluating the CWS or this guideline, or with respect to compliance with a legal instrument enforcing compliance.

Source emissions testing for total mercury shall be conducted using a method that has been approved by the Manager, Technology Standards Section, Standards Development Branch, Ministry of the Environment, or successor. Speciation testing (Ontario Hydro method) provides more detailed information that may be of interest if the facility is out of compliance with the

Canada-wide Standard limit. The speciation information may assist in the development of remedial actions.

Source emissions testing for dioxin and furan shall be conducted using Environment Canada Methods 1/RM/2 and 1/RM/23 or US EPA Method 23, determining emissions of all of the contaminants for which Toxic Equivalency Factors (TEFs) have been established by NATO/CCMS, and results expressed as I-TEQ using the NATO/CCMS TEFs. Compliance will be determined based on measured I-TEQ emission levels. Table 3 provides a listing of the contaminants involved, and the TEFs assigned to each contaminant.

In determining I-TEQ emission levels, where the analytical results indicate that the amount of a particular isomer of dioxin and furan, is less than the detection limit reported by the laboratory analyzing the source emission testing samples the amount of dioxin and furan shall be reported as the toxic equivalent concentration (I-TEQ) by using the reported detection limit as the amount present for that isomer. The reported detection limits are to be determined by the laboratory at the time the source emission testing samples are analyzed based on analysis of appropriate replicate low level samples or blanks. If the annual source emissions testing indicates that the concentration of dioxin and furan has remained consistently below 32 pg/Rm³ as I-TEQ for five (5) consecutive years, then the source operator/owner may exclude dioxin and furan from the annual source emissions testing every second year as long as the concentration of dioxin and furan continues to remain below 32 pg/Rm³ as I-TEQ.

TABLE 3: Toxic Equivalency Factors (TEFs)	
Congener	NATO/CCMS (1989)
PCDDs	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	0.5
1,2,3,4,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
1,2,3,4,6,7,8,9-OCDD	0.001
PCDFs	
2,3,7,8-TCDF	0.1

1,2,3,7,8-PeCDF	0.05
2,3,4,7,8-PeCDF	0.5
1,2,3,4,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
1,2,3,4,6,7,8,9-OCDF	0.001

3.1 Pollution Prevention for Biomedical Waste Incinerators

The operators of all sources affected by the Canada-wide Standards are encouraged to use pollution prevention strategies to meet or exceed the emission limits set in the Canada-wide Standards. However, in the case of biomedical waste incineration there are significant opportunities for emission reductions due to the adoption of such strategies.

In particular, operators should consider implementing mercury reduction plans including periodic mercury audits conducted after implementation of such plans. The results of the audits should evaluate measures taken such as staff training and education in the waste source/generating locations and an audit of the purchases and fate of mercury containing devices, articles and materials, including waste mercury amalgams, fluorescent lamps, switches and temperature control devices, etc.

Similarly, operators are encouraged to develop a dioxin and furan pollution prevention plan including a detailed waste input audit and a rationale describing the expected emission levels which would have been expected from wastes excluded from firing to the unit as part of the implementation of the plan.

Any pollution prevention efforts made by operators to meet the standards through means other than “bottom of stack” control measures should be documented and should include consideration of programs/initiatives for eliminating the use of mercury-containing products where such products can enter an incinerator waste feed stream, or diverting mercury-containing wastes from the incinerator feed as well as measures taken to prevent emissions of dioxins and furans (e.g., documentation that the unit is used solely for destruction of pathological and/or cytotoxic wastes). Documentation of the effectiveness of determined efforts should include a sound

estimate of the expected emissions from the facility resulting from the implementation of these measures, including a detailed rationale for the magnitude of those estimated emissions.

4.0 REPORTING

A report on any source emissions testing performed in accordance with the requirements under section 3.0, shall be forwarded in triplicate to the ministry's local district office within 90 days of completion of the testing. The report shall be in the format specified in the Source Testing Code, and shall include, but not be limited to:

- (1) an executive summary;
- (2) dates when source emissions testing was carried out;
- (3) process description, records of waste composition and feed rate during the source measurement;
- (4) records of operating conditions, including but not limited to:
 - (1) records of all continuous emission monitoring systems, including temperature and pressure sensors, for the period when the source emission testing was taking place;
 - (2) liquid and/or reagent and gas flow rates for all components of the air pollution control system;
 - (3) any other records that may affect the evaluation of the source emissions testing report;
- (5) procedures followed during the source emissions testing and any deviation from the proposed test protocol and the reasons therefore;
- (6) the results of the analyses of the stack emissions;
 - a summary table that compares the source emissions testing results, the monitoring data and the records of operating conditions during the source emissions testing to the requirements imposed by the Environmental Protection Act, Regulation 346 and this Guideline and which presents the estimated annual loadings of mercury and dioxins and furans (expressed as I-TEQ) from the source calculated using procedures consistent with currently accepted practices used to report emissions as required by O. Reg. 127/00.

5.0 ABBREVIATIONS

CCME	Canadian Council of Ministers of the Environment
CCMS	[NATO] Committee on Challenges to Modern Society
HCl	hydrogen chloride or hydrochloric acid
I-TEQ	international toxicity equivalents to 2,3,7,8 tetrachloro dibenzo- <i>p</i> -dioxin (calculated using the toxicity equivalence factors recommended by the NATO CCMS in 1989 and adopted by Canada in 1990)
kPa	kilopascals
mg/Rm ³	milligrams per reference cubic metre
NATO	North Atlantic Treaty Organization
O ₂	oxygen
pg/Rm ³	picograms per reference cubic metre
ppmv	parts per million by volume
R	reference conditions
SO ₂	sulphur dioxide
µg/Rm ³	micrograms per reference cubic metre

Guideline A-7

Air Pollution Control, Design and
Operation Guidelines for Municipal
Waste Thermal Treatment Facilities

GUIDELINE A-7

Air Pollution Control, Design and Operation Guidelines for Municipal Waste Thermal Treatment Facilities

Legislative Authority:

Environmental Protection Act

R.R.O. 1990, Regulation 347 (General – Waste Management)

Ontario Regulation 419/05 (Air Pollution – Local Air Quality)

Responsible Director:

Director, Standards Development Branch

Ministry of the Environment

Last Revision Date:

October 2010

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1.0 PURPOSE AND INTRODUCTION

The purpose of this guideline is to provide guidance to applicants applying for Certificates of Approval for municipal waste thermal treatment facilities under section 9 and Part V of the Environmental Protection Act (EPA). This guideline will set out minimum expected requirements that the Director may apply when exercising his or her discretion while considering applications on a case-by-case basis. Guideline A-7 should also be taken into account in meeting any requirements under the Environmental Assessment Act that may apply to the proposal. To the extent that this document sets out that something is “required” or “shall” be done or sets out a “requirement” or “limit”, it does so only to identify minimum expected requirements the application of which remain subject to the discretion of the Director.

During the review of applications for Certificates of Approval, the Ministry considers the requirements set out in applicable regulations as well as all applicable Ministry guidelines and policies. With this in mind, applicants for Certificates of Approval for municipal waste thermal treatment facilities should review this guideline with care while preparing their applications and supporting information for consideration by the Director.

This guideline sets out minimum recommendations for pollution control systems and maximum allowable “in-stack” contaminant emission levels from municipal waste thermal treatment facilities in Ontario. The guideline also sets out recommendations for acceptable design and operating parameters for thermal treatment facilities utilizing conventional incineration technology and other combustion equipment associated with municipal waste thermal treatment facilities.

Guideline A-7 applies to all thermal treatment facilities processing municipal waste including manufacturing facilities, such as cement and lime kilns, if they use municipal waste as an alternative fuel. This guideline also applies to other sites that combust (with or without energy recovery) any materials/ by-products resulting from the municipal waste thermal treatment process (e.g., synthesis gas, solids and/or liquids). It also covers pilot scale operations involving thermal treatment of municipal waste. However, where the operation of an experimental facility is proposed to be limited to thermal treatment of not more than 50 tonnes of municipal waste per year as a condition of a Certificate of Approval some of the requirements of this guideline may not apply.

Guideline A-7 does not apply to thermal treatment facilities where municipal waste is processed to produce gases, solids and/or liquids for use as raw material in a manufacturing process that does not involve combustion (with or without energy recovery) of those gases, solids and/ or liquids at the thermal treatment facility or the manufacturing facility. Additionally, this guideline does not apply to thermal treatment facilities that burn or otherwise thermally treat biomedical or other hazardous waste, or biomass, such as sewage sludge or woodwaste, either exclusively or in combination with a conventional fossil fuel.

The limits in this guideline for dioxins and furans, cadmium, lead, mercury, particulate matter and acid gases are technology based, developed using the maximum achievable control technology (MACT) principle, which is similar to the approach taken by other jurisdictions. In the United States major sources are expected to comply with standards that require the maximum degree of reduction in emissions of hazardous air pollutants. These MACT standards are based on the emission levels already achieved by best-performing similar facilities. This performance-based approach yields standards that are both reasonable and effective in reducing contaminant emissions.

While state-of-the-art facilities are capable of achieving very low dioxin and furan emission levels and often report values below the Level of Quantification, the numerical value for the dioxin and furan limit in this guideline remains the same (80 pg I-TEQ/Rm³) as in the previous version of Guideline A-7 (February 2004). The limit of 80 pg I-TEQ/Rm³ is also the Canada Wide Standard (CWS) and the lowest limit established by any jurisdiction for municipal waste thermal treatment facilities. The Ministry will continue to review technical advancements worldwide as well as regulatory developments in other jurisdictions, and if more stringent limits are established, including an updated CWS, Guideline A-7 may be updated accordingly.

Stringent technology based limits ensure that municipal waste thermal treatment facilities in Ontario incorporate state-of-the-art process and control equipment as well as best operational practices. This in turn will ensure that emissions discharged from municipal waste thermal treatment facilities are as low as technically feasible. Protection against potential environmental and health impacts is then confirmed through a technical review involving dispersion modeling of the estimated emissions and comparison of the results with air standards in Ontario Regulation 419/05 (Air Pollution – Local Air Quality). This Regulation also requires that all municipal waste thermal treatment facilities comply with a concentration limit for organic matter in Section 50 and a limit for opacity in section 46. All proponents of municipal waste thermal treatment facilities must demonstrate an ability to comply with Ontario Regulation 419/05 when submitting an application for a Certificate of Approval.

Thermal treatment facilities may also include other sources of air emissions, particularly odor and dust, aside from the stack that discharges emissions from the thermal treatment process. Owners and operators are expected to incorporate equipment and/or measures to minimize contaminant emissions from all sources, including unpaved roadways, waste storage and handling, shredding equipment, ash cooling and handling etc. Emissions from all sources will be considered during the review of applications for Certificates of Approval. Proponents should refer to the document “Procedure for Preparing an Emission Summary and Dispersion Modelling Report” available on the Ministry’s website, (www.ene.gov.on.ca/envision/gp/3614e03.pdf), for guidance on preparing an Emission Summary and Dispersion Modeling report for a proposed facility.

It is noted that if the requirements set out in this guideline, including the in-stack concentration limits for contaminants, are incorporated into a Certificate of Approval, compliance with these in-stack limits is expected to result in compliance with the point-of-impingement concentration standards, i.e. air standards, for those same contaminants currently set out in Ontario Regulation 419/05 and required to be met at

any point in the natural environment. In accordance with Guideline A-7, Certificates of Approval for municipal waste thermal treatment facilities can also include organic matter and opacity limits that are more stringent than in Ontario Regulation 419/05.

2.0 IN-STACK CONCENTRATION LIMITS

2.1 Limits for Municipal Waste Thermal Treatment Facilities excluding Cement and Lime Kilns

Facilities that thermally treat municipal waste or that combust materials/ by-products from thermal treatment of municipal waste are expected to meet the emission limits in the stack (or as otherwise specified) as set out in Table 1 of this Guideline.

Most of the concentration limits are expected to be complied with in the stack that discharges contaminants to the natural environment from the municipal waste thermal treatment process. It is noted, however, that the limits for organic matter and carbon monoxide are set out for the purpose of process control, i.e. to ensure good combustion in the piece of equipment that is used for combustion of gases generated during the thermal treatment of municipal waste. Therefore, the limits for organic matter and carbon monoxide are expected to be complied within the undiluted gases exiting such combustion equipment.

If other Ministry guidelines apply to any part of a thermal treatment facility, it can be expected that the requirements and/ or emission limits in all relevant guidelines will be considered and, where any limits or other apparent requirements are to be incorporated into a Certificate of Approval, the most stringent applicable requirements and/ or emission limits from those guidelines will likely be applied.

Table 1: In-Stack Emission Limits For Thermal Treatment Facilities Excluding Cement and Lime Kilns

TABLE 1		
Parameter	In-Stack Emission Limit	Verification of Compliance ¹
particulate matter (PM)	14 mg/Rm ³	Results from compliance source testing or calculated as the rolling arithmetic average of four (4) hours of data before dilution with any other gaseous stream, measured by a continuous emission monitoring system that provides data at least once every fifteen minutes
cadmium	7 µg/Rm ³	Results from compliance source testing
lead	60 µg/Rm ³	Results from compliance source testing
mercury	20 µg/Rm ³	Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
dioxins and furans	80 pg/Rm ³	Results from compliance source testing; results expressed as I-TEQ
hydrochloric acid (HCl)	18 ppm dv (27 mg/Rm ³) or an HCl removal efficiency of not less than 95%	Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
sulphur dioxide (SO ₂)	21 ppm dv (56 mg/Rm ³)	Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
nitrogen oxides (NO _x)	105 ppm dv (198 mg/ Rm ³)	Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
organic matter (undiluted, expressed as equivalent methane)	50 ppm dv (33 mg/ Rm ³)	Results from compliance source testing or calculated as the rolling arithmetic average of 10 minutes of data at the outlet of the piece of equipment where combustion of the gas stream resulting from thermal treatment of waste is completed but before dilution with any other gaseous stream takes place, measured by a continuous emission monitoring system that provides data at least once every minute
carbon monoxide	35 ppm dv (40 mg/Rm ³)	calculated as the rolling arithmetic average of four (4) hours of data at the outlet of the piece of equipment where combustion of the gas stream resulting from thermal treatment of waste is completed but before dilution with any other gaseous stream, measured by a continuous emission monitoring system that provides data at least once every fifteen minutes
opacity	10 percent	calculated as the rolling arithmetic average of six (6) minutes of data measured by a continuous emission monitoring system that provides data at least once every minute
	5 percent	calculated as the rolling arithmetic average of two (2) hours of data measured by a continuous emission monitoring system that provides data at least once every fifteen minutes

¹ Compliance source testing as set out in the facility's Certificate of Approval.

2.2 Limits for Existing Cement and Lime Kilns Burning Municipal Waste

Regardless of the fuel burnt, cement and lime kilns discharge many of the same contaminants (e.g. particulate matter, metals, nitrogen oxides, sulphur dioxide etc.) into the natural environment as dedicated municipal waste thermal treatment facilities.

Manufacturing of one tonne of cement clinker requires approximately 1.5 tonnes of raw materials (e.g. limestone), and approximately one tenth of a tonne of coal or alternate fuel of the same heating value. As such, cement manufacturing emissions are highly influenced not only by the properties of the combusted fuel, but by the properties of the raw materials processed. As the properties of both the raw materials and the fuels vary, emissions from cement manufacturing facilities, particularly emissions of mercury, sulphur dioxide and total hydrocarbons, also vary.

In order to reduce reliance on fossil fuels energy intensive industries worldwide are continuously seeking alternative energy sources. Along with a number of different types of waste materials and residues, certain fractions of municipal waste have been used successfully to replace coal and other conventional fuels particularly in Europe and also in Quebec, British Columbia, Nova Scotia and numerous states in the United States of America. The use of these alternative energy sources will avoid emissions that would result from burning of the existing fossil fuels, mostly coal and petroleum coke.

In accordance with R.R.O. 1990, Regulation 347 burning or co-incineration of waste in cement and lime kilns is considered thermal treatment of waste. Therefore, Certificates of Approval issued to existing cement and lime kilns to burn municipal waste (except biomass type waste only) as an alternative fuel can be expected to include in-stack emission limits in accordance with Table 2 of this guideline. Requirements for cement or lime kilns burning only biomass type waste as an alternative fuel would be established on a case by case basis during review of applications for Certificates of Approval for such proposals.

The following notes apply to Table 2:

- (1) If there is no limit for particulate matter in an existing Certificate of Approval issued to the facility, the limit of 50 mg/Rm³ can be expected to be included in the Certificate of Approval that will allow burning of municipal waste as an alternative fuel. Where a more stringent site-specific limit for particulate matter is already incorporated into an existing Certificate of Approval for manufacturing of cement or lime using existing raw materials and conventional fuels, the existing limit will be retained if it is more stringent than 50 mg/Rm³.

- (2) Limits for cadmium, lead and mercury set out in Table 2 can be expected to be included in a Certificate of Approval that will allow burning of municipal waste as an alternative fuel, unless the proponent can demonstrate that one or more of the specified metals are present in the existing raw materials and conventional fuels in such a quantity that the relevant limit(s) would be exceeded without the use of municipal waste as a fuel. In such a case, site-specific limits for one or more of the above metals may be established and incorporated into a Certificate of Approval. The site specific limits can be expected to be developed based on a review of relevant facility specific data that includes information on the discharge of cadmium, lead and/ or mercury from the facility (e.g. source testing data, analytical data for raw materials, mass balance calculations). Such site specific limits will take into account the variability of the raw material composition.
- (3) It is expected that cement and lime kilns can comply with the hydrogen chloride (HCl) limit in Table 2. A site-specific emission limit for HCl may, however, be incorporated into a Certificate of Approval based on HCl concentrations when using existing raw materials and conventional fuels. This will prevent any increase in HCl emissions resulting from use of municipal waste as fuel for the kiln.
- (4) A site-specific emission limit for sulphur dioxide (SO₂) can be expected to be incorporated into a Certificate of Approval based on SO₂ concentrations when burning conventional fuels. This will prevent any increase in SO₂ emissions resulting from use of municipal waste as fuel for the kiln. For kilns required to use continuous emission monitoring (or a method that will provide estimates of emissions that are at least as accurate as the estimates that would be provided by a continuous emission monitoring system) for SO₂ under Ontario Regulation 194/05 (Industry Emissions — Nitrogen Oxides and Sulphur Dioxide), the limit will be determined based on a review of a minimum of 6-months of Continuous Emission Monitoring System (CEMS) data (or data obtained using another method) for the kiln (1-hour, 24-hour and 30-day SO₂ averages in ppm_{dv} or mg/Rm³). The Ministry will continue to monitor the development of SO₂ control technology worldwide. As new proven technology is developed suitable for this industry sector, the Ministry will review this guideline to determine if limits can be adjusted.
- (5) A site-specific emission limit for oxides of nitrogen (NO_x) can be expected to be incorporated into a Certificate of Approval based on NO_x concentrations when burning conventional fuels. This will prevent any increase in NO_x emissions resulting from use of municipal waste as fuel for the kiln. For kilns required to use continuous emission monitoring (or a method that will provide estimates of emission that are at least as accurate as the estimates that would be provided by a continuous emission monitoring system) for NO_x under Ontario Regulation 194/05, the limit will be determined based on a review of a minimum of 6-months of CEMS data (or data obtained using another method) for the kiln (1-hour, 24-hour and 30-day NO_x averages in ppm_{dv} or mg/Rm³). The Ministry will continue to monitor the development of NO_x control technology worldwide. As new

proven technology is developed suitable for this industry sector, the Ministry will review this guideline to determine if limits can be adjusted.

- (6) Lime kilns that do not currently have CEMS for SO₂ and NO_x, can be expected to carry out a monitoring program to determine the normal ranges for the parameters when burning conventional fuels. The proponent of an alternate fuel should consult staff of the Ministry when planning such a program. The results of the monitoring program are expected to be included with an application for a Certificate of Approval to burn municipal waste as an alternate fuel.

Table 2: In-Stack Emission Limits for Cement and Lime Kilns

TABLE 2		
Parameter	In-Stack Emission Limit	Verification of Compliance ²
particulate matter (PM)	50 mg/Rm ³ or a site specific emission limit where a more stringent stack concentration limit is already in place for existing raw materials and conventional fuels (1)	Results from compliance source testing or calculated as the rolling arithmetic average of four (4) hours of data measured by a continuous emission monitoring system that provides data at least once every fifteen minutes
cadmium (Cd)	7 µg/Rm ³ unless existing raw materials and conventional fuels result in higher concentration (2)	Results from compliance source testing
lead (Pb)	60 µg/Rm ³ unless existing raw materials and conventional fuels result in higher concentration (2)	Results from compliance source testing
mercury (Hg)	20 µg/Rm ³ unless existing raw materials and conventional fuels result in higher concentration (2)	Results from compliance source testing or calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
dioxins and furans	80 pg/Rm ³	Results from compliance source testing; results expressed as I-TEQ
hydrochloric acid (HCl)	18 ppm _{dv} (27 mg/Rm ³) unless existing raw materials and conventional fuels result in higher concentration (3)	calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
sulphur dioxide (SO ₂)	Site specific limit not to exceed the in-stack SO ₂ concentration resulting from existing raw materials and conventional fuels. (4, 6)	calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
nitrogen oxides (NO _x)	Site specific limit not to exceed the in-stack NO _x concentration resulting from existing raw materials and fossil fuels (5, 6)	calculated as the rolling arithmetic average of 24 hours of data measured by a continuous emission monitoring system that provides data at least once every 15 minutes
organic matter	Section 50 (2) of Ontario Regulation 419/05	calculated as the rolling arithmetic average of 10 minutes of data measured by a continuous emission monitoring system that provides data at least once every minute
opacity	Section 46 of Ontario Regulation 419/05	calculated as the rolling arithmetic average of six (6) minutes of data measured by a continuous opacity monitor that provides data at least once every minute

² Compliance source testing as set out in the facility's Certificate of Approval. Owners and operators of cement and lime kilns can expect to be required, by conditions in Certificates of Approval, to maintain CEMS for SO₂, NO_x, THC, HCl and opacity.

2.3 Other Industrial Processes Involving Thermal Treatment of Municipal Waste

This guideline will also apply to other industrial processes, aside from cement and lime kilns that use thermal treatment equipment to process municipal waste. If, however, it can be demonstrated that the limits in this guideline are not consistent with the MACT principle, different limits may be set out in Certificates of Approval.

2.4 Thermal Treatment Equipment Used to Process Municipal Waste together with Other Waste

If municipal waste is proposed to be processed together with some other type of waste in a thermal treatment facility, the owner and operator of the facility can expect that the Director will develop his or her conditions of approval based on the waste type that warrants the most stringent limits and/ or other requirements.

Non-hazardous waste that is predominantly wood but does not meet the definition of woodwaste provided in Regulation 347 is considered to be municipal waste. For instance, rail ties and utility poles are usually treated with chemicals that place them outside the definition of woodwaste. This guideline applies to thermal treatment of rail ties and utility poles when they are proposed to be thermally treated either alone or together with other municipal waste.

On the other hand, if a proponent wishes to thermally treat a mixture of woodwaste and waste that is predominantly wood, such as railway ties or utility poles, the air emission requirements for such a facility will be established on a case by case basis. Special attention should be paid to chlorine content of the waste, presence of chlorinated organics and trace metals, particularly copper, all of which may contribute to increased emissions of dioxins and furans. Proponents should also include suitable control and monitoring equipment in the application for a Certificate of Approval. Additionally, the application should include proposed emission and operational limits that take into consideration the technology and its capabilities and that are based on credible emission data from the existing facility or emissions from a similar facility. Submissions must include detailed information to support development of site specific limits. It is also important to note that a “woodwaste combustor site”, as defined in Regulation 347, can thermally treat only “woodwaste”. A waste approval under part V of the EPA would be required for a mixed waste facility.

3.0 CONTINUOUS AND LONG-TERM MONITORING

3.1 Continuous Monitoring and Control Systems

Thermal treatment facilities, including facilities that combust materials/ by-products from thermal treatment of municipal waste, are expected to be equipped with control and monitoring systems to indicate and confirm compliance with the limits of this guideline,

as set out in conditions included in a Certificate of Approval as well as with requirements in any applicable regulations. Such systems are expected to be capable of readily indicating any aspect of a substandard operation, i.e. excursions outside the acceptable operating window established during initial performance testing. They are also expected to be capable of adjusting or modifying appropriate operating conditions to maintain compliance with the limits of this guideline, regulations and conditions of approval at all times.

Continuous monitoring systems at municipal waste thermal treatment facilities typically include many operational parameters all of which may not be specifically mentioned in this Guideline. For instance, continuous monitoring may be necessary for a pressure drop across air pollution control equipment, pH level for scrubbing media, flow rates etc. In addition, continuous monitoring and data acquisition systems typically include alarm functionality to alert operating personnel of any situations that have resulted or are likely to result, if not corrected, in operation outside the acceptable operating window. Certificates of Approval may include requirements for visible and audible alarms for operational parameters as well as for contaminants, with details determined during the approval process. Similarly waste feed cut off and facility shut down requirements based on continuous monitoring results may be determined during the approval process for inclusion of appropriate conditions on the facility's Certificate of Approval.

Continuous monitoring systems are expected to be capable of providing accurate and representative measurements of the relevant parameters, and they are expected to be equipped with recording devices for subsequent reference and analysis to assist in confirming compliance with conditions of approval and generally assessing performance of the thermal treatment facility. The continuous monitoring systems shall comply with the principles of the Environment Canada document "Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation" (Report EPS 1/PG/7, as amended in December 2005 or later) or any equivalent protocols as well as performance specifications approved under section 9 of the EPA. While EPS 1/PG/7 is written for power generation facilities and for monitoring of specific parameters, the principles apply to other facilities and other continuous monitoring instruments and parameters. Detailed performance specifications for all continuous monitoring systems can be expected to be set out in the Certificates of Approval issued to facilities that are required to include such systems.

Location of the measurement points for various parameters will depend on the parameter itself as well as the design and layout of the thermal treatment facility. For some of the parameters the measurement location is the stack that discharges contaminants from the municipal waste thermal treatment facility into the atmosphere. However, for operational parameters the monitoring locations will be dictated by the need to have control over the operating conditions; i.e. the parameter needs to be monitored where the parameter is considered to be critical for the performance of either the thermal treatment process or associated pollution control equipment. For instance, the Director may decide that it is important to have a temperature limit not only for the combustion zone but also for some other locations at the facility, such as the entrance to and/ or exit from a pollution control device. Similarly levels of oxygen, carbon monoxide and/ or organic matter are usually monitored in the undiluted gases exiting a

combustion device, such as a secondary chamber of a conventional two-stage incinerator with the data being fed into a computerized control loop to ensure good combustion control. The instruments that monitor process parameters are expected to be part of a system that can adjust the operation of the facility in order to ensure the operation remains within the acceptable operating envelope determined during commencement of operation and initial performance testing.

3.2 Continuously Monitored Parameters

Parameters that will be considered for continuous monitoring include:

- temperature
- organic matter
- carbon monoxide
- residual oxygen
- volumetric flow rate of the flue gas
- hydrogen chloride
- sulphur dioxide
- nitrogen oxides
- opacity
- particulate matter

Other parameters that may also be considered for continuous or long-term monitoring include:

- carbon dioxide
- hydrogen fluoride
- mercury
- dioxins and furans

Proponents for municipal waste thermal treatment facilities are advised to carefully consider the purpose of each monitor when preparing applications for Certificates of Approval such that appropriate monitoring requirements can be set out as a condition of approval. When monitoring of a certain parameter is considered advantageous, the intent of the monitor may be implemented either by installing a device for direct measurement of the parameter or of a suitable surrogate.

Final selection of required analyzers will be determined on a case by case basis at the time of review of the application for a Certificate of Approval. For instance, it may not

be essential to include continuous monitoring devices for both organic matter as well as carbon monoxide since these parameters are used as performance indicators of the combustion process. It is noted, however, that there is not always a direct correlation between the two parameters and that carbon monoxide may be the simpler parameter to monitor but that organic matter is the parameter which has a limit also in Ontario Regulation 419/05. Additionally, dedicated continuous monitoring of sulphur dioxide may not be necessary if hydrogen chloride is monitored continuously and the control method for hydrogen chloride ensures control of sulphur dioxide as well.

Where opacity monitoring is problematic due to a saturated plume, consideration may be given for installing the opacity monitor before the wet pollution control device if the main particulate collection device is dry and located before the wet device. Alternatively, opacity may be monitored in a heated slip stream. Another option is to install a continuous particulate matter monitor instead of an opacity monitor. The Ministry encourages the use of high sensitivity continuous particulate matter monitoring systems over opacity monitoring since particulate emissions have a direct environmental impact. Owners and operators may not be required to install an opacity monitor if the thermal treatment facility is equipped with a continuous particulate matter monitor.

Proponents for thermal treatment of municipal waste are encouraged to explore technical developments with respect to continuous or long-term sampling/ monitoring techniques and consider installation of such devices for measurement of emissions of mercury and dioxins/ furans. Methods such as Adsorption Method for Sampling of Dioxins and Furans (AMESA) can provide information on the ongoing performance of, as well as emission trends at a thermal treatment facility to support evaluation of the facility performance year round.

Owners and operators of thermal treatment facilities may also be able to monitor a variety of other parameters periodically, continuously or on a long-term basis to support the results of source testing and/ or to provide better data on annual emissions. For instance, where a continuous or long-term monitoring system provides samples for measurement of one pollutant, it may be possible to periodically analyze these same samples for quantification of other pollutants, e.g. a filter catch of particulate matter could also be analyzed for a variety of metals.

The onus on ensuring good performance, based on best practices in the municipal waste thermal treatment field, and compliance with the regulations and all conditions included in the facility's Certificate of Approval, lies with the owner and operator of the thermal treatment facility. Therefore it is the responsibility of those persons to incorporate the appropriate continuous control and monitoring systems in the design of the facility and to provide justification for the selection or omission of equipment while ensuring that sufficient safeguards are in place to ensure good performance at all times. An application for a Certificate of Approval is expected to include a detailed proposal for a monitoring and control system.

3.3 Quality Assurance and Quality Control

Owners and operators of municipal waste thermal treatment facilities are responsible for providing accurate data to the Ministry as well as to the public. In order to ensure data accuracy, the owners and operators are expected to take several steps in order to demonstrate due diligence. The following sequence of steps will ensure an increasingly higher level of confidence for the CEMS data.

3.3.1 Initial Certification

CEMS are expected to be certified after installation to ensure that the equipment meets the required performance specifications as set out in the Certificate of Approval. Certification involves passing the first Relative Accuracy Test which will mark the “in-service” date for the CEMS and will allow the owner/ operator to start reporting data.

3.3.2. Ongoing Quality Assurance Quality Control

Following initial certification, a written Quality Assurance Quality Control (QA/QC) Manual is expected to be developed to set out all the procedures in relation to daily, quarterly, semi-annual and annual performance evaluations, including annual Relative Accuracy Test Audits (RATAs). Once the Manual is developed, it is expected to be implemented. Guidance for developing the QA/QC procedures is provided in “Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation”, Environmental Protection Series, Report EPS 1/PG/7 (Revised) December 2005 or a later published version (EPS 1/PG/7).

3.3.3 Annual Audit

In order to enhance credibility of the CEMS data, a third party can be requested to carry out an annual audit to verify that the QA/QC Manual has been implemented and that the data from the CEMS can be considered reliable and accurate.

Certificates of Approval can be expected to include conditions relating to QA/QC.

3.4 Data Reporting for Continuously Monitored Parameters

3.4.1 Calculation of Average Emissions

While the measurement of a parameter may occur several times within a minute, the data acquisition systems associated with the continuous monitoring systems may record the measured data once every minute or less frequently.

Minute by minute data recording will be required whenever the averaging time for a parameter limit is less than an hour. In such cases, the data acquisition system is expected to “roll the data” minute by minute to produce a series of rolling averages, such as 6-minute, 10-minute and 30-minute averages.

Where the parameter limit is associated with an averaging time of at least one hour, valid hourly data obtained in accordance with EPS 1/PG/7 can be used to derive the concentration for the required averaging time (such as one-hour, two-hour, four-hour, 24-hour rolling averages). For shorter averaging time (such as 6-minute, 10-minute, 30-minute) an exemption of up to 30 continuous minutes could be allowed for the purpose of daily calibrations. Such an allowance implies that the concentration or emission rate reported to cover a period of time when calibration has occurred can be the average of the minute-by-minute data which includes the last valid reading before the calibration started and the first valid reading after the calibration was completed. Alternatively the missing data can be substituted with another acceptable value, e.g. that generated by a *Predictive Emission Monitoring System (PEMS)*.

Continuous monitoring systems may also experience malfunctions during which data is not available. When any continuous monitoring system is out of service due to failure or malfunction, the data substitution method discussed in EPS 1/PG/7 is expected to be followed. It is expected that backfilling procedures are developed and included in the facility's written QA/QC Manual in accordance with EPS 1/PG/7.

Certificates of Approval issued for thermal treatment facilities can be expected to specify the limits, together with the required averaging times, for all parameters that are required to be monitored continuously. Additionally, Certificates of Approval can be expected to set out reporting requirements for all continuously monitored parameters and action levels for operation such as waste feed reduction and complete facility shut down.

3.4.2. Shut Downs and Start Ups

Owners and operators of thermal treatment facilities are expected to achieve a stable, continuous operation and to take all possible steps to avoid shut down of the facility unless necessary due to breakdown of equipment. Certificates of Approval issued to municipal waste thermal treatment facilities may include conditions that require reduction of waste feed rate if a continuously monitored parameter is approaching its limit. If an operator is unable to bring the parameter back to the normal operating level within a reasonable time period, further waste feed rate reductions and ultimately waste feed cut off may be required. Incremental waste feed rate reductions and other measures to stabilize the process are intended to avoid the need for a complete shut down whenever possible.

Operators and operators of thermal treatment facilities should report all data generated by continuous monitoring systems from start up of the unit before any waste has been fed into the unit until all waste has been fully treated and the equipment is shut down. When reporting on compliance with the limits in this guideline, as set out in conditions included in a Certificate of Approval, the owners and operators may report the data for a period of up to three hours (or another period of time as may be set out in conditions of approval) from the start of the waste feed into the thermal treatment equipment separately from data generated during normal operation. Data for this transitional period, as well as for the period prior to start of waste feed, must be included in the

monthly and annual reports. Owners and operators of thermal treatment facilities are expected to address the transitional periods in the monthly, quarterly and/ or annual reports on facility operations as required by conditions of approval.

In the event of frequent shut downs, malfunctions and start ups, i.e. shut downs, malfunctions and start ups that happen more often than at other facilities of similar design, the owners and operators of the thermal treatment facility are expected to carefully investigate the reasons for the underlying operational issues and correct any problems as soon as possible to ensure that the facility operates with minimum transitional periods. In this regard the Ministry's expectation is that the number of transitional periods remains within a range typically experienced at other well-performing, state-of-the-art municipal waste thermal treatment facilities of similar design. Careful attention is expected to be paid to preventability of equipment outages with proper maintenance and operating procedures as well as back up measures and back up equipment.

Owners and operators are expected to show due diligence under all circumstances with detailed procedures written in an operations manual which is reviewed and updated, as necessary. Due diligence includes intensive training of staff with periodic refresher courses taught by experts on thermal treatment, air pollution control, environmental legislation and the requirements of Certificates of Approval.

Frequency of shutdowns, startups and malfunctions may be higher at newly constructed facilities and particularly at new facilities based on technologies that are not well proven in the municipal waste thermal treatment sector. Facilities intended for technology development would be issued a Certificate of Approval that is valid only for a limited period of time (e.g., pilot or demonstration facilities referred to in section 5.0.1 of Regulation 347). This guideline is not intended to address the operation of such facilities where technology development has not been fully completed and frequent changes to the facility are necessary due to ongoing operational issues and/ or process development. In the case of these developing facilities, the Ministry's local offices play a key role in determining if and when a facility can continue operations.

Detailed requirements for reporting of shut downs, malfunctions and start ups can be expected to be included in the Certificates of Approval issued to municipal waste thermal treatment facilities.

4.0 SOURCE TESTING

4.1 General

Owners and operators of thermal treatment facilities, including those that burn materials/ by-products from thermal treatment of municipal waste, can expect to have emission testing requirements included in the Certificates of Approval for their facilities in order to determine compliance. Completion of testing in accordance with the Ontario Source Testing Code under maximum approved feed rates for the equipment will likely

be required first within six months of start up and annually thereafter, as a minimum, all subject to the Certificate of Approval issued for the facility. The frequency recommended in this guideline may be increased as appropriate on a case by case basis (large capacity, type of municipal waste, new technology etc.) as determined during the approval process.

The Director under section 9 of the EPA may also require that source testing be repeated in the event that the testing has not been carried out in accordance with conditions of the Certificate of Approval issued for the facility, the specific recommendations at the time of the acceptance of the pretest plan and/ or for any other reason that renders the test results unreliable in the opinion of the Director. Owners and operators should under no circumstances discard any test results and repeat the testing without prior written agreement with staff of the Ministry.

The Ministry typically requires, as a condition of approval, source testing for many other contaminants aside from the ones included in Tables 1 and 2. This will assist in the evaluation of the performance of the facility and verification of compliance with Ontario Regulation 419/05 and any other relevant regulations and/ or guidelines. List of typical test contaminants is included in Appendix 1 of this Guideline.

When a test parameter is not detected, the emission rate or concentration must be reported based on the detection limit for that parameter. This will ensure that the facilities strive towards use of low detection limits and that reported emissions are conservative.

In cases where municipal waste being thermally treated belongs to a narrow category of municipal waste with a known composition and characteristics, the Director under section 9 of the EPA, may omit the requirement for testing of a parameter that is known to be absent from the waste feed into the thermal treatment facility.

4.2 Reporting Dioxin and Furan Emissions

Source testing for compliance with the dioxin and furan limit shall be conducted by determining the rate of emission for all of the dioxin and furan congeners for which International Toxicity Equivalency Factors (I-TEFs) have been established by NATO/CCMS. These I-TEFs are used in calculating the overall concentration expressed as I-TEQ which must comply with the limit set in Table 1 or Table 2, as applicable. I-TEFs and the calculation methodology have been included in Appendix 1 of this guideline.

In determining the I-TEQ emission level, where the analytical results indicate that the amount of a particular dioxin or furan congener is less than the detection limit reported by the laboratory analyzing the source testing samples, the I-TEQ concentration of the particular dioxin or furan congener shall be calculated using the reported detection limit as the amount present for that congener. The reported detection limits are expected to be determined by the laboratory at the time that the source testing samples are analyzed based on analysis of appropriate replicate low level samples or blanks.

The Ministry also recommends dioxin-like PCBs to be included in source testing campaigns to assist in determining whether or not facilities are likely to comply with the dioxin and furan air standard proposed to be included in Ontario Regulation 419/05 and to plan for early action in the event of potential non-compliance. The proposed air standard for dioxins and furans is expressed as WHO²⁰⁰⁵TEQ, based on the developmental effects associated with exposure to dioxins, furans and dioxin-like PCBs.

4.3 Report on Source Testing

A report on the source testing performed in accordance with section 4 of this guideline, can be expected to be required as a condition of a Certificate of Approval. Such a report should contain all of the test data and information as required by the Ontario Source Testing Code and the Certificate of Approval issued to the facility.

5.0 DESIGN AND OPERATION

The objective of this section is to provide guidance on the design and operation of thermal treatment facilities in order to achieve an environmental performance that is comparable to the best in the world. This section also covers proper management of ash or other residue.

For a facility or equipment that combusts (burns) gases generated by thermal treatment of waste, minimum design and operating parameters for combustion temperature, residence time and combustion air distribution are recommended to provide guidance to proponents in designing a thermal treatment facility that will achieve high combustion efficiencies. However, it is emphasized that these requirements are not intended to restrict technology development or dictate the equipment selection. The Ministry will consider alternative systems and alternative operating conditions for approval provided that these systems are designed and operated to achieve the contaminant emission limits set out in Table 1. Proponents proposing to use technologies that deviate from recommendations in this guideline are expected to include detailed justification for any alternative operational limits or deviation from other recommendations in the application for a Certificate of Approval. Each such application will be evaluated based on its own merits.

The Ministry will evaluate the design and operating parameters of thermal treatment facilities during the review of applications for Certificates of Approval for these facilities. Detailed engineering drawings, specifications and calculations to support the design and operating parameters are required for the evaluation. Drawings are not expected to be construction drawings, but they should include details that are needed for determining whether or not the proposed facility is capable of complying with the emission limits and other requirements set out in this guideline and Ontario Regulation 419/05.

The requirements in Section 5.1 apply only to the portion of the thermal treatment facility that combusts gases or other materials/ by-products from thermal treatment of

municipal waste and include requirements for combustion temperature, combustion gas residence time, combustion air distribution, oxygen availability, gas-phase turbulence and mixing, and range of operation.

Other requirements are provided in Sections 5.2 to 5.4 and include requirements for continuous operation of air pollution control systems, ash management and organic content of ash, pressure control and emergency exhaust.

5.1 Recommendations for Combustion

5.1.1 Combustion Temperature

Combustion temperature in the equipment used to burn gases generated during thermal treatment of municipal waste is critical to achieving high-efficiency combustion and destruction of organic compounds.

The Ministry acknowledges that temperatures in the combustion chamber or zone of municipal waste incinerators and other combustion equipment will vary with the design. A minimum temperature of 1000°C is considered adequate to ensure high-efficiency combustion and destruction of products from thermal treatment of municipal waste. The equipment that is used, at least in part, to destroy organic compounds, including products of incomplete combustion, and to meet the organic matter and the carbon monoxide limits set out in Table 1, shall be capable of sustaining, on a continuous basis, a temperature that is 100°C degrees greater than the minimum required operating temperature. This capability to operate at a temperature of up to 1100°C is expected to provide an adequate safety margin as the actual operating temperature should always be more than 1000°C unless an alternative temperature is approved.

An auxiliary burner is expected to be incorporated into the design to ensure that the minimum operating temperature is maintained:

- at start-up before the commencement of the thermal treatment cycle, ie. before any waste is fed into the equipment;
- during shutdown until all thermal treatment of waste has ceased; and
- at all times when waste is being thermally treated.

5.1.2 Combustion Gas Residence Time

The Ministry recognizes that there are municipal waste thermal treatment facilities in operation throughout the world with a wide range of combustion gas residence times in the portion of the facility that combusts gases from thermal treatment of waste. A minimum residence time of one second in the combustion zone at the minimum combustion temperature specified in this guideline is anticipated to be sufficient for providing high-efficiency destruction of the chemical species that may be present in the gas stream entering the combustion zone or equipment.

It is acknowledged, however, that performance of a combustion system is dependent on the combination of the temperature and the residence time together with equipment design that may affect gas turbulence. Therefore a combustion temperature that is lower than 1000°C may be acceptable if the residence time is increased accordingly. Additionally, certain combustion equipment used to burn materials/ by-products from thermal treatment may not be designed to achieve the combustion temperature specified in this guideline but its use in selected applications has proven to result in good combustion of the compounds present in those applications. It is the responsibility of the proponent to justify the temperature-residence time combination being proposed for an incineration or other combustion system.

The residence time shall be calculated from the point where most of the combustion has been completed and the combustion temperature has fully developed. If air is introduced downstream of the burner flame front, residence time shall be calculated from the final air injection point to the location of the thermocouple that is used to verify combustion temperature. In some cases, such as large mass burn units, overall design review, including temperature profiles, may need to be carried out to determine the portion of the unit that is considered to be the combustion zone for the purposes of residence time calculations.

If a proponent is of the opinion that residence time within a certain combustion device is not relevant for compliance with the in-stack contaminant concentration limits set out in Table 1, the proponent is expected to provide a detailed rationale for the opinion, preferably with manufacturer's data, relevant test data and information on requirements in other jurisdictions for facilities similar to the one being proposed. An application for a Certificate of Approval for such a facility will be reviewed on a case by case basis.

5.1.3 Combustion Air Distribution

Combustion air systems shall be designed to control air distribution within the thermal treatment equipment and/ or the device that combusts gases generated during thermal treatment of municipal waste. Ideally, control systems shall have the capability of adjusting the distribution of combustion air in order to provide adequate mixing of the gases and the desired level of residual oxygen in the exhaust gases under all loading conditions. The Ministry recognizes that these systems vary widely.

5.1.4 Oxygen Availability

Lack of sufficient oxygen during combustion of any combustible material, including gases generated during thermal treatment of municipal waste, is a contributing factor to the discharge of products of incomplete combustion. Components of thermal treatment facilities shall be designed and operated to ensure that there is sufficient residual oxygen in the flue gases from the component used for combustion of gases from thermal treatment of waste. Availability of oxygen and ability to control the amount of oxygen are intended to minimize the discharge of products of incomplete combustion at all times when waste is being thermally treated. A sufficient level of residual oxygen in

the exhaust gases is critical with respect to meeting the organic matter and carbon monoxide limits set out in this guideline.

Thermal treatment facilities are typically expected to be designed and operated to provide an oxygen rich atmosphere in the combustion zone or dedicated piece of combustion equipment with residual oxygen level of at least six (6) percent by volume on dry basis in the undiluted gases leaving the combustion zone.

The Ministry acknowledges that the recommendation of six (6) percent residual oxygen may be too conservative for some designs, such as those where the gases from the solid waste are a product of a carefully controlled gasification process, followed by elaborate cleaning and refining of the gases to the point of the gases becoming a gaseous fuel with consistent quality rather than being a complex mixture of products of incomplete combustion. In order to establish an appropriate oxygen level, there will be a need to balance between energy recovery, emissions of oxides of nitrogen and the system's ability to deal with variations in waste feed quality. The composition of waste can vary significantly depending on factors such as the extent and type of industrial activity, seasonal activities and level of recycling, and so will the gases from the thermal treatment of that waste. It is also noted that a proposal may involve use of "engineered fuel", solid or gaseous, made from municipal waste that meets certain specifications and is therefore expected to be of more consistent quality. In this case, the combustion process may not be subject to great challenges and an oxygen level below six (6) percent may be acceptable.

5.1.5 Gas-Phase Turbulence and Mixing

The design and operation of a thermal treatment facility shall provide a high degree of gas-phase turbulence and mixing in the combustion zone. This can usually be achieved through appropriately located/directed air jets, changes of flue gas flow direction, baffling, and constriction of cross-sectional flue gas flow area.

5.1.6 Range of Operation

Municipal waste thermal treatment facilities shall be designed and operated to achieve the required temperature, residence time, oxygen availability and turbulence over the expected range of operation, taking into account feed rate variations, as well as ultimate analysis, heating value, ash and moisture content of the waste together with combustion air requirements and heat losses.

5.2 Continuous Operation of Air Pollution Control Systems

Air pollution control systems for thermal treatment facilities are expected to be designed to operate on a continuous basis whenever there is waste being processed in the thermal treatment facility. The design of the system should consider:

- conditions that could lead to an unscheduled shutdown of the air pollution control system or the entire facility;

- means of ameliorating such conditions; and
- means for system venting when there is a need to bypass the air pollution control equipment.

Control systems at a thermal treatment facility shall be designed to ensure the shutdown of the thermal treatment facility immediately upon an unscheduled shutdown of the air pollution control system in a manner that will minimize air emissions, unless the system allows redirection of flue gases into equipment that operates and provides control that is equivalent to the control provided by the equipment that was shut down. The control system shall also be designed to record pertinent information for subsequent reporting to the Ministry's local district office and for an assessment of the reasons for the shutdown and potential measures to prevent a recurrence.

5.3 Ash Management and Organic Content of Ash

Municipal waste thermal treatment facilities typically generate residues that are collected from various parts within the facility. One such residue, often referred to as bottom ash, is typically removed from the chamber, vessel or other equipment into which the municipal waste is introduced. Some designs offer a capability to vitrify (solidify into a glass-like substance) this residue. Residue can also be collected from equipment used for energy recovery from gases from thermal treatment and from air pollution control equipment (fly ash). Owners and operators of thermal treatment facilities are encouraged to consider beneficial use of any residues where possible.

Under Regulation 347, fly ash from an incinerator's energy recovery and pollution control system must be handled separately from the bottom ash generated in the zone where municipal waste is incinerated. Similarly, for other types of thermal treatment facilities, the fly ash should be kept separate from the bottom ash or any other residue. Thermal treatment facility operators are expected to test the ash and other residues in accordance with the conditions included in a Certificate of Approval issued under Part V of the EPA (waste approval) before the ashes and/ or residues are transferred from the site of the thermal treatment facility.

Testing of bottom ash involves determination of organic content in all cases to confirm that it meets the definition of incinerator ash set out in Regulation 347. The organic content in ash should be determined using Loss on Ignition testing on dry ash samples with ferrous metals absent or as otherwise required by conditions included in a Certificate of Approval. Owners and operators of municipal waste thermal treatment facilities are expected to develop a detailed protocol for sampling and analysis of residues that are to be tested. The protocol is expected to be periodically reviewed and amended as experience with the facility is gained and test results are available. The operation of a thermal treatment facility is expected to be controlled such that the organic content of the bottom ash is minimized to the greatest degree possible.

In accordance with Regulation 347 incinerator ash (bottom ash), as defined, resulting from the incineration of waste that is neither hazardous waste nor liquid industrial waste is not a hazardous waste and may be disposed of at a site that is approved to receive

solid non-hazardous waste. Owners and operators of thermal treatment facilities processing municipal waste are not required to carry out Toxicity Characteristic Leachate Procedure (TCLP) on the bottom ash that meets the definition of incinerator ash (i.e. has an organic content of less than 10%). Testing using TCLP, however, is required if the organic content exceeds 10% unless the bottom ash is to be disposed of at a waste disposal site approved to accept hazardous waste. In the absence of testing, the owners and operators must assume that the bottom ash is hazardous waste and handle it accordingly.

Fly ash from thermal treatment of municipal waste, on the other hand, is assumed to be hazardous waste unless otherwise proven. Therefore, if an operator of a thermal treatment facility wishes to classify the fly ash, or any other residue aside from bottom ash, as non-hazardous, the ash or other residue must be tested to determine if it is leachate toxic. The Ministry's testing protocol, TCLP, is referenced in Regulation 347 while the sampling procedure and results evaluation procedure is in the Ministry's publication "Protocol for Sampling and Evaluating Fly Ash from Non-Hazardous Solid Waste Incineration Facilities" October 1990 as may be amended.

5.4 Pressure Control and Emergency Exhaust

Thermal treatment facilities shall be designed to operate under negative pressure during all phases of operation so that gaseous products from the thermal treatment of waste do not leak out of the thermal treatment facility. The requirement for negative pressure does not apply to equipment that may be designed to operate under pressure. A Certificate of Approval issued for the thermal treatment facility will include conditions relating to abnormal operating conditions, shut down and cessation of waste feed during abnormal operating conditions as well as use of the emergency exhaust.

6.0 SPECIAL CONSIDERATIONS

6.1 Small Experimental Facilities

At times, proponents may wish to submit applications for experimental facilities to advance development of new technologies. When such facilities are intended to treat not more than 50 tonnes of municipal waste per year, the Ministry may not require compliance with all aspects of this guideline. Depending on the nature of the proposal, Certificates of Approval issued for experimental facilities may not include in-stack concentration limits and continuous monitoring as well as source testing requirements but they will limit the total waste throughput to not more than 50 tonnes during an approved one-year period.

It is noted however that if the results of the experiments are intended to support a future application for a Certificate of Approval for a thermal treatment facility, it will be necessary to gather data on emissions and operational parameters during the experimentation. Need for data requirements will be determined on a case-by-case basis during the review of the application for the experimental facility.

No Certificate of Approval will be issued to any facility, including an experimental facility, unless the applicant can demonstrate that the facility is capable of complying with Ontario Regulation 419/05 on a consistent basis.

6.2 Small Batch-Type Units in Remote Locations in Northern Ontario

While this Ministry does not promote the use of small batch-type thermal treatment facilities for the sake of convenience, it is recognized that such facilities are a good option for safe disposal of municipal waste in remote locations. In places such as mining/logging camps in northern Ontario, landfill may not be feasible and hauling of waste to off-site disposal is costly and generates transportation related emissions to the environment. Therefore, it may be appropriate to apply the intent of this guideline with common sense such that safe waste management does not become prohibitively expensive with no real benefits to or perhaps even to the detriment of the environment due to illegal dumping, use of burn barrels or other inappropriate waste disposal practices.

Candidates for relief from application of this guideline, namely from extensive monitoring and source testing requirements, include thermal treatment facilities that do not employ energy recovery and that discharge into the atmosphere at a temperature of at least 600^{oC} or that will not employ any pollution control device or other system component where gases from thermal treatment are maintained within the temperature range from 200^{oC} to 600^{oC}. Since the system components at the above facilities avoid the temperature range that is known to promote formation of dioxins and furans, their emissions are not expected to be an issue. Good combustion control is considered sufficient to minimize release of organics including dioxins and furans.

Units that may qualify for deviation from some of the requirements of this guideline are expected to be batch-type units with a daily design capacity of not more than three tonnes of municipal waste. They must be equipped with the manufacturer's recommended combustion and air pollution controls as well as basic continuous monitors, such as temperature, oxygen and carbon monoxide, and operated in accordance with the manufacturer's recommendations. Owners and operators of a batch-type unit can expect to be required, as a condition of approval, to carry out one-time source testing to determine compliance unless the proponent and/ or the manufacturer can provide satisfactory confirmation based on third-party testing and certification that the unit is capable of complying with the contaminant emission limits of this guideline when operated in accordance with the manufacturer's recommendations and with minimal requirement for operator attention.

If the proponent wishes to be relieved of the one-time source testing requirement, an application for a Certificate of Approval must be supported by a report on testing by a competent third party. Such a report must include full details of operation as well as sampling and analytical procedures in accordance with the Ontario Source Testing Code to allow staff of the Ministry to evaluate the findings of the third party.

6.3 Other Experimental Facilities

From time to time existing industrial facilities may wish to carry out experiments with municipal waste to determine its suitability as an alternative fuel. Applicability of the best practices suggested in this guideline will be determined on a case-by-case basis. Aside from the amount of municipal waste and nature of the experiments, the overall duration of the experiments will be considered when establishing the appropriate conditions of approval.

6.4 Protection of Environment

All applications for certificates of approval for all facilities will be reviewed in detail to ensure protection of environment, e.g. compliance with this guideline and the air standards set out in Ontario Regulation 419/05. It is noted that the limits for the parameters in this guideline are stringent and compliance with these in-stack limits is expected to result in compliance with the current air standards (at points of impingement) for those same parameters in Ontario Regulation 419/05.

7.0 APPROVAL OF THERMAL TREATMENT FACILITIES

7.1 Approvals for a site where municipal waste is received and thermally treated

The EPA requires that a proponent of a facility that thermally treats municipal waste apply for approval to install and operate the facility. A Certificate of Approval is required under section 9 of the EPA (air approval) for air and noise emissions. Additionally an approval under Part V of the EPA (waste approval) is required to deal with waste receiving, handling, storage and other waste management issues as well as financial assurance for the facility. Full details of the approval process are available in Guide for Applying for Approval (Air & Noise) and Guide for Applying for Approval of Waste Disposal Sites both of which are available for downloading on the Ministry's website.

Proponents must also determine if the Environmental Assessment Act (EAA) applies to the planned facility. Generally, a proposed thermal treatment facility that produces energy is subject to Environmental Screening Process under Ontario Regulation 101/07 (Waste Management Projects) under the EAA, but this may not always be the case (e.g. some exemptions may apply, such as for a manufacturing facility using not more than 100 tonnes of waste per day for its own energy needs). Also, the provisions of Ontario Regulation 116/01 (Electricity Projects) under the EAA do not apply to anything that is designated under Part II or III of Ontario Regulation 101/07. Proponents should review and be aware of the requirements in Ontario Regulations 101/07 and 116/01. It should be noted that, if a proposal is subject to the requirements of the EAA, no approvals under the EPA can be issued until all of the requirements under the EAA have been met.

7.2 Approvals for a site where materials/ by-products from thermal treatment of municipal waste are combusted

It is recognized that some thermal treatment facilities may generate materials/ by-products that may be proposed for use as fuel at other facilities located outside the generating site (i.e. at off-site facilities). In all such cases the requirement for an air approval, in accordance with the provisions of section 9 of the EPA, will apply.

In view of the definition of “municipal waste” in Regulation 347, solid materials/ by-products from thermal treatment of municipal waste are classified as municipal waste and therefore a waste approval under part V of the EPA is required if such materials/ by-products are combusted at an off-site facility.

The need for a waste approval under part V of the EPA for off-site facilities that burn liquid materials/ by-products generated through thermal treatment of municipal waste will be determined on a case-by-case basis taking into account factors such as the quality of the liquid material/ by-product.

Waste approval under part V of the EPA is not required for off-site combustion of gaseous materials/ by-products generated through thermal treatment of municipal waste.

7.3 Conditions of Approval

Certificates of Approval issued by the Ministry for thermal treatment facilities typically incorporate emission limits, and monitoring and operating requirements, based on the limits and criteria set out in this guideline. The certificate(s) may also incorporate other requirements specific to the location and the nature of the application for approval.

8.0 DEFINITIONS

The following definitions are used in this guideline:

Biomass:

Biomass has the same meaning as in Ontario Regulation 160/99 made under the Electricity Act, 1998.

Burner Flame Front:

The visible luminous front zone of the flame, formed by the burner, in which intense localized gas phase combustion occurs.

Combustion Air:

The air supplied to the incinerator for the burning of the waste and/or the fuel.

Combustion Zone:

Combustion zone means the space where gaseous products from incineration, incomplete combustion, gasification, pyrolysis or any other thermal treatment method of the waste itself, undergo a complex sequence of exothermic reactions with an oxidant, such as oxygen. More specifically, the combustion zone in a piece of equipment associated with a municipal waste thermal treatment facility is the space where the combustion gas temperature remains within the specified combustion temperature referenced in this guideline.

Congener:

Each different structurally related chemical compound from a distinct chemical family such as the polychlorinated dibenzo-*p*-dioxins, polychlorinated dibenzofurans, polychlorinated biphenyls or other chemical group is referred to as a congener.

Dioxins:

Dioxins mean polychlorinated dibenzo-*p*-dioxins.

Director:

Director means any Ministry employee appointed in writing by the Minister pursuant to section 5 of the EPA as a Director for the purposes of section 9 and/or Part V of the EPA.

Experimental facility:

Experimental facility means a thermal treatment facility which is not operated commercially and/ or which does not provide a waste disposal service for a municipality, industry or a person but is operated to test feasibility of a system or to experiment with operating parameters or various pieces of auxiliary equipment

in order to develop or improve a technology in accordance with a defined experimentation plan that has clear objectives for the experiments. An experimental facility is not expected to operate on an ongoing basis but periodically and not longer than one year.

Feed Rate:

The weight of waste introduced or fed into the thermal treatment equipment per unit time.

Fly Ash (as defined in Regulation 347):

Fly ash means particulate matter removed from combustion flue gases.

Furans:

Furans mean polychlorinated dibenzofurans.

Gas-Phase Turbulence:

Turbulence in the combustion gases, denoting an irregular fluctuation (i.e. mixing and eddying) superimposed on the main stream. Good mixing of the products of incomplete combustion (primarily carbon monoxide and hydrocarbons) and of the combustion air is promoted by a highly turbulent flow of the gases.

Incinerator Ash (as defined in Regulation 347):

Incinerator ash means the ash residue, other than fly-ash, resulting from incineration where the waste is reduced to ashes containing by weight less than 10 per cent of combustible materials.

Level of Quantification (LoQ)

Level of quantification means, in respect of a substance, the lowest concentration that can be accurately measured using sensitive but routine sampling and analytical methods.

Loss on Ignition:

Loss on Ignition means an analytical test to determine the amount of combustible carbonaceous material in a sample, such as bottom ash.

Ministry:

Ministry means the Ontario Ministry of the Environment.

Municipal Waste (as defined in Regulation 347):

Municipal waste means,

- (a) any waste, whether or not it is owned, controlled or managed by a municipality, except,
 - (i) hazardous waste,
 - (ii) liquid industrial waste, or
 - (iii) gaseous waste, and
 - (iv) solid fuel, whether or not it is waste, that is derived in whole or in part from the waste included in clause (a)

Municipal Waste Thermal Treatment Facility:

Municipal waste thermal treatment facility means all pieces of equipment, mechanisms and things necessary for operation and control of a thermal treatment process, including the structure, vessel or thing in which thermal treatment of municipal waste takes place as well as all associated pollution control and/or gas cleaning equipment, energy recovery equipment, all equipment used for process control and/or monitoring and all auxiliary equipment necessary for proper functioning of all of the main pieces of equipment.

Negative Pressure:

A pressure that is less than ambient pressure.

Operating Parameters:

The variables in thermal treatment process that impact the performance and operation of a thermal treatment facility. These may include: the waste feed rate, composition, and heating value; combustion air feed rate(s); and heat production and losses.

Reference conditions:

Reference flue gas conditions are defined as follows:

- Temperature 25 °C
- Pressure 101.3 kPa
- Oxygen content 11%
- Water content nil (dry conditions)

Relative Accuracy Test:

Relative Accuracy Test has the same meaning as in Environment Canada document "Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation" (Report EPS 1/PG/7, as amended in December 2005 or later).

Stack:

Stack means the physical structure through which contaminants generated during thermal treatment of municipal waste are discharged into the natural environment. A stack to which in-stack contaminant concentration limits apply includes the main stack and it may also include a by-pass stack or an emergency vent.

Thermal Treatment (as defined in Regulation 347):

Thermal treatment includes incineration, gasification, pyrolysis or plasma arc treatment.

Thermal Treatment Facility:

For the purposes of this guideline thermal treatment facility includes all vessels and equipment at the site where thermal treatment of waste is carried out.

Toxicity Characteristic Leaching Procedure (as defined in Regulation 347):

Toxicity Characteristic Leaching Procedure means the Toxicity Characteristic Leaching Procedure, Method 1311, that appears in United States Environmental Protection Agency Publication SW-846 entitled "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", as amended from time to time, or a test method that the Director has approved in writing as equivalent.

Woodwaste (as defined in Regulation 347):

Woodwaste means waste,

- (a) that is wood or a wood product, including tree trunks, tree branches, leaves and brush,
 - (b) that is not contaminated with chromated copper arsenate, ammoniacal copper arsenate, pentachlorophenol or creosote, and
 - (c) from which easily removable hardware, fittings and attachments, unless they are predominantly wood or cellulose, have been removed,
- but does not include,
- (d) an upholstered article, or
 - (e) an article to which a rigid surface treatment is affixed or adhered, unless the rigid surface treatment is predominantly wood or cellulose.

9.0 ABBREVIATIONS

CCME	Canadian Council of Ministers of the Environment
CCMS	[NATO] Committee on Challenges to Modern Society
I-TEF	International Toxic Equivalency Factor derived for each dioxin and furan congener by comparing its toxicity to the toxicity of 2,3,7,8 tetrachloro dibenzo-p-dioxin, as recommended by the NATO CCMS in 1989 and adopted by Canada in 1990
I-TEQ	International Toxic Equivalent of dioxins and furans calculated using the I-TEFs, as recommended by the NATO CCMS in 1989 and adopted by Canada in 1990
kPa	kilopascals
mg/Rm ³	milligrams per reference cubic metre
NATO	North Atlantic Treaty Organization
O ₂	oxygen
pg/Rm ³	picograms per reference cubic metre
ppmdv	parts per million by dry volume
R	reference conditions
µg/Rm ³	micrograms per reference cubic metre
WHO ²⁰⁰⁵ TEQ	Toxic Equivalent of dioxins and furans calculated using the toxic equivalency factors (TEFs) derived for each dioxin and furan congener by comparing its toxicity to the toxicity of 2,3,7,8 tetrachloro dibenzo-p-dioxin, as recommended by the World Health Organization (WHO) in 2005

APPENDIX 1

TYPICAL TEST CONTAMINANTS AT MUNICIPAL WASTE THERMAL TREATMENT FACILITIES

Measured in stack unless otherwise noted

Gases:

Hydrogen Chloride
Hydrogen Fluoride
Oxides of Nitrogen expressed as Nitrogen Dioxide
Sulphur Dioxide
Carbon Monoxide*
Oxygen**
Total Hydrocarbons***
Carbon Dioxide

* measured in stack as well as in the undiluted gases exiting the chamber or zone where final combustion of gases generated through thermal treatment of municipal waste has taken place (operational parameter usually monitored continuously)

** measured in stack as well as in the undiluted gases exiting the chamber or zone where final combustion of gases generated through thermal treatment of municipal waste has taken place (operational parameter measured continuously)

*** expressed as methane on wet basis and measured in the undiluted gases exiting the chamber or zone where final combustion of gases generated through thermal treatment of municipal waste has taken place (operational parameter; may be measured continuously)

Particulate Matter

Total suspended particulate matter, including condensables

Metals:

Aluminum	Antimony
Arsenic	Barium
Beryllium	Boron
Cadmium	Calcium
Chromium	Cobalt
Copper	Fluorides
Iron	Lead
Lithium	Magnesium
Manganese	Mercury
Molybdenum	Nickel
Phosphorous	Selenium
Silicon	Silver
Sodium	Strontium
Thallium	Tin
Titanium	Vanadium
Zinc	

Chlorobenzenes (Dioxin/ furan precursors)

Monochlorobenzene (MCB)
1,2-Dichlorobenzene (1,2-DCB)
1,3-Dichlorobenzene (1,3-DCB)
1,4-Dichlorobenzene (1,4-DCB)
1,2,3-Trichlorobenzene (1,2,3-TCB)
1,2,4-Trichlorobenzene (1,2,4-TCB)
1,3,5-Trichlorobenzene (1,3,5-TCB)
1,2,3,4-Tetrachlorobenzene (1,2,3,4-TeCB)
1,2,3,5-Tetrachlorobenzene (1,2,3,5-TeCB)
1,2,4,5-Tetrachlorobenzene (1,2,4,5-TeCB)
Pentachlorobenzene (PeCB)
Hexachlorobenzene (HxCB)

Chlorophenols (Dioxin/ furan precursors)

2-monochlorophenol (2-MCP)
3-monochlorophenol (3-MCP)
4-monochlorophenol (4-MCP)
2,3-dichlorophenol (2,3-DCP)
2,4-dichlorophenol (2,4-DCP)
2,5-dichlorophenol (2,5-DCP)
2,6-dichlorophenol (2,6-DCP)
3,4-dichlorophenol (3,4-DCP)
3,5-dichlorophenol (3,5-DCP)
2,3,4-trichlorophenol (2,3,4-T ₃ CP)
2,3,5-trichlorophenol (2,3,5-T ₃ CP)
2,3,6-trichlorophenol (2,3,6-T ₃ CP)
2,4,5-trichlorophenol (2,4,5-T ₃ CP)
2,4,6-trichlorophenol (2,4,6-T ₃ CP)
3,4,5-trichlorophenol (3,4,5-T ₃ CP)
2,3,4,5-tetrachlorophenol (2,3,4,5-T ₄ CP)
2,3,4,6-tetrachlorophenol (2,3,4,6-T ₄ CP)
2,3,5,6-tetrachlorophenol (2,3,5,6-T ₄ CP)
Pentachlorophenol (PeCP)

Co-Planar PCBs (Dioxin-like PCBs)

PCB-077 (3,3',4,4'-TCB)
PCB-081 (3,4,4',5-TCB)
PCB-105 (2,3,3',4,4'-PeCB)
PCB-114 (2,3,4,4',5-PeCB)
PCB-118 (2,3',4,4',5-PeCB)
PCB-123 (2',3,4,4',5-PeCB)
PCB-126 (3,3',4,4',5-PeCB)
PCB-156 (2,3,3',4,4',5-HxCB)
PCB-157 (2,3,3',4,4',5'-HxCB)
PCB-167 (2,3',4,4',5,5'-HxCB)
PCB-169 (3,3',4,4',5,5'-HxCB)
PCB-189 (2,3,3',4,4',5,5'-HpCB)

Polycyclic Organic Matter

Acenaphthylene	Acenaphthene
Anthracene	Benzo(a)anthracene
Benzo(b)fluoranthene	Benzo(k)fluoranthene
Benzo(a)fluorene	Benzo(b)fluorene
Benzo(ghi)perylene	Benzo(a)pyrene
Benzo(e)pyrene	2-chloronaphthalene
Chrysene	Coronene
Dibenzo(a,c)anthracene	9,10 - Dimethylantracene
7,12 - Dimethylbenzo(a)anthracene	Fluoranthene
Fluorene	Indeno(1,2,3 - Cd)pyrene
3 - Methylcholanthrene	2 - Methylantracene
2 - Methylnaphthalene	1 - Methylnaphthalene
9 - Methylphenanthrene	1 - Methylphenanthrene
Perylene	Naphthalene
Picene	Phenanthrene
Tetralin	Pyrene
Dibenzo(a,h)anthracene	Triphenylene
Quinoline	Dibenzo(a,e)pyrene
O-terphenyl	Biphenyl
P-terphenyl	M-terphenyl

Volatile Organic Matter

Acetaldehyde	Acetone
Acrolein	Benzene
Bromodichloromethane	Bromoform
Bromomethane	Butadiene, 1,3 -
Butanone, 2 -	Carbon Tetrachloride
Chloroform	Cumene
Dibromochloromethane	Dichlorodifluoromethane
Dichloroethane, 1,2 -	Dichloroethene, Trans - 1,2 -
Dichloroethene, 1,1 -	Dichloropropane, 1,2 -
Ethylbenzene	Ethylene Dibromide
Formaldehyde	Mesitylene
Methylene Chloride	Styrene
Tetrachloroethene	Toluene
Trichloroethane, 1,1,1 -	Trichloroethene
Trichloroethylene, 1,1,2 -	Trichlorofluoromethane
Trichlorotrifluoroethane	Vinyl Chloride
Xylenes, M-, P- and O-	

Dioxins and Furans

Congeners listed in Table A below should be tested and the results used to calculate the toxic equivalent using the International Toxic Equivalency Factors (I-TEFs) as indicated in the table.

In order to calculate a concentration that reflects the overall toxicity of the dioxin and furan emissions from a source, I-TEFs are applied to 17 dioxins and furan congeners of concern set out in Column A of Table A. The most toxic of all dioxin and furan congeners is 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin) and therefore its I-TEF is identified as 1.0 in Column B of Table A. The toxicity of the other dioxin and furan congeners is identified in Column B of Table A relative to 2,3,7,8-TCDD. For instance, 2,3,4,7,8-Pentachlorodibenzofuran is half as toxic as 2,3,7,8-TCDD and therefore its I-TEF is 0.5.

The actual toxic equivalent (TEQ; to be inserted in Column D) of each congener in relation to 2,3,7,8-TCDD is calculated by multiplying the measured concentration of the congener (to be inserted in Column C) by the I-TEF of that congener (set out in Column B). The measured concentration to be inserted in Column C is the concentration that has been calculated based on sampling and analysis of a gas stream as part of a source testing campaign.

The total toxic equivalent of dioxins and furans discharged in the gas stream from a source is then obtained by summing up all of the individual TEQ values in Column D for each congener of concern in Column A as shown at the bottom of Column D (Total Toxicity Equivalent).

Compliance with the stack concentration limit for dioxin and furan emissions is achieved if the calculated Total Toxic Equivalent is less than the limit set out in the Certificate of Approval (the toxic equivalent of dioxins and furans in the undiluted gases at the outlet of the combustion source). A similar approach shall be used to assess whether or not the measured emissions, as applied in a dispersion model, comply with the point of impingement concentration limit for dioxins and furans.

Table A			
Dioxin and Furan Congeners of Concern	International Toxic Equivalency Factors (I-TEF's)	Concentration pg/m3 (sampled and analysed)	Toxic Equivalent (TEQ) pg I-TEQ/m3
A	B	C	D (D = B x C)
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.0		
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	0.5		
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1		
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1		
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1		
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01		
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	0.001		
2,3,7,8-Tetrachlorodibenzofuran	0.1		
2,3,4,7,8-Pentachlorodibenzofuran	0.5		
1,2,3,7,8-Pentachlorodibenzofuran	0.05		
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1		
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1		
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1		
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1		
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01		
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01		
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	0.001		
Total Toxic Equivalent			





PLEASE NOTE

This document, prepared by the [Legislative Counsel Office](#), is an office consolidation of this regulation, current to August 7, 2004. It is intended for information and reference purposes only.

This document is ***not*** the official version of these regulations. The regulations and the amendments printed in the [Royal Gazette](#) should be consulted to determine the authoritative text of these regulations.

For more information concerning the history of these regulations, please see the [Table of Regulations](#).

If you find any errors or omissions in this consolidation, please contact:

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CHAPTER E-9

ENVIRONMENTAL PROTECTION ACT

AIR QUALITY REGULATIONS

Pursuant to section 25 of the *Environmental Protection Act* R.S.P.E.I. 1988, Cap. E-9, Council made the following regulations:

1. In these regulations

Definitions

(a) “Act” means the *Environmental Protection Act* R.S.P.E.I. 1988, Cap. E-9; Act

(b) “air” means the air surrounding the earth, but does not include air contained within a building or pressurized containers, or confined under the surface of the earth; air

(c) “biomedical waste” means waste that is generated by human or animal health care facilities and clinical testing or research laboratories, including biomedical waste

- (i) human and animal anatomical waste,
- (ii) infectious non-anatomical waste,
- (iii) needles, sharp instruments and similar waste, and
- (iv) chemical and pharmaceutical waste,

but does not include waste from animal husbandry or household in origin, or generated in the food production, general building maintenance and office administration of such facilities or laboratories;

(d) “fuel-burning equipment” means any equipment, apparatus, device, mechanism or structure that burns solid, liquid or gaseous fuel for the purpose of vehicle transportation, heating, drying, generating power, processing steam or any combination thereof; fuel-burning equipment

(e) “ground level” means all that portion of the atmosphere beginning at one metre above the surface of the earth and extending vertically upwards for a distance of ten metres; ground level

(f) “hazardous substance” means any material that may pose a substantial threat or potential hazard to human health or the environment and includes those substances named in the Priority Substances List made under the *Canadian Environmental Protection Act* R.S.C. 1985 (4th Supp.), c. 16; hazardous substance

(g) “incinerator” means any equipment, apparatus, device, mechanism or structure that is designed to incinerate waste, and that incinerator

	is capable of controlling the combustion temperature, the degree of gaseous mixing and the length of time that combustion gases reside in the incinerator;
industrial source	(h) “industrial source” means any facility, operation, activity or equipment but does not include fuelburning equipment or incinerators;
permit	(i) “permit” means an authority in writing, issued by the Minister pursuant to the Act or these regulations, to operate an undertaking;
waste	(j) “waste” means solid, liquid or gaseous waste and includes used lubricating oil. (EC377/92)
Offence	2. (1) Subject to subsection 3(1), no person shall discharge a contaminant into the air from any industrial source, incinerator or fuel-burning equipment without a permit.
<i>Idem</i>	(2) Subject to subsection 3(1), no person shall discharge a contaminant into the air from an industrial source, incinerator or fuel-burning equipment which causes a concentration in the ambient air which is greater than the maximum concentration specified in a permit.
Determination of ambient air contaminant level	(3) Maximum ambient air contaminant levels will be determined (a) based on ground level concentration standards set out in Schedule A; or (b) based on such factors as may be determined by the Minister. (EC377/92)
Exemptions	3. (1) In subsection 2(1) or (2), industrial source, incinerator or fuel-burning equipment, does not include (a) motor vehicles, boats, aircraft and rail locomotives; (b) equipment used on agricultural lands for seeding, harvesting, fertilizing or controlling pests and weeds or equipment used on forestry lands for forest management; (c) a fire for the purpose of prevention or control of fires or the training of persons for fire fighting; (d) the burning of brush for the purpose of clearing land for cultivation, a roadway, rail line, pipeline or any other right-of-way; (e) a fire for the purpose of burning weeds or for forest management treatments; (f) fuel-burning equipment used for the purpose of domestic comfort heating, recreation, or food preparation; (g) fuel-burning equipment using fuel with a total sulphur content of less than 0.7% by weight; or (h) a plant or operation for the grinding, mixing, drying, or dehydrating of primary agricultural products where

- (i) the plant or operation burns fuel with a sulphur content of less than 0.7%, or
- (ii) any emissions from the plant or operation do not contain contaminants.

(2) Nothing in this section affects any requirement for a permit under the *Fire Prevention Act* R.S.P.E.I. 1988, Cap. F-11. (EC377/92)

Application, *Fire Prevention Act*

4. (1) Every application for a permit or renewal of a permit, to operate an industrial source, incinerator or fuel-burning equipment shall

- (a) be in the form set out in Schedule B with all the applicable information required thereunder;
- (b) be signed by the applicant; and
- (c) be accompanied by a fee in the amount required by section 4.1.

Permit application

(2) The applicant shall provide the Minister such additional information as the Minister may require. (EC377/92; 639/93; 161/04)

Information

4.1 (1) The fee payable for an application for an initial permit under section 4 or 6 shall be

Initial permit

- (a) made payable to the Provincial Treasurer;
- (b) based on reasonable projections of fuel consumption made by the applicant and acceptable to the Minister; and
- (c) in the amount as set out in Schedule D; and

(2) The application fee for a permit or a renewal of a permit shall be in the amount as set out in Schedule D. (EC161/04; 423/04)

Fees for permit

5. (1) When an application for a permit containing the information required by section 4 has been received, the Minister shall either

- (a) issue a permit authorizing the operation of the industrial source, incinerator, fuel-burning equipment, as the case may be, subject to any terms and conditions that the Minister considers appropriate; or
- (b) refuse to issue a permit by written notice to the applicant indicating reasons for the refusal.

Issue or refusal of permit

(2) The terms and conditions imposed under subsection (1) may be any or all of those set out in Schedule C.

Terms

(3) A permit issued under this section expires 12 months after the date of issue and may be renewed under section 4.

Expiry of permit

(3.1) For the avoidance of doubt, all permits issued prior to the coming into force of this subsection expire on the earlier of

Expiry of earlier permits

- (a) the expiry date stated in the permit; and
- (b) the date that is 12 months from the date this subsection comes into force.

Alteration of terms	<p>(4) The Minister may, at any time, after issuing a permit revoke the permit or impose additional terms or alter the terms and conditions of the permit, where the Minister believes on reasonable and probable grounds that continued operation of the industrial source, incinerator or fuel-burning equipment, is or may be</p> <ul style="list-style-type: none">(a) injurious to the health or safety or comfort of the public;(b) injurious or damaging to property, plant or animal life;(c) an interference with normal business;(d) obnoxious to the public; or(e) a threat to environmental health for any other reason.
Sale, etc.	<p>(5) If an industrial source, incinerator or fuel-burning equipment is sold, leased or otherwise disposed of, the permit in respect thereof expires immediately on the date of the sale, lease or other disposition. (EC377/92; 161/04)</p>
Renewal	<p>6. A permit may be renewed if</p> <ul style="list-style-type: none">(a) the application for renewal of a permit includes<ul style="list-style-type: none">(i) the existing permit number,(ii) all details respecting any changes in the documentation and information with respect to the existing permit as outlined in Schedule B,(iii) the renewal fee in the amount required by section 4.1, and(iv) any other information required by the Minister; and(b) the application for renewal is filed with the Minister at least 30 days prior to the expiration of a permit. (EC377/92; 639/93; 161/04)
Accidental or emergency release or discharge	<p>7. Where any accidental, emergency or unauthorized release or discharge of a contaminant into the air occurs the person in charge of the undertaking which caused the release or discharge shall immediately inform the Canadian Coast Guard at telephone number 1-800-565-1633, or such other number as may be listed, and within seven calendar days of the occurrence, submit a written report to the Minister specifying</p> <ul style="list-style-type: none">(a) the date and time of the release or discharge;(b) the duration of the release or discharge;(c) the composition of the release or discharge showing<ul style="list-style-type: none">(i) the concentration of air contaminants,(ii) the emission rate, and(iii) the total amount, by weight;(d) a description of the circumstances leading to the release or discharge;(e) the steps and procedures taken to control the release or discharge, as well as those taken to prevent similar releases or discharges in the future; and

(f) the steps and procedures taken to clean up the release or discharge. (EC377/92)

8. (1) No person shall burn, except where authorized by and in accordance with a valid and subsisting permit the following materials: Prohibited burning

- (a) used lubricating oil;
- (b) hazardous substances;
- (c) biomedical waste;
- (d) motor vehicle tires;
- (e) animal or human cadavers;
- (f) railway ties and other wood treated with wood preservatives;
- (g) waste materials from building or construction sites, or resulting from building demolition, unless permitted under the *Fire Prevention Act*;
- (h) trash, garbage, litter or other waste from commercial, industrial or municipal operations;
- (i) materials containing rubber or plastic;
- (j) spilled oil or oil production by-products except as may be required for the purposes of forest management or fire suppression treatment;
- (k) materials disposed of as part of reclamation operations; or
- (l) animal manure.

(2) No person shall burn or permit to be burned any waste, garbage or litter at a public disposal site, except where authorized by the Minister in writing. Idem, public disposal site

(3) No person shall burn or permit to be burned in any industrial source, fuel-burning equipment or incinerator, fuel or waste which the source, equipment or incinerator was not designed to burn. Idem

(4) No person shall burn or permit to be burned in any industrial source, fuel-burning equipment or incinerator, fuel or waste at a greater rate than that rate for which the source, equipment or incinerator was designed. (EC377/92) Idem

9. (1) No person shall, without a permit, store, handle, use or transport any solid, liquid or gaseous material or substance in such a manner that a contaminant is discharged into the air. Storage, etc.

(2) Subsection (1) does not apply to the storage, handling or use of any solid, liquid or gaseous material or substance for domestic or transportation purposes. (EC377/92) Exception

10. Any person who violates any provision of these regulations or fails to comply with any condition of a permit or fulfil any obligation imposed on him by these regulations is guilty of an offence and is liable on Offence, penalty

summary conviction to the penalties specified in section 32 of the Act.
(EC377/92)

SCHEDULE A**AMBIENT AIR CONTAMINANT GROUND
LEVEL CONCENTRATION STANDARDS**

Contaminant (1)	Maximum Allowable Average Concentrations For Applicable Time Period (2)			
	1 Hour	8 Hours	24 Hours	Annual
Carbon Monoxide	35 mg/m ³	15 mg/m ³		
Hydrogen Sulphide	15 µg/m ³		5 µg/m ³	
Sulphur Dioxide	900 µg/m ³		300 µg/m ³	60 µg/m ³
Nitrogen Dioxide	400 µg/m ³			100 µg/m ³
Total Suspended Particulates			120 µg/m ³	70 µg/m ³ *

* Geometric Mean

(1) Sampling will be in a manner and location specified by the Minister

(2) The values shown in this Schedule are the highest air contaminant concentrations which are normally allowed in the ambient air at ground level near industrial sources, incinerators and fuel burning equipment.

(EC377/92)

SCHEDULE B**APPLICATION FOR A PERMIT TO OPERATE AN INDUSTRIAL SOURCE,
INCINERATOR OR FUEL-BURNING EQUIPMENT**

Facility Information

Business Name:

Contact Person:

Mailing Address:Telephone:

Province:Postal Code:

Location:Property Tax #:

☐ Industrial Source☐ Existing Operation☐ Incinerator☐ New Operation☐ Fuel-burning Equipment☐ Alteration to existing operation

Signature of Applicant

Date:

Site Information

(1) A map or maps of the area within 500 metres of the land on which the undertaking is located or is proposed to be located showing

- (a) the topography of the area, including land contours;
- (b) the locations and description of buildings in the area;
- (c) the property boundaries; and
- (d) the land use of the area.

Plan

(2) A plan of the site on which the industrial source, incinerator or fuel-burning equipment is located showing

- (a) the exact or proposed location of the processing, manufacturing, fuel-burning, drying, storage or other equipment;
- (b) the points or areas of emission of all contaminants and their proposed elevation;
- (c) the location and description, including dimensions, of all buildings on the site; and
- (d) the location of all air contaminant control equipment.

*Emissions
Information*

(3) Specific information with respect to the industrial source, incinerator or fuel-burning equipment including

- (a) an overall description of the process, the expected production capacity, the maximum design production capacity and the hours of operation on a daily as well as an annual basis;
- (b) a detailed description of the fuel-burning, manufacturing, drying or other sub-processes which directly result in the emission of air contaminants;
- (c) a description and the amounts of raw materials, chemicals or other processing materials that are used;
- (d) the size and capacity of the major pieces of processing equipment;
- (e) the size, capacity, and design efficiency and description of the air contaminant control equipment;
- (f) the expected operational availability and the normal or expected preventive maintenance requirements for the air contaminant control equipment;
- (g) an overall flow diagram showing all major process equipment and expected flow rates, temperatures, pressures or other process operating variables which are relevant to the emission of air contaminants;
- (h) the composition, volumetric flow rate, velocity and temperature of every discharge to the air under normal and maximum production conditions;
- (i) the mass rate of release into the ambient air of all air contaminants on a daily as well as an annual basis, under normal and maximum production conditions;

- (j) information as to whether the composition of any discharge to the air or the release rate of any air contaminant will vary under different production rates, during start up, shut down or upset conditions;
 - (k) the calculated ground level concentration at the source property boundary of all air contaminants released under normal and maximum production conditions;
 - (l) a description of the procedures that will be followed to prevent or minimize the discharge of air contaminants in the event of a power failure, a malfunction of the air contaminant control equipment or a processing equipment failure;
 - (m) the proposed method and frequency of measuring air contaminant emission rates, including the procedures to be used;
 - (n) the proposed method and frequency of ambient air monitoring including the equipment, the analytical procedures to be used and the location of ambient air monitoring systems; and
 - (o) a materials balance which includes the following items:
 - (i) raw materials, chemicals and any other processing materials,
 - (ii) finished products and by-products, and
 - (iii) contaminants emitted respectively to air, land and water.
- (4) Specific information about an incinerator including
- (a) the type of undertaking to be served by the incinerator;
 - (b) the type and quantity of material to be incinerated on a daily and annual basis;
 - (c) the intended manner and frequency of operation of the incinerator;
 - (d) specification as to
 - (i) the size and capacity of the incinerator,
 - (ii) the method of charging the material into the incinerator,
 - (iii) the type and size of grate or hearth,
 - (iv) the maximum operating temperature,
 - (v) the provisions made for supplying fresh air for combustion, and
 - (vi) the retention time of gases in the combustion chambers,
 - (vii) the stack dimensions;
 - (e) plans and specifications for the proposed incinerator.
- (EC377/92)

Specific information

SCHEDULE C**TERMS AND CONDITIONS**

A permit may contain terms and conditions

- (a) requiring the operation of any equipment designed to control or eliminate the discharge of an air contaminant;
- (b) requiring that equipment designed to control or eliminate the discharge of an air contaminant be operated in a specified manner or at a specified minimum control efficiency;
- (c) requiring a specified level of maintenance or inspection of equipment designed to control or eliminate the discharge of an air contaminant;
- (d) specifying limits on the rate of emission or the total amounts of an air contaminant released to the ambient air;
- (e) specifying the maximum ambient air concentrations of an air contaminant in the immediate area of the industrial source;
- (f) requiring measurements of the rate or emission or the concentration of an air contaminant in the ambient air;
- (g) requiring the measurement or monitoring of meteorological conditions that have a bearing on the dispersion of an air contaminant;
- (h) requiring the collection of information, statistics or other data regarding operating conditions or circumstances that have a bearing on the emission of an air contaminant;
- (i) requiring the disposal of any wastes generated as a result of the control of an air contaminant in a manner or in a location acceptable to the Minister and consistent with any other Act or regulations governing the disposal of wastes;
- (j) specifying the nature, content and timing of reports to be submitted with respect to any condition contained in the permit;
- (k) requiring or specifying any other matter or thing that the Minister considers advisable in the circumstances.

(EC377/92)

SCHEDULE D**FEE STRUCTURE****Part 1 Fuel-Burning Equipment (Heavy Fuel Oil Users)**

Class 1A source, if the source has a permitted rate of release of one or more of the following:

- (a) sulphur dioxide > 1,000 tonnes per year, or
- (b) particulate matter > 1,000 tonnes per year

\$42,000 per year

Class 1B source, if the source has a permitted rate of release of one or more of the following:

- (a) sulphur dioxide > 500 tonnes per year, but \leq 1,000 tonnes per year
- (b) particulate matter > 500 tonnes per year, but \leq 1,000 tonnes per year

\$15,000 per year

Class 2 source, if the source has a permitted rate of release of one or more of the following:

- (a) sulphur dioxide > 250 tonnes per year, but \leq 500 tonnes per year
- (b) particulate matter > 250 tonnes per year, but \leq 500 tonnes per year

\$5,000 per year

Class 3 source, if the source has a permitted rate of release of one or more of the following:

- (a) sulphur dioxide > 100 tonnes per year, but \leq 250 tonnes per year
- (b) particulate matter > 100 tonnes per year, but \leq 250 tonnes per year

\$2,000 per year

Class 4 source, if the source has a permitted rate of release of one or more of the following:

- (a) sulphur dioxide > 10 tonnes per year, but \leq 100 tonnes per year
- (b) particulate matter > 10 tonnes per year, but \leq 100 tonnes per year

\$500 per year

Class 5 source, if the source has a permitted rate of release of one or more of the following:

- (a) sulphur dioxide \leq 10 tonnes per year
- (b) particulate matter \leq 10 tonnes per year

\$100 per year

Part 2 Incinerators

- 1. Quantity of material incinerated \leq 500 tonnes per year: \$100 per year
- 2. Quantity of material incinerated $>$ 500 tonnes per year: \$100 per year plus \$10 for each additional 100 tonnes (or fraction thereof) of material incinerated

Part 3 Industrial Sources (Asphalt Plants and Used Oil Burners)

- 1. \leq 15,000 litres fuel burned per year, \$100 per year
 - 2. $>$ 15,000 litres fuel burned per year, \$100 per year plus \$10 for each additional 15,000 litres (or fraction thereof) of fuel burned
- (EC423/04)

chapter Q-2, r. 19

Regulation respecting the landfilling and incineration of residual materials

Environment Quality Act

(chapter Q-2, ss. 31, 31.69, 57, 64.1, 70, 115.27, 115.34, 124.0.1 and 124.1)

CHAPTER I

DEFINITIONS, SCOPE OF APPLICATION AND PURPOSE

1. For the purposes of this Regulation,

(1) “fly ash” means particulate matter entrained in and carried by the combustion gases from a residual materials incineration facility and collected by a flue gas cleaning system or an energy recovery system, and includes residue generated by those systems that contains fly ash;

(2) “landfilling” means the final deposit of residual materials onto or into land;

(3) “operator” includes a person having the charge, management or control of a disposal facility;

(4) “watercourse or body of water” includes ponds, marshes and swamps, but excludes intermittent watercourses, peat bogs and ditches. The relative distance to a watercourse or body of water is measured from the high-water mark as defined in the Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains (chapter Q-2, r. 35) adopted pursuant to section 2.1 of the Environment Quality Act (chapter Q-2).

O.C. 451-2005, s. 1.

2. This Regulation applies to the following residual materials disposal facilities:

(1) landfills in the following classes, governed respectively by Divisions 2 to 6 of Chapter II:

- engineered landfills;
- trench landfills;
- northern landfills;
- construction or demolition waste landfills;
- remote landfills;

- (2) incineration facilities governed by Chapter III.

Residual materials transfer stations are governed by Chapter IV of this Regulation.

O.C. 451-2005, s. 2.

3. The purpose of this Regulation is to prescribe which residual materials may be accepted at the facilities referred to in section 2, the conditions subject to which the facilities are to be sited and operated and the conditions that apply to their closure and post-closure management.

O.C. 451-2005, s. 3.

CHAPTER II

LANDFILLS

DIVISION 1

GENERAL

4. The following may not be disposed of in a landfill to which this Chapter applies:

- (1) residual materials generated outside Québec;
- (2) hazardous materials within the meaning of paragraph 21 of section 1 of the Environment Quality Act (chapter Q-2);
- (3) residual materials in a liquid state at 20 °C, except residual materials from household waste;
- (4) residual materials which, when tested by a laboratory accredited by the Minister of Sustainable Development, Environment and Parks under section 118.6 of the Environment Quality Act, contain a free liquid, except in a remote landfill to which Division 6 applies;
- (5) livestock waste within the meaning of the Agricultural Operations Regulation (chapter Q-2, r. 26);
- (6) pesticides within the meaning of the Pesticides Act (chapter P-9.3);
- (7) biomedical waste to which the Regulation respecting biomedical waste (chapter Q-2, r. 12) applies, that is not treated by disinfection;
- (8) sludge with a dryness lower than 15%, except in a remote landfill to which Division 6 applies;
- (9) soils that, because of human activity, contain 1 or more contaminants in concentrations exceeding the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37), and any product resulting from the treatment of such soils by a stabilization, fixation or solidification process;
- (10) derelict motor vehicles;
- (11) mill residual materials within the meaning of section 1 of the Regulation respecting pulp and paper mills (chapter Q-2, r. 27) with a dryness lower than 25%, other than

- sludge from the biological treatment of process water, which may be disposed of by landfilling as soon as its dryness is 15% or greater; or

- lime sludge and residue from lime slaking, which may be disposed of by landfilling only if its dryness is 55% or greater;

(12) used tires within the meaning of the Regulation respecting used tire storage (chapter Q-2, r. 20), except in a northern landfill and in a remote landfill to which Divisions 4 and 6 apply respectively.

O.C. 451-2005, s. 4; O.C. 808-2007, s. 145; O.C. 451-2011, s. 1.

5. Inedible meat within the meaning of the Regulation respecting food (chapter P-29, r. 1) may be disposed of by landfilling only under the conditions prescribed by the Food Products Act (chapter P-29) and the regulations made under that Act.

O.C. 451-2005, s. 5.

6. With the exception of the other landfills authorized by this Regulation or any other regulation, the engineered landfills governed by Division 2 are the only landfills in which residual materials to which Division VII of Chapter I of the Environment Quality Act (chapter Q-2) applies may be deposited permanently onto or into land, except batches of branches, stumps or shrubs less than 60 m³ and soil excavated from land that has not been contaminated by human activity.

Despite the provisions of the first paragraph, the following may be disposed of in a landfill authorized for that purpose by the Minister under section 22 of the Environment Quality Act:

- (1) fibrous waste from sawmills;
- (2) fibrous waste of the same nature as fibrous waste from sawmills that originates from oriented strandboard manufacturing plants; and
- (3) ash, soils or sludge from the establishments referred to in subparagraphs 1 and 2 and that contain such waste.

O.C. 451-2005, s. 6; O.C. 451-2011, s. 2.

DIVISION 2

ENGINEERED LANDFILLS

§1. General

7. For the purposes of this Regulation, “engineered landfill” means any landfill developed and operated in accordance with this Division.

O.C. 451-2005, s. 7.

8. The following residual materials may be landfilled only in engineered landfills:

- (1) residue from the shredding of derelict motor vehicles;

(2) residue from any residual materials incineration facility, including biomedical waste incinerators, in particular bottom ash and fly ash. This provision does not apply to bottom ash generated by a facility incinerating residual materials produced in a territory referred to in section 87, which may also be landfilled in a trench landfill or northern landfill to which Divisions 3 and 4 apply respectively;

(3) subject to the provisions of Chapter VI of the Regulation respecting pulp and paper mills (chapter Q-2, r. 27), mill residual materials within the meaning of section 1 of that Regulation;

(3.1) subject to the second paragraph of section 6 of this Regulation, fibrous waste from sawmills and fibrous waste of the same nature that originates from oriented strandboard manufacturing plants, as well as ash and soils or sludge from those establishments and that contain such waste;

(4) oil refinery sludge; and

(5) inedible meat that, under the Food Products Act (chapter P-29) and the regulations made under that Act, may be disposed of in a landfill and that consists of animal carcasses or animal parts in respect of which a disposal order has been made under section 3.4, 11.1 or 11.2 of the Animal Health Protection Act (chapter P-42) or section 114 of the Health of Animals Regulations (C.R.C., c. 296).

O.C. 451-2005, s. 8; O.C. 808-2007, s. 145; O.C. 451-2011, s. 3.

9. Fly ash and incineration residue that contains fly ash must be landfilled in separate disposal areas reserved exclusively for that type of residual material and sited as provided by the applicable provisions of sections 20 to 24.

That requirement does not apply to ash or residue that has been decontaminated by means of a contaminant extraction process and that presents a risk to the environment no greater than that for other residual materials that may be accepted at the landfill.

O.C. 451-2005, s. 9.

10. The operator of an engineered landfill must accept the eligible residual materials that are generated

(1) in the territory of the regional county municipality in which the landfill is situated;

(2) in the territory of the city or town in which the landfill is situated, in the case of a city or town constituted on or after 1 January 2002 and whose territory is not within the territory of a regional county municipality;

(3) in the territory of any local municipality of fewer than 2,000 inhabitants if no other engineered landfill accessible by a road open year-round is situated closer to the municipality. For the purposes of this subparagraph, the population of a municipality is the number of inhabitants determined in the order made under section 29 of the Act respecting municipal territorial organization (chapter O-9); and

(4) in any territory that is not organized into a local municipality.

O.C. 451-2005, s. 10.

11. The operator of an engineered landfill must also accept inedible meat referred to in paragraph 5 of section 8 from the administrative region in which the landfill is situated. “Administrative region” means any region

established by the Décret concernant la révision des limites des régions administratives du Québec (chapter D-11, r. 1).

O.C. 451-2005, s. 11.

12. The operator of an engineered landfill is required, however, to accept residual materials as provided in sections 10 and 11 only if the tariffs payable are paid and all other conditions, if any, in the certificate of authorization are complied with.

The requirement to accept residual materials does not apply to landfills reserved exclusively for the use of an industrial, commercial or other establishment or in respect of the following residual materials:

- (1) mill residual materials within the meaning of section 1 of the Regulation respecting pulp and paper mills (chapter Q-2, r. 27);
- (2) fibrous waste from sawmills with an annual production capacity of 10,000 m³ or more and ash and soils or sludge from such sawmills that contain such waste;
- (3) sludge that is not from municipal water or sludge treatment or collection works, other sanitary wastewater collection or treatment works or treatment works for sludge from such works, or from sewer cleaning;
- (4) residue from residual materials incineration facilities including biomedical waste incinerators, in particular bottom ash and fly ash;
- (5) residual materials from an industrial process, except waste referred to in subparagraph 2 from sawmills with an annual production capacity of less than 10,000 m³.

O.C. 451-2005, s. 12; O.C. 808-2007, s. 145.

§2. Siting

General siting conditions

13. The disposal areas in an engineered landfill and the treatment system for leachate or water from those areas, other than surface water sediment basins, must be sited at a minimum distance of 1 km from any surface water or groundwater collection facility if the facility is used for the production of spring water or mineral water within the meaning of the Regulation respecting bottled water (chapter P-29, r. 2) or for the supply of a waterworks authorized under the Environment Quality Act (chapter Q-2).

The foregoing does not apply if the disposal areas or treatment system are not likely to alter the quality of the water.

O.C. 451-2005, s. 13.

14. The siting of an engineered landfill in the flood zone of a watercourse or body of water situated within the 100-year flood plain is prohibited.

“100-year flood plain” means the line that corresponds to the limit line of a flood likely to occur once every 100 years.

O.C. 451-2005, s. 14.

15. The siting of an engineered landfill in an area where ground movement is likely to occur is prohibited.

O.C. 451-2005, s. 15.

16. The siting of an engineered landfill on land underneath which there is free groundwater having a high potential aquifer is prohibited.

For the purposes of this section, a “high potential aquifer” exists where at least 25 m³ of water per hour may be drawn on a permanent basis from the same well.

O.C. 451-2005, s. 16.

17. An engineered landfill must integrate into the surrounding landscape. To that end, the following must be taken into account:

- (1) the physical characteristics of the landscape within a radius of 1 km, among other things its topography and the shape, surface area and height of its landforms;
- (2) the visual characteristics of the landscape, also within a radius of 1 km, including its visual accessibility and recreational and tourist interest (visibility, landscape organization and structure, aesthetic value, integrity, etc.);
- (3) the ability of the landscape to integrate or accommodate an engineered landfill;
- (4) the effectiveness of measures to mitigate visual impacts (screen, buffer zone, revegetation, reforestation, etc.).

O.C. 451-2005, s. 17.

18. In order to mitigate the nuisances that an engineered landfill may generate and to allow for the carrying out of any necessary remedial measures, a buffer zone at least 50 m wide must be maintained on the perimeter of the landfill or the disposal areas and the leachate or water treatment system sites, other than surface water sediment basins, and if present, the biogas gas pumping system and the removal facility. The buffer zone must be an integral part of the engineered landfill.

A buffer zone must not have any watercourse or body of water within it. Its interior and exterior boundaries must be maintained so that they are capable of being located at all times.

Only activities necessary to access and monitor the facilities, and activities consistent with the purposes referred to in the first paragraph are permitted in a buffer zone. That restriction does not prevent the establishment of all or part of a buffer zone on an existing landfill, so long as the achievement of those purposes is not compromised.

O.C. 451-2005, s. 18.

19. The siting of an engineered landfill must take into account the inherent geotechnical constraints of the natural materials present and the synthetic materials used as well as the prevailing hydrogeological conditions that may be altered as a consequence of the proposed landfill siting.

O.C. 451-2005, s. 19.

Containment protection

20. In order to protect the soil and groundwater from leachate contamination, engineered landfills may be sited only on land where the unconsolidated deposits on which the residual materials will be deposited form a natural homogenous layer with a constant hydraulic conductivity of 1×10^{-6} cm/s or less to a minimum depth of 6 m, the hydraulic conductivity to be established *in situ*.

The surface of the natural layer must be graded to an inclination of at least 2% to allow leachate to flow by gravity towards the drains.

O.C. 451-2005, s. 20.

21. Despite section 20, an engineered landfill may be sited on land where the underlying unconsolidated deposits meeting the requirements of that section are at a greater depth, provided that the disposal areas have

(1) an impermeable sideslope liner system

- consisting of materials with a constant hydraulic conductivity of 1×10^{-6} cm/s or less;
- at least 1 m wide;
- extending upwards to ground level;
- the base of which extends at least 1 m into the unconsolidated deposits meeting the requirements of section 20; or

(2) an alternative sideslope liner system if the alternative liner system is at least as effective as the liner system described in subparagraph 1.

Excavation in a disposal area that has an impermeable sideslope liner system must in no case compromise compliance with the requirements of the first paragraph of section 20.

O.C. 451-2005, s. 21.

22. An engineered landfill may also be sited on land where the unconsolidated deposits do not meet the impermeability requirements of section 20, provided that the disposal areas have a double liner system on the bottom and sideslopes that is composed of

(1) a lower composite liner consisting of

- (a) a layer of clayey materials at least 60 cm thick after compaction

- that consists of at least 50% by weight of particles 0.08 mm or finer in diameter and at least 25% by weight of particles 0.005 mm or finer in diameter;

- with a constant hydraulic conductivity of 1×10^{-7} cm/s or less throughout its thickness;

- (b) a geomembrane at least 1.5 mm thick placed over the layer of clayey materials; and

- (2) an upper liner consisting of a second geomembrane at least 1.5 mm thick.

The geomembranes must be of the high-density polyethylene (HDPE) type or have equivalent properties; they must be installed with an inclination of at least 2% to allow leachate to flow by gravity towards the drains.

An alternative double liner system may also be used in the case referred to in the first paragraph if it is at least as effective as the system required by the first paragraph.

O.C. 451-2005, s. 22; O.C. 451-2011, s. 4.

23. The base of the lower composite liner of an engineered landfill with a double liner system installed as provided in section 22 must be situated above the groundwater level. The lowering of the groundwater level by pumping, drainage or otherwise is permitted only on land where the unconsolidated deposits form a natural homogenous layer with a constant hydraulic conductivity of 5×10^{-5} cm/s or less through a minimum thickness of 3 m, the hydraulic conductivity to be established *in situ*.

Where the unconsolidated deposits meeting the requirements of the first paragraph are at a greater depth, the disposal areas must also have an impermeable sideslope liner system that complies with the requirements of the first paragraph of section 21; excavation in those disposal areas must not compromise compliance with the requirements of the first paragraph as regards the unconsolidated deposits.

O.C. 451-2005, s. 23.

24. An engineered landfill may also be sited in a rock quarry or a mine so long as

- (1) the quarry or mine is an open pit;

- (2) the quarry or mine floor is situated below the groundwater level; and

- (3) the average groundwater infiltration rate, calculated on an annual basis, is 5×10^{-4} m³ or less of water per square metre of quarry or mine wall situated below the groundwater level.

O.C. 451-2005, s. 24.

Leachate and water collection and treatment

25. An engineered landfill must have a system capable of collecting leachate and conveying it towards a treatment or discharge site. The collection system must incorporate the following components:

(1) a drainage layer placed across the base and sideslopes of the disposal areas over the soil liner or the geomembrane, as the case may be, and which, to a minimum depth of 50 cm,

- consists of materials having less than 5% by weight of particles 0.08 mm or finer in diameter;
- has a constant minimum hydraulic conductivity of 1×10^{-2} cm/s.

The drainage layer must not impair the integrity of the underlying geomembrane, if any;

(2) a network of drainage pipes and collectors embedded within the drainage layer on the bottom of the disposal areas. The pipes must

- have a smooth interior and a minimum diameter of 150 mm;
- have no synthetic filter sock;
- have a minimum slope of 0.5%;
- have cleanout ports.

Despite the foregoing, if, pursuant to section 21, an engineered landfill has an impermeable sideslope liner system, the leachate may be collected and removed by means of another system if the system ensures compliance with the requirements of section 27.

If any portion of the collection system used to convey the leachate to the treatment site is situated outside the landfill disposal areas, the pipes in that portion must be leakproof.

O.C. 451-2005, s. 25.

26. An engineered landfill which under this Regulation must have a double liner system must also have, in addition to the leachate collection system to be installed pursuant to section 25 over the upper geomembrane, a secondary leachate collection system placed between the 2 geomembranes and that consists of

(1) a system that incorporates the components prescribed by subparagraphs 1 and 2 of the first paragraph of section 25, except that

- the minimum thickness of the drainage layer must be 30 cm;
- the minimum diameter of the pipes must be 100 mm; or

(2) any other system if the system is at least as effective as the system referred to in subparagraph 1.

The secondary collection system must be designed to be monitored independently from the other collection systems on the site.

O.C. 451-2005, s. 26.

27. The leachate collection systems prescribed by this Regulation must be designed and installed so that the leachate head likely to accumulate at the base of the disposal areas cannot reach the level of the residual materials.

In addition, in the case of landfills sited as provided in section 22, the leachate head likely to accumulate over the upper liner must not exceed 30 cm, except at the sump pump.

O.C. 451-2005, s. 27.

28. Every component of a treatment system for leachate or water from an engineered landfill must be leakproof, except surface water sediment basins.

Every pond or basin that receives such leachate or water must, if sited on land where the unconsolidated deposits do not meet the requirements of the first paragraph of section 20, have a containment liner system on its bottom and sides consisting of the components described in subparagraphs *a* and *b* of subparagraph 1 of the first paragraph of section 22, or an alternative system if the alternative system is at least as effective.

O.C. 451-2005, s. 28.

29. Access to the leachate or water treatment system must be restricted by having the system situated inside a building or surrounded by a fence. The system must be accessible at all times by a road open to vehicular traffic. This section does not apply to surface water sediment basins.

O.C. 451-2005, s. 29.

30. An engineered landfill must be built so that surface water cannot flow into the disposal areas, in particular by the use of perimeter trenches or any other collection system.

O.C. 451-2005, s. 30.

31. If the liner containment system for the disposal areas and the components of the leachate or water treatment system are below groundwater level, the disposal areas must, if the pressure exerted by the groundwater is likely to impair the integrity of the containment system, have a system that collects and evacuates the groundwater so as to reduce the pressure.

The groundwater collection system must

(1) incorporate all the components prescribed by section 25, except that

- the minimum thickness of the drainage layer must be 30 cm;
- the minimum diameter of the pipes must be 100 mm; or

(2) incorporate other components if the components are at least as effective as the components referred to in subparagraph 1.

The system must be designed to be monitored independently from the other collection systems on the site.

The operation of the groundwater collection system may be halted if the hydraulic pressure exerted by the groundwater is offset by the weight of the landfilled residual materials or by the liquid accumulated in the disposal areas and in the ponds or basins forming part of the leachate or water treatment system.

O.C. 451-2005, s. 31.

Collection and removal of biogas

32. An engineered landfill must have a system capable of collecting all biogas produced in the disposal areas and of releasing it into the environment or of directing it towards a reclamation or removal facility, so as among other things to ensure compliance with the limit values prescribed by section 60.

In the case of landfills having a maximum capacity greater than 1,500,000 m³ or sited as provided in section 24, or as soon as a landfill receives 50,000 tons or more of residual materials per year, the biogas collection system must have a gas pumping device except if such a device is not warranted because of the nature of the residual materials accepted and the low quantity of biogas likely to be produced.

In addition, if it is not reclaimed, the biogas collected in engineered landfills referred to in the second paragraph must be removed by means of thermal destruction equipment capable of destroying at least 98% of the organic compounds other than methane, or capable of reducing the concentration of those compounds to less than 20 ppm hexane equivalent, by volume, measured on a dry basis at 3% oxygen. The destruction equipment must be designed for a minimum retention time of 0.3 seconds at a minimum temperature of 760 °C. The biogas removal requirements are mandatory as long as the concentration of methane generated by the residual materials exceeds 25% by volume.

Biogas may also be removed as provided in the third paragraph using any other destruction equipment if the destruction equipment is at least as efficient as the equipment required by that paragraph and allows for continuous monitoring of its operation and for annual testing of its efficiency in destroying organic compounds other than methane.

O.C. 451-2005, s. 32; O.C. 451-2011, s. 5.

33. Access to the gas pumping device and biogas removal facility, if any, must be restricted by having them situated inside a building or surrounded by a fence. The device and facility must be accessible at all times by a road open to vehicular traffic.

O.C. 451-2005, s. 33.

Quality assurance and control

34. The size, choice and placement of materials must be such that the landfill containment liner system, leachate and water collection and treatment systems, the biogas collection and removal system and network of groundwater observation wells referred to in section 65 and which are present in an engineered landfill pursuant to this Regulation will operate properly, even on a long-term basis, considering the physical, chemical and biological processes that may take place in the landfill during the development, operation and post-closure management periods.

The systems must also be designed to be monitored, maintained and cleaned throughout the entire period.

O.C. 451-2005, s. 34.

35. All the materials and equipment to be used in the development of an engineered landfill, whether for containment purposes or for the installation of a system referred to in section 34, must be verified by independent experts before and during the development or installation and by laboratory or *in situ* tests to ensure that the materials or equipment comply with the applicable standards.

O.C. 451-2005, s. 35.

36. The landfill development work must be performed under the supervision of independent experts who must among other things verify the qualifications of the workers assigned to performing the work, as well as the quality of the techniques used and the systems installed.

As and when the development work is completed, the operator of a landfill must send to the Minister the reports of the independent experts in charge of verifying and supervising the work as required by section 35 and this section confirming compliance of the installation with the applicable standards, or indicating cases of non-compliance with those standards and remedial measures to be taken.

O.C. 451-2005, s. 36; O.C. 666-2013, s. 1.

§3. Operation

General operating conditions

37. The operator of an engineered landfill must verify whether the residual materials received may be landfilled, in particular by a visual inspection.

O.C. 451-2005, s. 37.

38. Residual materials received for landfilling in an engineered landfill must be weighed and undergo radiological testing by devices capable of detecting the presence of radioactive materials.

The devices for weighing the residual materials and for testing the residual materials for radioactivity must be installed at the entrance to the site, be used and maintained so as to provide reliable data and be calibrated at least once a year.

The provisions of this section regarding the weighing of residual materials do not apply to a landfill reserved exclusively for the use of an industrial, commercial or other establishment if the data relating to the quantity of residual materials (in weight) that are landfilled may be obtained otherwise and under the same conditions of accessibility and conservation as those set out in section 39.

Similarly, the provisions of this section regarding the testing of residual materials for radioactivity do not apply to the landfill referred to in the third paragraph if, by reason of the nature of the activities of the establishment using the landfill and the composition of the residual materials landfilled, the residual materials cannot contain any radioactive material.

O.C. 451-2005, s. 38.

39. For every load of residual materials brought to an engineered landfill, the operator must enter in a log

- (1) the name of the carrier;

- (2) the nature of the residual materials and, in the case of decontaminated sludge, fly ash or soil, or soil from land rehabilitation work, the results of the analyses or measures establishing that they may be landfilled;
- (3) the source of the residual materials and, if they result from an industrial process, the name of the producer;
- (4) the quantity of residual materials, expressed in weight; and
- (5) the date on which they were landfilled.

The logs and their appendices must be kept on the premises of the landfill site for the duration of its operation and be made available to the Minister. Following closure of the site, the logs must be kept by the operator until the operator is released under section 85 from all obligations.

O.C. 451-2005, s. 39; O.C. 451-2011, s. 6.

40. The operator must also enter in the log, for every load of materials referred to in the second and third paragraphs of section 42 and the third and fourth paragraphs of section 50 and to be used to cover the residual materials landfilled in the disposal areas, the nature and quantity of the materials.

If the materials consist of the soils referred to in subparagraph 2 of the first paragraph of section 39, the operator may accept them only after receipt of the results of the analyses or measures showing they comply with the requirements of the above sections. Those results must also be entered in the annual log.

O.C. 451-2005, s. 40; O.C. 451-2011, s. 7.

40.1. The operator is required to confirm the acceptance of soil when soil referred to in subparagraph 2 of the first paragraph of section 39 is received. For that purpose, for each batch of soil of 200 tons or less, the operator must have a sample taken to have it analyzed for all contaminants likely to be present in the soil among those referred to in the second paragraph of section 42 and the third paragraph of section 50, in the case of soil used to cover residual materials, or in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37) in the case of soil intended for landfilling.

For every batch of soil of more than 200 tons, in addition to the sampling provided for in the first paragraph, the operator must have an additional sample taken and have it analyzed for each additional fraction of soil of 400 tons or less.

The results of the analyses must be entered in the log.

O.C. 451-2011, s. 8.

41. As soon as they are deposited in a disposal area, residual materials must be spread and compacted except in the case of sludge, soil referred to in subparagraph 2 of the first paragraph of section 39, residual materials that are baled and animal carcasses or animal parts.

In order to minimize the release of odours, the spread of fires, the proliferation of animals or insects, and blowing litter, the residual materials must be covered at the end of each day of operation with a layer of soil or other materials referred to in section 42, or be covered in another manner enabling the above purposes to be accomplished.

The daily cover requirement does not apply to a landfill reserved exclusively for the use of an industrial, commercial or other establishment if the residual materials received are not likely to generate the nuisances referred to above.

Residual materials containing asbestos or that are likely to release dust into the atmosphere, and animal carcasses or animal parts, must be covered with other materials as soon as they are deposited in the disposal area, even before

being compacted. For the purposes of this paragraph, “containing asbestos” has the meaning assigned by section 1.1 of the Safety Code for the construction industry (chapter S-2.1, r. 4).

Residual materials at a temperature likely to create fires, in particular bottom ash, fly ash and any other incineration residue, is to be landfilled only once it has cooled sufficiently to prevent any risk of fire.

O.C. 451-2005, s. 41; O.C. 451-2011, s. 9.

42. The soil used for the daily cover of the residual materials must have a constant minimum hydraulic conductivity of 1×10^{-4} cm/s and less than 20% by weight of particles 0.08 mm or finer in diameter.

The soil may also contain contaminants in a concentration equal to or lower than the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37) for volatile organic compounds and in Schedule II to that Regulation for other contaminants. Those limit values do not apply to contaminants that do not originate from human activity. The thickness of the cover layer consisting of such contaminated soil must not exceed 60 cm.

Other material may be used to cover the residual materials if the other material meets the requirements of the first paragraph, does not contain substances that are not accepted at the landfill, and is capable of accomplishing the purposes referred to in the second paragraph of section 41.

The operator must periodically verify, at the frequency specified in the authorization obtained pursuant to section 22 or 31.5 of the Environment Quality Act (chapter Q-2), whether the soils or other materials used to cover the residual materials meet the requirements of the first paragraph. For that purpose, the operator must have representative samples of the soils or materials measured and analyzed and the results of the measures and analyses must appear in the annual report prepared pursuant to section 52.

Despite the foregoing, residual materials may be covered temporarily using materials other than soil that does not meet the requirements of the first paragraph. In such a case, no residual materials may be subsequently deposited until the temporary cover has been removed or brought into conformity with that paragraph.

Contaminated soil or residual materials to be used as cover material may be stockpiled at an engineered landfill only in areas that meet the containment requirements set out in this Regulation and that have not received the final cover prescribed by section 50.

O.C. 451-2005, s. 42; O.C. 451-2011, s. 10.

43. Residual materials must be landfilled in limited disposal areas which, as they successively fill up, allow for progressive redevelopment of the landfill in compliance with sections 50 and 51.

O.C. 451-2005, s. 43.

44. The leachate and water collection and treatment systems, the biogas collection and removal systems and the network of groundwater observation wells referred to in section 65 must at all times be maintained in proper working order. For that purpose, they must be periodically inspected and maintained or cleaned at the frequency specified in the authorization obtained pursuant to section 22 or 31.5 of the Environment Quality Act (chapter Q-2). In addition, the leachate collection systems must function in such manner as to comply with the requirements of section 27.

O.C. 451-2005, s. 44.

45. Every engineered landfill must have, at the landfill entrance,

(1) a conspicuous sign indicating the type of landfill, the name, address and telephone number of the operator and any other person in charge of the landfill, as well as the business hours; and

(2) a barrier or other device restricting access to the landfill after business hours or in the absence of the personnel in charge of overseeing the acceptance of residual materials or their compaction and covering.

O.C. 451-2005, s. 45.

46. The landfilling operations in an engineered landfill must not be visible from a public area or from the ground floor of a dwelling located within a radius of 1 km, that distance to be measured from the disposal areas.

O.C. 451-2005, s. 46.

47. No person may burn residual materials in an engineered landfill. An operator may not allow the burning of such materials in an engineered landfill.

O.C. 451-2005, s. 47; O.C. 451-2011, s. 11.

48. The operator of an engineered landfill must take the necessary measures to minimize the release of odours that cause odour nuisances beyond the limits of the landfill and to prevent wind dispersal or scattering of residual materials and the emission of dust visible in the atmosphere more than 2 m from the emission source.

As needed, the operator must clean on-site roads, the entrances and devices installed to contain the residual materials in the disposal areas and the immediate surroundings so that no residual materials remain in those areas.

O.C. 451-2005, s. 48.

49. The operator of an engineered landfill must take the necessary measures to prevent or eliminate any infestation of pests on the landfill site and in the immediate surroundings.

O.C. 451-2005, s. 49.

50. The residual materials landfilled in the disposal areas of an engineered landfill must, once they have reached the maximum authorized height or landfilling operations are terminated, be covered with a final cover as soon as climatic conditions permit.

The final cover system must have, from the bottom up,

(1) a drainage layer consisting of soil with a constant minimum hydraulic conductivity of 1×10^{-3} cm/s through a minimum thickness of 30 cm, designed to collect landfill gas while allowing the circulation of liquids;

(2) an impermeable soil layer with a constant maximum hydraulic conductivity of 1×10^{-5} cm/s through a minimum thickness of 45 cm after compaction, or a geomembrane at least 1 mm thick;

(3) a barrier soil layer at least 45 cm thick, having characteristics that preserve the integrity of the impermeable layer; and

- (4) a soil layer at least 15 cm thick, suitable for vegetation.

The soil referred to in subparagraph 1 of the second paragraph may contain contaminants in a concentration equal to or lower than the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37) for volatile organic compounds and in Schedule II to that Regulation for other contaminants. The soils referred to in subparagraphs 2 and 3 of the second paragraph may also contain such contaminants in a concentration equal to or lower than the limit values set out in Schedule I to that Regulation. The limit values prescribed by this paragraph do not apply to contaminants that do not originate from human activity.

The layers referred to in subparagraphs 1 to 4 of the second paragraph may consist of another material if the material will achieve protection efficiency at least equivalent to that of the materials prescribed in those subparagraphs, the material meets where applicable the requirements of the third paragraph and the minimum thickness of the layers is as prescribed in those subparagraphs.

The final cover slope must be of at least 2% and no more than 30% to allow water to flow away from the disposal areas and limit soil erosion. In addition, in the case of disposal areas that have an impermeable sideslope liner system pursuant to section 21, surface water infiltration into the disposal areas must be reduced by extending the layers referred to in subparagraphs 2, 3 and 4 of the second paragraph beyond the liner perimeter, or by another cover procedure that reduces water infiltration into the disposal areas.

The provisions of sections 34 to 36 relating to quality assurance and control apply, with the necessary modifications, to the final cover of disposal areas prescribed by this section.

O.C. 451-2005, s. 50; O.C. 451-2011, s. 12.

51. Not later than 1 year after installation of the final cover, the final layer must be given a vegetative layer consisting of species not likely to impair the impermeability of the cover.

Damage such as holes, fissures or subsidence that may occur in the final cover must be repaired immediately to prevent water from pooling over or infiltrating into the disposal areas, until the areas have been fully stabilized.

O.C. 451-2005, s. 51.

52. The operator of an engineered landfill must prepare, for each year of operation, a report containing

- (1) a compilation of the data collected pursuant to sections 39 and 40 relating to the nature, the source and quantity of residual materials landfilled and materials received for cover purposes;
- (2) a plan and data showing the progression on the site of the landfilling operations, including filled disposal areas, areas in operation and current available landfill capacity;
- (3) the results of the testing or measurements performed pursuant to sections 63, 64, 66 and 68, other than results sent to the Minister pursuant to section 71, and a summary of the data from the sampling or analyses required under other provisions of this Regulation;
- (4) a certificate stating that the measurements and samples prescribed by this Regulation were taken in compliance with best practices and the provisions of this Regulation, as the case may be;
- (5) any information or document indicating the places where the measurements or samples were taken, in particular the number and location of the monitoring points, the methods and devices used and the names of the laboratories or persons taking the measurements or samples; and
- (6) a summary of the work carried out pursuant to this Regulation.

The report must be sent to the Minister in a computer medium using the technology-based documents prescribed by the Minister within 90 days following the end of each year of operation and include any other information the Minister may require under section 68.1 of the Environment Quality Act (chapter Q-2).

O.C. 451-2005, s. 52; O.C. 451-2011, s. 13.

Leachate and water

53. The leachate and water collected by a collection system in an engineered landfill may be discharged into the environment only if there is compliance with the following limit values:

Parameters - Substances	Limit values	Average monthly limit values*
Ammoniacal nitrogen (expressed as N)	25 mg/l	10 mg/l
Fecal coliforms	1,000 CFU/100 ml	
Phenolic compounds	0.085 mg/l	0.030 mg/l
5-day biochemical oxygen demand (BOD ₅)	150 mg/l	65 mg/l
Suspended solids	90 mg/l	35 mg/l
Zinc (Zn)	0.17 mg/l	0.07 mg/l
pH	greater than 6.0 but lower than 9.5	

“* The average monthly limit values apply only to water or leachate discharged after treatment. They are established using an arithmetic average, except for the limit value relating to fecal coliforms which is established using a geometric average.

In addition, the Minister may determine parameters to be measured or substances to be analyzed according to the composition of the materials received for disposal, and set the limit values to be complied with for those parameters or substances. The limit values may be in addition to or in substitution for the limit values previously set.

A batch discharge is prohibited.

For the purposes of this Regulation, a discharge into the environment includes a discharge into a sewer system that does not convey wastewater to a treatment facility established and operated in accordance with an authorization issued under the Environment Quality Act (chapter Q-2).

O.C. 451-2005, s. 53; O.C. 451-2011, s. 14.

54. The limit values prescribed by section 53 do not apply to surface water collected within the perimeter of a buffer zone established pursuant to section 18 if an analysis of the surface water shows that there is no compliance with the limit values before the surface water enters the buffer zone.

In that case, the quality of the surface water must not, in relation to the parameters or substances listed in section 53, be deteriorated in any manner before it reaches the outside perimeter of a buffer zone established pursuant to section 18.

O.C. 451-2005, s. 54.

55. Leachate and water collected by a collection system that does not comply with the limit values prescribed by section 53 must not be diluted in any manner before being discharged into the environment, other than dilution caused by precipitation.

O.C. 451-2005, s. 55.

56. Artificial infiltration of leachate or water into disposal areas is permitted only in engineered landfills for the purpose of accelerating the degradation of the residual materials, subject to the following conditions:

- (1) prior authorization under the Environment Quality Act (chapter Q-2);
- (2) the infiltration must take place in areas where there has been a deposit of a minimum thickness of 4 m of residual materials;
- (3) if the infiltration is the result of surface spraying or sprinkling techniques, it can take place only in disposal areas that do not have a final cover and those techniques must not cause surface pooling or aerosol formation.

O.C. 451-2005, s. 56.

Groundwater

57. Subject to section 59, groundwater migrating into the soil where disposal areas or a leachate or water treatment system are sited must comply with the following limit values at the observation wells installed pursuant to section 65:

Parameters - Substances	Limit values*
Ammoniacal nitrogen (expressed as N)	1.5 mg/l
Benzene	0.005 mg/l

Boron (B)	5 mg/l
Cadmium (Cd)	0.005 mg/l
Chlorides (expressed as Cl ⁻)	250 mg/l
Chromium (Cr)	0.05 mg/l
Fecal coliforms	0 CFU/100 ml
Total cyanides (expressed as CN ⁻)	0.2 mg/l
Ethylbenzene	0.0024 mg/l
Iron (Fe)	0.3 mg/l
Manganese (Mn)	0.05 mg/l
Mercury (Hg)	0.001 mg/l
Nickel (Ni)	0.02 mg/l
Nitrates + nitrites (expressed as N)	10 mg/l
Lead (Pb)	0.01 mg/l
Sodium (Na)	200 mg/l
Total sulphates (SO ₄ ⁻²)	500 mg/l
Total sulphides (expressed as S ⁻²)	0.05 mg/l
Toluene	0.024 mg/l
Xylene (o, m, p)	0.3 mg/l

“* The limit values correspond to the limit values that apply to water intended for human consumption.

In addition, the Minister may determine the parameters to be measured or substances to be analyzed on the basis of the composition of the residual materials received for disposal, and set the limit values to be complied with for those parameters or substances. The limit values may be in addition to or in substitution for the limit values set out in the first paragraph.

O.C. 451-2005, s. 57.

58. The limit values listed in section 57 do not apply if an analysis of the groundwater shows that there is no compliance with those limit values before the groundwater migrates into the soil where the disposal areas or the leachate or water treatment system are situated.

In that case, the quality of the groundwater must not, in relation to the parameters or substances listed in section 57, be deteriorated in any manner as a result of its migration into that soil.

O.C. 451-2005, s. 58.

59. Groundwater that re-emerges within the monitoring perimeter established under section 65 is subject to section 53, except as regards suspended solids.

The same applies to any groundwater that is collected in the perimeter and discharged on the surface.

O.C. 451-2005, s. 59.

Biogas

60. The concentration of methane in biogas produced by the residual materials disposed of in an engineered landfill must not exceed 25% of its lower explosive limit, or 1.25% by volume, if it is emitted or migrates into and accumulates in the soil and the buildings or facilities (other than the leachate, water and biogas collection or treatment systems) situated at a maximum distance of 150 m from the disposal areas without exceeding the outside perimeter of any buffer zone established under section 18.

For the purposes of this section, “lower explosive limit” means the lowest concentration, by volume, of a gas in a gas mixture above which a flare may sustain itself at a temperature of 25°C and a pressure of 101.325 kPa.

O.C. 451-2005, s. 60.

61. The operation of the biogas collection system in an engineered landfill must begin not later than 1 year after a disposal area has received a final cover.

However, in the case of landfills referred to in the second paragraph of section 32, the biogas collection system and the biogas removal equipment must be designed to operate so that the collection and removal of any biogas produced by the landfilled residual materials may begin, even though the disposal area has not yet received a final cover, not later than 5 years after the landfilling in the case of landfills receiving 100,000 tons or less of residual materials per year or, in the case of landfills receiving more than 100,000 tons per year, not later than 1 year after the landfilling.

The operation of a biogas collection system must not result in an increase in temperature likely to cause a fire in a disposal area.

O.C. 451-2005, s. 61.

62. During the operating period of a biogas collection system that has a gas pumping device pursuant to the second paragraph of section 32, the concentration of nitrogen or oxygen must be respectively less than 20% and 5% by volume in each drain and wet well in the system situated in every section of disposal areas that have received a final cover.

In addition, the concentration of methane at the surface of the disposal areas served by the system must be less than 500 ppm, in volume, in that operating period regardless of whether or not the areas have received a final cover.

The operation of a gas pumping device for the biogas produced in all or part of a disposal area may be halted if, throughout a period of 5 years, all the measurements of the methane generated by the residual materials in the disposal area show a concentration of less than 25% by volume.

O.C. 451-2005, s. 62.

Monitoring and supervision measures

63. The operator of an engineered landfill must, at the frequency indicated below, take or have a sample taken of the leachate or water collected by each collection system in the landfill and in resurgent water within the groundwater monitoring perimeter established under section 65, and have the samples analyzed

(1) at least once a year, for the purpose of measuring the parameters or substances referred to in sections 53, 57 and 66;

(2) at least 3 times a year, in the spring, summer and fall, if the leachate or water is not conveyed to a treatment system, for the purpose of measuring the parameters or substances listed in section 53; or

(3) at least once a month, if the leachate or water is conveyed to a treatment facility established and operated pursuant to an authorization issued under the Environment Quality Act (chapter Q-2), for the purpose of measuring the parameters or substances referred to in section 53, except fecal coliforms.

The leachate and water to be sampled pursuant to the first paragraph must be sampled before being discharged into the environment or, if applicable, before being treated or discharged towards a treatment facility. For the purposes of this section, there is a discharge of surface water into the environment if the water flows out of a buffer zone established under section 18.

If the surface water does not comply with the limit values listed in section 53 before flowing into the buffer zone established under section 18, the water must also be sampled and analyzed as provided in subparagraph 2 of the first paragraph before entering the buffer zone.

The operator must also take or have a weekly sample taken of the discharges into the environment from every leachate or water treatment system in the landfill, other than surface water sediment basins, and have the samples analyzed to measure the parameters or substances listed in section 53.

Each of the samples must be a single sample (grab sample). In the case of resurgent water, the sampling must be carried out at the resurgence point.

The flow of the leachate collected by the collection systems prescribed by sections 25 and 26 and the flow of the discharges from the treatment system in the landfill must be separately and continuously measured and the results recorded.

O.C. 451-2005, s. 63; O.C. 451-2011, s. 15.

64. At least once a year, the operator of an engineered landfill must leak test or have the pipes in the leachate or water collection system that are situated outside the disposal areas leak tested.

Before being put into service and every 3 years thereafter, each component of the leachate or water treatment system likely to release leachate or water must be leak tested.

O.C. 451-2005, s. 64.

65. In order to monitor the quality of the groundwater migrating into the soil where the disposal areas or a leachate or water treatment system are sited, the operator must install 1 or more networks of observation wells in accordance with the following provisions.

If the leachate or water treatment system is situated in whole or in part within 150 m of the disposal areas, a single network of observation wells is required, otherwise the disposal areas and the treatment system location must each have its own network.

The number of wells in a network of observation wells depends on the surface area occupied by the disposal areas and the treatment system. The location of the wells and the number of sampling points required depends on the hydrogeological conditions of the sites, subject to the following:

- (1) no observation well is to be situated beyond the outside perimeter of a buffer zone established pursuant to section 18;
- (2) the observation wells must be situated at a maximum distance of 150 m hydraulically downgradient from the disposal areas or location of the treatment system so that the groundwater at that distance can be monitored. If all or part of a buffer zone has been established on an existing landfill, the monitoring perimeter may be extended to include the landfill, but without exceeding the distance of 150 m from the disposal areas or related treatment system;
- (3) a network of observation wells must consist of at least 3 wells for the first 8 ha of land and 1 well for each additional 8-ha portion of land or remaining portion of less than 8 ha;
- (4) at least 1 additional observation well to monitor the quality of groundwater before its migration into the soil where the disposal areas or treatment system are situated must be installed hydraulically upgradient, or if the hydraulic upgrade cannot be determined because of hydrogeological conditions, at any other location making it possible to ascertain the quality of the groundwater representative of the groundwater migrating into the monitoring perimeter established under this section.

For the purposes of this section, a pond, basin or reservoir, except surface water sediment basins, in which water accumulates that does not comply with the limit values set out in section 53 is considered to form an integral part of the water treatment system.

O.C. 451-2005, s. 65; O.C. 451-2011, s. 16.

66. At least 3 times a year, in the spring, summer and fall, the operator of an engineered landfill must take or have a groundwater sample taken at each sampling point of the observation wells installed pursuant to section 65, and have the samples analyzed to monitor the parameters or substances listed in section 57 and compliance with section 58, and to measure the following indicative parameters or substances:

- (1) electrical conductivity;
- (2) phenolic compounds;
- (3) 5-day biochemical oxygen demand (BOD5);
- (4) chemical oxygen demand (COD);
- (5) iron.

During sampling, the groundwater piezometric level must also be measured.

After a minimum 2-year monitoring period, the samples taken need no longer be analyzed for the parameters or substances whose concentration measured in the leachate before treatment, if any, has consistently been lower than the limit values listed in section 57, except in the case of indicative parameters or substances. The reduction in the number of parameters or substances to be analyzed applies as long as the annual analyses of leachate, before treatment, show that that condition is met. In addition, the analysis for 2 of the 3 required annual samplings may pertain only to the indicative parameters or substances listed in the first paragraph.

The Minister may establish a different list of indicative parameters or substances according to the composition of the residual materials received for disposal, in which case the parameters or substances may be in addition to or in substitution for the parameters or substances listed above.

Despite the foregoing, as soon as the analysis of a sample shows significant fluctuation for a parameter or substance or that a limit value has been exceeded, all the subsequent samples taken at the sampling point concerned must undergo a comprehensive analysis of the parameters or substances listed in section 57 until the situation is remedied.

O.C. 451-2005, s. 66.

67. At least 4 times a year, at intervals spread evenly throughout the year, the operator of an engineered landfill must monitor or have the concentration of methane in the soil and inside the buildings and facilities monitored in order to ensure compliance with the requirements of section 60. The operator is, however, exempt from that monitoring requirement if the landfilled residual materials are not likely to generate methane.

The number and location on the site of the methane monitoring points are determined according to the geological and hydrogeological conditions and the siting features, subject to the following:

- (1) the measurements in the soil must be taken at a minimum of 4 monitoring points distributed evenly around the disposal areas;
- (2) if the disposal areas exceed 8 ha, a monitoring point must be added for each additional 8-ha portion of land or remaining portion of less than 8 ha.

The date, time, temperature and barometric pressure must be recorded every time a measurement is taken pursuant to the second paragraph.

O.C. 451-2005, s. 67.

68. During the operating period of a biogas collection system that has a gas pumping device pursuant to the second paragraph of section 32, the flow of biogas must be continuously measured and the results recorded. For the purpose of ensuring compliance with the requirements of section 62, the operator must also monitor or have the following monitored:

(1) at least every 3 months:

- the concentration of methane generated by the residual materials;
- the concentration of nitrogen or oxygen and the temperature in each drain and wet well;

(2) at least once a year, the concentration of methane at the surface of the disposal areas of an engineered landfill that receives 100,000 tons or less of residual materials per year; or

(3) at least 3 times a year, in the spring, summer and fall, the concentration of methane at the surface of the disposal areas of an engineered landfill that receives more than 100,000 tons of residual materials per year. The frequency may, however, be reduced to once a year for all or part of a disposal area that has received a final cover if, after a minimum 2-year monitoring period of that area or part of area, none of the measurements has shown that the limit value set out in the second paragraph of section 62 has been exceeded. The reduction applies as long as the annual monitoring shows compliance with the limit value, otherwise the frequency of the measurements is 3 times a year until the situation is remedied for that area or part of area.

Where thermal destruction equipment for biogas is required pursuant to the second paragraph of section 32, the destruction temperature and flow rate of the biogas must be continuously measured and recorded and the destruction efficiency for the organic compounds other than methane must be verified at least once a year.

O.C. 451-2005, s. 68.

69. The leachate or water samples taken pursuant to this Regulation must not be filtered in any manner during sampling or prior to analysis.

The groundwater samples taken for analysis of metals and metalloids may be filtered during sampling as long as they are filtered at all sampling points.

O.C. 451-2005, s. 69.

70. The samples taken pursuant to this Regulation must be sent for analysis to laboratories accredited by the Minister under section 118.6 of the Environment Quality Act (chapter Q-2).

The analysis reports prepared by the laboratories must be kept by the operator for a minimum of 5 years after the date on which they were prepared.

O.C. 451-2005, s. 70.

71. The operator must, within 30 days following the last day of the month of the sampling, send the results of the analyses of the samples taken pursuant to this Regulation to the Minister in a computer medium using the technology-based documents prescribed by the Minister.

If limit values prescribed by this Regulation have been exceeded, the operator must, within 15 days after being so informed, report to the Minister on the measures taken or to be taken to remedy the situation.

The operator must also, within 30 days after the last day of the month during which the operator is so informed, send to the Minister the results of the measures taken pursuant to section 67 and the results of the measurements of the methane concentration at the surface of the disposal areas and the destruction efficiency verification for organic compounds carried out pursuant to section 68.

O.C. 451-2005, s. 71; O.C. 451-2011, s. 17.

Watchdog committee

72. The operator of an engineered landfill must form a committee within 6 months after landfilling operations commence that is to exercise the function provided for in section 57 of the Environment Quality Act (chapter Q-2).

To that end, the operator is to invite in writing the following bodies and groups to designate a representative on the committee:

- (1) the local municipality in which the landfill is situated;
- (2) the metropolitan community and the regional county municipality in which the landfill is situated;
- (3) the persons residing in the vicinity of the landfill;
- (4) a local or regional environmental protection group or body;
- (5) a local or regional group or body likely to be affected by the landfill.

The operator's representative designated by the operator is also to sit on the committee.

Any vacancy on the committee is to be filled in keeping with the procedure described in the second paragraph.

Failure by 1 or more bodies or groups to designate a representative does not prevent the committee from operating ; the committee is to exercise its functions even though 1 or more members have yet to be designated.

O.C. 451-2005, s. 72.

73. The committee may, if the majority of the members agree, invite other bodies or groups to sit on the committee and designate a representative.

O.C. 451-2005, s. 73.

74. The members of the committee designate a chair and a secretary from among their number; if the majority of the members agree, a person who is not a member of the committee may be designated as secretary.

O.C. 451-2005, s. 74.

75. The members of the committee must meet at least once a year.

Unless a majority of the members decide otherwise, the meetings of the committee are held in the territory of the local municipality in which the landfill is situated.

O.C. 451-2005, s. 75.

76. The secretary must post the agenda of every committee meeting at least 10 days prior to the meeting in the places indicated by the municipal bodies referred to in the second paragraph of section 72.

The secretary must also post the minutes of the meeting in the same places within 30 days following the meeting and send a copy of the minutes to the Minister.

The minutes of the committee meetings are available to any person on request to the secretary.

O.C. 451-2005, s. 76.

77. The operator must inform the committee of any application for authorization pertaining to the landfill made under the Environment Quality Act (chapter Q-2), and of any change in management responsibility for the landfill.

The operator must also, in a timely manner, make available to or provide the committee with all the documents or information necessary for the exercise of its functions, in particular the certificates of authorization pertaining to the landfill, the logs after removing the names of the residual materials carriers and producers, the annual reports, the results of the analyses, monitoring or measurements required by this Regulation, the closure report prepared under section 81 and the status report prepared under section 84.

O.C. 451-2005, s. 77; O.C. 451-2011, s. 18.

78. All operating expenses of the committee, including the costs of the meeting room and the material resources necessary for the committee to exercise its functions, are payable by the operator.

The expenses incurred for the meetings of the committee are payable by the operator for a maximum of 4 meetings per year.

O.C. 451-2005, s. 78.

79. The operator must allow committee members free access during the landfill's business hours to the landfill and to any equipment or facility at the landfill.

O.C. 451-2005, s. 79.

§4. Closure

80. The operator must permanently close the engineered landfill when it has reached its maximum capacity or landfilling operations are terminated. The operator must immediately notify the Minister in writing of the date of closure.

O.C. 451-2005, s. 80.

81. Within 6 months following the date on which the engineered landfill is closed, the operator must send to the Minister a closure report prepared by independent experts, attesting to

(1) the working order, effectiveness and reliability of the landfill liner system, the leachate or water collection and treatment systems, the biogas collection and evacuation or removal system and the network of groundwater observation wells, installed at the landfill in accordance with this Regulation;

(2) compliance with the limit values that apply to discharges of leachate or water, to emissions of biogas and to groundwater; and

(3) compliance with the requirements of this Regulation or with the certificate of authorization as regards the final landfill cover and the integration of the landfill into the surrounding landscape.

The closure report must specify any instances of non-compliance with this Regulation or the certificate of authorization and indicate the remedial measures to be taken.

O.C. 451-2005, s. 81.

82. A conspicuous sign must be posted at the entrance to an engineered landfill that has been permanently closed stating that the landfill is closed and that the disposal of residual materials is prohibited.

O.C. 451-2005, s. 82.

§5. Post-closure management

83. The requirements of this Division continue to apply, with the necessary modifications, to a permanently closed engineered landfill, for as long as the landfill is likely to be a source of contamination.

Once a landfill is closed, the owner is responsible, in particular,

(1) for maintaining the integrity of the final cover over the landfilled residual materials;

(2) for monitoring and maintaining the leachate or water collection and treatment systems, the biogas collection and evacuation or removal system and the network of groundwater observation wells;

(3) for the carrying out of samplings, analyses and measurements of leachate, water and biogas; and

(4) for leak testing the leachate or water collection pipes situated outside the landfill disposal areas and every component in the leachate or water treatment system.

O.C. 451-2005, s. 83.

84. The operator of an engineered landfill may apply to the Minister to be released from any environmental monitoring or maintenance obligation under this Regulation if, during a post-closure monitoring period of a minimum duration of 5 years,

(1) none of the parameters or substances analyzed in the leachate or water samples taken before treatment has exceeded the limit values set out in section 53;

(2) none of the parameters or substances analyzed in the groundwater samples has contravened sections 57 to 59; and

(3) the concentration of methane has been measured in the components of the biogas collection system at a frequency of at least 4 times per year at intervals spread evenly throughout the year, and all the measurements have indicated a concentration of methane less than 1.25% by volume.

To that end, the operator must have a status report pertaining to the state of the landfill and, where applicable, its environmental impacts, prepared by independent experts; the operator must send the status report to the Minister.

O.C. 451-2005, s. 84.

85. If it is established, particularly in the light of the status report prepared pursuant to section 84, that there is compliance with the conditions referred to in the first paragraph of that section, that the landfill complies in every respect with the applicable standards and that it is no longer likely to be a source of contamination, an operator who so requests is released by the Minister from the environmental monitoring and maintenance obligations under this Regulation.

O.C. 451-2005, s. 85.

DIVISION 3

TRENCH LANDFILLS

86. Trench landfills may be established in the territories enumerated in section 87, in which only residual materials generated in the territories are accepted, including sludge which, although generated elsewhere, is treated in the territories.

Trench landfills must be sited and operated in accordance with this Division, which also prescribes the conditions that apply to their closure and post-closure management.

O.C. 451-2005, s. 86.

87. Trench landfills are permitted in the following territories only:

- (1) in the North, as defined in section 94;
- (2) in any part of territory that is not organized into a local municipality and that is situated more than 100 km by a road open year-round from an engineered landfill site that is not reserved exclusively for the use of an industrial, commercial or other establishment;
- (3) in the territory of the James Bay region, as described in the schedule to the James Bay Region Development and Municipal Organization Act (chapter D-8.2), excluding the towns of Chibougamau and Chapais;
- (4) in any territory inaccessible by a road open year-round, including every island that is not connected to the mainland by a bridge or a boat service operational year-round;
- (5) in the regional county municipalities of Minganie and Caniapiscau;
- (6) in the part of the territory of Ville de la Tuque situated west of the 73rd meridian.

O.C. 451-2005, s. 87; O.C. 451-2011, s. 19.

88. Subject to the conditions set out in the second paragraph, sections 13 to 16, 18, 19, 28 to 30 and 34 to 36 apply, with the necessary modifications, to the siting of a trench landfill.

The siting is also subject to the following conditions:

- (1) the minimum distance between the trench area and any watercourse or body of water must be 150 m;
- (2) the minimum distance between the trench area and any catchment installation for surface water or groundwater intended for human consumption must be 500 m. That requirement does not apply if the landfill is not likely to alter the quality of the water;
- (3) the bottom of the trenches must be at least 1 m above the rock and the groundwater level. Any lowering of the groundwater level by pumping, draining or otherwise is prohibited.

O.C. 451-2005, s. 88.

89. Sections 37, 39, 40, 40.1, 43 to 49, 52 to 55, 57 to 59, 63 to 66 and 69 to 71 apply to the operation of a trench landfill, with the necessary modifications, in particular as follows: the quantity of residual materials referred to in subparagraph 4 of the first paragraph of section 39 may be expressed in volume, and the maximum distance authorized by subparagraph 2 of the third paragraph of section 65 for the installation of groundwater quality monitoring wells is extended to 300 m from the trench area.

The provisions of sections 63, 65 and 66 do not apply to a trench landfill that is completely sited on a mine tailings heap if the monitoring and supervision measures prescribed by those sections cannot be implemented due to physical constraints inherent to the heap. In that case, the operator must see to the implementation of substitution measures that, in addition to being better adapted to those constraints, allow water monitoring and supervision as close as possible to those prescribed by sections 63, 65 and 66.

O.C. 451-2005, s. 89; O.C. 451-2011, s. 20.

90. The operation of a trench landfill is also subject to the following conditions :

(1) in order to minimize the release of odours, the spread of fires, the proliferation of animals or insects, and blowing litter, the residual materials deposited in the trenches must, at least once a week from May to October, be covered with a layer of soil or other material referred to in paragraph 4, or be covered in another manner if the above purposes are accomplished. The weekly cover requirement does not apply to a landfill reserved exclusively for the use of an industrial, commercial or other establishment if the residual materials received are not likely to generate the nuisances referred to above;

(2) residual materials containing asbestos, sludge and animal carcasses or animal parts must be covered with other materials as soon as they are deposited. That requirement does not apply if the residual materials deposited are covered in another manner as provided for in paragraph 1. The words “containing asbestos” have the same meaning as in the fourth paragraph of section 41;

(3) the soil used to cover the residual materials may contain contaminants in a concentration equal to or lower than the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37) for volatile organic compounds and in Schedule II to that Regulation for other contaminants. Those limit values do not apply to contaminants that do not originate from human activity. The thickness of the cover layer consisting of such contaminated soil may not exceed 60 cm;

(4) other material may be used to cover the residual materials deposited in trenches if the other material does not contain any substance that is not accepted in a trench landfill and is capable of accomplishing the purposes referred to in paragraph 1.

O.C. 451-2005, s. 90.

91. When the height of the residual materials deposited in a trench reaches the ground surface at the perimeter of the trench area, the trench area must be covered with a soil layer at least 60 cm thick including, in its upper portion, a layer at least 15 cm thick that is suitable for vegetation. The latter layer may also consist of a layer not more than 30 cm thick of another material that is suitable for vegetation.

With the exception of the layer of soil or other material suitable for vegetation, the trench cover may also consist of soils containing contaminants in a concentration equal to or lower than the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37). Those limit values do not apply to contaminants that do not originate from human activity.

In order to allow the water to flow away from the trench area and limit soil erosion, the final cover must also be graded to a slope of at least 2% without exceeding

- (1) 5%, if the slope at the perimeter of the trench area does not exceed that percentage; or
- (2) the percentage of the slope at the perimeter of the trench area, if that slope is greater than 5%.

Not later than 1 year after installation of the final cover, the final layer must be given a vegetative layer. Damage such as holes, fissures or subsidence that may occur in the final cover must be repaired immediately to prevent water from pooling, until the trench area has been fully stabilized.

The provisions of sections 34 to 36 relating to quality assurance and control apply, with the necessary modifications, to the final trench cover prescribed by this section.

O.C. 451-2005, s. 91; O.C. 451-2011, s. 21.

92. If all or part of a trench landfill is temporarily closed for a period of 3 months or more, and subject to the second paragraph, the residual materials deposited in a trench must be covered with at least 30 cm of soil at the latest by the expiry of the third month.

Any trench that is unused for a period of 6 months must be filled in as provided in section 91 at the latest by the expiry of the sixth month.

O.C. 451-2005, s. 92.

93. Sections 80 to 85 apply, with the necessary modifications, to the closure of a trench landfill and to its post-closure management.

O.C. 451-2005, s. 93.

DIVISION 4

NORTHERN LANDFILLS

94. Landfills may be established in the North, in which only residual materials generated in the North are accepted, including sludge which, although generated elsewhere, is treated in the North.

Northern landfills must be sited and operated in accordance with this Division.

For the purposes of this Division, “the North” means the territories listed below:

(1) the territory situated north of the 55th parallel;

(2) Municipalité de Côte-Nord-du-Golfe-du-Saint-Laurent, the municipalities of Blanc-Sablon, Bonne-Espérance, Gros-Mécatina and Saint-Augustin, Ville de Schefferville and the territory within a radius of 10 km from the limits of that town, the Naskapi Village of Kawawachikamach and any other municipality constituted under the Act respecting the municipal reorganization of the territory of Municipalité de Côte-Nord-du-Golfe-du-Saint-Laurent (1988, chapter 55; 1996, chapter 2).

O.C. 451-2005, s. 94; O.C. 451-2011, s. 22.

95. Northern landfills must be sited at a minimum distance of

(1) 150 m from any watercourse or body of water; and

(2) 500 m from any catchment installation for surface water or groundwater intended for human consumption.

The first paragraph does not apply if the landfill is not likely to alter the quality of the water referred to in that paragraph.

O.C. 451-2005, s. 95.

96. Northern landfills must be surrounded by a fence or any other device so as

- (1) to prevent wind dispersal of the residual materials and contain them in the disposal areas;
- (2) to prevent animals from entering the landfill; and
- (3) to prevent access to the landfill after business hours.

The landfills must also be surrounded by a fire barrier at least 15 m wide devoid of all vegetation.

A conspicuous sign must be posted at the landfills indicating the type of landfill, the name and address of the operator and any other person in charge of the landfill, as well as the business hours.

O.C. 451-2005, s. 96.

97. The bottom of the disposal areas of a northern landfill must be above the permafrost line at a minimum distance of 30 cm above the groundwater level. Any lowering of the groundwater level by pumping, draining or otherwise is prohibited.

The removed materials must be stockpiled on the perimeter of the site to be used to cover the residual materials.

Sludge must be deposited in an area separate from the area in which other residual materials are deposited so as to facilitate the burning of the residual materials.

O.C. 451-2005, s. 97.

98. Northern landfills must have a surface water collection system to prevent the surface water from being contaminated by residual materials or from penetrating into the disposal areas. Once collected, the surface water must be discharged outside the landfill site.

O.C. 451-2005, s. 98.

99. Combustible residual materials deposited in northern landfills must be burned at least once a week, weather conditions permitting.

Residual materials containing asbestos, and animal carcasses or animal parts must be covered with soil or other residual materials as soon as they are deposited. The words “containing asbestos” have the same meaning as in the fourth paragraph of section 41.

The soil used to cover the residual materials may contain contaminants in a concentration equal to or lower than the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37) for volatile organic compounds and in Schedule II to that Regulation for other contaminants. Those limit values do not apply to contaminants that do not originate from human activity.

O.C. 451-2005, s. 99; O.C. 451-2011, s. 23.

100. If all or part of a northern landfill is closed or unused for a period of 6 months or more, the residual materials deposited in the landfill must be covered after being burned with a layer of soil at least 30 cm thick at the latest by the expiry of the sixth month.

The soil referred to in the first paragraph may contain contaminants in a concentration equal to or lower than the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37). Those limit values do not apply to contaminants that do not originate from human activity.

O.C. 451-2005, s. 100; O.C. 451-2011, s. 24.

DIVISION 5

CONSTRUCTION OR DEMOLITION WASTE LANDFILLS

101. For the purposes of this Division, “construction or demolition waste” means any material from the construction, renovation or demolition of immovables, bridges, roads or other structures, and includes stone, debris or rubble, fragments of concrete, masonry or asphalt, siding materials, wood, metal, glass, textile materials and plastics, but excludes

(1) materials rendered unrecognizable by burning, crushing, shredding or otherwise, containers of paint, solvent, sealant, adhesive or other similar materials, wood treated to prevent the presence of mould or to increase resistance to decay, yard waste such as grass, leaves and woodchips, and materials, other than bituminous coated material, containing asbestos. The words “containing asbestos” have the same meaning as in the fourth paragraph of section 41; and

(2) any material mingled with household garbage, materials from an industrial process or any of the materials referred to in subparagraph 1.

Trees, branches and stumps removed to allow for construction work, soil excavated from land including soil containing 1 or more contaminants in a concentration lower than or equal to the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37), and residual materials from a facility that recovers or reclaims construction or demolition waste or from another recovery or reclamation facility authorized under the Environment Quality Act (chapter Q-2) are considered to be construction or demolition waste to which this Division applies insofar as in all cases the materials, although of a composition similar to that of construction or demolition waste, were unable to be recovered or reclaimed. The limit values referred to in this paragraph for contaminants do not apply to contaminants that do not originate from human activity.

O.C. 451-2005, s. 101.

102. Any establishment or enlargement of construction or demolition waste landfills is prohibited. The term “enlargement” includes any alteration that results in an increase in landfill capacity.

That prohibition does not apply to projects to establish or enlarge a dry materials disposal site within the meaning of the Regulation respecting solid waste (chapter Q-2, r. 13), replaced by this Regulation, in respect of which, before 1 December 1995, a notice required under section 31.2 of the Environment Quality Act (chapter Q-2) or an application for a certificate was filed with the Minister and, on 19 January 2006, no decision has been made by the Government or the Minister granting or refusing the authorization or certificate applied for. Those projects may be continued as projects to establish or enlarge a construction or demolition waste landfill and are subject to the provisions of this Division.

O.C. 451-2005, s. 102.

103. Construction or demolition waste landfills referred to in the second paragraph of section 102 may be established or enlarged only for the purpose of filling a pit or quarry within the meaning of the Regulation respecting pits and quarries (chapter Q-2, r. 7) if the depth of the pit or quarry allows for waste to be landfilled to an average thickness of at least 3 m.

Only construction or demolition waste within the meaning of section 101 of this Regulation may be disposed of in a landfill referred to in the first paragraph.

O.C. 451-2005, s. 103.

104. Subject to the conditions set out in the second paragraph, sections 13 to 16, 19, 28 to 30 and 34 to 36 apply, with the necessary modifications, to the siting of construction or demolition waste landfills.

The siting is also subject to the following conditions:

- (1) the minimum distance between the disposal areas and any watercourse or body of water must be 150 m;
- (2) the bottom of the disposal areas must be at least 1 m above the groundwater level. The lowering of the groundwater level by pumping, draining or otherwise is prohibited. That prohibition does not apply to landfills in operation on 19 January 2006 if their siting complies with the provisions of this Regulation that apply to containment and the collection of leachate in engineered landfills. In such a case, the leachate collection system must be designed and installed so that the hydraulic head at the base of the disposal areas cannot reach the level of the residual materials deposited in the disposal areas.

The minimum distances prescribed by the second paragraph are measured from the disposal areas in the pit or quarry.

O.C. 451-2005, s. 104.

105. Sections 37 to 40.1, 43 to 49, 52 to 55, 57 to 60, 63 to 67 and 69 to 79 apply to the operation of construction or demolition waste landfills, with the necessary modifications and in particular as follows: the maximum distance authorized under subparagraph 2 of the third paragraph of section 65 for the installation of groundwater quality monitoring wells must not exceed the perimeter of the landfills.

The operation of the landfills is also subject to the following conditions:

- (1) subject to subparagraph 2, construction or demolition waste deposited in the landfills must, at least once a month during the operation period, be graded and covered with a layer of soil or material that
 - consists of less than 20% by weight of particles 0.08 mm or finer in diameter;
 - has a constant minimum hydraulic conductivity of 1×10^{-4} cm/s;
 - does not contain material that is not accepted in such a landfill;
 - accomplishes the purposes referred to in the second paragraph of section 41;
- (2) bituminous coated material containing asbestos must be covered with other materials on being unloaded in a disposal area. The words “containing asbestos” have the same meaning as in the fourth paragraph of section 41;
- (3) (*subparagraph revoked*).

The soil used to cover construction or demolition waste may also contain contaminants in a concentration equal to or lower than the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37). Those limit values do not apply to contaminants that do not originate from human activity.

The operator must periodically verify, at the frequency specified in the authorization obtained pursuant to section 22 or 31.5 of the Environment Quality Act (chapter Q-2), whether the soils or other materials used to cover the residual materials meet the requirements of subparagraph 1 of the second paragraph of this section. For that purpose, the operator must have representative samples of the soils or materials measured and analyzed and the results of the measurements and analyses must appear in the annual report prepared pursuant to section 52.

O.C. 451-2005, s. 105; O.C. 451-2011, s. 25.

106. When the height of landfilled construction or demolition waste reaches a level that is 90 cm below the ground surface at the perimeter of a disposal area, the area must receive a final cover consisting of, from the bottom up,

(1) an impermeable soil layer with a constant maximum hydraulic conductivity of 1×10^{-5} cm/s, through a minimum thickness of 45 cm after compaction, or a geomembrane at least 1 mm thick placed on a soil layer at least 30 cm thick having characteristics that preserve the integrity of the geomembrane; and

(2) a barrier soil layer at least 45 cm thick if the above-mentioned impermeable layer is a soil layer, or 60 cm thick if the impermeable layer is a geomembrane. The upper portion of the layer prescribed by this subparagraph must also, to a depth of between 15 and 30 cm, consist of soil or materials suitable for vegetation. The characteristics of the soil or other materials used must be such as to preserve the integrity of the impermeable layer.

In addition, any raising of the ground surface at the perimeter of a disposal area is prohibited.

With the exception of the layer of soil or material suitable for vegetation, the layers referred to in subparagraphs 1 and 2 of the first paragraph may also consist of soils containing contaminants in a concentration equal to or lower than the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37). Those limit values do not apply to contaminants that do not originate from human activity. The layers may also consist of other material if the material meets where applicable the requirements of this paragraph and the minimum thickness of the layers is as prescribed in those subparagraphs.

In order to allow the water to flow away from the disposal area and limit soil erosion, the final cover must also be graded

- (1) to a slope of 2%, if the slope at the perimeter of the disposal area does not exceed that percentage; or
- (2) to a slope that equals the slope percentage at the perimeter of the disposal area, if that perimeter slope is greater than 2%.

Not later than 1 year after installation of the final cover, the final layer must be given a vegetative layer. Damage such as holes, fissures or subsidence that may occur in the final cover must be repaired immediately to prevent water from pooling over or infiltrating into the disposal area, until the disposal area has been fully stabilized.

The provisions of sections 34 to 36 relating to quality assurance and control apply, with the necessary modifications, to the final cover of disposal areas prescribed by this section.

O.C. 451-2005, s. 106; O.C. 451-2011, s. 26.

107. Every construction or demolition waste landfill must have a system that collects and removes the biogas produced in the landfill.

The system must be in operation not later than 1 year after a disposal area has received a final cover.

O.C. 451-2005, s. 107.

108. The final profile of filled construction or demolition waste landfills including the final cover must not exceed the ground surface at the perimeter of the disposal areas, except to the extent that the raising of the surface of the disposal areas relative to the ground is necessary to meet the requirements of the fourth paragraph of section 106, in which case the height of the landfilled residual materials may exceed the limit prescribed by that section.

O.C. 451-2005, s. 108.

109. Residual materials in a construction or demolition waste landfill that has been unused for a period of 12 months or more must, at the latest by the expiry of the twelfth month, be covered as required by sections 106 and 108 which apply with the necessary modifications.

O.C. 451-2005, s. 109.

110. Sections 80 to 85 apply, with the necessary modifications, to the closure of construction or demolition waste landfills and to their post-closure management.

O.C. 451-2005, s. 110.

DIVISION 6

REMOTE LANDFILLS

111. Landfills may be established in the territories referred to in section 112, in which only residual materials generated in those territories are accepted.

The landfills, referred to as “remote landfills”, must be sited and operated in accordance with this Division, which also prescribes the conditions that apply to their closure.

O.C. 451-2005, s. 111.

112. Remote landfills are permitted in the following territories only:

- (1) territories that are not organized into local municipalities;
- (2) territories inaccessible by road and every island that is not connected to the mainland by a bridge or a boat service;
- (3) the territory of the James Bay region, as described in the schedule to the James Bay Region Development and Municipal Organization Act (chapter D-8.2);
- (4) the territories referred to in the third paragraph of section 94; and
- (5) the part of the territory of Ville de La Tuque situated west of the 73rd meridian.

Except the territories referred to in subparagraph 4 of the first paragraph, those landfills may not serve more than 100 persons on average, on a yearly basis.

In addition, in the territories referred to in subparagraphs 1, 3 and 5 of the first paragraph, only the following persons or municipalities may establish and operate a remote landfill:

- (1) the Minister of Natural Resources and Wildlife or another authority responsible under the Act for the management of lands in the domain of the State;
- (2) a regional county municipality;
- (3) the manager of an outfitting operation or of a controlled territory within the meaning of the Act respecting the conservation and development of wildlife (chapter C-61.1);
- (4) the person responsible for an industrial camp governed by the Regulation respecting sanitary conditions in industrial or other camps (chapter Q-2, r. 11);
- (5) Municipalité de Baie-James;
- (6) the person appointed under section 166 of the Environment Quality Act (chapter Q-2) to exercise the functions, duties and powers of the Minister of Sustainable Development, Environment and Parks on Category I land in the territory referred to in section 133 of that Act;
- (7) Ville de La Tuque.

O.C. 451-2005, s. 112; O.C. 451-2011, s. 27.

113. A remote landfill may not accept residual materials from

- (1) a dwelling or an establishment served by a residual materials collection service or situated 100 km or nearer by road from an engineered landfill that is not reserved exclusively for the use of an industrial, commercial or other establishment, or from an incineration facility referred to in section 121, as long as those disposal facilities remain accessible by road; or
- (2) an establishment in which more than 100 people are lodged, on a yearly basis or the equivalent.

O.C. 451-2005, s. 113; O.C. 451-2011, s. 28.

114. Remote landfills must be sited at a minimum distance of

- (1) 150 m from any watercourse or body of water; and
- (2) 500 m from any catchment installation for surface water or groundwater intended for human consumption. That requirement does not apply if the landfill is not likely to alter the quality of the water.

O.C. 451-2005, s. 114.

115. No person may burn residual materials in a remote landfill. An operator may not allow the burning of such materials in a remote landfill.

The prohibition in the first paragraph is however not applicable to a remote landfill in the North as defined in section 94 that has a fire barrier at least 15 m wide and devoid of all vegetation extending outward from the burning area.

O.C. 451-2005, s. 115; O.C. 451-2011, s. 29.

116. The bottom of the disposal areas of every remote landfill must be a minimum distance of 30 cm above bedrock and the groundwater level. Any lowering of the groundwater level by pumping, draining or otherwise is prohibited.

O.C. 451-2005, s. 116.

117. From May to October, the residual materials deposited in a remote landfill must be covered at the end of each day of use or at least once a week where those materials are burned pursuant to the second paragraph of section 115, with a layer of soil or with a layer of lime, or be covered in another manner that minimizes the release of odours, the spread of fires, the proliferation of animals or insects, and blowing litter.

Residual materials containing asbestos, and animal carcasses or animal parts must be covered with other residual materials as soon as they are deposited. That requirement does not apply if the residual materials deposited in the remote landfill are covered in another manner as provided for in the first paragraph. The words “containing asbestos” have the same meaning as in the fourth paragraph of section 41.

O.C. 451-2005, s. 117; O.C. 451-2011, s. 30.

118. Sludge with a dryness lower than 15% to be landfilled in a remote landfill must be landfilled in a separate pit reserved exclusively for that type of residual material.

O.C. 451-2005, s. 118.

119. When the height of the residual materials reaches the ground surface at the perimeter of the landfill, the remote landfill must be covered with a layer of materials at least 30 cm thick consisting of soil including a layer at least 15 cm thick that is suitable for vegetation, or consisting of a layer of another material not more than 30 cm thick that is suitable for vegetation. Any raising of the ground surface at the perimeter of the landfill is prohibited.

In order to allow water to flow away from the landfill and limit soil erosion, the final cover must also be graded to a slope of at least 2% without exceeding

- (1) 5%, if the slope at the perimeter of the remote landfill does not exceed that percentage; or
- (2) the percentage of the slope at the perimeter of the remote landfill if that slope is greater than 5%.

O.C. 451-2005, s. 119.

120. If a remote landfill is temporarily closed for a period of 3 months or more, and subject to the second paragraph, the residual materials deposited in the landfill must be covered with at least 30 cm of soil at the latest by the expiry of the third month.

A remote landfill that is unused for a period of 12 months must be filled in at the latest by the expiry of that period and section 119 applies, with the necessary modifications.

O.C. 451-2005, s. 120.

CHAPTER III

RESIDUAL MATERIALS INCINERATION FACILITIES

DIVISION 1

GENERAL

121. This Chapter applies to incineration facilities that incinerate at least 1 of the following types of residual materials:

- (1) household garbage collected by or for a municipality;
- (2) sludge from municipal water or sludge treatment or collection works, other sanitary wastewater collection or treatment works or treatment works for sludge from such works, or from sewer cleaning.

O.C. 451-2005, s. 121.

122. The provisions of the Regulation respecting biomedical waste (chapter Q-2, r. 12) and the Clean Air Regulation (chapter Q-2, r. 4.1) that apply to biomedical waste incineration facilities also apply to the residual materials incineration facilities governed by this Chapter that receive biomedical waste referred to in section 1 of the Regulation respecting biomedical waste.

Where this Regulation is inconsistent with the above regulations, the provisions that ensure greater environmental protection are to prevail.

O.C. 451-2005, s. 122; O.C. 666-2013, s. 2.

123. Residual materials that, under paragraphs 1 to 6, 8 to 10 and 12 of section 4, may not be disposed of in an engineered landfill may not be disposed of in an incineration facility governed by this Chapter.

In addition, inedible meat within the meaning of the Regulation respecting food (chapter P-29, r. 1) may be disposed of in such an incineration facility only under the conditions prescribed by the Food Products Act (chapter P-29) and the regulations made under that Act.

O.C. 451-2005, s. 123.

DIVISION 2

SITING AND OPERATION

124. The incineration facilities governed by this Chapter must have a handling area or pit where the residual materials are received and that must be situated inside a building.

The handling area and pit must be impermeable.

The handling area must be cleaned at the end of each day of operation.

No non-incinerated residual material or incinerator ash may be stored outside the incineration facility buildings ; no truck containing residual materials, including ash, may be parked on the premises of the facility for a period of more than 1 hour.

O.C. 451-2005, s. 124; O.C. 451-2011, s. 31.

125. An incineration facility governed by this Chapter that receives biomedical waste referred to in paragraphs 1 to 3 of section 1 of the Regulation respecting biomedical waste (chapter Q-2, r. 12), or animal carcasses or animal parts, must be laid out so that the residual materials are unloaded in an area separate from the area where the other types of residual materials are deposited, and are conveyed to the combustion chamber or chambers by means of an independent feed system.

The requirements of the first paragraph do not apply in the case of animal carcasses or animal parts of domestic pets that are not from establishments that breed or sell domestic pets or that shelter, care for or protect them.

O.C. 451-2005, s. 125.

126. An incineration facility governed by this Chapter that has a rated capacity of less than 1 ton per hour must have at least 2 combustion chambers.

Gases from the primary combustion chamber must be brought to a temperature greater than 1,000°C for at least 1 second when they reach the final combustion chamber.

In addition, no residual materials may be fed into the primary combustion chamber during the preheating of the final combustion chamber, or be ignited until the temperature of the gases in the final combustion chamber has been maintained at a temperature of at least 1,000°C for a minimum of 15 minutes.

The facility must have auxiliary gas or liquid fossil fuel burners.

O.C. 451-2005, s. 126.

127. An incineration facility governed by this Chapter must have a sampling system that continuously measures and records the concentration of carbon monoxide, carbon dioxide and oxygen in the combustion gases emitted into the atmosphere. It must also have a system that continuously measures and records the gas temperature at the outlet of the final combustion chamber.

If the incineration facility has a rated capacity of 1 ton or more per hour, it must also have a sampling system that continuously measures and records the opacity of the combustion gases or the concentration of the particles emitted into the atmosphere.

In addition, if an incineration facility has a rated capacity of 2 tons or more per hour and burns halogenated materials, it must have a sampling system that continuously measures and records the concentration of hydrogen chloride in the combustion gases emitted into the atmosphere.

All measurements must be kept by the operator for a minimum of 4 years and be made available to the Minister.

O.C. 451-2005, s. 127.

128. Sections 37 to 39, paragraph 1 of section 45, sections 48, 52 and 72 to 79 apply, with the necessary modifications, to the operation of every incineration facility governed by this Chapter.

Sections 38 and 72 to 79 do not apply to an incineration facility that disposes of residual materials generated in any of the territories referred to in section 87 or 94.

O.C. 451-2005, s. 128.

DIVISION 3

GAS EMISSIONS

129. The opacity of grey or black combustion gas emitted into the atmosphere by an incineration facility governed by this Chapter must not exceed 20% except

- (1) for a maximum of 4 minutes per hour at which time the opacity of the emissions may attain a maximum of 40%; or
- (2) on igniting the combustion chamber or blowing tubes at which time the opacity of the emissions may attain a maximum of 60% for a maximum of 4 minutes.

The opacity of the emissions is measured using the Micro-Ringelmann Chart in the manner set out in Schedule I.

O.C. 451-2005, s. 129.

130. Subject to section 133, the incineration facilities governed by this Chapter must not emit combustion gases into the atmosphere that contain

- (1) more than 20 mg/m^3 of particles if the facilities have a rated capacity equal to or greater than 1 ton per hour, or more than 50 mg/m^3 of particles if the rated capacity is lower. "Particle" means any substance, except chemically uncombined water, which exists in a finely divided liquid or solid state in suspension in a gaseous environment;
- (2) more than 50 mg/m^3 of hydrogen chloride. That limit value may be exceeded without, however, exceeding 100 mg/m^3 , in the case of a facility that has a rated capacity of less than 1 ton per hour;
- (3) more than 57 mg/m^3 of carbon monoxide calculated as the arithmetic average of all measurements taken during a 4-hour period;
- (4) more than 0.08 ng/m^3 of polychlorinated dibenzofurans and polychlorinated dibenzo [b, e] [1,4] dioxins. That contaminant concentration is calculated by adding the concentrations of each of the congeners listed in Schedule II and multiplying the sum obtained by the corresponding toxicity equivalency factor determined in that Schedule; or
- (5) more than $20 \text{ }\mu\text{g/m}^3$ of mercury or, if the facility incinerates only sludge referred to in paragraph 2 of section 121, more than $70 \text{ }\mu\text{g/m}^3$ of mercury.

O.C. 451-2005, s. 130.

DIVISION 4

GAS EMISSIONS MONITORING

131. The measurements taken to monitor compliance with the limit values set out in section 130 are expressed as units of mass per cubic metre of dry combustion gas, at a reference temperature of 25 °C and pressure of 101.3 kPa, corrected to 11% oxygen according to the following formula:

$$E = E_a \times (9.9 / (20.9 - A))$$

where

“E” is the corrected concentration;

“E_a” is the dry concentration at the above temperature and pressure; and

“A” is the percentage of oxygen, on a dry basis, in the combustion gases at the sampling point.

O.C. 451-2005, s. 131.

132. The operator of an incineration facility governed by this Chapter that has a rated capacity equal to or greater than 1 ton per hour must, at least once a year, perform source emissions testing of the combustion gases emitted into the atmosphere or have such testing performed for the purpose of measuring the parameters mentioned in section 130, with 3 samples per run for the parameters referred to in paragraphs 1, 2, 4 and 5 of that section. If the rated capacity of the incineration facility is less than 1 ton per hour, that testing requirement is reduced to at least once every 3 years.

O.C. 451-2005, s. 132.

133. A limit value set out in paragraphs 1, 2, 4 and 5 of section 130 is considered to be complied with if the following conditions are met:

- (1) the arithmetic average of the 3 sampling results from the same sampling run performed pursuant to section 132 is lower than or equal to the limit value;
- (2) at least 2 of the results are lower than the limit value;
- (3) none of the 3 results exceeds the limit value by more than 20%.

O.C. 451-2005, s. 133.

134. The emissions testing of the gas required by section 132 must be performed using the methods described in Book 4 of the Guide d'échantillonnage à des fins d'analyses environnementales published by the Ministère du Développement durable, de l'Environnement et des Parcs. A report of the testing performed as provided in that Book must be sent to the Minister within 120 days after the end of each sampling run. The report must contain a statement by its author certifying that the testing was performed in accordance with the methods described in that Book.

The gas samples must be sent for analysis to laboratories accredited by the Minister under section 118.6 of Environment Quality Act (chapter Q-2).

O.C. 451-2005, s. 134.

DIVISION 5

PROCESS WATER AND OTHER LIQUID

135. Sections 29, 53, 55, 63 and 69 to 71 apply, with the necessary modifications, to process water used in an incineration facility governed by this Chapter to cool the incineration residue or to reduce the emissions of contaminants into the atmosphere, and to liquid from the handling area or pit where the residual materials are received.

O.C. 451-2005, s. 135.

CHAPTER IV

RESIDUAL MATERIALS TRANSFER STATIONS

DIVISION 1

GENERAL

O.C. 451-2011, s. 33.

136. This Chapter applies to residual materials transfer stations, except transfer stations that receive only construction or demolition waste within the meaning of section 101.

“Transfer station” means any facility where residual materials are unloaded to be prepared for further transport to another place for disposal.

O.C. 451-2005, s. 136.

137. The only residual materials that may be accepted at a transfer station are those authorized by this Regulation to be disposed of in an engineered landfill or an incineration facility to which Chapters II and III apply respectively.

Despite the foregoing, sludge with a dryness lower than 25% may not be accepted at a transfer station.

O.C. 451-2005, s. 137; O.C. 451-2011, s. 32.

138. The operations at a transfer station involving the loading and unloading of residual materials must be carried out inside a building. No residual material may be stockpiled outside the building. No truck containing residual materials may be parked on the premises of the transfer station for a period of more than 1 hour.

When transfer activities cease for a period of more than 12 hours, all the residual materials received must be conveyed to their destination so that no residual materials remain inside the building or on the premises of the transfer station. That requirement does not apply if the building referred to in the first paragraph has an air collection and treatment system that prevents any nuisance odour caused by the residual materials remaining in the building for a period of more than 12 hours.

O.C. 451-2005, s. 138.

139. Subject to section 139.2, sections 37 to 39, paragraph 1 of section 45, sections 48, 49, subparagraph 1 of the first paragraph of section 52 and the second and third paragraphs of section 124 apply, with the necessary modifications, to residual materials transfer stations.

The operations logs maintained by a transfer station must also indicate the destination of the transferred residual materials and the data must be compiled in the annual reports of those stations. The logs are not required to be kept after a transfer station is closed if the information entered in them has been transferred into the operations logs of the disposal facilities that received the residual materials.

In addition, section 29, subparagraph 4 of the first paragraph and the second paragraph of section 52, sections 53, 55, 63 and 69 to 71 apply, with the necessary modifications, to liquid from the residual materials handling area.

O.C. 451-2005, s. 139; O.C. 451-2011, s. 34.

DIVISION 2

LOW CAPACITY TRANSFER STATIONS

O.C. 451-2011, s. 35.

139.1. A low capacity transfer station established in accordance with this Division may be operated only by or for a municipality.

“Low capacity transfer station” means a transfer station that is established for the transfer of 200 metric tons or less of residual materials every week.

O.C. 451-2011, s. 35.

139.2. Despite the provisions of section 139, the provisions of section 38 do not apply to a low capacity transfer station. The quantity of residual materials entered in the operations logs of such a station pursuant to subparagraph 4 of the first paragraph of section 39 may be expressed in volume.

The provisions of sections 29, 37, 39, subparagraphs 1 and 4 of the first paragraph and the second paragraph of section 52, and the second and third paragraphs of section 124 do not apply to a low capacity transfer station where it is established for the transfer of 30 metric tons or less of residual materials every week.

In addition, the provisions of section 138 do not apply to a low capacity transfer station where the residual materials are deposited in a closed and watertight container and conveyed to a disposal facility at least once a week from May to October.

A local municipality may only have on its territory 1 low capacity transfer station established for the transfer of more than 30 metric tons of residual materials every week. This also applies to a transfer station established for the transfer of 30 metric tons or less of residual materials every week and used in whole or in part for the transfer of household garbage.

O.C. 451-2011, s. 35.

139.3. The maximum volume of residual materials that may be stored in a low capacity transfer station must not at any time exceed 300 m³. In the case of a station established for the transfer of 30 metric tons or less of residual materials every week, the volume may not exceed 100 m³.

O.C. 451-2011, s. 35.

139.4. Despite the provisions of section 139.1, where a low capacity transfer station is situated in a territory inaccessible by a road open year-round within the meaning of paragraph 4 of section 87, a quantity of residual materials greater than 200 metric tons may be transferred every week from November to April. In addition, during the same period, the provisions of section 139.3 do not apply to such a station.

O.C. 451-2011, s. 35.

CHAPTER V

FINANCIAL GUARANTEE

140. The operation of the facilities to which Divisions 2, 3 and 5 of Chapter II and Chapters III and IV apply, except a transfer station referred to in the second paragraph of section 139.2, is subject to the provision of a financial guarantee by the operator or by a third party on the operator's behalf to guarantee, during the operation and on closure, the performance of the operator's obligations under the Environment Quality Act (chapter Q-2), the regulations, an order or an authorization.

The amount of the financial guarantee is established as follows:

Class of facility	Guarantee
Engineered landfill and construction or demolition waste landfill	
- receiving less than 20,000 tons per year	\$100,000
- receiving from 20,000 to 100,000 tons per year	\$300,000
- receiving more than 100,000 tons per year without exceeding 300,000 tonnes per year	\$500,000
- receiving more than 300,000 tons per year	\$1,000,000
Trench landfill	\$50,000 per landfill, maximum \$250,000 for the operator of more than 1 landfill
Incineration facility	1% of capital cost, minimum \$100,000 maximum \$2,000,000
Transfer station	\$100,000

O.C. 451-2005, s. 140; O.C. 451-2011, s. 36.

141. The financial guarantee must be in one of the following forms:

- (1) cash, a bank money order or a certified cheque made out to the Minister of Finance;
- (2) bearer bonds issued or guaranteed by Québec, Canada or a Canadian province, the United States of America or one of its member States, the International Bank for Reconstruction and Development, a municipality or a school board in Canada or a fabrique in Québec;
- (3) a security or guarantee policy, with a stipulation of solidarity and renunciation of the benefits of discussion and division, issued by a legal person authorized to give guarantees under the Bank Act (S.C. 1991, c. 46), the Act respecting trust companies and savings companies (chapter S-29.01), the Act respecting insurance (chapter A-32) or the Act respecting financial services cooperatives (chapter C-67.3);
- (4) an irrevocable letter of credit issued by a bank or a financial services cooperative.

O.C. 451-2005, s. 141.

142. The sums of money, orders, cheques or bonds provided as a guarantee must be deposited with the Minister of Finance pursuant to the Deposit Act (chapter D-5) for the operational period of the facility and for a period of 12 months following the closure of the facility or the revocation or transfer of the certificate of authorization, whichever occurs first.

O.C. 451-2005, s. 142.

143. A financial guarantee provided in the form of security, a financial guarantee policy or a letter of credit must have a term of not less than 12 months. At least 60 days before the expiry of the financial guarantee, the proponent must send renewal of the financial guarantee or any other financial guarantee that meets the requirements of sections 140 and 141 to the Minister of Sustainable Development, Environment and Parks.

The financial guarantee must also contain a clause setting the time period for filing a claim based on a failure by the operator to perform obligations at not less than 12 months after expiry of the financial guarantee or, as the case may be, its revocation, rescission or cancellation.

A clause of revocation, rescission or cancellation of a financial guarantee may take effect only if prior notice of at least 60 days is sent to the Minister by registered or certified mail.

O.C. 451-2005, s. 143.

144. If the operator fails to perform an obligation and the default persists after a notice from the Minister to remedy the failure, the Minister may use the financial guarantee provided pursuant to section 140 to pay expenses necessary for performance of the obligation. In such a case, the sums required to fulfil a financial guarantee provided under this Chapter become payable.

O.C. 451-2005, s. 144.

CHAPTER VI

CERTIFICATE OF AUTHORIZATION

145. No person may establish or enlarge an engineered landfill or a construction or demolition waste landfill referred to in the second paragraph of section 102 without being the owner of the land on which the landfill is to be established or enlarged, including the land on which any system necessary to its operation is to be situated if the land is not the land on which the disposal areas and other landfill equipment or facilities are to be situated.

After its establishment or enlargement, the landfill and the land on which the landfill or any system necessary to its operation is situated must continue to be owned by the same person or municipality, including after a transfer of the disposal facility.

O.C. 451-2005, s. 145.

146. Section 55 of the Environment Quality Act (chapter Q-2) relating to the authorization requirement set out in section 22 of the Act does not apply to remote landfills to which Division 6 of Chapter II applies. Despite the foregoing, the operator is required, before establishing or altering such a landfill, to give notice in writing of the establishment or alteration to the Minister and the regional county municipality in which the landfill is situated, or the local municipality in which the landfill is situated if the territory of the local municipality is not within the territory of a regional county municipality. The notice must specify where the landfill is situated and indicate the number of persons the landfill is to serve on a yearly basis or provide the data necessary to enable the equivalent of that number to be determined.

Likewise, the provisions of section 55 do not apply to a transfer station referred to in the second paragraph of section 139.2. In such a case, the operator must notify in writing the Minister and the regional county municipality with an indication of the location of such a station, the weekly quantity of residual materials that will be transferred at the station and the user community concerned.

O.C. 451-2005, s. 146; O.C. 451-2011, s. 37.

147. An application for an authorization under section 22 of the Environment Quality Act (chapter Q-2) relating to the establishment or alteration of a residual materials disposal facility referred to below must be accompanied by the following information and documents, in addition to those required under section 22 of the Act or under the Regulation respecting the application of the Environment Quality Act (chapter Q-2, r. 3):

(1) in the case of an application for the establishment or enlargement of an engineered landfill or a construction or demolition waste landfill that was authorized by the Government under section 31.5 of the Environment Quality Act,

(a) a copy of the titles confirming the applicant's ownership of the lots or parts of lots covered by the application, and the location certificate for each lot or part of lot;

(b) the plans and specifications of any facility required for the establishment and operation of the landfill, including any equipment or works to reduce, control, contain or prevent the deposit, release, emission or discharge of contaminants into the environment;

(c) all documents and information required under the conditions specified in the authorization granted pursuant to section 31.5 of that Act;

(d) any document or information showing compliance with the conditions set out in this Regulation if the application involves for the landfill or any of its components an exemption from a requirement of this Regulation or the use of an alternative system, technique or material, to the extent that a provision of this Regulation gives entitlement to such an exemption or use;

(2) in the case of any other application concerning an engineered landfill or a construction or demolition waste landfill,

(a) a copy of the titles confirming the applicant's ownership of the lots or parts of lots covered by the application, and the location certificate for each lot or part of lot;

(b) the general characteristics of the disposal facility, including information regarding the user community to be served by the project, and the nature and quantity of the residual materials to be landfilled;

(c) the capacity and life of the landfill, the project schedule for the various phases, the estimated costs for the siting, operation, closure and post-closure management of the landfill, in particular for the monitoring and follow-up measures;

(d) a general plan of the disposal facility showing

- the location and dimensions of the facility, including the buffer zone, with geographic coordinates or, where applicable, the numbers of the lots or parts of lots covered by the application;

- the current land use and zoning within a radius of 2 km;

- the location of every airport within a radius of 8 km;

- the public thoroughfares, access roads, watercourses or bodies of water, wetlands (marshes, swamps, peat bogs), flood plains and mapped 100-year flood plains or flood zones identified by the municipalities, and wooded sectors, dwellings and any other construction within a radius of 1 km;

- the current drainage pattern and general topography of the land within a radius of 1 km;

- the location of every catchment site or works for surface water or groundwater for human or animal consumption, and of the protection areas around the site or works;

(e) a description of the local geology including, for the land covered by the application, a detailed stratigraphy, a geological survey performed using a representative number of stratigraphic borings (a minimum of 4 borings for the first 5 ha of land and an additional boring for each additional 5 ha or 5-ha portion), a soil characterization using a representative number of samples, and an estimate of the volumes of materials available for the establishment and operation of the landfill;

(f) a description of the local hydrogeology including, for the land covered by the application, a piezometric map, the levels of observation wells and other water points (resurgences, streams, outcrops of the water table), groundwater characteristics including location and depth, hydraulic conductivity determined from *in-situ* tests, direction of flow, migration velocity, the relationship between the various hydrostratigraphic units and with the surface hydrographic network, and groundwater susceptibility to pollution determined from a representative number of observation wells or piezometers (a minimum of 4 wells or piezometers for the first 5 ha of land and an additional well or piezometer for each additional 5 ha or 5-ha portion);

(g) a map showing, within a radius of 1 km, the location of the geological and hydrogeological observation points used, rock outcrops and unconsolidated deposits, areas sensitive to erosion and ground movement and land where, because of current or past use, contaminants could be potentially present in concentrations equal to or greater than the limit values set out in Schedule I to the Land Protection and Rehabilitation Regulation (chapter Q-2, r. 37);

(h) the results of the groundwater samples taken on the land covered by the application for the purpose of verifying the parameters and substances listed in sections 57 and 66, using a representative number of samples (a minimum of 1 sample per piezometer);

(i) a description of the physico-chemical and bacteriological characteristics of the surface water near any points of discharge into the environment, and the uses of the surface water;

(j) a study showing the integration of the landfill into the surrounding landscape;

(k) the plans and specifications of any facility required for the establishment and operation of the landfill, including any equipment or works to reduce, control, contain or prevent the deposit, release, emission or discharge of contaminants into the environment, including

- a topographical survey of the land showing the contour lines at intervals of not more than 1 m;
 - a survey of the servitudes encumbering the land and of the surface and underground equipment present;
 - a land development plan (scale between 1 :1,000 and 1 :1,500) showing among other things natural screens, the features to ensure integration into the landscape, the areas reserved for the removal or stockpiling of cover materials, the location of the buildings to be used by employees and for storing equipment, deforestation areas, vehicle traffic areas, weighing equipment, fences and gates, surface water, groundwater and biogas monitoring points and longitudinal and cross sections of the land showing its original and final contours;
 - the plans and profiles of the drainage systems with cross sections of the various components, their description and location of the points of discharge into the environment;
 - a description of the impermeable liner system for the disposal areas and of the leachate and water treatment system;
 - a description of the final cover for the disposal areas, with cross sections of the components;
 - a description of the equipment and works to be used to collect and treat leachate, with an estimate of the quality and quantity of leachate treated having regard to the variability of its characteristics, how the equipment and works are to be managed, how the leachate is to be characterized and treated and how the treatment waste is to be disposed of, as well as the location of the points of discharge into the environment;
 - a description of the equipment and works to be used to prevent or control migration into the soil or emission into the atmosphere of the gas produced by the decomposition of landfilled residual materials, including biogas detection, combustion or treatment equipment and the composition of the gas;
- (l) the quality assurance and quality control programs to ensure the application of sections 34 to 36;
- (m) the operational specifications for the landfill, including
- assignment of the personnel required for the operation;
 - the measures to be taken to ensure the maintenance and repair of the machinery and its replacement if required;
 - the control measures for the residual materials accepted (nature, quality, origin) and the measures to be applied when the materials are unacceptable;
 - the control measures for the daily cover materials to ensure compliance with section 42;
 - the systems inspection, maintenance and cleaning program to be implemented to ensure the application of section 44;
 - the programs to be implemented to monitor and supervise surface water, groundwater and biogas quality to ensure the application of sections 63 to 71, indicating in particular the location of the observation wells and the particulars of their installation;

- (*n*) where required, any document or information referred to in subparagraph *d* of paragraph 1;
- (3) in the case of an application concerning a trench landfill,
 - (*a*) a copy of every document confirming the applicant's rights on the land covered by the application;
 - (*b*) the documents and information referred to in subparagraphs *b* to *i* and *k* to *n* of subparagraph 2, which apply with the necessary modifications;
 - (*c*) if a landfill is planned to be sited completely on a mine tailings heap, the documents or information establishing that physical constraints justify the implementation of substitution measures for water monitoring and supervision, as permitted by section 89, and that those measures meet the conditions in that section;
- (4) in the case of an application concerning a northern landfill,
 - (*a*) the documents and information referred to in subparagraphs *b* and *d* of subparagraph 1, subparagraphs *b* to *d* of subparagraph 2 and subparagraph *a* of subparagraph 3, which apply with the necessary modifications;
 - (*b*) a survey of the servitudes encumbering the land and of the surface and underground equipment present;
 - (*c*) the plans and profiles of the drainage system;
 - (*d*) a description of the soil at the landfill site to a minimum depth of 30 cm below the residual materials floor level;
 - (*e*) the operational specifications for the landfill; and
- (5) in the case of an application concerning a residual materials transfer station or a residual materials incineration facility,
 - the documents and information referred to in subparagraph *b* of subparagraph 1, subparagraphs *b* to *d* of subparagraph 2, subparagraph *a* of subparagraph 3 and subparagraph *e* of subparagraph 4, which apply with the necessary modifications.

The plans and specifications required under this section must be approved by an engineer who is a member of the Ordre des ingénieurs du Québec.

O.C. 451-2005, s. 147; O.C. 451-2011, s. 38.

148. If the information or documents required under section 147 have been provided to the Minister in connection with a preceding application, they need not be sent again if the applicant attests to their accuracy.

O.C. 451-2005, s. 148.

149. (*Revoked*).

O.C. 451-2005, s. 149; O.C. 441-2008, s. 10.

CHAPTER VI.1

MONETARY ADMINISTRATIVE PENALTIES

O.C. 666-2013, s. 3.

149.1. A monetary administrative penalty of \$250 in the case of a natural person or \$1,000 in other cases may be imposed on any person who fails

- (1) to have, at the landfill entrance, a sign complying with paragraph 1 of section 45;
- (2) to form a watchdog committee within the period and in the manner provided for in the first and second paragraphs of section 72 or to ensure the operation of the committee in the case provided for in the fifth paragraph of that section;
- (3) to fill any vacancy on the watchdog committee according to the terms referred to in the fourth paragraph of section 72;
- (4) to inform the watchdog committee of any situation referred to in the first paragraph of section 77 or to make available to or provide the committee with, in a timely manner, all the documents or information prescribed by the second paragraph of that section;
- (5) to pay all operating expenses of the watchdog committee in accordance with section 78;
- (6) to post at the entrance to a landfill that has been permanently closed a sign complying with section 82 or the third paragraph of section 96, as the case may be.

O.C. 666-2013, s. 3.

149.2. A monetary administrative penalty of \$350 in the case of a natural person or \$1,500 in other cases may be imposed on any person who fails

- (1) to comply with the accessibility conditions prescribed by section 29 or 33;
- (2) to obtain the reports referred to in the second paragraph of section 36 or to send them to the Minister in accordance with that paragraph;
- (3) to enter in a log the information prescribed by the first paragraph of section 39, the first or second paragraph of section 40 or the third paragraph of section 40.1;
- (4) to keep the log and its appendices referred to in section 39 or to make them available to the Minister, for the periods and on the conditions provided for in the second paragraph of section 39;
- (5) to enter the results referred to in the fourth paragraph of section 42 or 105 in the annual report provided for in section 52;
- (6) to have, at the landfill entrance, a barrier or other device complying with paragraph 2 of section 45;
- (7) to prepare an annual report containing the data, documents or information provided for in subparagraphs 1 to 6 of the first paragraph of section 52 or to comply with the periods and conditions for sending the report provided for in the second paragraph of section 52;
- (8) to keep the analysis reports referred to in the second paragraph of section 70 during the period provided for therein;
- (9) to send to the Minister the results referred to in the first or third paragraph of section 71 in accordance with the periods and conditions for transmission provided for therein;

(10) to immediately notify the Minister in writing of the date of closure of a landfill in accordance with section 80;

(11) to have prepared or to send to the Minister, within the period provided for in section 81, the closure report referred to therein containing the elements prescribed by subparagraphs 1 to 3 of the first paragraph or the second paragraph of that section;

(12) to keep or make available to the Minister the results referred to in the fourth paragraph of section 127 within the periods and on the conditions provided for therein;

(13) to send to the Minister the sampling report referred to in the first paragraph of section 134 according to the periods and conditions provided for therein;

(14) to give notice in writing to the Minister and the regional county municipality in the cases and on the conditions provided for in the first or second paragraph of section 146;

(15) to notify the Minister in writing in the case and according to the period and conditions provided for in the second paragraph of section 155.

O.C. 666-2013, s. 3.

149.3. A monetary administrative penalty of \$500 in the case of a natural person or \$2,500 in other cases may be imposed on any person who fails

(1) to accept, in an engineered landfill, the eligible residual materials generated in the territories referred to in paragraphs 1 to 4 of section 10 or the inedible meat referred to in section 11;

(2) to comply with the conditions provided for in section 17 relating to the integration of an engineered landfill into the surrounding landscape;

(3) to maintain a buffer zone complying with the first or second paragraph of section 18 or to comply with the activity restrictions in such a zone in accordance with the third paragraph of that section;

(4) to meet the conditions provided for in section 19 or 30 relating to the siting of a landfill;

(5) to provide the zones or components referred to in the first paragraph of section 31 with a groundwater collection system in the cases provided for therein;

(6) to ensure that a groundwater collection system referred to in the first paragraph of section 31 complies with the conditions provided for in the second or third paragraph of that section or that it be halted only in the case provided for in the fourth paragraph of that section;

(7) to verify whether the residual materials received in a landfill may be landfilled in accordance with section 37;

(8) to weigh residual materials received for landfilling in a landfill or to perform radiological testing as soon as the materials are received and in the manner prescribed by the first paragraph of section 38;

(9) to comply with the conditions for the installation, use or maintenance of the devices referred to in the second paragraph of section 38, as provided for in that paragraph;

(10) to obtain the results of the analyses or measures provided for in the second paragraph of section 40 before receiving the soils referred to therein;

- (11) to verify the acceptance of soils referred to in section 40.1 by having taken to have them analyzed the samples referred to in the first or second paragraph of that section in accordance with the conditions provided for therein;
- (12) to comply with the conditions relating to the deposit or covering of the residual materials provided for in the first or second paragraph of section 41;
- (13) to comply with the conditions provided for in the first, second, third or fifth paragraph of section 42 relating to soils or other materials that may be used to cover residual materials;
- (14) to make the periodic verifications prescribed by the fourth paragraph of section 42 according to the frequency and conditions provided for therein;
- (15) to landfill residual materials in the zones prescribed by section 43;
- (16) to comply with the visibility conditions provided for in section 46 regarding residual materials landfilling operations;
- (17) to take the measures prescribed by the first paragraph of section 48 to prevent wind dispersal or scattering of residual materials referred to therein;
- (18) to proceed with the cleaning prescribed by the second paragraph of section 48 in the case and on the conditions provided for therein;
- (19) to take the necessary measures to prevent or eliminate any infestation of pests in accordance with section 49;
- (20) to cover the landfilled residual materials with a final cover in the cases provided for in the first paragraph of section 50 and in accordance with paragraphs second, third, fourth, fifth and sixth of that section;
- (21) to comply with the conditions provided for in the first or second paragraph of section 51 relating to the vegetative layer or the repair of a final cover of an engineered landfill;
- (22) to comply with the conditions provided for in section 56 permitting the infiltration of leachate or water into residual materials disposal areas;
- (23) to measure the groundwater piezometric level in the case provided for in the second paragraph of section 66;
- (24) to continuously measure the flow of biogas during the operating period of a biogas collection system referred to in section 68 or record the results in accordance with the first paragraph of that section;
- (25) to monitor or have monitored every 3 months the concentrations prescribed by subparagraph 1 of the first paragraph of section 68;
- (26) to comply with the conditions provided for in the first or second paragraph of section 69 relating to the samples referred to therein;
- (27) to send for analysis to a laboratory accredited by the Minister the samples taken pursuant to this Regulation in accordance with the first paragraph of section 70;
- (28) to allow watchdog committee members free access to the landfill and to any equipment or facility at the landfill in accordance with section 79;
- (29) to comply with the conditions provided for in paragraphs 1, 3 or 4 of section 90 relating to a trench landfill;
- (30) to comply with the conditions provided for in the first, second, third or fourth paragraph of section 91 relating to the final cover of a trench landfill;

- (31) to comply with the conditions provided for in the first or second paragraph of section 92 in case of a temporary closure of all or part of a trench landfill for a period of 3 months or more;
- (32) to surround a northern landfill by a fence or any other device complying with subparagraphs 1 to 3 of the first or a fire barrier complying with the second paragraph of section 96;
- (33) to comply with the conditions provided for in the second or third paragraph of section 97 relating to the materials removed or sludge from a northern landfill;
- (34) to provide a northern landfill with a surface water collection system or to discharge the water collected outside the landfill site in accordance with section 98;
- (35) to burn the combustible residual materials referred to in the first paragraph of section 99 at the frequency and on the conditions provided for therein;
- (36) to comply with the concentrations of contaminants prescribed by the third paragraph of section 99 or the second paragraph of section 100 relating to the soil used as final cover of the residual materials;
- (37) to comply with the conditions provided for in the first paragraph of section 100 in the case of closure or non-use of a northern landfill for a period of 6 months or more;
- (38) to comply with the conditions provided for in subparagraph 1 of the second paragraph of section 105 relating to a construction or demolition waste landfill;
- (39) to comply with the concentrations of contaminants prescribed by the third paragraph of section 105 or 106 relating to the soil used as final cover for the construction or demolition waste;
- (40) to make the periodic verifications prescribed by the fourth paragraph of section 105 at the frequency and on the conditions provided for therein;
- (41) to comply with the conditions provided for in the first, third, fourth or fifth paragraph of section 106 relating to the final cover of a construction or demolition waste landfill;
- (42) to comply with the prohibition to raise the ground surface provided for in the second paragraph of section 106;
- (43) to comply with the conditions provided for in the first paragraph of section 117 relating to the cover of residual materials deposited in a remote landfill;
- (44) to comply with the landfilling conditions provided for in section 118 relating to the sludge referred to therein;
- (45) to comply, as the case may be, with the conditions provided for in the first or second paragraph of section 120 in the case of closure or non-use of a remote landfill;
- (46) to provide an incineration facility referred to in the first paragraph of section 124 with a handling area or pit complying with the first or second paragraph of that section or clean the handling area in accordance with the third paragraph of that section;
- (47) to comply with the conditions provided for in the fourth paragraph of section 124 relating to storage or parking outside an incineration facility;
- (48) to provide an incineration facility referred to in the first paragraph of section 126 with at least 2 combustion chambers operating in compliance with the second or third paragraph of that section;

- (49) to equip an incineration facility referred to in the first paragraph of section 126 with auxiliary burners complying with the fourth paragraph of that section;
- (50) to equip an incineration facility referred to in the first, second or third paragraph of section 127 with the systems complying with that section;
- (51) to send, for analysis, to a laboratory accredited by the Minister the gas samples referred to in section 134 in accordance with the second paragraph of that section;
- (52) to comply with the conditions provided for in the first paragraph of section 138 relating to the loading and unloading of residual materials at a transfer station, the stockpiling or parking outside such a station;
- (53) to comply with the conditions provided for in the second paragraph of section 138 where residual materials transfer activities cease for a period of more than 12 hours;
- (54) to comply with the maximum volumes of residual materials that may be stored in a transfer station in the cases and on the conditions provided for in section 139.3;
- (55) to obtain a guarantee the amount of which is established by section 140 in the cases and on the conditions provided for therein;
- (56) to send renewal of the guarantee or another guarantee to the Minister in the cases referred to in section 143 according to the time limits and conditions provided for in that section;
- (57) to comply with the conditions provided for in the second paragraph of section 159 relating to the height of the residual materials layers.

O.C. 666-2013, s. 3.

149.4. A monetary administrative penalty of \$750 in the case of a natural person or \$3,500 in other cases may be imposed on any person who fails

- (1) to comply with the conditions provided for in the first paragraph of section 9 relating to the landfilling of fly ash or residue that contains fly ash;
- (2) to site an engineered landfill on land that complies with the conditions, in particular the siting conditions, prescribed by section 20, the first paragraph of section 21 or section 22;
- (3) to ensure that the excavation carried out in a zone referred to in the second paragraph of section 21 complies with the conditions provided for therein;
- (4) to comply with the conditions provided for in section 23 relating to the liner system referred to therein or at groundwater level;
- (5) to comply with the conditions provided for in section 24 regarding the siting of an engineered landfill in a rock quarry or a mine;
- (6) to provide an engineered landfill with a collection system complying with the first or third paragraph of section 25 or any other system in the case and on the conditions provided for in the second paragraph of that section;
- (7) to provide an engineered landfill referred to in section 26 with a second collection system complying with that section;
- (8) to comply with the conditions on design or the installation of leachate collection systems provided for in section 27;

- (9) to ensure that every component of a system referred to in the first paragraph of section 28 is leakproof in accordance with that section;
- (10) to provide an engineered landfill referred to in the first or second paragraph of section 32 with a biogas collection system complying with that section;
- (11) to remove biogas collected in the landfills referred to in the second paragraph of section 32 using the equipment complying with the third or fourth paragraph of that section;
- (12) to comply with the conditions provided for in the first or second paragraph of section 34 relating to the materials or the installation of the systems referred to in that section;
- (13) to have verified the materials and equipment referred to in section 35 in accordance with that section;
- (14) to have the work referred to in the first paragraph of section 36 supervised by independent experts in accordance with that section;
- (15) to comply with the conditions provided for in the fourth or fifth paragraph of section 41 relating to the cover or landfilling of the residual materials referred to therein;
- (16) to comply with the conditions provided for in the sixth paragraph of section 42 relating to the stockpiling in an engineered landfill of the contaminated soils or residual materials referred to therein;
- (17) to maintain at all times in proper working order the systems referred to in section 44 or to control, maintain or clean those systems in accordance with that section;
- (18) to ensure that the systems referred to in section 44 work as to guarantee compliance with the requirements of section 27;
- (19) to comply with the terms provided for in the first, second or third paragraph of section 61 regarding the operation of the systems and equipment referred to therein;
- (20) to ensure that the concentration of nitrogen or oxygen prescribed by the first paragraph of section 62 are met in the cases and on the conditions referred to therein;
- (21) to comply with the conditions provided for in the third paragraph of section 62 relating to the halting of the biogas pumping system referred to therein;
- (22) to take or have taken or have analyzed the samples prescribed by section 63 according to the frequency and conditions provided for in the first, second, third, fourth and fifth paragraphs of that section;
- (23) to measure the flow of the leachate or the flow of the discharges referred to in the sixth paragraph of section 63, on the conditions referred to therein;
- (24) to leak test or have leak tested the pipes or components referred to in the first or second paragraph of section 64 according to the frequency and conditions provided for therein;
- (25) to install the required number of wells or networks of observation wells prescribed by section 65 in the cases and on the conditions provided for therein;
- (26) to take or have taken or have analyzed the samples prescribed by the first paragraph of section 66 according to the frequency and conditions provided for in the first, third, or, in the case provided for therein, the fifth paragraph of that section;

(27) to measure or have measured the concentration of methane at the frequency and on the conditions provided for in section 67;

(28) to measure or have measured the concentration of methane at the frequencies and on the conditions provided for in subparagraph 2 or 3 of the first paragraph of section 68 in the cases referred to therein;

(29) to continuously measure the destruction temperature or the flow rate of the biogas referred to in the first or second paragraph of section 68 or to verify the destruction efficiency for the organic compounds other than methane in the cases and on the conditions provided for in the second paragraph of that section;

(30) to permanently close a landfill in the cases provided for in section 80;

(31) to cover as soon as deposited the residual materials referred to in paragraph 2 of section 90 or the second paragraph of section 99 or 117 with other materials or soils in the cases provided for in those sections;

(32) to cover as soon as deposited bituminous coated materials referred to in subparagraph 2 of the second paragraph of section 105 with other materials;

(33) to provide a construction or demolition waste landfill with a system referred to in section 107 and to put in operation such system on the date provided for in the second paragraph of that section;

(34) to comply with the conditions provided for in section 108 relating to the final profile of a filled construction or demolition waste landfill;

(35) to comply with the conditions provided for in section 119 relating to the final cover of a remote landfill;

(36) to comply with the conditions provided for in the first paragraph of section 125 relating to the layout of an incineration facility referred to in that section;

(37) to perform or have performed the testing provided for in section 132 in the cases and on the conditions and according to the methods provided for in that section or the first paragraph of section 134.

O.C. 666-2013, s. 3.

149.5. A monetary administrative penalty of \$1,000 in the case of a natural person or \$5,000 in other cases may be imposed on any person who

(1) deposits permanently the residual materials referred to in the first paragraph of section 6 elsewhere than on a landfill authorized as provided for in that section;

(2) does not comply with the conditions and restrictions for siting provided for in section 13, 14, 15 or 16 relating to a landfill;

(3) fails to send to the Minister the information provided for in the second paragraph of section 71 in the case provided for therein;

(4) establishes a trench landfill in a territory other than those provided for in section 87 or does not comply with the conditions provided for in section 86 regarding the establishment of such landfill in one of the territories;

(5) does not comply with the conditions provided for in section 88 relating to the siting of a trench landfill or the lowering of the groundwater level;

(6) does not comply with the conditions permitting the establishment of a northern landfill provided for in section 94 or the conditions relating to the siting of such landfill provided for in section 95;

(7) does not comply with the conditions provided for in the first paragraph of section 97 relating to the bottom of the disposal areas of a northern landfill or the lowering of the groundwater level;

(8) does not comply with the conditions permitting the establishment or enlargement of a construction or demolition waste landfill referred to in the second paragraph of section 102 provided for in the first paragraph of section 103;

(9) does not comply with the conditions provided for in the second paragraph of section 104 relating to the siting of a construction or demolition waste landfill;

(10) establishes a remote landfill in a territory other than those provided for in section 112 or does not comply with the conditions provided for in section 111 or 114 regard the establishment or siting of such landfill in one of the territories;

(11) receives, in a remote landfill, residual materials prohibited pursuant to section 113;

(12) does not comply with the conditions provided for in section 116 relating to the bottom of the disposal areas of a remote landfill or the lowering of the groundwater level;

(13) operates a transfer station referred to in the first paragraph of section 139.1 while unauthorized to do so pursuant to that section;

(14) does not comply with the restriction provided for in the fourth paragraph of section 139.2 regarding the number of low capacity transfer stations that may be established in a territory referred to therein;

(15) establishes or enlarges a landfill referred to in section 145 without complying with the conditions provided for therein;

(16) does not comply with the conditions provided for in the second, third or fifth paragraph of section 161 relating to the acceptance for landfilling in the sites referred to therein of residual materials or materials referred to therein.

O.C. 666-2013, s. 3.

149.6. A monetary administrative penalty of \$1,500 in the case of a natural person or \$7,500 in other cases may be imposed on any person who

(1) disposes in a landfill referred to in section 4 materials, objects or substances referred to in any of paragraphs 1 or 3 to 12 of that section;

(2) landfills residual materials listed in section 8 in a place other than a landfill, in contravention of section 8;

(3) burns or allows to be burned residual materials in an engineered landfill, in contravention of section 47;

(4) batch discharges of leachate or water, in contravention of the third paragraph of section 53;

(5) dilutes, before their discharge into the environment, leachate or water referred to in section 55, in contravention of section 55;

(6) establishes or enlarges a construction or demolition waste landfill, in contravention of the first paragraph of section 102;

(7) disposes in a construction or demolition waste landfill materials other than the waste within the meaning of section 101, in contravention of the second paragraph of section 103;

- (8) burns or allows to be burned residual materials in a remote landfill, in contravention of section 115;
- (9) disposes in an incineration facility referred to in the first paragraph of section 123 materials, objects or substances listed in section 4;
- (10) accepts in a transfer station materials other than those allowed pursuant to section 137;
- (11) accepts residual materials after the date provided for in the first paragraph of section 159 for the disposal areas referred to in that section;
- (12) fails to permanently close a landfill referred to in the fourth paragraph of section 161, or the area or trench of such landfill, where it is prescribed to do so by that paragraph.

O.C. 666-2013, s. 3.

149.7. A monetary administrative penalty of \$2,000 in the case of a natural person or \$10,000 in other cases may be imposed on any person who

- (1) disposes, in a landfill referred to in section 4, of hazardous materials, in contravention of paragraph 2 of that section;
- (2) fails to take the measures prescribed by the first paragraph of section 48 to minimize the release of odours that cause odour nuisances beyond the limits of an engineered landfill;
- (3) emits dust visible in the atmosphere more than 2 m from the emission source, in contravention of the first paragraph of section 48;
- (4) discharges into the environment leachate and water referred to in the first paragraph of section 53 that do not comply with the limit values prescribed therein or those determined by the Minister pursuant to the second paragraph of that section;
- (5) fails to ensure that the quality of the surface water referred to in the second paragraph of section 54 is not deteriorated in the case provided for therein;
- (6) fails to ensure that the groundwater referred to in the first paragraph of section 57 complies at the observation wells with the limit values prescribed or those determined by the Minister pursuant to the second paragraph of that section;
- (7) fails to ensure that the quality of the groundwater referred to in the second paragraph of section 58 is not deteriorated in the case provided for therein;
- (8) fail to ensure that the concentration referred to in section 60 or the second paragraph of section 62 complies with the values provided for therein;
- (9) emits into the atmosphere grey or black emissions the opacity of which exceeds 20% in the cases provided for in section 129;
- (10) emits into the atmosphere combustion gases that do not comply with the values prescribed by paragraphs 1 to 5 of section 130.

O.C. 666-2013, s. 3.

CHAPTER VII

PENAL SANCTIONS

O.C. 451-2005, c. VII; O.C. 666-2013, s. 4.

150. Every person who contravenes paragraph 1 of section 45, section 72, 77, 78 or 82 or the third paragraph of section 96 commits an offence and is liable, in the case of a natural person, to a fine of \$1,000 to \$100,000 or, in other cases, to a fine of \$3,000 to \$600,000.

O.C. 451-2005, s. 150; O.C. 451-2011, s. 39; O.C. 666-2013, s. 5.

151. Every person who contravenes section 29 or 33, the second paragraph of section 36 or 39, the first paragraph of section 40, paragraph 2 of section 45, section 52 or 70, the first or third paragraph of section 71, section 81, the fourth paragraph of section 127, section 146 or the second paragraph of section 155 commits an offence and is liable, in the case of a natural person, to a fine of \$2,000 to \$100,000 or, in other cases, to a fine of \$6,000 to \$600,000.

Every person who fails

(1) to enter in a log the information prescribed by the first paragraph of section 39, the first or second paragraph of section 40 or the third paragraph of section 40.1,

(2) to enter the results referred to in the fourth paragraph of section 42 or 105 in the annual report provided for in section 52,

(3) to immediately notify the Minister of the date of closure of an engineered landfill in accordance with section 80,

(4) to send to the Minister the testing report referred to in the first paragraph of section 134 in accordance with the time limits and conditions provided for therein,

also commits an offence and is liable to the same fines.

O.C. 451-2005, s. 151; O.C. 451-2011, s. 40; O.C. 666-2013, s. 5.

152. Every person who contravenes section 10, 11, 17, 18, 19, 30, 31, 37 or 38, the first or second paragraph of section 40.1, the first or second paragraph of section 41, the first, second, third or fifth paragraph of section 42, section 43 or 46, the second paragraph of section 48, section 49, 50, 51 or 56, the second paragraph of section 66, the introduction or subparagraph 1 of the first paragraph section 68, section 69, the first paragraph of section 70, section 79, paragraph 1, 3 or 4 of section 90, the first, second, third or fourth paragraph of section 91, section 92, the first or second paragraph of section 96, the second or third paragraph of section 97, section 98, the first or third paragraph of section 99, section 100, subparagraph 1 of the second paragraph or third paragraph of section 105, the first, second, third, fourth or fifth paragraph of section 106, the first paragraph of section 117, section 118, 120, 124 or 126, the first, second or third paragraph of section 127, the second paragraph of section 134, section 138, 139.3, 140, 143 or the second paragraph of section 159 commits an offence and is liable, in the case of a natural person, to a fine of \$2,500 to \$250,000 or, in other cases, to a fine of \$7,500 to \$1,500,000.

Every person who fails

(1) to obtain the results of the analyses or measures provided for in the second paragraph of section 40 before receiving the soils referred to therein,

(2) to periodically make the verifications prescribed by the fourth paragraph of section 42 or 105 at the frequency and on the conditions provided for therein,

(3) to take the measures prescribed by the first paragraph of section 48 to minimize wind dispersal or scattering of residual material referred to therein,

also commits an offence and is liable to the same fines.

O.C. 451-2005, s. 152; O.C. 451-2011, s. 41; O.C. 666-2013, s. 5.

153. Every person who contravenes the first paragraph of section 9, any of sections 20 to 28, 32, 34 or 35, the first paragraph of section 36, the fourth or fifth paragraph of section 41, the sixth paragraph of section 42, section 44 or 61, the first or third paragraph of section 62, section 63, 64 or 65, the first, third or fifth paragraph of section 66, section 67, subparagraph 2 or 3 of the first paragraph or the second paragraph of section 68, paragraph 2 of section 90, the second paragraph of section 99, subparagraph 2 of the second paragraph of section 105, section 107 or 108, the second paragraph of section 117 or section 119, 125 or 132 commits an offence and is liable, in the case of a natural person, to a fine of \$4,000 to \$250,000 or, in other cases, to a fine of \$12,000 to \$1,500,000.

Every person who fails

(1) to permanently close an engineered landfill in the cases provided for in section 80,

(2) to take samples of the gases referred to in section 134 in accordance with the methods prescribed by the first paragraph of that section,

also commits an offence and is liable to the same fines.

O.C. 451-2005, s. 153; O.C. 666-2013, s. 5.

154. Every person who

(1) contravenes the first paragraph of section 6, section 13, 14, 15 or 16, the second paragraph of section 71, the first paragraph of section 86, section 87 or 88, the first paragraph of section 94, 95, 97 or 103, the second paragraph of section 104, the first paragraph of section 111, section 112, 113, 114 or 116, the first paragraph of section 139.1, the fourth paragraph of section 139.2, section 145 or the second, third or fifth paragraph of section 161,

(2) pursuant to this Regulation, makes a declaration, communicates information or files a document that is false or misleading,

commits an offence and is liable, in the case of a natural person, to a fine of \$5,000 to \$500,000 or, despite article 231 of the Code of Penal Procedure (chapter C-25.1), to a maximum term of imprisonment of 18 months, or to both the fine and imprisonment, or, in other cases, to a fine of \$15,000 to \$3,000,000.

O.C. 451-2005, s. 154; O.C. 666-2013, s. 5.

154.1. Every person who contravenes any of paragraphs 1 or 3 to 12 of section 4, 8 or 47, the third paragraph of section 53, section 55, the first paragraph of section 102, the second paragraph of section 103, section 115, the first paragraph of section 123, section 137, the first paragraph of section 159 or the fourth paragraph of section 161 commits an offence and is liable, in the case of a natural person, to a fine of \$8,000 to \$500,000 or, despite article 231 of the Code of Penal Procedure (chapter C-25.1), to a maximum term of imprisonment of 18 months, or to both the fine and imprisonment, or, in other cases, to a fine of \$24,000 to \$3,000,000.

O.C. 666-2013, s. 5.

154.2. Every person who contravenes paragraph 2 of section 4, the first or second paragraph of section 53, the second paragraph of section 54, section 57, the second paragraph of section 58, section 60, the second paragraph of section 62, the first paragraph of section 129 or section 130 commits an offence and is liable, in the case of a natural person, to a fine of \$10,000 to \$1,000,000 or, despite article 231 of the Code of Penal Procedure (chapter C-25.1), to a maximum term of imprisonment of 3 years, or to both the fine and imprisonment, or, in other cases, to a fine of \$30,000 to \$6,000,000.

Every person who

(1) fails to take the measures prescribed by the first paragraph of section 48 to minimize the release of odours that cause odour nuisances beyond the limits of an engineered landfill,

(2) emits dust visible in the atmosphere more than 2 m from the emission source, in contravention of the first paragraph of section 48,

also commits an offence and is liable to the same fines.

O.C. 666-2013, s. 5.

154.3. Every person who contravenes any other requirement imposed by this Regulation also commits an offence and is liable, where no other penalty is provided for by this Chapter or the Environment Quality Act (chapter Q-2), to a fine of \$1,000 to \$100,000 in the case of a natural person or, in other cases, to a fine of \$3,000 to \$600,000.

O.C. 666-2013, s. 5.

CHAPTER VIII

TRANSITIONAL, AMENDING AND MISCELLANEOUS

155. In addition to the remote landfills and the transfer stations referred to in the second paragraph of section 139.2 that are exempt from the application of section 55 of the Environment Quality Act (chapter Q-2) under section 146, the following sites are also exempt from the application of that section 55:

(1) sites where compost only is landfilled in accordance with section 72 of the Regulation respecting waste water disposal systems for remote dwellings (chapter Q-2, r. 22);

(2) sites where inedible meat only is landfilled in accordance with section 7.3.1 of the Regulation respecting food (chapter P-29, r. 1);

(3) incineration facilities that have a rated capacity of less than 1 ton per hour in which only inedible meat is incinerated in accordance with the Regulation respecting food.

Despite the foregoing, in the case of a project to establish or alter an incineration facility referred to in subparagraph 3 of the first paragraph, at least 30 days before carrying out the project the operator is required to so notify the Minister in writing by means of a project notice showing the location of the facility and describing its technical and operating characteristics. The project notice must be accompanied by a statement from an engineer certifying that the project conforms to the Environment Quality Act and its regulations.

The sites referred to in subparagraphs 1 and 2 of the first paragraph are also exempt from the application of section 65 of the Environment Quality Act.

O.C. 451-2005, s. 155; O.C. 451-2011, s. 42.

155.1. Sections 64.2 to 64.12 of the Environment Quality Act (chapter Q-2) related to the fixing of tariffs by the operator of a residual materials disposal facility apply to engineered landfills governed by Division 2 of Chapter II of this Regulation.

O.C. 451-2011, s. 43.

156. This Regulation replaces the Regulation respecting solid waste (chapter Q-2, r. 13), except to the extent that that Regulation continues to apply as provided in the following provisions.

O.C. 451-2005, s. 156.

157. For a 3-year period beginning on 19 January 2006, the sanitary landfill sites, in-trench disposal sites for solid waste and dry materials disposal sites governed by the Regulation respecting solid waste (chapter Q-2, r. 13) that are in operation on that date continue to be governed by the Regulation respecting solid waste and the certificates of authorization or conformity issued before that date, subject to section 159 and to the following:

- (1) sections 10 to 12 relating to the requirement to accept residual materials apply, with the necessary modifications, to those sanitary landfill sites as of 19 January 2006;
- (2) sections 39 and 40 relating to the log apply, with the necessary modifications, to those sanitary landfill sites and dry materials disposal sites as of 19 January 2006;
- (3) the daily and final coverings of the residual materials deposited in the disposal areas of those sanitary landfill sites may be done using materials different from those prescribed by the Regulation respecting solid waste, provided there is compliance with the requirements of the first paragraph of section 32 and sections 42 and 50, which apply with the necessary modifications; the daily covering of the residual materials must, however, be done in compliance with section 41 as of 19 January 2006;
- (4) section 47 relating to the prohibition on the burning of residual materials applies, with the necessary modifications, to those in-trench disposal sites for solid waste as of 19 January 2006;
- (5) subparagraphs 1 and 2 of the first paragraph and the second paragraph of section 52 relating to the annual report apply, with the necessary modifications, to those sanitary landfill sites and dry materials disposal sites as of 19 January 2006;
- (6) sections 80 to 82 relating to site closure apply, with the necessary modifications, to those sanitary landfill sites, in-trench disposal sites for solid waste and dry materials disposal sites as of 19 January 2006;
- (7) as of 19 January 2006, only construction or demolition waste within the meaning of section 101 may be landfilled in those dry materials disposal sites; in addition, the prohibition on enlargement set out in section 102 applies to those dry materials disposal sites as of 19 January 2006, except for the cases provided for in the second paragraph of that section. The covering of the residual materials deposited in dry materials disposal areas may be done using materials different from those prescribed by the Regulation respecting solid waste, provided there is compliance with the requirements of the second and third paragraphs of section 105 and sections 106 and 107, as the case may be, which apply with the necessary modifications;
- (8) as of 19 January 2006, an enlargement of a sanitary landfill site or in-trench disposal site for solid waste is considered to be a project to establish an engineered landfill or trench landfill governed by this Regulation. For the purposes of this paragraph, enlargement includes any alteration that results in an increase in landfill capacity;
- (9) the provisions of Chapter V relating to the provision of a financial guarantee that apply to engineered landfills, trench landfills and construction or demolition waste landfills apply respectively, with the necessary modifications, to those sanitary landfill sites, in-trench disposal sites for solid waste and dry materials disposal sites as of the sixth month following 19 January 2006.

O.C. 451-2005, s. 157; O.C. 451-2011, s. 44.

158. Not later than at the end of the thirtieth month following 19 January 2006, the operator of a site referred to in section 157 must send a notice to the Minister informing the Minister that the operator intends to

(1) permanently cease the operation of the site on or before the expiry date of the 3-year period provided for in that section; or

(2) continue to operate the site after the 3-year period.

If the operator chooses to continue the operations, the notice must be sent with a report of an independent expert establishing that the disposal areas or trenches in which residual materials will be landfilled after the expiry date of the three-year period comply with the provisions of this Regulation that apply to those areas or trenches under section 161. The report must contain certification by the expert of that compliance.

O.C. 451-2005, s. 158.

159. In sanitary landfill sites in operation on the date of coming into force of this Regulation, disposal areas that do not meet the containment protection requirements of section 20, 21, 22 or 24 and that received a final cover before that date may in no case receive other residual materials after that date.

As for disposal areas that meet the containment protection requirements of section 20, 21, 22 or 24 but do not meet the other requirements of Division 2 of Chapter II, and disposal areas that do not meet those containment protection requirements and have not received a final cover before 19 January 2006, the height of the residual materials layers relative to the surrounding landform may not exceed the following limits:

(1) the height of the outboard sideslopes, which consist of the above-grade layers of residual materials, may not exceed 4 m, that height being measured from the ground surface at the perimeter of the disposal area, excluding the final cover. Any raising of the ground surface at that perimeter is prohibited;

(2) the disposal area must in addition be graded so that the final profile of the residual materials layers, excluding the final cover, is as follows:

(a) the inclination of the sideslopes referred to above must not exceed 30%; and

(b) the inclination of the cover deck from the crest to the sideslopes must not exceed

- 5%, if the ground slope at the perimeter of the disposal area is equal to or lower than that percentage; or

- the percentage of the ground slope at the perimeter of the disposal area, if that slope is greater than 5%.

Disposal areas that comply with all of the provisions of Division 2 of Chapter II are, with respect to the height of the layers of residual materials, exempt from the limits set out in the second paragraph and are governed by the landscape integration rule set out in section 17.

O.C. 451-2005, s. 159.

160. The following continue to be governed by the Regulation respecting solid waste (chapter Q-2, r. 13) and by their certificates of authorization or conformity, as long as they remain closed:

- (1) disposal sites that were permanently closed before 19 January 2006 ;
- (2) disposal areas in the disposal sites in operation on the date of coming into force of this Regulation that received a final cover before that date or, pursuant to section 157, receive residual materials in the 3-year period following that date and receive a final cover at the latest on the expiry of that period.

O.C. 451-2005, s. 160.

161. As of the expiry date of the 3-year period following 19 January 2006, and subject to the second, third and fourth paragraphs, the sanitary landfill sites, in-trench disposal sites for solid waste and dry materials disposal sites referred to in section 157 are, except with respect to siting standards, governed by the provisions of this Regulation that apply respectively to engineered landfills, trench landfills and construction or demolition waste landfills as regards the acceptance of residual materials and the conditions for the development, operation, closure and post-closure management of the disposal areas or trenches in which residual materials will be landfilled as of the date mentioned above. The first paragraph of section 18 requiring the creation of a buffer zone does not apply to leachate or water treatment systems, gas pumping devices or biogas removal facilities in existence on 19 January 2006. In addition, in the case of the landfill used exclusively by the waste water treatment plant of Ville de Montréal in operation on that date, the minimum width of the buffer zone prescribed by the first paragraph of section 18 is reduced to 10 m around the landfill, including any future enlargement, so long as only the ash from the sludge incinerator and the sands generated by the operation of that station are landfilled.

In addition, after the expiry of the 3-year period following 19 January 2006, residual materials may be accepted in in-trench disposal sites for solid waste existing on 1 May 2000 only if the sites are located in a territory described in section 87 which at all times meets the requirements of subparagraphs 2 and 4 of that section, and the landfilling is done in trenches that meet the siting standards prescribed by section 88.

Similarly, after the expiry of the 3-year period mentioned above, construction or demolition waste may be accepted at dry materials disposal sites existing on 1 May 2000 only if the sites meet the requirements of section 103 and the landfilling is done in disposal areas that meet the siting standards prescribed by section 104. The siting standards do not apply to disposal areas if their siting complies with the provisions of this Regulation that apply to containment and the collection of leachate in engineered landfills.

A landfill referred to in the second or third paragraph, or a disposal area or a trench in such a landfill, must be permanently closed as soon as residual materials may no longer be accepted owing to non-compliance with those paragraphs.

Despite the provisions of the second and fourth paragraphs of this section, residual materials generated in the territory of Ville de Lebel-sur-Quévillon remain accepted in the in-trench disposal site operated by the municipality before 19 January 2009 and located in the territory of Ville de Senneterre, up to the landfill capacity authorized on that date so long as it is sited and operated in accordance with the provisions prescribed by sections 88 to 93.

O.C. 451-2005, s. 161; O.C. 82-2009, s. 1; O.C. 451-2011, s. 45.

162. As of 19 January 2006, waste disposal sites in the North and outfitters' waste-pits governed by the Regulation respecting solid waste (chapter Q-2, r. 13) that are in operation on that date are governed by the provisions of this Regulation that apply respectively to northern landfills and remote landfills.

O.C. 451-2005, s. 162.

163. For a 3-year period beginning on 19 January 2006, the incinerators governed by the Regulation respecting solid waste (chapter Q-2, r. 13) that are in operation on that date continue to be governed by that Regulation, the Regulation respecting the quality of the atmosphere (chapter Q-2, r. 38) and the certificates of authorization or conformity issued before that date, subject to the following:

- (1) the provisions of section 128 concerning the application of section 39 and of subparagraph 1 of the first paragraph and the second paragraph of section 52 apply, with the necessary modifications, to those incinerators as of 19 January 2006;
- (2) the provisions of section 128 concerning the application of sections 72 to 79 apply to those incinerators as of the expiry of the sixth month following 19 January 2006;
- (3) paragraphs 4 and 5 of section 130 apply to those incinerators as of the expiry of the twelfth month following 19 January 2006;
- (4) the provisions of Chapter V concerning the provision of a financial guarantee that apply to incineration facilities governed by Chapter III apply to those incinerators, with the necessary modifications, as of the sixth month following 19 January 2006;
- (5) as of 19 January 2006, any increase in the incinerator capacity of those incinerators is governed by the provisions of this Regulation that apply to incineration facilities governed by Chapter III.

As of the expiry date of the 3-year period following 19 January 2006, the incinerators referred to in the first paragraph are governed by the provisions of this Regulation that apply to incineration facilities governed by Chapter III.

O.C. 451-2005, s. 163.

164. Residual materials disposal sites not governed by the Regulation respecting solid waste (chapter Q-2, r. 13) that were permanently closed before 19 January 2006 are exempt from the application of this Regulation as long as they remain closed.

If the disposal sites referred to in the first paragraph are in operation on 19 January 2006, they are also exempt from the application of the Regulation but only for the 3-year period following that date, except for any enlargement of the landfills or increase in incinerator capacity, which is governed by the third paragraph; enlargement includes any alteration that results in an increase in landfill capacity.

On the expiry of the 3-year period, those disposal sites are, except with respect to the siting standards, governed in the case of landfills by Chapter II as regards acceptance of residual materials and the conditions for the development, operation, closure and post-closure management of the disposal areas or trenches in which residual materials will be landfilled after the expiry of the 3-year period, and in the case of incinerators that receive residual materials referred to in section 121, by Chapter III.

In addition, section 158 applies, with the necessary modifications, to the operator of a landfill referred to in this section.

O.C. 451-2005, s. 164.

165. Sections 157, 163 and 164 may not operate to prevent this Regulation from applying to an existing disposal site within a time period shorter than the time period provided for in those sections if the operator chooses to bring the site into compliance with those provisions earlier than required.

O.C. 451-2005, s. 165.

166. Despite sections 157 to 165, the limit values set out in section 53 apply to the leachate or water from a disposal site to which those sections apply as soon as it is conveyed for treatment to a facility where the leachate or water from disposal areas governed by this Regulation is also treated.

The same applies to the biogas removal requirements in the third paragraph of section 32 that apply to biogas from a disposal site to which those sections apply as soon as it is conveyed for removal to a facility where biogas from disposal areas governed by this Regulation is also removed.

O.C. 451-2005, s. 166.

167. As of 19 January 2006, the mixed waste transfer stations governed by the Regulation respecting solid waste (chapter Q-2, r. 13) that are in operation on that date are governed by the provisions of Chapter IV that apply to residual materials transfer stations.

The operators of those facilities have a 6-month period to provide a financial guarantee that meets the requirements of sections 140 to 144.

O.C. 451-2005, s. 167.

168. *(Revoked).*

O.C. 451-2005, s. 168; O.C. 666-2013, s. 6.

169. *(Amendment integrated into c. Q-2, r. 1.001, s. 13).*

O.C. 451-2005, s. 169.

170. *(Amendment integrated into c. Q-2, r. 2, ss. 47 and 48).*

O.C. 451-2005, s. 170.

171. *(Amendment integrated into c. Q-2, r. 3, s. 7).*

O.C. 451-2005, s. 171.

172. *(Amendment integrated into c. Q-2, r. 3, s. 15).*

O.C. 451-2005, s. 172.

173. (*Amendment integrated into c. Q-2, r. 3, s. 16*).

O.C. 451-2005, s. 173.

174. (*Amendment integrated into c. Q-2, r. 3.001, s. 36*).

O.C. 451-2005, s. 174.

175. (*Amendment integrated into c. Q-2, r. 3.001, s. 56*).

O.C. 451-2005, s. 175.

176. (*Amendment integrated into c. Q-2, r. 6.01, s. 1*).

O.C. 451-2005, s. 176.

177. (*Amendment integrated into c. Q-2, r. 9, s. 2*).

O.C. 451-2005, s. 177.

178. (*Amendment integrated into c. Q-2, r. 12.2, s. 95*).

O.C. 451-2005, s. 178.

179. (*Amendment integrated into c. Q-2, r. 12.2, s. 101*).

O.C. 451-2005, s. 179.

180. (*Amendment integrated into c. Q-2, r. 12.2, s. 107*).

O.C. 451-2005, s. 180.

181. (*Amendment integrated into c. Q-2, r. 12.2, Sch. X*).

O.C. 451-2005, s. 181.

182. (*Amendment integrated into c. Q-2, r. 15.2, s. 2*).

O.C. 451-2005, s. 182.

183. (*Amendment integrated into c. Q-2, r. 20, s. 22*).

O.C. 451-2005, s. 183.

184. *(Amendment integrated into c. Q-2, r. 20, s. 66.1).*

O.C. 451-2005, s. 184.

185. *(Amendment integrated into c. Q-2, r. 20, s. 67).*

O.C. 451-2005, s. 185.

186. This Regulation applies to the immovables in a reserved area or an agricultural zone established under the Act respecting the preservation of agricultural land and agricultural activities (chapter P-41.1).

O.C. 451-2005, s. 186.

187. *(Omitted).*

O.C. 451-2005, s. 187.

SCHEDULE I

(s. 129)

CHART TO MEASURE OPACITY OF GREY OR BLACK EMISSIONS

Opacity is evaluated using a chart in good condition, printed within the last 5 years, that complies with the following specifications:

The Micro Ringelmann Chart is printed on a card 12.8 cm long by 8.6 cm wide on which opacities of 20%, 40%, 60% and 80% (No. 1, No. 2, No. 3 and No. 4 respectively) are represented in order, in an alignment of vertical rectangles 24 mm by 58 mm (± 1 mm), within which a 13 mm (± 1 mm) slit is made (see figure below). Each degree of opacity is represented by an ultra fine grid of black lines on a white background, according to the following specifications:

For opacity No. 1: Black grid lines measuring 0.055 mm that are 0.555 mm apart with white spaces 0.5 mm by 0.5 mm.

For opacity No. 2: Black grid lines measuring 0.128 mm that are 0.555 mm apart with white spaces 0.427 mm by 0.427 mm.

For opacity No. 3: Black grid lines measuring 0.205 mm that are 0.555 mm apart with white spaces 0.35 mm by 0.35 mm.

For opacity No. 4: Black grid lines measuring 0.305 mm that are 0.555 mm apart with white spaces 0.25 mm by 0.25 mm.

The month and year the chart was printed must be indicated in the lower left-hand corner.

CHART SPECIMEN



No.1 No.2 No. 3 No. 4
MICRO RINGELMANN CHART

Month/year

Slit in the card

Opacity is measured from an observation point between 30 and 400 m from the emission point. The observation point must allow full view of the emissions. The sun must be oriented in the 140° sector to the observer's back. The observer must make observations using a line of vision that is perpendicular to the direction of the plume.

The observer holds the chart at arm's length and looks at the emission through the slit in the card. The observer notes the scale number (No. 1, 2, 3 or 4) that best suits the opacity observed. No. 0 is used to indicate that no emission is visible and No. 4 applies to an opacity of 100%.

Opacity evaluation must be carried out where the opacity is maximum, in a part of the plume where there is no condensed water vapour. The observer must not look continually at the plume but rather must observe the plume momentarily every 15 seconds. Opacity evaluation is carried out over a 60-minute period without interruption between each period (240 observations in 60 minutes) or two 30-minute periods with an interruption at half time (120 observations in 30 minutes, twice).

Where water vapour condenses and becomes visible at a certain distance from the emission point, the opacity must be evaluated between the emission point and the condensation point of the water vapour.

When condensed water vapour is present in the plume, at its emission point, the opacity of the plume must be observed at the point where the vapour is no longer visible.

The following formula is used to establish emission opacity:

P = NEU at opacity No. 1 X 20%		
<div style="border-bottom: 1px solid black; display: inline-block; width: 80%;"></div> number of observations		
where P is the percentage of emission opacity and NEU is the number of equivalent units.		
Each number on the chart represents as many equivalent units.		

A single observation may suffice for the application of section 129.

O.C. 451-2005, Sch. I.

SCHEDULE II

(s. 130)

INTERNATIONAL TOXICITY EQUIVALENCY
FACTORS FOR SPECIFIC PCDD
(POLYCHLORODIBENZO-P-DIOXINS) AND PCDF
(POLYCHLORODIBENZOFURANS) CONGENERS

Congeners	Toxicity equivalency factors
2,3,7,8-T ₄ CDD	1
1,2,3,7,8-P ₅ CDD	1
1,2,3,4,7,8-H ₆ CDD	0.1
1,2,3,6,7,8-H ₆ CDD	0.1
1,2,3,7,8,9-H ₆ CDD	0.1
1,2,3,4,6,7,8-H ₇ CDD	0.01
OCDD	0.0001
2,3,7,8-T ₄ CDF	0.1
2,3,4,7,8-P ₅ CDF	0.5
1,2,3,7,8-P ₅ CDF	0.05
1,2,3,4,7,8-H ₆ CDF	0.1
1,2,3,7,8,9-H ₆ CDF	0.1
1,2,3,6,7,8-H ₆ CDF	0.1
2,3,4,6,7,8-H ₆ CDF	0.1
1,2,3,4,6,7,8-H ₇ CDF	0.01
1,2,3,4,7,8,9-H ₇ CDF	0.01
OCDF	0.0001

O.C. 451-2005, Sch. II; O.C. 15-2007, s. 79.

REFERENCES

O.C. 451-2005, 2005 G.O. 2, 1182
O.C. 15-2007, 2007 G.O. 2, 525
O.C. 808-2007, 2007 G.O. 2, 2581
O.C. 441-2008, 2008 G.O. 2, 1331
O.C. 82-2009, 2009 G.O. 2, 193
O.C. 451-2011, 2011 G.O. 2, 1084
O.C. 666-2013, 2013 G.O. 2, 1764

The Clean Air Regulations

being

Chapter C-12.1 Reg 1 (effective November 1, 1989).

NOTE:

This consolidation is not official. Amendments have been incorporated for convenience of reference and the original statutes and regulations should be consulted for all purposes of interpretation and application of the law. In order to preserve the integrity of the original statutes and regulations, errors that may have appeared are reproduced in this consolidation.

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Appendix

CHAPTER C-12.1 REG 1

The Clean Air Act

Title

- 1** These regulations may be cited as *The Clean Air Regulations*.

Interpretation

- 2** In these regulations:

- (a) **“Act”** means *The Clean Air Act*;
- (b) **“opacity”** means the degree expressed as a percentage to which an air contaminant obstructs the passage of light and obscures the view of an object in the background;
- (c) **“uncombined water”** means water that is not chemically bound to any other substance.

27 Oct 89 cC-12.1 Reg 1 s2.

Permit for industrial source, fuel-burning equipment

- 3(1)** An applicant for a permit to operate an industrial source or any fuel-burning equipment shall include with the application:

- (a) the fee prescribed by any regulation made pursuant to the Act for the type of permit applied for; and
- (b) any information and material prescribed in subsection (2) that is applicable to the industrial source or fuel-burning equipment for which a permit is sought.

- (2)** For the purposes of subsection 8(2) of the Act, the information and material required to be included in an application for a permit to operate an industrial source or fuel-burning equipment is:

- (a) a map of the area adjoining the land on which the industrial source or fuel-burning equipment is or is to be located, showing:
 - (i) the topography of the area, including land contours;
 - (ii) the locations and descriptions of buildings in the area;
 - (iii) the property boundaries; and
 - (iv) the land use of the area;
- (b) a plan or sketch of the site on which the industrial source or fuel-burning equipment is or is to be located, showing:
 - (i) the exact location of the processing, manufacturing, fuel-burning, drying, storage and other equipment;

C-12.1 REG 1**CLEAN AIR**

- (ii) the points or areas of emission of all air contaminants and the proposed elevation of the points or areas of emission;
- (iii) the location and description, including dimensions, of all buildings on the site; and
- (iv) the location of all air contaminant control equipment; and
- (c) specific information with respect to the industrial source or fuel-burning equipment, including:
 - (i) an overall description of the process to be used, the expected production capacity, the maximum design production capacity and the proposed hours of operation, on a daily basis as well as an annual basis;
 - (ii) a detailed description of the fuel-burning, manufacturing, drying and other sub-processes to be used which will directly result in the emission of air contaminants;
 - (iii) a description of raw materials, chemicals or other processing materials that are to be used, and the amounts that are to be used;
 - (iv) the size, age, make and capacity of the major pieces of processing equipment to be used;
 - (v) the size, age, make, capacity, design efficiency and description of the air contaminant control equipment to be used;
 - (vi) the expected operational availability of the air contaminant control equipment and the normal or expected preventive maintenance requirements for the air contaminant control equipment;
 - (vii) an overall flow diagram showing:
 - (A) all major process equipment and air contaminant control equipment; and
 - (B) expected flow rates, temperatures, pressures and other process variables which are relevant to the emission of air contaminants;
 - (viii) the expected composition, volumetric flow rate, velocity and temperature of every atmospheric emission under normal and maximum production conditions;
 - (ix) the expected mass rate of release into the ambient air of all air contaminants on a daily basis as well as an annual basis, under normal and maximum production conditions;
 - (x) information about the possible variations in the composition of any atmospheric emission or the release rate of any air contaminant under different production rates, during start-up, shut-down or upset conditions;
 - (xi) the calculated ground level concentrations of all air contaminants that may be released under normal and maximum production conditions;

- (xii) a description of the procedures that are to be followed to prevent or minimize the discharge of air contaminants in the event of a power failure, a malfunction of the air contaminant control equipment or a process equipment failure;
- (xiii) the proposed method and frequency of measuring air contaminant emission rates, including the analytical procedures to be used;
- (xiv) the proposed method and frequency of ambient air monitoring including the equipment, the analytical procedures to be used and the location of ambient air monitoring systems;
- (xv) a description of the procedures for:
 - (A) starting; and
 - (B) stopping;the source or equipment; and
- (xvi) a materials balance which includes:
 - (A) raw materials, chemicals and any other processing materials;
 - (B) finished products and by-products; and
 - (C) contaminants emitted to air, land and water.

27 Oct 89 cC-12.1 Reg 1 s3.

Permit for incinerator

4(1) An applicant for a permit to operate an incinerator shall include with the application:

- (a) the fee prescribed by any regulation made pursuant to the Act for the permit; and
 - (b) the information and material respecting the incinerator prescribed in subsection (2).
- (2) For the purposes of subsection 8(2) of the Act, the information and material required to be included in an application for a permit to operate an incinerator is:
- (a) a map of the area in which the incinerator is or is to be located showing:
 - (i) the topography of the area, including land contours;
 - (ii) the location and description of buildings in the area;
 - (iii) the property boundaries; and
 - (iv) the land use of the area;
 - (b) information with respect to the incinerator installation, including:
 - (i) the type of building or process to be served by the incinerator;
 - (ii) the type and quantity of waste to be incinerated;
 - (iii) the manner in which the incinerator is to be operated;

C-12.1 REG 1**CLEAN AIR**

- (iv) incinerator specifications, including:
 - (A) the size, age, capacity, design efficiency, make and model of the incinerator;
 - (B) the method of charging the waste into the incinerator;
 - (C) the type and size of grate or hearth;
 - (D) the maximum operating temperature;
 - (E) the provisions made for supplying fresh air for combustion; and
 - (F) the retention time of gases in the combustion chambers; and
- (v) the stack dimensions; and
- (c) a set of plans and any additional specifications that may be available for the proposed incinerator; and
- (d) a description of the air contaminant control equipment to be used in the operation of the incinerator.

27 Oct 89 cC-12.1 Reg 1 s4.

Certification of plans, specifications

5 Every plan, specification or other technical information submitted to support an application for a permit is to be certified as accurate by a professional engineer within the meaning of *The Engineering Profession Act* or by a person otherwise qualified to do so.

27 Oct 89 cC-12.1 Reg 1 s5.

Renewal

- 6(1)** No permit is to be renewed unless an application for renewal is filed with the minister prior to the expiration of the permit.
- (2)** An applicant for renewal of a permit shall include with the application:
 - (a) the number of the permit to be renewed;
 - (b) all details respecting any changes in the information and materials provided by the applicant pursuant to section 3 or 4 with respect to the permit to be renewed; and
 - (c) the fee prescribed by any regulation made pursuant to the Act for renewal of the permit.

27 Oct 89 cC-12.1 Reg 1 s6.

Permit to alter

7 An applicant for a permit to alter, add to or change an industrial source, incinerator or fuel-burning equipment in a manner that affects the emission of air contaminants shall include with the application:

- (a) details of the alterations, additions or changes that are proposed; and
- (b) revised estimates of air contaminant emission rates.

27 Oct 89 cC-12.1 Reg 1 s7.

Report of accidental discharge

8 Where an accidental, emergency or unauthorized release or discharge of an air contaminant occurs that results in air pollution, the person in charge of the industrial source, incinerator or fuel-burning equipment that caused the release or discharge shall:

- (a) as soon as practicable provide the minister with preliminary notification of the occurrence; and
- (b) within three working days of the occurrence, submit to the minister a written report setting forth:
 - (i) the date and time of the release or discharge;
 - (ii) the duration of the release or discharge;
 - (iii) the composition of the release or discharge showing:
 - (A) the concentration of the air contaminant;
 - (B) the mass emission rate; and
 - (C) the total amount, by weight, of the air contaminant;
 - (iv) a description of the circumstances leading to the release or discharge;
 - (v) the steps and procedures taken to minimize the release or discharge;
 - (vi) the steps and procedures taken to prevent similar releases or discharges in the future; and
 - (vii) a report containing a discussion or analysis of both the immediate and long-term effects that the release or discharge may have on the environment.

27 Oct 89 cC-12.1 Reg 1 s8.

C-12.1 REG 1**CLEAN AIR****Prohibition, maximum concentration of air contaminants**

9(1) No person shall operate or permit the operation of any industrial source, incinerator or fuel-burning equipment in a manner that results in the discharge of a quantity of air contaminants that, either alone or in combination with a quantity of the same air contaminants emitted from another industrial source, incinerator or fuel-burning equipment, causes a concentration of the air contaminants in the ambient air that is:

- (a) greater than the maximum concentration set forth:
 - (i) in the permit for the industrial source, incinerator or fuel-burning equipment; or
 - (ii) where a permit is not required or a maximum concentration has not been specified in a permit, in the Appendix to these regulations;
 - (b) injurious to the health or safety or comfort of the public;
 - (c) injurious or damaging to property or to plant and animal life;
 - (d) an interference with normal business; or
 - (e) obnoxious to the public.
- (2) Subsection (1) applies:
- (a) to the operation of all industrial sources, incinerators and fuel-burning equipment:
 - (i) whether or not a permit is required for their operation; and
 - (ii) notwithstanding that they are being operated in accordance with the terms and conditions contained in a permit; and
 - (b) during all process operating conditions and circumstances, including normal steady state operation, start-up, shut-down and upset conditions.

27 Oct 89 cC-12.1 Reg 1 s9.

Prohibition, visible emissions from existing sources, etc.

10(1) Unless otherwise authorized in a valid and subsisting permit and subject to subsection (2), no person shall cause or permit a discharge into the ambient air from an industrial source, incinerator or fuel-burning equipment of any air contaminant that exhibits an opacity greater than 40% averaged over a period of six consecutive minutes.

- (2) If the presence of uncombined water is the only reason for a failure to comply with subsection (1), the failure to comply is not a violation of subsection (1).
- (3) Notwithstanding subsection (1), no person shall cause or permit a discharge into the atmosphere of an air contaminant in a quantity sufficient to cause a visibility problem on public roadways or developed property.

27 Oct 89 cC-12.1 Reg 1 s10.

Prohibition, burning

11(1) No person shall cause or permit the burning of trash, garbage, industrial waste or any other material or waste in an open fire or an incinerator in a manner that causes air pollution.

(2) Without limiting the generality of subsection (1), no person shall cause or permit the burning of:

- (a) waste or spent lubricating oil;
- (b) hazardous substances as defined in *The Environmental Management and Protection Act*;
- (c) hazardous wastes as defined in *The Environmental Management and Protection Act*;
- (d) motor vehicle tires; or
- (e) animal cadavers;

except in accordance with the authorization in a valid and subsisting permit to operate an industrial source or incinerator or any fuel-burning equipment.

(3) Subject to subsection (4) and without limiting the generality of subsection (1), no person shall cause or permit the burning in an open fire of:

- (a) railway ties and other wood treated with wood preservatives;
- (b) waste materials from building or construction sites;
- (c) trash, garbage or other waste from commercial, industrial or municipal operations;
- (d) materials containing rubber or plastic;
- (e) spilled oil or oil production by-products;
- (f) materials disposed of as part of reclamation operations; or
- (g) animal manure.

(4) Subsection (3) does not apply where the burning is authorized in a valid and subsisting permit to operate an industrial source or incinerator or any fuel-burning equipment.

Appendix
Ambient Air Quality Standards

POLLUTANT ⁽¹⁾	AVERAGE CONCENTRATION FOR APPLICABLE TIME PERIOD				
	1 HOUR	8 HOURS	24 HOURS	30 DAYS	ANNUAL
SUSPENDED PARTICULATES			120 micrograms per cubic metre		*70 micrograms per cubic metre
SETTLEABLE PARTICULATES				2.0 milligrams per square centimetre	
SOIL INDEX			1.5 COH units		
POTASH				0.15 milligrams of K per square centimetre OR 0.15 milligrams of CL per square centimetre	
SULFUR DIOXIDE	450 (0.17) micrograms per cubic metre		150 (0.06) micrograms per cubic metre		**30 (0.01) micrograms per cubic metre
SULFATION				30 mg of sulphur trioxide per 100 cm ²	
CARBON MONOXIDE	15 (13) milligrams per cubic metre	6 (5) milligrams per cubic metre			
OXIDANTS (OZONE)	160 (0.08) micrograms per cubic metre				
NITROGEN DIOXIDE	400 (.2) micrograms per cubic metre				**100 (.05) micrograms per cubic metre
HYDROGEN SULPHIDE	15 (10.8) micrograms per cubic metre		5 (3.6) micrograms per cubic metre		

NOTE: Volume units, in parts per million or parts per billion for H₂S, are in brackets.

* Geometric Means

** Arithmetic Means

⁽¹⁾ Sampling will be in a manner and location specified by the Minister.

Canada-wide Standards for Mercury Implementation Plan for Saskatchewan - Waste Incineration Facilities December 2001



New Waste Incineration Facilities

General accountability: Saskatchewan's overall approach to management of mercury emissions from new waste incineration facilities will be to incorporate the Canada-wide Standard into the conditions of permits to operate issued pursuant to Saskatchewan's Clean Air Act and Clean Air Regulations. If the construction of a new waste incineration facility is such that it would be considered to be a "development", during the project development and assessment stage, management of mercury emissions will be introduced through the processes associated with The Environmental Assessment Act. These provisions will apply for municipal waste incineration, medical waste incineration, hazardous waste incineration and sewage sludge incineration as defined within the Canada-wide Standard.

Public role: Under sections 11, 12 and 13 of Saskatchewan's Environmental Assessment Act, the public may inspect environmental impact statements, submit written comments and attend public meetings regarding new projects classified as "developments" such as may include large municipal, medical or hazardous waste incinerators. Public feedback is obtained through these means during the assessment phase for new waste incineration facilities. Public meetings may be held as appropriate to afford local stakeholders the opportunity to have input to the assessment process. In this way the public will have the ability to ensure that the Canada-wide Standard will be met at any new facility. Once operational, information on mercury emissions may be obtained through direct request to the ministry or through The Freedom of Information and Protection of Privacy Act.

Access to information: Facility performance information is generally made available to the general public, upon request. Once operational, information on mercury emissions may be obtained through direct request to the ministry or through The Freedom of Information and Protection of Privacy Act.

Verifiable progress: New waste incineration facilities will require a permit to operate, which will specify annual stack testing to demonstrate compliance.

Co-benefits: Permits for new waste incinerators within Saskatchewan will specify limits for a number of compounds. It is anticipated that particulate, dioxin and other emissions will also be controlled in any new facility.

Existing Waste Incineration Facilities

General accountability: Saskatchewan's overall approach to management of mercury emissions from existing waste incineration facilities will be to incorporate the Canada-wide Standard into the conditions of permits to operate issued pursuant to Saskatchewan's Clean Air Act and Clean Air Regulations. Since all operational waste incinerators in Saskatchewan are operated as components of waste management of hospital operations, and all are of relatively small capacity of less than 120 tonnes per year, permit conditions will provide for choice of pollution control upgrading and stack testing or "determined efforts" including mercury diversion planning and waste audits.

Milestones and deliverables: It is anticipated that the initial thrust of permit implementation will be to encourage voluntary actions through mercury diversion planning and subsequent waste auditing. It is noted that while all existing waste incinerators are operated by hospitals, the waste stream sent to these incinerators would allow classification as either a medical waste or municipal waste incinerators.



Public role: There is no pre-defined public role in the implementation of environmental standards for existing waste incineration facilities in Saskatchewan. However, information on mercury emissions from existing waste incinerators or measures taken to control emissions may be obtained through direct request to the ministry or through The Freedom of Information and Protection of Privacy Act.

Access to information: Facility performance information is generally made available to the general public, upon request. Once operational, information on mercury emissions may be obtained through direct request to the ministry or through The Freedom of Information and Protection of Privacy Act.

Verifiable progress: Existing waste incineration facilities will require a permit to operate, which will specify either emission controls and annual stack testing to demonstrate compliance or demonstration of “determined efforts” including mercury diversion planning and waste audits.

Co-benefits: Permits for existing waste incinerators within Saskatchewan specify limits for a number of compounds. It is anticipated that particulate, dioxin (through the Dioxin and Furan Canada-wide Standards) and other emissions will also be controlled at existing facilities.



Air Emissions Monitoring

In order to ensure that air quality is maintained at a level that does not harm the natural environment or public health or safety, some permits issued under Yukon's Air Emissions Regulations include a requirement to monitor the levels of contaminants released to the air. Permittees may be required to conduct continuous monitoring and/or manual stack testing for these contaminants of concern: nitrogen oxides (NO_x), sulphur dioxide (SO₂), particulate matter less than 2.5 microns in diameter (PM_{2.5}), carbon monoxide (CO), hydrogen sulphide (H₂S), sulphuric acid mist (H₂SO₄) or any other contaminant specific to the permitted activity. Manual stack testing must be done in accordance with a testing method acceptable to the Environmental Programs Branch.

Acceptable Source Testing Methods

The following source testing methods are acceptable to the Environmental Programs Branch:

- Any method listed in the U.S. Code of Federal Regulations, Title 40, Chapter 1, Part 60 (Standards of Performance for New & Modified Stationary Sources), [Appendix A](#), that is applicable to the permitted activity and to the contaminants for which monitoring is required;
- Environment Canada references:
 - [Reference Method EPS 1/RM/2 for the Measurement of Releases of Selected Semi-Volatile Organic Compounds from Stationary Sources](#);
 - [Reference Method EPS 1/RM/8 for Source Testing: Measurement of Releases of Particulate from Stationary Sources](#);
 - [Reference Method EPS 1/RM/15 for the Monitoring of Gaseous Emissions from Fossil Fuel-fired Boilers](#);
- Saskatchewan Environment Standard reference methods for source testing: APC-31: Measurement of Emissions of Particulates from Stationary Sources;
- [Alberta Stack Sampling Code](#)
- [Ontario Source Testing Code \(version #2\), Report#ARB-66-80](#)
- [British Columbia Field Sampling Manual – Stationary Emissions Testing Code 1995](#)
- [Quebec Sampling of Atmospheric Emissions from Stationary Sources](#)
- [Manitoba Stack Sampling Protocol](#)
- American Society for Testing & Materials (ASTM) UOP 9 – 85 : [Hydrogen Sulfide in Gases by the Tutwiler Method](#)

Other source testing methods, not listed above, could be acceptable subject to the prior written approval of the Environmental Programs Branch. Please contact the Branch with details of the method proposed to confirm its acceptability in Yukon.

Related Topics

- [Air Emissions Regulations Fact Sheet](#)
- [Air Emissions Regulations](#)
- [Environment Act](#)

For more information, please contact:

Environmental Programs Branch (V-8)
Environment Yukon
Box 2703
Whitehorse, Yukon
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Copies of Yukon Government regulations may be viewed online at <http://www.environmentyukon.gov.yk.ca/monitoringenvironment/> or at any Yukon Public Library, territorial agent, territorial representative or regional services office. You may purchase copies at the Inquiry Centre, Yukon Government Administration Building, 2071-2nd Avenue in Whitehorse, or by mail from the Subscriptions Clerk, Yukon Government Queen's Printer, Box 2703, Whitehorse, Yukon, Y1A 2C6 (phone (867) 667-5783 or toll free 1-800-661-0408 extension 5783).



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O.I.C. 1998/207
ENVIRONMENT ACT

ENVIRONMENT ACT

Pursuant to section 145 of the *Environment Act*, the Commissioner in Executive Council orders as follows:

1. The annexed *Air Emissions Regulations* are hereby made.

2. Section 2 of the said Regulations comes into force 60 days after the day on which the Regulations are made.

Dated at Whitehorse, in the Yukon Territory, this 24th day of November, 1998.

Commissioner of the Yukon

DÉCRET 1998/207
LOI SUR L'ENVIRONNEMENT

LOI SUR L'ENVIRONNEMENT

Le Commissaire en conseil exécutif, conformément à l'article 145 de la *Loi sur l'environnement*, décrète ce qui suit :

1. Le *Règlement sur les émissions atmosphériques*, paraissant en annexe, est par les présentes établi.

2. L'article 2 du même règlement entre en vigueur 60 jours suivant la date à laquelle le règlement a été établi.

Fait à Whitehorse, dans le territoire du Yukon, ce 24 novembre 1998.

Commissaire du Yukon

AIR EMISSIONS REGULATIONS

PART I - INTERPRETATION

Definitions

1. In these regulations

“Act” means the *Environment Act*; «*loi*»

“air emission control system” means a system or device installed, attached or incorporated into a motor or motor vehicle by the manufacturer of the motor or motor vehicle to prevent or lessen the release of any air contaminant; «*dispositif antipollution* »

“external reviewer” means a person who is named on the roster established under section 11.03; «*évaluateur externe* »
(“*external reviewer*” added by O.I.C. 2014/150)

“incinerator” means equipment used for the burning of solid waste where air intake and combustion temperature may be controlled; «*incinérateur* »

“motor vehicle” means a vehicle that is designed to be self-propelled in any manner except solely by muscular power; «*véhicule automobile* »

“nameplate capacity” means the manufacturer's rated power input capacity as shown on a label permanently affixed by the manufacturer to the engine or system; «*puissance nominale* »

“observer” means a person designated by the Minister as qualified to be a visible emissions reader; «*observateur* »

“open burning” means the combustion of material without control of the combustion air and without a stack or chimney to vent the emitted products of combustion to the atmosphere; «*brûlage à ciel ouvert* »

“sell” includes to offer for sale or to advertise for sale; «*vente* »

“solid waste” includes waste which originates from residential, commercial, industrial or institutional sources, from the demolition or construction of buildings or other structures or is specified in a solid

RÈGLEMENT SUR LES ÉMISSIONS ATMOSPHÉRIQUES

PARTIE 1- DÉFINITIONS

Définitions

1. Les définitions suivantes s'appliquent au présent règlement.

« brûlage à ciel ouvert » La combustion de matériel sans le contrôle de l'air de combustion, ni cheminée pour évacuer les produits de combustion dans l'atmosphère; “*open burning*”

« déchets solides » Y sont assimilés les déchets ménagers, commerciaux et industriels, les déchets provenant des institutions, les décombres, les débris de construction, les déchets solides au sens prévu dans un plan de gestion de déchets solides et s'entend notamment des détritits au sens de la loi, mais non de la broussaille et des produits du bois qui ne sont pas mélangés à d'autres matériaux; “*solid waste*”

« dispositif antipollution » Dispositif ou système qui sert à prévenir ou à réduire les émissions atmosphériques et que les fabricants de moteurs ou de véhicules automobiles incorporent à leurs produits ou installent sur ceux-ci; “*air emission control system*”

« évaluateur externe » Personne inscrite sur la liste constituée en application de l'article 11.03. “*external reviewer*”
(«*évaluateur externe* » ajouté par Décret 2014/150)

« examen technique » Analyse des renseignements techniques effectuée par un évaluateur externe. “*technical review*”
(«*examen technique* » ajouté par Décret 2014/150)

« incinérateur » Dispositif qui sert à brûler les déchets solides et avec lequel il est possible de contrôler l'entrée d'air et la température de combustion. “*incinerator*”

« loi » La *Loi sur l'environnement*; “*Act*”

« observateur » Personne désignée par le ministre comme ayant la compétence requise pour établir l'opacité des émissions visibles; “*observer*”

waste management plan to be solid waste and for greater certainty includes litter, as defined in the Act, but does not include untreated brush or wood products that are not mixed with other materials;
« déchets solides »

“source” means any stationary property, real or personal, taken as a whole, that emits or may emit contaminants into the air; « source de pollution »

“sulphur content” means the amount of sulphur by weight as determined by methods approved by the Minister. « teneur en soufre »

“technical information” includes any data, plans, assumptions, conclusions and other information submitted in support of an application for a permit;
« renseignements techniques »
(“technical information” added by O.I.C. 2014/150)

“technical review” means an analysis of technical information conducted by an external reviewer.
« examen technique »
(“technical review” added by O.I.C. 2014/150)

« puissance nominale » La puissance d'entrée nominale indiquée par le fabricant sur la plaque apposée de façon permanente sur le moteur ou le dispositif; “nameplate capacity”

« renseignements techniques » S'entend notamment des données, des plans, des hypothèses, des conclusions et des autres renseignements présentés à l'appui d'une demande de permis. “technical information”
(« renseignements techniques » ajouté par Décret 2014/150)

« source de pollution » Toute installation fixe ¾ qu'il s'agisse d'un bien réel ou d'un bien personnel ¾ qui rejette ou peut rejeter des polluants dans l'atmosphère;
“source”

« teneur en soufre » La quantité de soufre au poids établie selon des méthodes de calcul approuvées par le ministre; “sulphur content”

«véhicule automobile» Véhicule conçu pour se mouvoir de lui-même de quelque façon que ce soit, exception faite des véhicules qui ne peuvent se déplacer qu'avec la force musculaire; “motor vehicle”

«vente» Y sont assimilées l'offre de vente et la publicité relative à la vente. “sell”

PART II - EMISSION CONTROL

Release of emissions

2. No person shall undertake an activity listed in Schedule 1 except as authorized by a permit issued under these regulations.

Opacity of Visible Emissions

3.(1) Where the opacity of visible emissions from a source is not regulated by the terms and conditions of a permit issued under these regulations, the visible emissions released from the source shall not exceed an opacity of 40% as measured by

(a) an observer determining the opacity, or

(b) another method of determining opacity as prescribed by the Minister.

(2) Where an observer is to determine opacity in subsection 1, the observer shall determine the opacity of

PARTIE II- RÉDUCTION DES ÉMISSIONS

Émissions atmosphériques

2. Il est interdit de mener les activités visées à l'annexe 1 autrement qu'aux termes d'un permis délivré sous le régime du présent règlement.

Opacité des émissions visibles

3.(1) Lorsqu'un permis est silencieux quant à l'opacité des émissions visibles provenant d'une source de pollution, l'opacité de ces émissions ne doit pas dépasser 40%, valeur qui est établie par un observateur ou par tout autre moyen que prescrit le ministre à cette fin.

(2) Pour établir l'opacité des émissions visibles, l'observateur calcule la moyenne de 24 relevés pris

visible emissions by averaging 24 consecutive readings taken over a period of 6 consecutive minutes at 15 second intervals.

Fuel Sulphur Content

4. No person shall use fuel for

- (a) heating;
- (b) generating steam or electricity; or
- (c) combustion in industrial processes,

that has a sulphur content in excess of 1.1%, except as authorized by a permit issued under these regulations.

Open Burning

5. No person shall open burn or allow the open burning of solid waste in an amount greater than 5 kilograms per day, except as authorized by a permit issued under these regulations.

Damage and Harm

6. No person shall release or allow the release of any air contaminant to such extent or degree as may

- (a) cause or be likely to cause irreparable damage to the natural environment; or
- (b) in the opinion of a health officer, cause actual or imminent harm to public health or safety.

Fuel Burning Equipment

7. (1) For the purposes of this section, "fuel burning equipment" does not include wood burning appliances used for domestic heating.

(2) No person shall burn or allow to be burned in any fuel burning equipment or incinerator any fuel or waste except the type of fuel or waste the equipment or incinerator was designed by the manufacturer to burn.

consécutivement aux quinze secondes pendant six minutes.

Teneur en soufre du combustible

4. Il est interdit d'utiliser à des fins de chauffage, de production de vapeur, de production d'électricité ou de combustion industrielle du combustible dont la teneur en soufre est supérieure à 1,1 % autrement qu'aux termes d'un permis délivré sous le régime du présent règlement.

Brûlage à ciel ouvert

5. Il est interdit de brûler ou de permettre qu'on brûle à ciel ouvert plus de 5 kg de déchets solides par jour autrement qu'aux termes d'un permis délivré sous le régime du présent règlement.

Dommages et risques

6. Il est interdit de rejeter ou de permettre qu'on rejette dans l'atmosphère des polluants à des concentrations qui causeront ou risquent vraisemblablement de causer des dommages irréparables à l'environnement ou qui, de l'avis d'un agent de la santé, présentent un danger $\frac{1}{4}$ réel ou imminent $\frac{3}{4}$ à la santé ou à la sécurité publique.

Dispositif de brûlage de combustibles

7.(1) Aux fins du présent article, «dispositif de brûlage de combustibles» ne s'entend pas des systèmes de chauffage au bois utilisés à des fins domestiques.

(2) Il est interdit de brûler ou de permettre qu'on brûle dans un dispositif de brûlage de combustibles ou dans un incinérateur des combustibles ou des déchets autres que ceux pour lesquels ces systèmes ont été conçus par le fabricant.

**PART III - MOTOR AND MOTOR
VEHICLE EMISSIONS**

**Tampering with Air Emission Control
System**

8. No person shall remove, tamper with or otherwise alter an air emission control system in such a manner as to render it inoperable or lessen its efficiency.

PART IV - MONITORING

Measuring and Recording Equipment

9. Where,

- (a) the opacity of visible emissions from a source exceeds levels established in subsection 3(1);
- (b) the release of an air contaminant may cause or is likely to cause irreparable damage to the natural environment; or
- (c) in the opinion of a health officer, the release of an air contaminant may cause actual or imminent harm to public health or safety

the Minister may order the operator of a source:

- (i) to install and maintain in good working condition equipment to measure and record the results of any tests for air contaminants designated by the Minister;
- (ii) to report measurements obtained pursuant to paragraph (i) as the Minister may determine;
- (iii) to reduce the level of air contaminants released such that the concerns stated in paragraphs (a), (b) or (c) are remedied or require the operator to obtain a permit under these regulations; and
- (iv) to keep records obtained as a result of any testing required by paragraph (i) at the site of the source or at a location specified in a permit for a minimum of two years.

**PARTIE III - ÉMISSIONS PROVENANT DES
MOTEURS ET DES VÉHICULES
AUTOMOBILES**

Sabotage des dispositifs antipollution

8. Il est interdit de modifier un dispositif antipollution, notamment de l'enlever ou de le saboter, de sorte à en empêcher le bon fonctionnement ou à en diminuer le rendement.

PARTIE IV - SURVEILLANCE

Dispositif de mesure et d'enregistrement

9. S'il est contrevenu au paragraphe 3(1) ou à l'article 6, le ministre peut ordonner à l'opérateur d'une source de pollution :

- a) d'installer et de garder en bon état de fonctionnement un dispositif pour mesurer et enregistrer les résultats de tests de détection de polluants atmosphériques désignés par le ministre;
- b) de faire rapport des résultats des tests de détection selon les modalités établies par le ministre;
- c) de réduire la quantité de polluants rejetés dans l'atmosphère, afin de répondre aux préoccupations que vise le présent article ou exiger qu'il obtienne un permis sous le régime du présent règlement;
- d) de conserver à l'endroit où se trouve la source de pollution ou à celui indiqué au permis, pour au moins deux ans, les résultats de tests de détection.

Availability of Information

10. The operator of a source shall make any information measured and recorded in accordance with section 9 available to an environmental protection officer upon request.

PART V - PERMITTING

Information Requested

11. Persons applying for a permit or renewal of a permit under these regulations shall make the application in a form provided by the Minister and submit the information specified by the Minister, including

- (a) the name, business address and telephone number of the applicant;
- (b) a description of the source of the contaminants that may be released into the air;
- (c) the type and quantity of the contaminants that may be released into the air;
- (d) one set of plans and drawings clearly showing the layout of the facility, location of individual equipment, and points of discharge, building dimensions and stack heights;
- (e) a description of air quality control devices, including efficiency and other design criteria and photocopies of the manufacturer's specifications for the air quality control devices establishing that the equipment is capable of complying with applicable emission criteria in the permit;
- (f) a map or aerial photograph, on a scale of 1:50,000 detailing the location of the facility, homes, buildings, roads and other adjacent facilities within a five kilometre radius of the facility;
- (g) specifications for any equipment, including incinerators, that may be used and a description of the mitigative measures planned to control air emissions and the disposal and handling of all types of ash; and,
- (h) a description of any equipment or devices the applicant intends to use to monitor the release of contaminants into the air.

Accès aux renseignements

10. L'opérateur d'une source de pollution est tenu de remettre sur demande à l'agent de protection de l'environnement les relevés obtenus conformément à l'article 9.

PARTIE V - PERMIS

Renseignements requis

11. Toute demande de permis ou de renouvellement de permis est soumise selon la formule que prescrit le ministre; la demande contient les renseignements que ce dernier exige, notamment :

- a) le nom du demandeur ainsi que son adresse et numéro de téléphone d'entreprise;
- b) une description de la source de pollution;
- c) le type et la quantité de polluants qui seront peut-être rejetés dans l'atmosphère;
- d) une copie des plans et dessins montrant clairement la disposition de l'installation, l'emplacement de chaque pièce d'équipement, les points d'émission, les dimensions de l'édifice et la hauteur des cheminées;
- e) une description des dispositifs de contrôle de la qualité de l'air énonçant les critères de conception de ces dispositifs, notamment leur rendement, et une photocopie des caractéristiques techniques qui montre que les dispositifs permettront à l'opérateur de se conformer aux exigences du permis;
- f) une carte ou une photographie aérienne dressée à une échelle de 1 : 50 000 montrant l'emplacement de l'installation, des résidences, des constructions, des chemins et autres installations situées dans un rayon de cinq kilomètres de l'installation;
- g) les caractéristiques techniques de tout dispositif de brûlage de combustibles, notamment un incinérateur, qui sera peut-être utilisé, ainsi qu'une description des mesures qui seront prises pour réduire les émissions atmosphériques et gérer l'élimination et le transport des cendres;

h) une description de tout équipement ou appareil qui sera utilisé pour surveiller le rejet de polluants dans l'atmosphère;

Requirement for technical review

11.01(1) Upon receipt of an application for a permit, the Minister shall determine whether a technical review is required.

(Subsection 11.01(1) added by O.I.C. 2014/150)

(2) If a technical review is required, the Minister shall provide to the applicant, as soon as practicable, a written notice that states

- (a) a technical review is required before the Minister can further consider the application;
- (b) the applicant is responsible for paying the cost of the technical review;
- (c) the cost of the technical review; and
- (d) the timeline for completion of the technical review.

(Subsection 11.01(2) added by O.I.C. 2014/150)

(3) A written notice is considered to be received by the applicant on the seventh day after the day on which the Minister sends it.

(Subsection 11.01(3) added by O.I.C. 2014/150)

Payment for technical review

11.02(1) Upon making a determination that a technical review is required, the Minister shall suspend consideration of the application until the applicant has paid to the Minister the cost of the technical review.

(Subsection 11.02(1) added by O.I.C. 2014/150)

(2) If the applicant has not paid the cost of the technical review within 60 days of the date of receiving the written notice, as determined in accordance with subsection 11.01(3), the application

- (a) is considered to be abandoned; and
- (b) shall not be further considered by the Minister.

(Subsection 11.02(2) added by O.I.C. 2014/150)

Nécessité d'un examen technique

11.01(1) À la réception d'une demande de permis, le ministre détermine si un examen technique est nécessaire.

(Paragraphe 11.01(1) ajouté par Décret 2014/150)

(2) Si un examen technique est nécessaire, le ministre fournit à l'auteur de la demande, dès que possible, un avis écrit faisant état de ce qui suit :

- a) un examen technique est nécessaire avant que le ministre poursuive l'examen de la demande;
- b) il incombe à l'auteur de la demande de payer les coûts de l'examen technique;
- c) les coûts de l'examen technique;
- d) le délai pour compléter l'examen technique.

(Paragraphe 11.01(2) ajouté par Décret 2014/150)

(3) L'avis écrit est considéré avoir été reçu par l'auteur de la demande le septième jour suivant son envoi par le ministre.

(Paragraphe 11.01(3) ajouté par Décret 2014/150)

Paiement du coût d'un examen technique

11.02(1) Lorsqu'il détermine qu'un examen technique est nécessaire, le ministre suspend l'examen de la demande jusqu'à ce que l'auteur de la demande lui verse le coût de l'examen technique.

(Paragraphe 11.02(1) ajouté par Décret 2014/150)

(2) Si l'auteur de la demande n'a pas payé les coûts de l'examen technique dans les 60 jours suivant la réception de l'avis écrit, établie en conformité avec le paragraphe 11.01(3), la demande :

- a) d'une part, est considérée abandonnée;
- b) d'autre part, ne fait plus l'objet d'un examen par le ministre.

(Paragraphe 11.02(2) ajouté par Décret 2014/150)

(3) If an application is considered to be abandoned, the Minister may destroy the application and any technical information related to it.

(Subsection 11.02(3) added by O.I.C. 2014/150)

(4) The Minister may refund the payment for a technical review to the applicant only if, before the Minister enters into a contract for services with an external reviewer in respect of that technical review, the applicant provides the Minister with written notice that they wish to withdraw their application from consideration.

(Subsection 11.02(4) added by O.I.C. 2014/150)

Roster of external reviewers

11.03(1) The Minister may establish a roster that contains the names of persons who are qualified to conduct a technical review.

(Subsection 11.03(1) added by O.I.C. 2014/150)

(2) The Minister may, at any time, add to or remove from the roster a person's name.

(Subsection 11.03(2) added by O.I.C. 2014/150)

Conduct of technical review

11.04(1) Upon entering into a contract for services with the Minister, an external reviewer shall conduct a technical review.

(Subsection 11.04(1) added by O.I.C. 2014/150)

(2) At the conclusion of a technical review, the external reviewer shall provide a written report to the Minister that contains

(a) the external reviewer's opinion of the quality, accuracy and appropriateness of the technical information; and

(b) any recommendations that, in the external reviewer's opinion, would improve or correct the quality, accuracy or appropriateness of the technical information.

(Subsection 11.04(2) added by O.I.C. 2014/150)

(3) The Minister may use or rely upon any information contained in a written report for the purposes of

(a) deciding whether or not to issue or amend a permit to which the written report relates; or

(3) Si une demande est considérée abandonnée, le ministre peut la détruire avec les renseignements techniques qui y sont liés.

(Paragraphe 11.02(3) ajouté par Décret 2014/150)

(4) Le ministre peut rembourser le paiement pour un examen technique à l'auteur de la demande que si, avant que ne soit conclu un contrat de services entre le ministre et un évaluateur externe relativement à cet examen technique, l'auteur de la demande fournit un avis écrit au ministre de son intention de retirer sa demande pour examen.

(Paragraphe 11.02(4) ajouté par Décret 2014/150)

Liste des évaluateurs externes

11.03(1) Le ministre peut constituer une liste contenant les noms des personnes compétentes pour effectuer un examen technique.

(Paragraphe 11.03(1) ajouté par Décret 2014/150)

(2) Le ministre peut en tout temps ajouter ou supprimer le nom d'une personne sur la liste.

(Paragraphe 11.03(2) ajouté par Décret 2014/150)

Conduite d'un examen technique

11.04(1) Dès la conclusion d'un contrat de services avec le ministre, un évaluateur externe procède à un examen technique.

(Paragraphe 11.04(1) ajouté par Décret 2014/150)

(2) À la conclusion de l'examen technique, l'évaluateur externe remet un rapport écrit au ministre contenant ce qui suit :

a) l'avis de l'évaluateur externe quant à la qualité, la justesse et la pertinence des renseignements techniques;

b) les recommandations qui, selon l'évaluateur externe, permettraient d'améliorer ou d'apporter des correctifs à la qualité, la justesse et la pertinence des renseignements techniques.

(Paragraphe 11.04(2) ajouté par Décret 2014/150)

(3) Le ministre peut utiliser les renseignements contenus dans un rapport écrit ou s'appuyer sur ceux-ci :

a) soit pour déterminer s'il délivre ou modifie le permis visé par le rapport écrit;

(b) determining the appropriate terms and conditions to be included in a permit to which the written report relates.

(Subsection 11.04(3) added by O.I.C. 2014/150)

(4) A written report that is provided to the Minister under subsection (2) is the property of the Minister.

(Subsection 11.04(4) added by O.I.C. 2014/150)

Issuance of Permits

12.(1) The Minister may issue or renew a permit to an applicant subject to any terms and conditions that the Minister considers appropriate or may refuse to issue or renew a permit to an applicant.

(2) A permit may be issued or renewed for a period of up to 10 years.

(Subsection 12(2) amended by O.I.C. 2014/150)

(3) It is a term of every permit that a permittee shall provide notice to the Minister, in writing and as soon as is reasonably feasible, of any significant change of circumstances involving the permitted activity, including a change in ownership of the permitted activity.

(4) An environmental protection officer may from time to time conduct an inspection of a site for which a permit issued under these regulations applies to determine whether any of the activities at the site contravene a term or condition of the permit.

Public Register

13.(1) The Minister shall establish a public register for the purpose of recording the persons to whom permits are issued under these regulations.

(2) The Minister shall provide public access during normal office hours to the public register.

Fees

(Section 14 repealed by O.I.C. 2014/150)

b) soit pour fixer les modalités appropriées applicables au permis visé par le rapport écrit.

(Paragraphe 11.04(3) ajouté par Décret 2014/150)

(4) Un rapport écrit présenté au ministre en application du paragraphe (2) est la propriété du ministre. »

(Paragraphe 11.04(4) ajouté par Décret 2014/150)

Délivrance de permis

12.(1) Le ministre peut délivrer ou renouveler un permis en l'assortissant des modalités et des conditions qu'il estime appropriées; il peut également refuser de délivrer ou de renouveler tout permis.

(2) Le permis est délivré ou renouvelé, selon le cas, pour une durée maximale de 10 ans.

(Paragraphe 12(2) modifié par Décret 2014/150)

(3) Tout permis est censé comporter une clause enjoignant son titulaire de donner avis par écrit au ministre dans les meilleurs délais de tout changement important dans les circonstances relatives à l'activité visée par le permis, notamment un changement dans la propriété de l'activité.

(4) Tout agent de protection de l'environnement peut procéder à l'inspection d'un lieu visé par un permis délivré sous le régime du présent règlement en vue d'établir si les activités qui y sont menées sont conformes au permis.

Registre public

13.(1) Le ministre constitue un registre public où est enregistré le nom des titulaires de permis délivrés sous le régime du présent règlement.

(2) Le ministre permet l'accès durant les heures normales de travail au registre public.

Droits

(Article 14 abrogé par Décret 2014/150)

SCHEDULE 1

ANNEXE 1

**SCHEDULE OF ACTIVITIES
THAT REQUIRE A PERMIT**

**LISTE DES ACTIVITÉS POUR LESQUELLES
UN PERMIS EST NÉCESSAIRE**

- 1.** Manufacturing of asphalt.
- 2.** Production and exploration of oil and natural gas, including combustion products of flaring or burning petroleum and the release of petroleum vapours, but not including the release of combustion products or vapours that may occur during emergency flaring or burning.
- 3.** Quarrying, crushing and screening of stone, clay, shale, coal or minerals in an excavation covering an area greater than 4 hectares.
- 4.** Processing or handling of coal at a rate of greater than 5,000,000 British Thermal Units per hour.
- 5.** Operation of equipment capable of generating, burning or using, according to the manufacturer's specifications, heat energy equivalent to or greater than 5,000,000 British Thermal Units per hour.
- 6.** Operation of incinerators capable of burning, according to the manufacturer's specifications, more than 5 kilograms of solid waste per day.
- 7.** Operation of equipment for incineration of special waste, as defined in the Special Waste Regulations, or soil contaminated with any contaminant in excess of the generic numerical soil standard or the matrix numerical soil standard as defined in Schedule 1 or 2, as the case may be, of the Contaminated Sites Regulations.
- 8.** Operation of electricity generating facilities with a maximum nameplate capacity equal to or more than 1.0 Megavolt ampere (at unity power factor equivalent to 1.0 megawatt).
- 9.** Storage or other handling of solid, liquid or gaseous materials or substances in such a manner that causes or may cause an adverse effect.

- 1.** La fabrication de bitume.
- 2.** La prospection et la production de pétrole et de gaz naturel, y compris les produits de combustion résultant du torchage ou du brûlage du pétrole et le rejet de gaz naturel; n'y sont pas assimilés le rejet de produits de combustion ou les gaz qui résultent du brûlage ou du torchage effectué en situation d'urgence.
- 3.** L'exploitation en carrière, le concassage ou le triage de pierres, d'argile, de schiste argileux, de charbon ou de minerai si l'excavation couvre plus de quatre hectares.
- 4.** Le traitement ou le transport du charbon à un taux supérieur à 5 000 000 Btu/h.
- 5.** L'opération de dispositifs pouvant produire, brûler ou utiliser, selon les indications du fabricant, de l'énergie thermique équivalent à 5 000 000 Btu/h ou plus.
- 6.** L'opération d'incinérateurs pouvant brûler, selon les indications du fabricant, plus de 5 kg de déchets solides par jour.
- 7.** L'opération de dispositifs pour l'incinération de déchets spéciaux, au sens du Règlement sur les déchets spéciaux ou de sol pollué par un polluant en quantité supérieure à la norme établie soit à l'annexe 1 ou à l'annexe 2, selon le cas, du Règlement sur les lieux pollués.
- 8.** L'exploitation d'une installation de production d'électricité ayant une puissance nominale maximale d'au moins 1,0 mégawatt mégavolt ampère (facteur de puissance unité égal à 1,0 mégawatt).
- 9.** Stockage ou manutention de substances solides, liquides ou gazeuses d'une manière causant ou pouvant causer des effets néfastes.

O.I.C. 1998/207
ENVIRONMENT ACT

SCHEDULE 2

(Schedule 2 repealed by O.I.C. 2014/150)

DÉCRET 1998/207
LOI SUR L'ENVIRONNEMENT

ANNEXE 2

(Annexe 2 abrogée par Décret 2014/150)