

## 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.<sup>[179]</sup> New stationary continuous source testing methods can be approved if they meet the requirements of US EPA Method Validation Protocol Method 301.<sup>[180]</sup> 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, O<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub>, HCl and HF. Opacity measurements would be used as the filter bag leak detection system

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<sup>179</sup> British Columbia Field Sampling Manual Part B: Air and Air Emissions Testing. Stationary Air Emissions Testing. 2003.

<sup>180</sup> 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 O<sub>2</sub>, SO<sub>2</sub> 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.<sup>[181]</sup> 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.<sup>[182]</sup> 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)<sup>[183]</sup> 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.

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<sup>181</sup> Durham/York Residual Waste Study Environmental Assessment, November 27, 2009, Stantec Consulting Ltd

<sup>182</sup> Status of Particulate Matter Continuous Emission Monitoring Systems, EPRI, Palo Alto, CA: 2001. 1004029.

<sup>183</sup> 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.<sup>[184]</sup> 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.<sup>[185]</sup>

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.<sup>[186]</sup>

**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

<sup>184</sup> 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.

<sup>185</sup> Ibid.

<sup>186</sup> 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 O<sub>2</sub> concentration, pressure, temperature, and water vapour content of exhaust gas be continuously monitored. Periodic, instead of continuous, monitoring of HCl, HF, and SO<sub>2</sub> 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.<sup>[187]</sup> 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.<sup>[188] [189]</sup> 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

<sup>187</sup> British Columbia. Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples. 2003

<sup>188</sup> US Environmental Protection Agency 40 CFR Parts 60, 61 and 63

<sup>189</sup> 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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**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 <sub>2</sub> )	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 <sub>2</sub> , O <sub>2</sub> instrumental)	EPA 3a	–	
Gas composition and molecular weight (CO <sub>2</sub> , O <sub>2</sub> 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 <sub>x</sub> )	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 ( $\text{O}_2$ )	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 ( $\text{PM}_{10}$ )	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 ( $\text{SO}_2$ )	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 PM<sub>10</sub> and PM<sub>2.5</sub>. 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.<sup>[190]</sup> Most of the stations collect air quality and weather data continuously. The six CACs reported continuously are: O<sub>3</sub>, CO, SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>10</sub>, PM<sub>2.5</sub>. 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.<sup>[191]</sup> 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:<sup>[192]</sup>

- |                       |                                      |
|-----------------------|--------------------------------------|
| ▪ 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 |

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<sup>190</sup> Metro Vancouver Air Quality website: <http://www.metrovancouver.org/services/air/management/Pages/default.aspx>

<sup>191</sup> Metro Vancouver. Technical Appendix Air Quality Data 2006. Accessible at: <http://www.bcairquality.com/readings/>

<sup>192</sup> 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.<sup>[193]</sup>

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.

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<sup>193</sup> 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.<sup>[194]</sup> In 2000, the CCME also developed ambient air quality CWS for particulate matter and ozone.<sup>[195]</sup>

### ***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/Rm<sup>3</sup>.

### ***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/Rm<sup>3</sup>.<sup>[196]</sup>

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.<sup>[197]</sup>

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/Rm<sup>3</sup>).<sup>[198]</sup>

### ***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<sup>[199]</sup>, the CCME also developed ambient air quality CWS for particulate matter (PM) and ozone in 2000.<sup>[200]</sup> The CWS set an overall ambient target for PM<sub>2.5</sub> for 2010 at 30 µg/Rm<sup>3</sup> (24-hour averaging time based on the 98<sup>th</sup> percentile ambient measurement annually averaged over three consecutive years). The CWS does not set stack or industry sector specific targets.

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<sup>194</sup> Canadian Council of Ministers of the Environment. Canada-Wide Standards for Mercury Emissions. June 2000

<sup>195</sup> Canadian Council of Ministers of the Environment Canada-Wide Standards for Particulate Matter (PM) and Ozone. 2000

<sup>196</sup> Canadian Council of Ministers of the Environment Canada-Wide Standards for Dioxins and Furans. 2001

<sup>197</sup> Canadian Council of Ministers of the Environment Canada-Wide Standards for Dioxins and Furans. 2001.

<sup>198</sup> Canadian Council of Ministers of the Environment (CCME). (2007). Review of Dioxins and Furans from Incineration In Support of a Canada-wide Standard Review

<sup>199</sup> Canadian Council of Ministers of the Environment. Operating & Emissions Guidelines for MSW Incinerators Report CCME-TS/WM-TRE003, June 1989.

<sup>200</sup> 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 PM<sub>10</sub> as the CCME considered the reduction in PM<sub>10</sub> to come along with a reduction in PM<sub>2.5</sub>. Therefore the report does not discuss total particulate matter, or PM<sub>2.5</sub>.

The CCME reviewed its CWS for particulate matter (PM) and ozone in 2005 and recommended keeping the 2000 targets.<sup>[201]</sup>

#### 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 <sup>3</sup> @ 11% O <sub>2</sub>	20 <sup>1</sup>
Sulphur Dioxide (SO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	260 <sup>2</sup>
Hydrogen Chloride (HCl)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	75 or 90% removal <sup>1</sup>
Nitrogen Oxides (NO <sub>x</sub> ) (as NO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	400 <sup>2</sup>
Carbon Monoxide (CO)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	57 (114 for RDF Systems) <sup>1</sup>

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<sup>201</sup> 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 <sup>3</sup> @ 11% O <sub>2</sub>	100 <sup>2</sup>
Lead (Pb)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	50 <sup>2</sup>
Mercury (Hg)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	20 <sup>3</sup>
PCDD/F TEQ (Dioxins and Furans)	ng/Rm <sup>3</sup> @ 11% O <sub>2</sub>	0.08 <sup>4</sup>
Opacity	%	5 <sup>5</sup>

**NOTES:**

N. Def. = Not Defined

<sup>1</sup> CCME Operating and Emissions Guidelines for MSW Incinerators Report CCME-TS/WM-TRE003, June 1989. Table 4.2: Stack Discharge Limits (at 11% O<sub>2</sub>)

<sup>2</sup> 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

<sup>3</sup> CCME Canada-Wide Standards for Mercury Emissions (2000)

<sup>4</sup> CCME Canada-Wide Standards for Dioxins and Furans (2001)

<sup>5</sup> 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<sup>[202]</sup>. 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<sup>[203]</sup> 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.

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<sup>202</sup> BC *Environmental Management Act*. Chapter 53. Part 3 – Municipal Waste Management. 2010.

<sup>203</sup> 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 <sup>3</sup> @ 11% O <sub>2</sub>	20	1	2
Carbon Monoxide (CO)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	55 <sup>3</sup>	4-hour rolling average	Continuous monitoring
Sulphur Dioxide (SO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	250	1	2
Nitrogen Oxides (NO <sub>x</sub> as NO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	350	1	2
Hydrogen Chloride (HCl)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	70	8-hour rolling average	Continuous monitoring
Hydrogen Fluoride (HF)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	3	1	2
Total Hydrocarbons (as CH <sub>4</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	40	1	2
Arsenic (As) <sup>4</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	4	1	2
Cadmium (Cd) <sup>4</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	100	1	2
Chromium (Cr) <sup>4</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	10	1	2
Lead (Pb) <sup>4</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	50	1	2
Mercury (Hg)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	200	1	2
Chlorophenols	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	1	1	2
Chlorobenzenes	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	1	1	2
Polycyclicaromatic Hydrocarbons	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	5	1	2
Polychlorinated Biphenyls	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	1	1	2
Total PCDD/F TEQ (Dioxins and Furans) <sup>5</sup>	ng/Rm <sup>3</sup> @ 11% O <sub>2</sub>	0.5	1	2
Opacity	%	5	1hr avg, data every 10 sec	Continuous monitoring

**NOTES:**

BC Limits are based on 20°C.

<sup>1</sup> To be averaged over the approved sampling and monitoring method

<sup>2</sup> All sampling and monitoring methods, including continuous monitors, are to be approved by the Regional Manager.

<sup>3</sup> For RDF systems the limit shall be 110 mg/m<sup>3</sup>

<sup>4</sup> The concentration is total metal emitted as solid and vapour

<sup>5</sup> 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/m<sup>3</sup> for smaller facilities versus 20 mg/m<sup>3</sup> for larger facilities) reflecting the absence of APC equipment to control particulate. The carbon monoxide limit is the same as 55 mg/m<sup>3</sup> for large and small facilities where the fuel is MSW, but increases to 110 mg/m<sup>3</sup> 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<sup>[204]</sup>, 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)).<sup>[205]</sup> 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.

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<sup>204</sup> BC *Environmental Management Act*. Waste Discharge Regulation. 2008. Website:  
[http://www.bclaws.ca/EPLibraries/bclaws\\_new/document/ID/freeside/50\\_320\\_2004#section6](http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/50_320_2004#section6)

<sup>205</sup> BC *Environmental Management Act*. May 5, 2010. Website:  
[http://www.bclaws.ca/EPLibraries/bclaws\\_new/document/ID/freeside/03053\\_02](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 <sup>3</sup> @ 11% O <sub>2</sub>	180	1	2
Carbon Monoxide (CO)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	55 <sup>3</sup>	4-hour rolling avg	Continuous
Carbon Monoxide (if burning RDF)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	110	4-hour rolling avg	Continuous
Sulphur Dioxide (SO <sub>2</sub> )	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	450	1	2
Nitrogen Oxides (NO <sub>x</sub> as NO <sub>2</sub> )	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	400	1	2
Hydrogen Chloride (HCl)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	100	8-hour rolling avg	Continuous
Hydrogen Fluoride (HF)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	3	1	2
Opacity	%	10		

**NOTES:**

BC Limits are based on 20°C.

<sup>1</sup> To be averaged over the approved sampling and monitoring method

<sup>2</sup> All samples and monitoring methods, including continuous monitors, are to be approved by the Regional Manager

<sup>3</sup> For RDF systems the limit shall be 110 mg/m<sup>3</sup>

**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 <sup>1</sup>	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 <sup>3</sup> @ 11% O <sub>2</sub> (4-h rolling average)	55 mg/m <sup>3</sup> @ 11% O <sub>2</sub> (4-h rolling average)	110 mg/m <sup>3</sup> @ 11% O <sub>2</sub> (4-h rolling average)
<b>Emission Control Systems<sup>2</sup></b>			
Flue Gas Temperature at Inlet or Outlet of Emission Control Device <sup>3</sup>	Not to exceed 140°C	Not to exceed 140°C	Not to exceed 140°C
Opacity <sup>4</sup>	Less than 5%	Less than 5%	Less than 5%

#### NOTES:

<sup>1</sup> For excess Air type – as required by design.

<sup>2</sup> Applicable to incinerators equipped with such systems

<sup>3</sup> The flue gas temperature at the inlet or outlet will depend on the type of emission control device in use

<sup>4</sup> 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<sub>2.5</sub> were adopted by the Ministry of Healthy Living and Sport (BC MHLS, 2009).<sup>[206]</sup> These objectives are summarized in Table 8-5.

<sup>206</sup> 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<sup>[207]</sup> 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 (PM<sub>10</sub>), and fine particulate matter (PM<sub>2.5</sub>).<sup>[208]</sup> In 2008, Metro Vancouver's objectives were equivalent or more stringent than both the CWS and BC objectives for these CACs.<sup>[209]</sup> A provincial 24-hour AAQO for PM<sub>2.5</sub> 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/m<sup>3</sup> and an annual planned goal of 6 µg/m<sup>3</sup>.

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<sup>207</sup> Health Canada. National Ambient Air Quality Objectives. <http://www.hc-sc.gc.ca/ewh-semt/pubs/air/naago-onqaa/index-eng.php>

<sup>208</sup> Greater Vancouver Regional District (GVRD). Air Quality Management Plan. September 2005  
<http://www.metrovancouver.org/about/publications/Publications/AQMPSeptember2005.pdf>

<sup>209</sup> 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 ( $\text{SO}_2$ )	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 <sup>4</sup>
	24-hour	3	6	NA	NA			NA
Hydrogen Sulphide ( $\text{H}_2\text{S}$ )	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 ( $\text{NO}_2$ )	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 ( $\text{O}_3$ )	1-hour	NA			100	160	300	NA
	8-hour	NA			65 ppb <sup>3</sup>			126
	24-hour	NA			30	50	NA	NA
	Annual	NA			NA	30	NA	NA
PM <sub>2.5</sub>	24-hour	25 <sup>1</sup>			30 <sup>2</sup>			25
	Annual	8			NA			12
PM <sub>10</sub>	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 ( $\text{CH}_2\text{O}$ )	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

<sup>1</sup> Based on 98<sup>th</sup> percentile value for one year.

<sup>2</sup> The Canada-wide Standard is referenced to the 98<sup>th</sup> percentile value averaged over three consecutive years.

<sup>3</sup> 8-hour daily maximum is based on fourth highest annual value, average over three consecutive years.

<sup>4</sup> Metro Vancouver TRS desirable, acceptable and tolerable levels are 7, 14 and 1414  $\mu\text{g}/\text{m}^3$ , respectively.

**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”.<sup>[210]</sup> 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<sup>[211]</sup> under Part 4 (Energy Projects) and Part 6 (Waste Disposal Projects) of the regulation. BCEAA Reviewable Projects Regulations applicable to WTE projects are

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<sup>210</sup> BCMOE Interim Policy: Determining Best Achievable Technology Standards, May 2008

<sup>211</sup> *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.<sup>[212]</sup>

**Table 9-6: BCEAA Reviewable Projects Regulation Applicable to WTE Projects**

Project Category	New Project	Modification of Existing Project
<b>Part 4 – Power Plant</b>	<b>Criteria:</b> (1) A new facility with a rated nameplate capacity of $\geq 50$ MW of electricity that is (a) a hydroelectric power plant (b) a thermal electric power plant, or (c) another power plant	<b>Criteria:</b> (1) Modification of an existing facility that results in the facility having a rated nameplate capacity that has increased by $\geq 50$ MW of electricity
<b>Part 6 – Local Government Solid Waste Management</b>	<b>Criteria:</b> (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.	<b>Criteria:</b> (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).

<sup>212</sup> 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<sup>[213]</sup> 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<sup>[214]</sup> 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.<sup>[215]</sup> The table also summarizes the long-term monitoring requirements as well as the monitoring techniques used at the facility.<sup>[216, 217]</sup>

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<sup>213</sup> Greater Vancouver Regional District Air Quality Management Bylaw No. 1082, 2008.  
[http://www.metrovancouver.org/boards/bylaws/Bylaws/RD\\_Bylaw\\_1082.pdf](http://www.metrovancouver.org/boards/bylaws/Bylaws/RD_Bylaw_1082.pdf)

<sup>214</sup> Greater Vancouver Regional Solid Waste Management Plan. July, 1995.

<sup>215</sup> AECOM. Management of Municipal Solid Waste in Metro Vancouver – A comparative Analysis of Options for Management of Waste After Recycling. June, 2009.

<sup>216</sup> Air-Tec Consulting Ltd. Metro Vancouver Waste-to-Energy Facility Compliance Testing Report. February 2010 Emission Survey. Feb. 2010.

<sup>217</sup> 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) <sup>(1)</sup>	Averaging Period	Monitoring Technique
Total Particulate Matter (TPM)	mg/Rm <sup>3</sup>	20	3.8	Manual stack testing	Primary: EPS 1/RM/8 Method E Supporting: EPA Method 5 <sup>2</sup>
Sulphur Dioxide (SO <sub>2</sub> )	mg/Rm <sup>3</sup>	200	85	24-hour average and Manual stack testing	Primary: CEMS EPS 1/PG/7 Supporting: EPA Method 6
Hydrogen Chloride (HCl)	mg/Rm <sup>3</sup>	55	23.6	Manual stack testing	Primary: EPS 1/RM/1 Supporting: EPA Method 26, BC Method 7176106 and 7066101 <sup>2</sup>
Hydrogen Fluoride (HF)	mg/Rm <sup>3</sup>	3	0.1	Manual stack testing	Primary: EPS 1/RM/1 Supporting: EPA Method 26, BC Method 7176106 and 7066101 <sup>2</sup>
Nitrogen Oxides (NO <sub>x</sub> ) (as NO <sub>2</sub> )	mg/Rm <sup>3</sup>	350	265	24-hour average	CEMS: EPS 1/PG/7
Carbon Monoxide (CO)	mg/Rm <sup>3</sup>	55	23	4-hour rolling average	CEMS: EPS 1/PG/7
Cadmium (Cd)	µg/Rm <sup>3</sup>	100	0.6	Manual stack testing	Primary: EPA Method 29 <sup>2</sup>
Lead (Pb)	µg/Rm <sup>3</sup>	50	5.9		
Mercury (Hg)	µg/Rm <sup>3</sup>	200	2		
Cd + Hg + Tl	µg/Rm <sup>3</sup>	200	2		
Sum (As, Co, Ni, Se, Te)	µg/Rm <sup>3</sup>	1000	8		
Sum (Sb, Pb, Cr, Cu, Mn, V, Zn)	µg/Rm <sup>3</sup>	5000	69		
Total Hydrocarbons (as CH <sub>4</sub> )	mg/m <sup>3</sup>	40	4.3	Manual stack testing	Primary: EPA Method 18 <sup>2</sup>
PCDD/F TEQ (Dioxins and Furans)	ng/Rm <sup>3</sup>	0.5	0.002	Manual stack testing	Primary: EPS 1/RM/2, 1/RM/3, 1/RM/23 Supporting: EPA Method 23 <sup>3</sup>
PAH	µg/Rm <sup>3</sup>	5	0.13	N/A	Primary: EPS 1/RM/2, 1/RM/3, 1/RM/23 Supporting: EPA Method 23 <sup>3</sup>
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% O<sub>2</sub> and dry basis unless otherwise noted.

<sup>1</sup> Actual Emissions for the Burnaby incinerator were extracted from the AECOM (June, 2009) report.

<sup>2</sup> Air-Tec Consulting Ltd. Metro Vancouver Waste-to-Energy Facility Compliance Testing Report. February 2010 Emission Survey. Feb. 2010.

<sup>3</sup> 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 SO<sub>2</sub> 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<sup>[218]</sup> 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.

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<sup>218</sup> 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<sub>x</sub> VLN™ system (patent pending) and a Selective Non-Catalytic Reduction (SNCR) system are proposed to achieve NO<sub>x</sub> emissions levels that meet Provincial NO<sub>x</sub> 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 <sup>3</sup> /s	220 m <sup>3</sup> /s	220 m <sup>3</sup> /s
Authorized Discharge Period	Continuous	Continuous	Continuous
Total Particulate Matter (1)	15 mg/m <sup>3</sup>	15 mg/m <sup>3</sup>	9.0 mg/m <sup>3</sup>
Particulate matter less than 10 µm in diameter (PM <sub>10</sub> ) (2)	No limit stipulated	No limit stipulated	23.0 mg/m <sup>3</sup>
Particulate Matter less than 2.5 µm in diameter (PM <sub>2.5</sub> ) (2)	No limit stipulated	No limit stipulated	22.0 mg/m <sup>3</sup>
Opacity	5%	5%	5%
Flue gas temperature (3)	No limit stipulated	190C	190C
Carbon Monoxide (CO)	No limit stipulated	110.0 mg/m <sup>3</sup> (4)	83.0 mg/m <sup>3</sup>
Hydrogen Chloride (HCl)	No limit stipulated	70.0 mg/m <sup>3</sup>	27.5 mg/m <sup>3</sup> (1hr) 23.8 mg/m <sup>3</sup> (24hr)
Hydrogen Fluoride (HF)	No limit stipulated	3.0 mg/m <sup>3</sup>	1.8 mg/m <sup>3</sup> (1hr) 0.9 mg/m <sup>3</sup> (24hr)
Sulphur Dioxide (SO <sub>2</sub> )	No limit stipulated	200.0 mg/m <sup>3</sup> (5)	50.0 mg/m <sup>3</sup>
Nitrogen Oxides (NO <sub>x</sub> )	No limit stipulated	No limit stipulated	150.0 mg/m <sup>3</sup> (1hr) 123.0 mg/m <sup>3</sup> (24hr)
Total Hydrocarbons as CH <sub>4</sub>	No limit stipulated	40.0 mg/m <sup>3</sup>	4.8 mg/m <sup>3</sup>
Dioxins and Furans (I-TEQ)	No limit stipulated	8.0E-08 mg/m <sup>3</sup>	8.14E-08 mg/m <sup>3</sup> (6)
Total Mercury (Hg)	No limit stipulated	0.02 mg/m <sup>3</sup>	0.02 mg/m <sup>3</sup>
Class I metals (Total of Cd, Hg, Tl)	No limit stipulated	0.2 mg/m <sup>3</sup>	Note 7
Class II metals (Total of As, Co, Ni, Se, Te)	No limit stipulated	1.0 mg/m <sup>3</sup>	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 <sup>3</sup>	Note 7
Polychlorinated biphenyls (PCBs)	No limit stipulated	No limit stipulated	0.0005 mg/m <sup>3</sup> <sup>(8)</sup>
Chlorophenols	No limit stipulated	No limit stipulated	0.0005 mg/m <sup>3</sup> <sup>(9)</sup>
Chlorobenzene	No limit stipulated	No limit stipulated	0.0005 mg/m <sup>3</sup> <sup>(10)</sup>
Lead (Pb)	No limit stipulated	(7)	0.05 mg/m <sup>3</sup>
Arsenic (As)	No limit stipulated	(7)	0.004 mg/m <sup>3</sup>
Cadmium (Cd)	No limit stipulated	(7)	0.0072 mg/m <sup>3</sup>
Chromium (Cr)	No limit stipulated	(7)	0.001 mg/m <sup>3</sup>
Poly Aromatic Hydrocarbons (PAH)	No limit stipulated	0.005 mg/m <sup>3</sup>	0.0025 mg/m <sup>3</sup> <sup>(11)</sup>

#### NOTES:

Concentrations are at the following standard conditions: dry gas, 293.15K, 101KPa, 11%O<sub>2</sub>

<sup>1</sup> Total particulate matter concentrations referred to in PA-17426 constitute filterable particulate matter as determined by EPA Method 5.

<sup>2</sup> Includes filterable and condensable particulate matter as determined by US EPA test methods 5 and 202, excluding chlorides and ammonium.

<sup>3</sup> Measured after baghouse.

<sup>4</sup> 4-hour rolling average.

<sup>5</sup> 24-hour rolling average.

<sup>6</sup> CCME Standard (corrected to 20°C) is 8.14E-08 mg/m<sup>3</sup>.

<sup>7</sup> 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).

<sup>8</sup> Includes total of mono, di, tri, tetra penta, hexa, hepta, octa, nona, and deca chlorinated bi-phenols.

<sup>9</sup> Includes di, tri, tetra, and penta chlorophenol.

<sup>10</sup> Includes di, tri, tetra, penta and hexa chlorobenzene.

<sup>11</sup> 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).<sup>[219]</sup> The Enerkem Waste to Ethanol plant in Edmonton was approved on April 21, 2009, under the *Environmental Protection and Enhancement Act*.<sup>[220]</sup> As part of its terms and conditions, the permit authorizes air emissions under the following conditions.

<sup>219</sup> Pers. Comm. Amit Banerjee, Designated Director under the *Environmental Protection and Enhancement Act* (AEnv) and Magda Kingsley, Stantec, February 29, 2010

<sup>220</sup> 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*<sup>[221]</sup> 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 <sub>x</sub> (expressed in NO <sub>2</sub> )	10 kg/hr
	SO <sub>2</sub>	1.3 kg/hr
Boiler Stack	NO <sub>x</sub> (expressed in NO <sub>2</sub> )	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

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<sup>221</sup> 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.<sup>[222]</sup>

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.<sup>[223]</sup>

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

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<sup>222</sup> Ontario Ministry of the Environment. Guideline A-7: Air Pollution Control, Design and Operation Guidelines for Municipal Waste Thermal Treatment Facilities. October 2010.

<sup>223</sup> 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/Rm<sup>3</sup> to 32 pg/Rm<sup>3</sup>. 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/Rm<sup>3</sup> 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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sub>x</sub> ) (as NO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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)	$\mu\text{g/Rm}^3$ @ 11% O <sub>2</sub>	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)	$\mu\text{g/Rm}^3$ @ 11% O <sub>2</sub>	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)	$\mu\text{g/Rm}^3$ @ 11% O <sub>2</sub>	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	$\mu\text{g/Rm}^3$ @ 11% O <sub>2</sub>	N.Def.	N.Def.	
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	$\mu\text{g/Rm}^3$ @ 11% O <sub>2</sub>	N.Def.	N.Def.	
PCDD/F TEQ (Dioxins and Furans)	$\text{ng/Rm}^3$ @ 11% O <sub>2</sub>	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 <sup>3</sup>	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% O<sub>2</sub> 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"> <li>▪ At start-up before the commencement of the thermal treatment cycle, i.e., Before any waste is fed into the equipment</li> <li>▪ During shutdown until all thermal treatment of waste has ceased</li> <li>▪ At all times when waste is being thermally treated.</li> </ul>

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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"><li>▪ Conditions that could lead to an unscheduled shutdown of the air pollution control system or the entire facility;</li><li>▪ Means of ameliorating such conditions; and</li><li>▪ Means for system venting when there is a need to bypass the air pollution control equipment.</li></ul> <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.<sup>[224]</sup>

**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 <sup>3</sup>	120	–
Sulphur Dioxide (SO <sub>2</sub> )	µg/m <sup>3</sup>	275	–
Hydrogen Chloride (HCl)	µg/m <sup>3</sup>	20	–
Nitrogen Oxides (NO <sub>x</sub> ) (as NO <sub>2</sub> )	µg/m <sup>3</sup>	200	–
Carbon Monoxide (CO)	–	N. Def.	–
Cadmium (Cd)	µg/m <sup>3</sup>	2	–
Lead (Pb)	µg/m <sup>3</sup>	2	–
Mercury (Hg)	µg/m <sup>3</sup>	2	–
PCDD/F TEQ (Dioxins and Furans)	pg TEQ/m <sup>3</sup>	–	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.<sup>[225]</sup> 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).<sup>[226]</sup>

<sup>224</sup> 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

<sup>225</sup> The 2007 IWSA Directory of Waste-to-Energy Plants. Ted Michaels. 2007

<sup>226</sup> 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.<sup>[227]</sup>

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 <sup>1, 2</sup>	
		Existing Facilities	New Facilities
Total Particulate Matter (TPM)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	17.5	14.0
Sulphur Dioxide (SO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	53.2 <sup>4</sup>	55.0 <sup>3</sup>
Hydrogen Chloride (HCl)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	30.3 <sup>5</sup>	26.1 <sup>5</sup>
Nitrogen Oxides (NO <sub>x</sub> ) (as NO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	237 to no limit <sup>7</sup>	197.5 <sup>6</sup>
Carbon Monoxide (CO)	–	40 to 200 <sup>8</sup>	41 to 200 <sup>8</sup>
Cadmium (Cd)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	24.5	7.0
Lead (Pb)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	280.1	98.0
Mercury (Hg)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	35.0	35.0
PCDD/F (Dioxins and Furans)	ng (total mass basis) @ 11% O <sub>2</sub>	21.0 <sup>9</sup>	9.1 <sup>9</sup>
Opacity	%	10	10

#### NOTES:

N. Def. = Not Defined

All emission limits are measured at 11% O<sub>2</sub>, 25°C and 101.3 kPa

<sup>1</sup> Large MWC unit has a capacity greater than 250 tons/d

<sup>2</sup> Units have been converted to Ontario MoE A-7 concentration units to allow direct comparison

<sup>3</sup> or 80% reduction by weight or volume of potential SO<sub>2</sub> emissions, whichever is less stringent

<sup>4</sup> or 75% reduction by weight or volume of potential SO<sub>2</sub> emissions, whichever is less stringent

<sup>5</sup> or 95% reduction of potential HCl emissions by weight, whichever is less stringent

<sup>6</sup> 180 ppmdv @ 7% O<sub>2</sub> for 1st year of operation, 150 ppmdv @ 7% O<sub>2</sub> after 1st year of operation

<sup>7</sup> NO<sub>x</sub> limit varies by combustor type: 210 ppmdv @ 7% O<sub>2</sub> for Mass Burn Rotary Waterwall, 180 ppmdv @ 7% O<sub>2</sub> for Fluidized Bed, 205 ppmdv @ 7% O<sub>2</sub> for Mass Burn Waterwall, 250 ppmdv @ 7% O<sub>2</sub> for Refuse-derived fuel, no limit for Mass Burn Refractory (after Apr. 28, 2009)

<sup>8</sup> CO limit varies per technology: 40 mg/Rm<sup>3</sup> @ 11% O<sub>2</sub> for Modular Starved-Air and Excess Air Unit; 200 mg/Rm<sup>3</sup> @ 11% O<sub>2</sub> for Spreader Stoker Refuse-derived fuel

<sup>9</sup> 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

<sup>227</sup> 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 <sup>[228]</sup>. 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. <sup>[229]</sup> 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 <sup>3</sup> @ 11% O <sub>2</sub>	19	18
Sulphur Dioxide (SO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	53 <sup>1</sup>	
Hydrogen Chloride (HCl)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	30 <sup>2</sup>	
Nitrogen Oxides (NO <sub>x</sub> ) (as NO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	270	
Carbon Monoxide (CO)	–	N. Def.	
Cadmium (Cd)	µg/m <sup>3</sup> @ 11% O <sub>2</sub>	28	14
Lead (Pb)	µg/m <sup>3</sup> @ 11% O <sub>2</sub>	308	140

<sup>228</sup> 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.

<sup>229</sup> 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](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 <sub>2</sub>	56 <sup>3</sup>	35 <sup>3</sup>
PCDD/F (Dioxins and Furans)	$\text{ng}/\text{m}^3$ @ 11% O <sub>2</sub>	42 <sup>4</sup>	25 <sup>5</sup>
Opacity	%	10 <sup>6</sup>	

#### NOTES:

N. Def. = Not Defined

All emission limits are converted to 11% O<sub>2</sub>, 25°C and 101.3 kPa

<sup>1</sup> Or 25% of the potential SO<sub>2</sub> emission concentration (75% reduction by weight or volume), whichever is less stringent.

<sup>2</sup> Or 5% of the potential HCl emission concentration (95% reduction by weight or volume), whichever is less stringent.

<sup>3</sup> Or 15% of the potential mercury emission concentration (85% reduction by weight), whichever is less stringent.

<sup>4</sup> 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 m<sup>3</sup> (total mass) @ 7% O<sub>2</sub>.

<sup>5</sup> 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 m<sup>3</sup> (total mass) @ 7% O<sub>2</sub>.

<sup>6</sup> 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.<sup>[230]</sup> 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.<sup>[231]</sup> 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*.<sup>[232]</sup>

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<sup>[233]</sup> 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.<sup>[234]</sup> These emissions standards are less stringent than the criteria summarized in Table 9-15.

<sup>230</sup> Washington Administrative Code. Energy Recovery and Incineration Facilities, WAC 173-350-240.  
<http://apps.leg.wa.gov/wac/default.aspx?cite=173-350-240>

<sup>231</sup> Washington Administrative Code. Performance Standards, WAC 173-350-040  
<http://apps.leg.wa.gov/wac/default.aspx?cite=173-350-040>

<sup>232</sup> Revised Code of Washington. *Washington Clean Air Act*. Chapter 70.94 RCW.

<sup>233</sup> Washington Administrative Code. Solid Waste Incinerator Facilities, WAC 173-434. <http://apps.leg.wa.gov/wac/default.aspx?cite=173-434>

<sup>234</sup> 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 <sup>1</sup>	Large Facilities <sup>2</sup>
Particulate Matter (PM)	mg/m <sup>3</sup> @ 11% O <sub>2</sub>	48	32
Sulphur Dioxide (SO <sub>2</sub> )	mg/m <sup>3</sup> @ 11% O <sub>2</sub>	92	
Hydrogen Chloride (HCl)	mg/m <sup>3</sup> @ 11% O <sub>2</sub>	52	
Opacity	%	5	

**NOTES:**

Units have been converted to 11%O<sub>2</sub> and 25°C to allow direct comparison

<sup>1</sup> Small facilities have a capacity less than 250 tons/day

<sup>2</sup> Large facilities have a capacity equal to or greater than 250 tons/day

<sup>3</sup> For an hourly average

<sup>4</sup> Except if uncontrolled emissions of SO<sub>2</sub> are reduced by at least 80% and a procedure acceptable to ecology or the authority for monitoring is developed

<sup>5</sup> 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

<sup>6</sup> 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
<b>Combustion</b>	
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.
<b>Combustion Air</b>	
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.
<b>Particulate Control Device Temperature</b>	
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.”<sup>[235]</sup>

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<sup>235</sup> 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 values<sup>2</sup> 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 <sup>1</sup>
Total Particulate Matter (TPM)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	9.2 <sup>2</sup>
Sulphur Dioxide (SO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	45.8 <sup>2</sup>
Hydrogen Chloride (HCl)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	9.2 <sup>2</sup>
Nitrogen Oxides (NO <sub>x</sub> ) (as NO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	183.2 <sup>2</sup>
Carbon Monoxide (CO)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	45.8 <sup>2</sup>
Cadmium (Cd)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	N. Def.
Lead (Pb)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	N. Def.
Mercury (Hg)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	45.8 <sup>3</sup>

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Contaminant	Concentration Units	EU Directive 2000/76/EC of the European Parliament and Council on the Incineration of Waste <sup>1</sup>
Cd + Tl	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	45.8 <sup>3</sup>
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	458.1 <sup>3</sup>
PCDD/F TEQ (Dioxins and Furans)	ng/Rm <sup>3</sup> @ 11% O <sub>2</sub>	0.092

#### NOTES:

N. Def. = Not Defined

<sup>1</sup> Units have been converted to Ontario MOE A-7 concentration units to allow direct comparison

<sup>2</sup> Daily average value by periodic stack test. In addition, the Directive contains half-hourly emission limit values for the same pollutants

<sup>3</sup> 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.<sup>[236]</sup>

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.<sup>[237]</sup> 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).<sup>[238]</sup>

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.

<sup>236</sup> [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)

<sup>237</sup> [http://europa.eu/legislation\\_summaries/environment/waste\\_management/l28045\\_en.htm](http://europa.eu/legislation_summaries/environment/waste_management/l28045_en.htm)

<sup>238</sup> 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 <sup>3</sup> 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 <sub>2</sub>	50	200/50	1 – 40	1 – 150
NO <sub>x</sub> (as NO <sub>2</sub> )	<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 <sup>3</sup> (non-continuous sample)		0.01 – 0.1 ng/m <sup>3</sup> (non-continuous sample)	
Ammonia	Not included in WID		<10	1 – 10
N <sub>2</sub> 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.<sup>[239]</sup>

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.

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<sup>239</sup> [http://europa.eu/legislation\\_summaries/environment/waste\\_management/l28045\\_en.htm](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<sub>x</sub> the Netherlands have specified a limit at 70 mg/Nm<sup>3</sup> and Austria and Switzerland (not an EU member country) have specified a limit at 80 mg/Nm<sup>3</sup>.

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.<sup>[240]</sup> 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.<sup>[241]</sup> 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.<sup>[242]</sup>

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<sup>240</sup> Germany Federal Environmental Agency, 2005

<sup>241</sup> Waste Incineration – A Potential Danger? Bidding Farewell to Dioxin Spouting. Federal Ministry of the Environment, Nature Conservation and Nuclear Safety, September 2005

<sup>242</sup> 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) <sup>(5,6)</sup>	EU Directive 2000/76/EC of the European Parliament And Council on the incineration of waste <sup>(6)</sup>
			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 <sup>3</sup> @ 11% O <sub>2</sub>	20 <sup>(1)</sup>	20	17	18	32	14	14.0	9.22 <sup>(12)</sup>
Sulphur Dioxide (SO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	260 <sup>(2)</sup>	250	56	53 <sup>(17)</sup>	92 <sup>(22)</sup>	56	55.0 <sup>(7)</sup>	45.82 <sup>(12)</sup>
Hydrogen Chloride (HCl)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	75 or 90% removal <sup>(1)</sup>	70	27	30 <sup>(18)</sup>	52 <sup>(22)</sup>	27	26.1 <sup>(8)</sup>	9.22 <sup>(12)</sup>
Nitrogen Oxides (NO <sub>x</sub> ) (as NO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	400 <sup>(2)</sup>	350	207	270	N. Def.	198	197.5 <sup>(9)</sup>	183.22 <sup>(12)</sup>
Carbon Monoxide (CO)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	57 (114 for RDF Systems) <sup>(1)</sup>	55 (14)	N. Def.	N. Def.	N. Def.	40	41 to 200 <sup>(10)</sup>	45.82 <sup>(12)</sup>
Cadmium (Cd)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	100 <sup>(2)</sup>	100 <sup>(15)</sup>	14	14	N. Def.	7	7.0	N. Def.
Lead (Pb)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	50 <sup>(2)</sup>	50 <sup>(15)</sup>	142	140	N. Def.	60	98.0	N. Def.
Mercury (Hg)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	20 <sup>(3)</sup>	200 <sup>(15)</sup>	20	35 <sup>(19)</sup>	N. Def.	20	35.0	45.83 <sup>(13)</sup>
Cd + Tl	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	N. Def.	N. Def..	N. Def.	N. Def.	N. Def.	N. Def.	N. Def.	45.83 <sup>(13)</sup>
Sum (Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	N. Def.	N. Def.	N. Def.	N. Def.	N. Def.	N. Def.	N. Def.	458.13 <sup>(13)</sup>
PCDD/F TEQ (Dioxins and Furans)	ng/Rm <sup>3</sup> @ 11% O <sub>2</sub>	0.08 <sup>(4)</sup>	0.5 <sup>(16)</sup>	0.08	25 <sup>(20)</sup>	N. Def.	0.08	9.1 <sup>(11)</sup>	0.092
Organic Matter (as Methane)	mg/Rm <sup>3</sup>	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% O<sub>2</sub>)
- (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 SO<sub>2</sub> emissions, whichever is less stringent
- (8) Or 95% reduction of potential HCl emissions by weight, whichever is less stringent
- (9) 180 ppm<sub>dv</sub> @ 7% O<sub>2</sub> for 1st year of operation, 150 ppm<sub>dv</sub> @ 7% O<sub>2</sub> after 1st year of operation
- (10) CO limit varies per technology: 40 mg/Rm<sup>3</sup> @11% O<sub>2</sub> for Modular Starved-Air & Excess Air Unit; 200 mg/Rm<sup>3</sup> @11% O<sub>2</sub> 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/m<sup>3</sup>
- (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 SO<sub>2</sub> 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 m<sup>3</sup> (total mass) @ 7% O<sub>2</sub>.

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 <sup>[1]</sup> (Canada)	SEMASS Boiler No. 3 (US) <sup>[3]</sup>	Spittelau (Austria) <sup>[10]</sup>		Zisterdorf (Austria) <sup>[10]</sup>		SITA Isle of Man Incinerator <sup>[2]</sup>			Linz (Austria) <sup>[7]</sup>	I/S Reno-Nord WTE (Denmark) Facility <sup>[5]</sup>			SELCHP (England) <sup>[6]</sup>	TREA Breisgau (Germany) <sup>[8]</sup>			Coventry WTE Facility (UK) (2009 Permit) <sup>[9]</sup>			Lungsjoverket (Sweden) <sup>[11]</sup>	
					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	8 Hour Average		
Total Particulate Matter	mg/m <sup>3</sup>	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 <sup>3</sup>	55	45.8	124.9	93.2		46.6		93.2	46.6					46.6			93.2	46.6	93.2				
SO <sub>2</sub>	mg/m <sup>3</sup>	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 <sub>x</sub>	mg/m <sup>3</sup>	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 <sup>3</sup>	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 <sup>3</sup>	3			0.7		0.3				1.9	0.28	0.9							1.9				
TOC	mg/m <sup>3</sup>					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 <sup>3</sup>	40	49.8																					
As	mg/m <sup>3</sup>	0.004																						
Cr	mg/m <sup>3</sup>	0.01																						
Hg	mg/m <sup>3</sup>	0.2	0.015	0.020		0.093		0.047			0.047			0.047		0.009				0.047				
Cd	mg/m <sup>3</sup>	0.1	0.007	0.029		0.093		0.009																
Cd,Tl	mg/m <sup>3</sup>		0.047								0.047			0.047			0.009			0.047				
Pb	mg/m <sup>3</sup>	0.05	0.051	0.313																				
Sum of As, Ni, Co, Pb, Cr, Cu, V, Mn, Sb	mg/m <sup>3</sup>		0.47								0.47			0.47			0.093			0.47				
Dioxins/Furans I-TEQ	ng/m <sup>3</sup>	0.5	0.061	22.9 <sup>[4]</sup>				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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sub>x</sub> as NO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sub>4</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sub>4</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	-	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 <sup>3</sup> @ 11% O <sub>2</sub>	-	N.D.	N.D.	N.D.			9.3	19	9.3	N.D.	
Arsenic (As)	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	-	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	-	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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/m<sup>3</sup> 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 SO<sub>2</sub> emissions, whichever is less stringent

(4) or 95% reduction of potential HCl emissions by weight, whichever is less stringent

(5) 180 ppm<sub>dv</sub> @ 7% O<sub>2</sub> for the 1st year of operation, 150 ppm<sub>dv</sub> @ 7% O<sub>2</sub> after 1st year of operation

(6) CO limit varies per technology: 40 mg/Rm<sup>3</sup> @ 11% O<sub>2</sub> for Modular Starved-Air and Excess Air Unit; 200 mg/Rm<sup>3</sup> @ 11% O<sub>2</sub> 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).<sup>[243]</sup>

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.

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<sup>243</sup> 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.

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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, CxHy 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 CH<sub>4</sub>) has been required, although Ontario has used (and continues to use) a similar approach requiring the monitoring and reporting of organic matter (as CH<sub>4</sub>), 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<sup>3</sup>). 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<sup>3</sup>. 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 ½ 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 <sup>(1)</sup>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(2)</sup>  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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sub>x</sub> as NO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(3)</sup> .	3	To be monitored over the approved sampling and monitoring period	Methods to be approved by Regional Manager
Total Hydrocarbons (expressed as equivalent CH <sub>4</sub> ) <sup>(4)</sup>	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(1)</sup>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	P or C <sup>(4)</sup>	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 <sup>(5)</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(5)</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(5)</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(5)</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(6)</sup>	%	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

<sup>(1)</sup> 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.

<sup>(2)</sup> 97% of the half-hour average values over an annual rolling average will not exceed 9 mg/Rm<sup>3</sup>. 100% of the half-hour average values will not exceed 28 mg/Rm<sup>3</sup>.

<sup>(3)</sup> 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.

<sup>(4)</sup> Daily Average ELV for mercury applies regardless of monitoring method.

<sup>(5)</sup> 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.

<sup>(6)</sup> 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/Rm<sup>3</sup> on a daily basis with compliance based on manual stack testing.</p> <p>The new proposed limit would be 10 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> 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/Rm<sup>3</sup> 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/Rm<sup>3</sup> limit to be exceeded the upper limit of 28 mg/Rm<sup>3</sup> is never to be exceeded. Thus, even when emission control systems require service, the 28 mg/Rm<sup>3</sup> 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/m<sup>3</sup> limit to the proposed limit of 9 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> on a daily basis with compliance based on a CEM system.</p> <p>The new proposed limit would be 50 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> on a daily basis with compliance based on a CEM system.</p> <p>There would also be a new proposed limit of 100 mg/Rm<sup>3</sup> 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 <sub>2</sub>	<p>The 1991 BC Criteria limit is 250 mg/Rm<sup>3</sup> on a daily basis with compliance based on a CEM system.</p> <p>The new proposed limit would be 50 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> on a daily basis with compliance based on a CEM system.</p> <p>There would also be a new proposed limit of 190 mg/Rm<sup>3</sup> 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 <sub>x</sub> as NO <sub>2</sub>	<p>The 1991 BC Criteria limit is 350 mg/Rm<sup>3</sup> on a daily basis with compliance based on a CEM system.</p> <p>The new proposed limit would be 190 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> on a daily basis with compliance based on a CEM system.</p> <p>There would also be a new proposed limit of 350 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> on a daily basis with compliance based on manual stack testing.</p> <p>The new proposed limit would be 10 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> on a daily basis with compliance based on manual stack testing.</p> <p>There would also be a new proposed limit of 60 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> on a daily basis with compliance based on manual stack testing.</p> <p>The new proposed limit would be 1 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> on a daily basis with compliance based on manual stack testing.</p> <p>There would also be a new proposed limit of 4 mg/Rm<sup>3</sup> 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 <sub>4</sub>	<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 <sub>4</sub> )	<p>NA – see organic matter rationale – no value proposed. The 1991 BC Criteria limit is 40 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> 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/Rm<sup>3</sup>. 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/Rm<sup>3</sup> with compliance based on manual stack testing.</p> <p>New proposed limit would be 0.014 mg/Rm<sup>3</sup> 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/Rm<sup>3</sup> 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/Rm<sup>3</sup>. 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/Rm<sup>3</sup> 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/Rm<sup>3</sup>. 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/Rm<sup>3</sup> with compliance based on manual stack testing.</p> <p>New proposed limit would be 0.02 mg/Rm<sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> with compliance based on manual stack testing. New proposed limit would be 0.08 ng/Rm <sup>3</sup> 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<sub>x</sub> 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 <sub>2</sub>	Consistent with current approach based on annual stack testing methods approved by the Regional Manager.	New requirement. Would require CEM.
NO <sub>x</sub> as NO <sub>2</sub>	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 <sub>4</sub>	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 SO<sub>2</sub> 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<sub>x</sub>, 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/Rm<sup>3</sup> 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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## 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.<sup>[244]</sup> 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.<sup>[245]</sup>

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 <sup>[246]</sup>	Hyks and Astrup (2009) <sup>[247]</sup>	Worldwide Range Found in MSWI Bottom Ash <sup>[248]</sup>
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

<sup>244</sup> AECOM report, 2009

<sup>245</sup> AECOM report, 2009

<sup>246</sup> UBA. 2001. Draft of a German Report with basic information for a BREF-Documents "Waste Incineration". Umweltbundesamt

<sup>247</sup> 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

<sup>248</sup> Sabbas, *et al.* 2003. Management of municipal waste incineration residues. In *Waste Management* 23 (2003) 61-88

Parameter	Units	Typical German Values <sup>[246]</sup>	Hyks and Astrup (2009) <sup>[247]</sup>	Worldwide Range Found in MSWI Bottom Ash <sup>[248]</sup>
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.<sup>[249]</sup>

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<sup>[250]</sup>. 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.<sup>[251] [252]</sup>

**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

<sup>249</sup> Algonquin Power Energy from Waste Facility Fact Sheet, <http://www.peelregion.ca/pw/waste/facilities/algonquin-power.htm#ash>

<sup>250</sup> Chiang, K.Y. Wang, K. S. , Lin, F. L, Toxicology Environmental Chemistry 64, 1997

<sup>251</sup> Evaluation of GVRD Municipal Incinerator Ash as a Supplementary Cementing Material in Concrete, AMEC, 2004

<sup>252</sup> 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

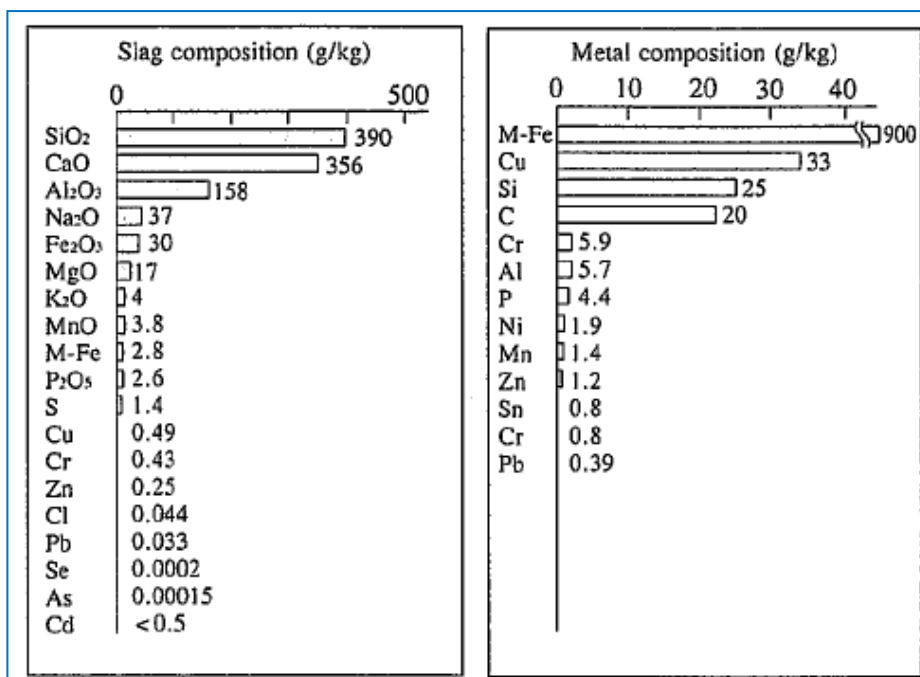
The types and composition of the solid residues produced by gasification facilities treating MSW depends on the particular gasification technology being considered as well as the composition of the waste being treated. The following paragraphs discuss the solid residues arising from the Nippon Steel “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.<sup>[253]</sup>

**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.

<sup>253</sup> 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.<sup>[254]</sup> 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.<sup>[255]</sup>

**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.<sup>[256]</sup>

The following table (Table 10-4) shows the composition of mineral granulate that was produced by the Thermoselect process (Karlsruhe, Germany).<sup>[257]</sup>

**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 <sup>3</sup>	Approximately 1,400
Ignition Loss	%TS	0.1
Carbon, total	%TS	<0.01

<sup>254</sup> W.F.M Hesseling. 2002. Case Study ThermoSelect Facility Karlsruhe

<sup>255</sup> Interstate Waste Technology. 2006. Thermoselect Technology an Overview. Presented to the Delaware Solid Waste Management Technical Working Group January 10, 2006

<sup>256</sup> Thermoselect. 2005. Thermoselect Plant and Process Description

<sup>257</sup> 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.”<sup>[258]</sup>

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<sup>[259]</sup>. 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

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<sup>258</sup> EU landfill directive

<sup>259</sup> 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.<sup>[260]</sup>

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.”<sup>[261]</sup>

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<sup>[262]</sup> (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.

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<sup>260</sup> Air pollution control residues from waste incineration: Current UK situation and assessment of alternative technologies. Rani, *et al.* 2007

<sup>261</sup> [http://europa.eu/legislation\\_summaries/environment/sustainable\\_development/l28168\\_en.htm](http://europa.eu/legislation_summaries/environment/sustainable_development/l28168_en.htm)

<sup>262</sup> 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.<sup>[263]</sup>

### 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.<sup>[264],[265]</sup>

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<sup>263</sup> Management of APC residues from WTE Plants. ISWA. 2008

<sup>264</sup> Solid Residues from Municipal Waste Incinerators in England and Wales. Environment Agency. May 2002

<sup>265</sup> 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).<sup>[266]</sup>

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.<sup>[267],[268]</sup>

The following table (Table 10-5) presents a list of TC contaminants and their associated regulatory levels.

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<sup>266</sup> National Renewable Energy Laboratory. 1999. Beneficial Use and Recycling of Municipal Waste Combustion Residues – A Comprehensive Resource Document

<sup>267</sup> 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

<sup>268</sup> 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 Levels<sup>269</sup>**

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

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<sup>269</sup> 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.<sup>[270]</sup>

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.<sup>[271]</sup>

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.<sup>[272]</sup>

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

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<sup>270</sup> Office of Solid Waste, US Environmental Protection Agency. 1995. Guidance for the Sampling and Analysis of Municipal Waste Combustion Ash for the Toxicity Characteristic

<sup>271</sup> Department of Environmental Protection, Florida, Solid Waste Section. 2001. Guidance for Preparing Municipal Waste-to-Energy Ash Beneficial Use Demonstrations

<sup>272</sup> 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.<sup>[273]</sup>

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.<sup>[274]</sup>

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.<sup>[275]</sup> 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.<sup>[276]</sup>

#### 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

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<sup>273</sup> WAC 173-306: Special incinerator ash management standards. 2000

<sup>274</sup> WAC 173-303-100: Dangerous waste criteria

<sup>275</sup> WAC 173-303-141: Treatment, storage, or disposal of dangerous waste. 2003

<sup>276</sup> 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.<sup>[277]</sup>

## **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*<sup>[278]</sup> (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 BCMOE for the introduction of waste into the environment. If the waste discharge is governed by a Code of Practice approved by BCMOE, 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

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<sup>277</sup> GUIDELINE A-7 Combustion and Air Pollution Control Requirements for New Municipal Waste Incinerators. Ontario Ministry of the Environment. 2004

<sup>278</sup> 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*<sup>[279]</sup> (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*<sup>[280]</sup>, 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.

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<sup>279</sup> BC Hazardous Waste Regulation, B.C. Reg. 63, April 1, 2009

<sup>280</sup> 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*<sup>[281]</sup>, *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*<sup>[282]</sup>, *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.

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<sup>281</sup> 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

<sup>282</sup> 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.<sup>[283]</sup>

APC residues typically contain high levels of leachable toxic substances which must be managed as hazardous waste<sup>[284]</sup> 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.

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<sup>283</sup> Management of Bottom Ash from WTE Plants. An overview of management options and treatment methods

<sup>284</sup> 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<sup>[285]</sup>**

Treatment Principle	Examples of Processes and Unit Operations	Bottom Ash	Fly Ash
<b>Separation</b>	▪ 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	
<b>Stabilization and/or Solidification</b>	▪ Addition of hydraulic binders	1	1,3
	▪ Addition of pore-filling additives	1,2	1
	▪ Chemical stabilization	1	1
<b>Thermal Treatment</b>	▪ 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.<sup>[286]</sup>

<sup>285</sup> 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

<sup>286</sup> 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.<sup>[287]</sup>

**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. <sup>[288]</sup>	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<sup>[289]</sup> 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.

<sup>287</sup> Management of Bottom Ash from WTE Plants. An overview of management options and treatment methods

<sup>288</sup> Thomas Astrup. Pretreatment and utilization of waste incineration bottom ashes: Danish experiences. 2007

<sup>289</sup> 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<sup>[290]</sup>**

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.

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<sup>290</sup> 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).<sup>[291]</sup>

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.<sup>[292]</sup>

<sup>291</sup> Ferreira *et al.* 2003. Possible applications for municipal solid waste fly ash. *Journal of Hazardous Materials*. 96 (203), 201-216

<sup>292</sup> 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.<sup>[293]</sup>

- **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.<sup>[294]</sup>

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

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<sup>293</sup> Management of APC residues from WTE Plants. ISWA. 2008

<sup>294</sup> 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.<sup>[295]</sup>

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.<sup>[296]</sup> 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.

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<sup>295</sup> Quina, *et al.* Treatment and use of air pollution control residues from MSW incineration: An overview. Waste Management. 2008

<sup>296</sup> 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 Madaleine	440	N/A	160	N/A
Wainwright Energy From Waste Facility	N/A	100% Landfill	N/A	N/A
<b>Total</b>	<b>183,963</b>		<b>26,640</b>	

### ***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.<sup>[297]</sup> 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

<sup>297</sup> 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<sup>[298]</sup> 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

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<sup>298</sup> 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.<sup>[299]</sup>

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.<sup>[300]</sup>

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.<sup>[301]</sup> 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

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<sup>299</sup> GTAA Partners in Project Green – Algonquin Power – By-Product Synergies. 2009

<sup>300</sup> 2007 GENIVAR report

<sup>301</sup> 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 (PM<sub>10</sub>) and 2.5 micron (PM<sub>2.5</sub>) 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<sub>x</sub> 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<sub>x</sub> emissions can regularly be achieved through SCR. With SNCR, the level of NO<sub>x</sub> 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  $\text{NO}_x$ ) must be considered.

10. Emission releases from WTE facilities have decreased substantially in the US between 1990 and 2005.  $\text{SO}_x$  and  $\text{NO}_x$  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<sub>x</sub> 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  $9 \text{ mg/Rm}^3$  for 97% of the operating period on a 12 month rolling average, and less than  $28 \text{ mg/Rm}^3$  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  $64 \text{ ug/Rm}^3$ .
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  $35 \text{ mg/m}^3$  for facilities ranging in size from 3 to 39 MWh, and  $20 \text{ mg/m}^3$  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  $\text{SO}_x$ , CO and  $\text{NO}_x$ . 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<sub>x</sub> 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

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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 <sup>(1)</sup>	Daily Average	Average Period and Monitoring Method	Half Hourly Average	Average Period and Monitoring Method
Total Particulate Matter (TPM)	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(2)</sup>  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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sub>x</sub> as NO <sub>2</sub> )	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(3)</sup> .
Total Organic Carbon	mg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	P or C <sup>(4)</sup>	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 <sup>(1)</sup>	Daily Average	Average Period and Monitoring Method	Half Hourly Average	Average Period and Monitoring Method
Chlorophenols <sup>(5)</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(5)</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(5)</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(5)</sup>	µg/Rm <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>3</sup> @ 11% O <sub>2</sub>	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 <sup>(6)</sup>	%	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  
<sup>(1)</sup> 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.  
<sup>(2)</sup> 97% of the half-hour average values over an annual rolling average will not exceed 9 mg/Rm<sup>3</sup>. 100% of the half-hour average values will not exceed 28 mg/Rm<sup>3</sup>.  
<sup>(3)</sup> 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.  
<sup>(4)</sup> Daily Average ELV for mercury applies regardless of monitoring method.  
<sup>(5)</sup> 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.  
<sup>(6)</sup> 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	<a href="http://www.aaecorp.com/power.html">www.aaecorp.com/power.html</a>	No reference facilities, claims to be able to treat waste and biomass
Mass Burn Incineration	ATCO Power	n/a	n/a	n/a	<a href="http://www.atcopower.com">www.atcopower.com</a>	No reference facilities, but actively investigating energy from waste
Mass Burn Incineration	Babcock & Wilcox Volund	1997	Billingham, UK	224,000 tpy	<a href="http://www.volund.dk">www.volund.dk</a>	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	<a href="http://www.CNIM.com">www.CNIM.com</a>	DBO
Modular Two Stage Combustion	Consutech Systems LLC	n/a	Iraq	5333 lbs/hr	<a href="http://www.consutech.com/">http://www.consutech.com/</a>	Design and manufacture incineration and APC equipment
Mass Burn Incineration	Covanta	1990	Huntsville, Alabama	625 tpd	<a href="http://www.covantaholding.com/">www.covantaholding.com/</a>	Operate 41 facilities in the US, 1 Burnaby - utilize Martin GmbH tech
Modular Two Stage Combustion	Enerwaste	2005	Egegik, Alaska	3.5 tpd	<a href="http://www.enerwaste.com">www.enerwaste.com</a>	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	<a href="http://www.fisia-babcock.com/">http://www.fisia-babcock.com/</a>	One of the 4 main suppliers of mass burn technology
Mass Burn Incineration	JFE	2003	Hirano Plant, Japan	900 tpd	<a href="http://www.jfe-eng.co.jp/en">www.jfe-eng.co.jp/en</a>	
Fluidized Bed Incineration	JFE	2006	Banpoo WTE Plant, Thailand	100 tpd	<a href="http://www.jfe-eng.co.jp/en">www.jfe-eng.co.jp/en</a>	
Mass Burn Incineration	KAB TAKUMA GmbH	2003	Salzbergen, Germany	90.000 tpy	<a href="http://www.kab-takuma.com/">http://www.kab-takuma.com/</a>	
Mass Burn Incineration	Martin GmbH	1999	Neunkirchen, Germany	408 tpd	<a href="http://www.martingmbh.de/index.php">http://www.martingmbh.de/index.php</a>	One of the four main suppliers of mass burn technology
Mass Burn Incineration	Naanovo Energy Inc.	March 2010	The Gambia	n/a	<a href="http://www.naanovo.com">www.naanovo.com</a>	14 MW facility. Not sure as to the status.
Mass Burn Incineration	Seghers Keppel Technology Group	n/a	Beveren, Belgium	2 x 319 tpd	<a href="http://www.keppelseghers.com">www.keppelseghers.com</a>	
Mass Burn Incineration	Standardkessel Baumgarte	2007	MSZ 3 Moscow, Russia	330,000 tpy	<a href="http://www.standardkessel-baumgarte.com/">http://www.standardkessel-baumgarte.com/</a>	Five reference facilities located on their website.
	Steinmuller	n/a	n/a	n/a	<a href="http://www.steinmuller.co.za/default.asp?fid=0&amp;sid=24&amp;L=1">http://www.steinmuller.co.za/default.asp?fid=0&amp;sid=24&amp;L=1</a>	Mechanical engineers
Mass Burn Incineration	TPS Termiska	1992	Greve-in-Chianti, Italy	67,000 tpy	<a href="http://www.tps.se/subpage.aspx?MS=14839,15014">www.tps.se/subpage.aspx?MS=14839,15014</a>	
Mass Burn Incineration	Veolia Environmental Services	2003	Hampshire, UK	90,000 tpy	<a href="http://www.VeoliaES.com">www.VeoliaES.com</a>	More than 80 plants worldwide
Mass Burn Incineration	Von Roll Nova	2007	Issy-les-Moulineaux (Paris), France	460,000 tpy	<a href="http://www.aee-vonrollnova.ch">http://www.aee-vonrollnova.ch</a>	One of the four main suppliers of mass burn technology
Mass Burn Incineration	Wheelabrator Technologies Inc.	1985	Baltimore	2,000 tpd	<a href="http://www.wheelabratortechnologies.com">www.wheelabratortechnologies.com</a>	Operates 21 facilities in the US
Mass Burn Incineration	Wulff Energy and Environmental Systems	n/a	n/a	n/a	<a href="http://www.wulff-hamburg.de">http://www.wulff-hamburg.de</a>	Boiler, combustion and drier technologies

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Appendix A – Database of Current Technology Vendors

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	<a href="http://cityclean2000.com/">http://cityclean2000.com/</a>	
Gasification	Coaltec Energy	n/a	Carterville, Illinois	Test Facility	<a href="http://www.coaltecenergy.com">www.coaltecenergy.com</a>	
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	<a href="http://www.ebara.co.jp/en/">www.ebara.co.jp/en/</a>	
Gasification	Emery Energy Company	n/a	Salt Lake City, Utah (Pilot Plant)	25 tpd	<a href="http://www.emeryenergy.com">www.emeryenergy.com</a>	
Gasification	Energos	1998	Ranheim, Norway	10,000 tpy	<a href="http://www.energ.co.uk/energy_from_waste">www.energ.co.uk/energy_from_waste</a>	
Gasification	Energy Products of Idaho	1989	Tacoma, Washington	317 tpd	<a href="http://www.energyproducts.com">www.energyproducts.com</a>	
Gasification	EnerTech Environmental	1997 – 2000 (Demonstration Facility)	Ube City, Japan	18 tpd	<a href="http://www.enertech.com">www.enertech.com</a>	
Gasification	Envirotherm GmbH	2000	Schwarze Pumpe, Germany	300,000 tpy	<a href="http://envirotherm.de/">http://envirotherm.de/</a>	
Gasification	Eurotech	n/a	Quetzaltenango, Guatemala	n/a	<a href="http://www.eurotecguatemala.com/maineng.htm">www.eurotecguatemala.com/maineng.htm</a>	
Gasification	Forevergreen Enterprises	Not yet constructed	DeKalb County	n/a	<a href="http://www.fgenterprises.net">www.fgenterprises.net</a>	
Gasification	Foster Wheeler	1998	Finland	80,000 tpy	<a href="http://www.fwc.com">www.fwc.com</a>	
Gasification	Full Circle Energy	n/a	n/a	n/a	<a href="http://www.fullcircleanergy.net">www.fullcircleanergy.net</a>	
Gasification/Thermal Cracking	GEM America	2000	Tythegston Landfill Site, South Wales	36 tpd	<a href="http://www.gemamericainc.com">www.gemamericainc.com</a>	
Gasification	Global Energy Inc.	1992	Westfield Development Centre, UK	n/a	<a href="http://www.globalenergyinc.com">www.globalenergyinc.com</a>	
Gasification	Global Energy Solutions Inc	n/a	Japan, Germany, Belgium, Korea, Malta, UK	1-25 tph	<a href="http://www.globalenergychicago.com">www.globalenergychicago.com</a>	
Gasification	Global Warming Prevention Technologies Inc.	n/a	Anchoarge, Alaska; Kuala Lumpur, Malaysia	25 tpd	<a href="http://www.gwpt.com">www.gwpt.com</a>	
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	<a href="http://www.ils-partners.com">www.ils-partners.com</a>	
Gasification	Interstate Waste Technologies (IWT) (uses Thermoselect)	1999	Chiba, Japan	93,000 tpy	<a href="http://www.iwtonline.com">www.iwtonline.com</a>	
Gasification	ITI Energy Ltd.	n/a	South West England	72,000 tpy	<a href="http://www.iti-energy.com/">http://www.iti-energy.com/</a>	
Gasification	JFE	2003	Kakamigahara Plant, Japan	192 tpd	<a href="http://www.jfe-eng.co.jp/en">www.jfe-eng.co.jp/en</a>	
Gasification	Karlsruhe Institute of Technology	1993 rotating grate gasifier; 2000 slagging gasifier	Schwarze Pumpe, Germany	700 tpd	<a href="http://www.fzk.de">www.fzk.de</a>	
Gasification	Lurgi	1993 rotating grate gasifier; 2000 slagging gasifier	Schwarze Pumpe, Germany	700 tpd	<a href="http://www.lurgi.com">www.lurgi.com</a>	
Gasification	Nippon Steel	2002	Akita, Japan	400 tons per day	-	
Gasification	Ntech Environmental	1991	Chung Gung Municipality, Taiwan	27 tpd	<a href="http://www.ntech-environmental.com">www.ntech-environmental.com</a>	
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	<a href="http://pyrolyzerllc.com/">http://pyrolyzerllc.com/</a>	
Gasification	SenreQ International	2002	Barrow, Alaska	27 tpd	-	
Gasification	Sierra Energy Corporation	n/a	n/a	n/a	<a href="http://www.sierraenergycorp.com/">http://www.sierraenergycorp.com/</a>	
Gasification	SVZ	n/a	n/a	n/a	-	
Gasification	Rentech	1997	Burlington, Vermont	272 tpd	<a href="http://www.silvasgas.com">www.silvasgas.com</a>	
Gasification	Terragon Environmental Technologies Inc.	n/a	n/a	Small-scale (Only for remote communities, outposts etc.)	<a href="http://www.terragon.net/MAGS.html">www.terragon.net/MAGS.html</a>	
Gasification	TGE Tech	2007	Tel Aviv	181 tpd	-	
Gasification	Thermogenics, Inc.	n/a	n/a	n/a	<a href="http://www.thermogenics.com">www.thermogenics.com</a>	
Gasification	Thermoselect	1999 – 2004	Karlsruhe, Germany	250,000 tpy	<a href="http://www.thermoselect.com">www.thermoselect.com</a>	
Gasification	Thide Environmental	2004	Arras, France	50,000 tpy	<a href="http://www.thide.com">www.thide.com</a>	
Gasification	Waste-to-Energy	Reference facilities do not process MSW (only biomass)	n/a	n/a	<a href="http://www.wastetoenergy.co.uk">www.wastetoenergy.co.uk</a>	
Gasification	Whitten Group International	1991	Taiwan	8,100 tpy	-	
<b>Plasma Arc Gasification</b>						
Plasma Arc Gasification	AdaptiveNRG	2005	Monterey, Mexico (portable)	33,000 tpy	<a href="http://www.adaptivenrg.com">www.adaptivenrg.com</a>	
Plasma Arc Gasification	AlterNRG (Westinghouse Plasma Technology)	1999	Yoshi, Japan	n/a	<a href="http://www.alternrg.com">www.alternrg.com</a>	
Plasma Arc Gasification	EnviroArcTechnologies	Pilot Plant	Hofors, Sweden	.7 tph	<a href="http://www.enviroarc.com">www.enviroarc.com</a>	
	Europlasma	n/a	n/a	n/a	<a href="http://www.europlasma.com/">http://www.europlasma.com/</a>	Plasma torches
Plasma Arc Gasification	Geoplasma LLC	1999	Japan, Germany, Belgiu, Korea, Malta, UK	24 tpd	<a href="http://www.geoplasma.com">www.geoplasma.com</a>	
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	<a href="http://www.greenpowersystems.com">www.greenpowersystems.com</a>	
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	<a href="http://www.inentec.com">www.inentec.com</a>	
Plasma Arc Gasification	MPM Technologies Inc.	1987 – 1988	Libby, Montana (Pilot Plant)	45 tpd; 108 tpd (continuous feed)	<a href="http://www.mpmtech.com">www.mpmtech.com</a>	
Plasma Arc Gasification	Peat International Inc	2007	Kaohsiung, Taiwan	9 tpd	<a href="http://www.peat.com">www.peat.com</a>	
Plasma Arc Gasification	Plasco Energy Group	2007	Ottawa, Canada	31,100 tpy	<a href="http://www.plasco.com">www.plasco.com</a>	
Plasma Arc Gasification	Plasma Arc Technologies	n/a	n/a	n/a	<a href="http://www.plasmaarctech.com">www.plasmaarctech.com</a>	
Plasma Arc Gasification	Plasma Environmental Technologies Inc.	No operating facilities.	n/a	n/a	<a href="http://www.plasmaenvironmental.com">www.plasmaenvironmental.com</a>	
Plasma Arc Gasification	Plasma Waste Recycling	n/a	n/a	n/a	<a href="http://www.plasma-wr.com">www.plasma-wr.com</a>	
Plasma Arc Gasification	PyroGenesis Inc.	2000	Montreal, Quebec	10 tpd	-	
Plasma Arc Gasification	Recovered Energy Inc. (Westinghouse)	1999	Hitachi plant in Japan	3 tph	<a href="http://www.recoveredenergy.com">www.recoveredenergy.com</a>	

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Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
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	<a href="http://www.solenagroup.com">www.solenagroup.com</a>	
Plasma Arc Gasification	Startech Environmental Corporation	2001	Bristol, Connecticut	4.5 tpd (Demonstration Facility)	<a href="http://www.startech.net">www.startech.net</a>	
Plasma Arc Gasification	Sun Energy Group LLC	2011	New Orleans	n/a	<a href="http://www.sunenergygrp.com">www.sunenergygrp.com</a>	
Plasma Arc Gasification	US Plasma	n/a	n/a	n/a	-	
Plasma Arc Gasification	Westinghouse Plasma/GeoPlasma	2002	Utashinai & Mihama Mikata, Japan	n/a	<a href="http://www.westinghouse-plasma.com">www.westinghouse-plasma.com</a>	
Pyrolysis						
Pyrolysis	Balboa Pacific Corporation	n/a	n/a	n/a	<a href="http://www.balboa-pacific.com">www.balboa-pacific.com</a>	
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	<a href="http://www.conradind.com/to_tech_develop.asp">www.conradind.com/to_tech_develop.asp</a>	
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	<a href="http://www.energ.co.uk">www.energ.co.uk</a>	
Pyrolysis	Entech Renewable Energy	2006	Korea	60 tpd (MSW)	<a href="http://www.entech.net.au/ws1/">http://www.entech.net.au/ws1/</a>	
Pyrolysis	International Energy Solutions	2004	Romoland, California	16,500 tpy (MSW)	<a href="http://www.wastetopower.com">www.wastetopower.com</a>	
Pyrolysis	JND Thermal Process	n/a	Hamburg, Germany	Test Facility	<a href="http://www.jnd.co.uk">www.jnd.co.uk</a>	
Pyrolysis	Mitsui Babcock	2000	Yame Seibu, Japan	219 tpd	<a href="http://www.doosanbabcock.com">www.doosanbabcock.com</a>	
Pyrolysis	Mitsui R-21	2002	Toyohashi City, Japan	400 tpd	<a href="http://www.gec.jp/JSIM_DATA/WASTE/WASTE_3/html/Doc_436.html">http://www.gec.jp/JSIM_DATA/WASTE/WASTE_3/html/Doc_436.html</a>	
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	<a href="http://www.rcrinternational.com">www.rcrinternational.com</a>	
Pyrolysis	Splainex Ecosystems Ltd.	n/a	n/a	n/a	<a href="http://www.splainex.com">www.splainex.com</a>	
Pyrolysis	Takuma	2005	Kakegawa, Japan		<a href="http://www.takuma.co.jp/english/">www.takuma.co.jp/english/</a>	
Pyrolysis	Technip / Waste Gen	1987	Burgau, Germany	36,200 tpy	<a href="http://www.wastegen.com/alternative.htm">www.wastegen.com/alternative.htm</a>	
Pyrolysis amd Gasification	Techtrade	2002	Hamm, Germany	100,000 tpy	<a href="http://www.tech-trade.de/index.html">www.tech-trade.de/index.html</a>	RDF
Pyrolysis	Thide/Hitachi	2003	Izumo, Japan	63,500 tpy	-	
Pyrolysis	TPF Group (Serpac Pyroflam)	2005	Keflavik, Iceland	41 tpd	<a href="http://www.tpf-bs.be">www.tpf-bs.be</a>	
Pyrolysis and Gasification	WasteGen (UK)	2000	Hamm, Germany	100,000 tpy	<a href="http://www.wastegen.com/wastegenuk.htm">www.wastegen.com/wastegenuk.htm</a>	

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	<a href="http://www.advancedplasmapower.com">www.advancedplasmapower.com</a>	
Thermal Cracking Technology						
Thermal Cracking Technology	GEM Waste to Energy Inc.	1998	Romsey, England	0.7 tph	<a href="http://www.gemcanadawaste.com/index2.html">www.gemcanadawaste.com/index2.html</a>	
Thermal Oxidation						
Thermal Oxidation	Zeros Technology Holding	No existing plant			<a href="http://www.zerosinc.com">www.zerosinc.com</a>	
Waste to Fuel						
Waste to Fuel	BioEngineering Resources (BRI)	2003	Fayetteville, Arkansas	1.3 tpd (Pilot Plant)	<a href="http://www.brienergy.com">www.brienergy.com</a>	
Waste to Fuel	BlueFire Ethanol Inc.	2002	Izumi, Japan		<a href="http://bluefireethanol.com/production_plant/">http://bluefireethanol.com/production_plant/</a>	
Waste to Fuel	Changing World Technologies	1999	Philadelphia, PA	Test Facility	<a href="http://www.changingworldtech.com">www.changingworldtech.com</a>	
Waste to Fuel	Enerkem	2003	Sherbrooke, Quebec	5 tpd (MSW pellets)	<a href="http://www.enerkem.com">www.enerkem.com</a>	
Waste to Fuel	Enerkem (Novera)	To be constructed 2009	Edmonton, Alberta	100,000 tpy	<a href="http://www.enerkem.com">www.enerkem.com</a>	
Waste to Fuel	Genahol Inc.	2007	Lake County, Indiana	30 million gallons ethanol/year	<a href="#">Not constructed yet</a>	
Waste to Fuel	Indiana Ethanol Power	2008	Lake County, Indiana	1,500 tons per day	<a href="#">Not constructed yet</a>	
Waste to Fuel	Masada OxyNol	n/a	n/a	n/a	-	
Waste to Fuel	Power Ecalene Fuels	n/a	n/a	n/a	<a href="http://powerecalene.com">http://powerecalene.com</a>	Converts syngas to alcohol
Waste to Fuel	Range Fuels Inc.	2008	Denver Colorado	5 oven dried tonnes	<a href="http://www.rangefuels.com">www.rangefuels.com</a>	
Other Methodologies						
Kearns Disintegrator	Quantum Solutions Technology Ventures Inc.	1983	Cape Breton Isaldn, Nova Scotia	Prototype	<a href="http://www.gstv.ca/gstv-about.html">www.gstv.ca/gstv-about.html</a>	
Steam Reforming Plant	Elementa	2007	Sault Ste. Marie	n/a	<a href="http://www.elementagroup.com/">http://www.elementagroup.com/</a>	





## Thermal Treatment Technologies Database



**Thermal Treatment Technologies Database (MSW as a Feedstock)**

Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
<b>Conventional Combustion</b>						
Mass Burn Incineration	Advanced Alternative Energy (AAEC)	n/a	n/a	n/a	<a href="http://www.aaecorp.com/power.html">www.aaecorp.com/power.html</a>	No reference facilities, claims to be able to treat waste and biomass.
Mass Burn Incineration	ATCO Power	n/a	n/a	n/a	<a href="http://www.atcopower.com">www.atcopower.com</a>	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	<a href="http://www.CNIM.com">www.CNIM.com</a>	DBO.
Modular Two Stage Combustion	Consutech Systems LLC	n/a	Iraq	5333 lbs/hr	<a href="http://www.consutech.com/">http://www.consutech.com/</a>	Design and manufacture incineration and APC equipment.
Mass Burn Incineration	Covanta	1990	Huntsville, Alabama	625 tpd	<a href="http://www.covantaholding.com/">www.covantaholding.com/</a>	Operate 41 facilities in the US, 1 Burnaby - utilize Martin Gmbh tech.
Modular Two Stage Combustion	Enerwaste	2005	Egegik, Alaska	3.5 tpd	<a href="http://www.enerwaste.com">www.enerwaste.com</a>	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	<a href="http://www.fisia-babcock.com/">http://www.fisia-babcock.com/</a>	One of the 4 main suppliers of mass burn technology.
Mass Burn Incineration	JFE	2003	Hirano Plant, Japan	900 tpd	<a href="http://www.ife-eng.co.jp/en">www.ife-eng.co.jp/en</a>	
Fluidized Bed Incineration	JFE	2006	Banpoo WTE Plant, Thailand	100 tpd	<a href="http://www.ife-eng.co.jp/en">www.ife-eng.co.jp/en</a>	
Mass Burn Incineration	KAB TAKUMA GmbH	2003	Salzbergen, Germany	90.000 tpy	<a href="http://www.kab-takuma.com/">http://www.kab-takuma.com/</a>	
Mass Burn Incineration	Martin GmbH	1999	Neunkirchen, Germany	408 tpd	<a href="http://www.martingmbh.de/index.php">http://www.martingmbh.de/index.php</a>	One of the 4 main suppliers of mass burn technology.
Mass Burn Incineration	Naanovo Energy Inc.	March 2010	The Gambia	n/a	<a href="http://www.naanovo.com">www.naanovo.com</a>	14 MW facility. Not sure as to the status.
Mass Burn Incineration	Seghers Keppel Technology Group	n/a	Beveren, Belgium	2 x 319 tpd	<a href="http://www.keppelseghers.com">www.keppelseghers.com</a>	
Mass Burn Incineration	Standardkessel Baumgarte	2007	MSZ 3 Moscow, Russia	330,000 tpy	<a href="http://www.standardkessel-baumgarte.com/">http://www.standardkessel-baumgarte.com/</a>	5 reference facilities located on their website.
	Steinmuller	n/a	n/a	n/a	<a href="http://www.steinmuller.co.za/default.asp?fid=0&amp;sid=24&amp;L=1">http://www.steinmuller.co.za/default.asp?fid=0&amp;sid=24&amp;L=1</a>	Mecanical engineers.
Mass Burn Incineration	TPS Termiska	1992	Greve-in-Chianti, Italy	67,000 tpy	<a href="http://www.tps.se/subpage.aspx?MS=14839,15014">www.tps.se/subpage.aspx?MS=14839,15014</a>	
Mass Burn Incineration	Veolia Environmental Services	2003	Hampshire, UK	90,000 tpy	<a href="http://www.VeoliaES.com">www.VeoliaES.com</a>	More than 80 plants worldwide.
Mass Burn Incineration	Von Roll Nova	2007	Issy-les-Moulineaux (Paris), France	460,000 tpy	<a href="http://www.aee-vonrollinova.ch">http://www.aee-vonrollinova.ch</a>	One of the 4 main suppliers of mass burn technology.
Mass Burn Incineration	Wheelabrator Technologies Inc.	1985	Baltimore	2,000 tpd	<a href="http://www.wheelabratortechnologies.com">www.wheelabratortechnologies.com</a>	Operates 21 facilities in the US..
Mass Burn Incineration	Wulff Energy and Environmental Systems	n/a	n/a	n/a	<a href="http://www.wulff-hamburg.de">http://www.wulff-hamburg.de</a>	Boiler, combustion and drier technologies.

Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
<b>Gasification</b>						
Gasification	Ambient Eco Group	2002	n/a	75,000 to 250,000 tpy		
Gasification	City Clean 2000 Inc.	n/a	n/a	n/a	<a href="http://cityclean2000.com/">http://cityclean2000.com/</a>	
Gasification	Coaltec Energy	n/a	Carterville, Illinois	Test Facility	<a href="http://www.coaltecenergy.com">www.coaltecenergy.com</a>	
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	<a href="http://www.ebara.co.jp/en/">www.ebara.co.jp/en/</a>	
Gasification	Emery Energy Company	n/a	Salt Lake City, Utah (Pilot Plant)	25 tpd	<a href="http://www.emeryenergy.com">www.emeryenergy.com</a>	
Gasification	Energos	1998	Ranheim, Norway	10,000 tpy	<a href="http://www.enerq.co.uk/energy_from_waste">www.enerq.co.uk/energy_from_waste</a>	
Gasification	Energy Products of Idaho	1989	Tacoma, Washington	317 tpd	<a href="http://www.energyproducts.com">www.energyproducts.com</a>	
Gasification	EnerTech Environmental	1997-2000 (Demonstration Facility)	Ube City, Japan	18 tpd	<a href="http://www.enertech.com">www.enertech.com</a>	
Gasification	Envirotherm GmbH	2000	Schwarze Pumpe, Germany	300,000 tpy	<a href="http://envirotherm.de/">http://envirotherm.de/</a>	
Gasification	Eurotech	n/a	Quetzaltenango, Guatemala	n/a	<a href="http://www.eurotecguatemala.com/maineng.htm">www.eurotecguatemala.com/maineng.htm</a>	
Gasification	Forevergreen Enterprises	Not yet constructed	DeKalb County	n/a	<a href="http://www.fqenterprises.net">www.fqenterprises.net</a>	
Gasification	Foster Wheeler	1998	Finland	80,000 tpy	<a href="http://www.fwc.com">www.fwc.com</a>	
Gasification	Full Circle Energy	n/a	n/a	n/a	<a href="http://www.fullcircleenergy.net">www.fullcircleenergy.net</a>	
Gasification / Thermal Cracking	GEM America	2000	Tythegston Landfill Site, South Wales	36 tpd	<a href="http://www.gemamericainc.com">www.gemamericainc.com</a>	
Gasification	Global Energy Inc.	1992	Westfield Development Centre, UK	n/a	<a href="http://www.globalenergyinc.com">www.globalenergyinc.com</a>	
Gasification	Global Energy Solutions Inc	n/a	Japan, Germany, Belgium, Korea, Malta, UK	1-25 tph	<a href="http://www.globalenergychicago.com">www.globalenergychicago.com</a>	
Gasification	Global Warming Prevention Technologies Inc.	n/a	Anchoarge, Alaska; Kuala Lumpur, Malaysia	25 tpd	<a href="http://www.gwpt.com">www.gwpt.com</a>	
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	<a href="http://www.ils-partners.com">www.ils-partners.com</a>	
Gasification	Interstate Waste Technologies (IWT) (uses Thermoselect)	1999	Chiba, Japan	93,000 tpy	<a href="http://www.iwtonline.com">www.iwtonline.com</a>	
Gasification	ITI Energy Ltd.	n/a	South West England	72,000 tpy	<a href="http://www.iti-energy.com/">http://www.iti-energy.com/</a>	
Gasification	JFE	2003	Kakamigahara Plant, Japan	192 tpd	<a href="http://www.jfe-eng.co.jp/en">www.jfe-eng.co.jp/en</a>	
Gasification	Karlsruhe Institute of Technology	1993 rotating grate gasifier; 2000 slagging	Schwarze Pumpe, Germany	700 tpd	<a href="http://www.fzk.de">www.fzk.de</a>	
Gasification	Lurgi	1993 rotating grate gasifier; 2000 slagging	Schwarze Pumpe, Germany	700 tpd	<a href="http://www.lurgi.com">www.lurgi.com</a>	
Gasification	Nippon Steel	2002	Akita, Japan	400 tons per day		
Gasification	Ntech Environmental	1991	Chung Gung Municipality, Taiwan	27 tpd	<a href="http://www.ntech-environmental.com">www.ntech-environmental.com</a>	
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	<a href="http://pyrolyzerllc.com/">http://pyrolyzerllc.com/</a>	
Gasification	SenreQ International	2002	Barrow, Alaska	27 tpd		
Gasification	Sierra Energy Corporation	n/a	n/a	n/a	<a href="http://www.sierraenergycorp.com/">http://www.sierraenergycorp.com/</a>	
Gasification	SVZ	n/a	n/a	n/a		
Gasification	Rentech	1997	Burlington, Vermont	272 tpd	<a href="http://www.silvasgas.com">www.silvasgas.com</a>	
Gasification	Terragon Environmental Technologies Inc.	n/a	n/a	Small-scale (Only for remote communities, outposts etc.)	<a href="http://www.terragon.net/MAGS.html">www.terragon.net/MAGS.html</a>	
Gasification	TGE Tech	2007	Tel Aviv	181 tpd		
Gasification	Thermogenics, Inc.	n/a	n/a	n/a	<a href="http://www.thermogenics.com">www.thermogenics.com</a>	
Gasification	Thermoselect	1999-2004	Karlsruhe, Germany	250,000 tpy	<a href="http://www.thermoselect.com">www.thermoselect.com</a>	
Gasification	Thide Environmental	2004	Arras, France	50,000 tpy	<a href="http://www.thide.com">www.thide.com</a>	
Gasification	Waste-to-Energy	Reference facilities do not process MSW (only	n/a	n/a	<a href="http://www.wastetoenergy.co.uk">www.wastetoenergy.co.uk</a>	
Gasification	Whitten Group International	1991	Taiwan	8,100 tpy		



Type of Technology	Company	Operating Since	Reference Facility(ies)	Size	Website	Comments
<b>Plasma Arc Gasificaiton</b>						
Plasma Arc Gasification	AdaptiveNRG	2005	Monterey, Mexico (portable)	33,000 tpy	<a href="http://www.adaptivenrg.com">www.adaptivenrg.com</a>	
Plasma Arc Gasification	AlterNRG (Westinghouse Plasma Technology)	1999	Yoshi, Japan	n/a	<a href="http://www.alternrg.com">www.alternrg.com</a>	
Plasma Arc Gasification	EnviroArcTechnologies	Pilot Plant	Hofors, Sweden	.7 tph	<a href="http://www.enviroarc.com">www.enviroarc.com</a>	
	Europlasma	n/a	n/a	n/a	<a href="http://www.europlasma.com/">http://www.europlasma.com/</a>	Plasma torches.
Plasma Arc Gasification	Geoplasma LLC	1999	Japan, Germany, Belgiu, Korea, Malta, UK	24 tpd	<a href="http://www.geoplasma.com">www.geoplasma.com</a>	
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	<a href="http://www.greenpowersystems.com">www.greenpowersystems.com</a>	
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	<a href="http://www.inentec.com">www.inentec.com</a>	
Plasma Arc Gasification	MPM Technologies Inc.	1987-1988	Libby, Montana (Pilot Plant)	45 tpd; 108 tpd (continuous feed)	<a href="http://www.mpmtech.com">www.mpmtech.com</a>	
Plasma Arc Gasification	Peat International Inc	2007	Kaohsiung, Taiwan	9 tpd	<a href="http://www.peat.com">www.peat.com</a>	
Plasma Arc Gasification	Plasco Energy Group	2007	Ottawa, Canada	31,100 tpy	<a href="http://www.plasco.com">www.plasco.com</a>	
Plasma Arc Gasification	Plasma Arc Technologies	n/a	n/a	n/a	<a href="http://www.plasmaarctech.com">www.plasmaarctech.com</a>	
Plasma Arc Gasification	Plasma Environmental Technologies Inc.	No operating facilities.	n/a	n/a	<a href="http://www.plasmaenvironmental.com">www.plasmaenvironmental.com</a>	
Plasma Arc Gasification	Plasma Waste Recycling	n/a	n/a	n/a	<a href="http://www.plasma-wr.com">www.plasma-wr.com</a>	
Plasma Arc Gasification	PyroGenesis Inc.	2000	Montreal, Quebec	10 tpd		
Plasma Arc Gasification	Recovered Energy Inc. (Westinghouse)	1999	Hitachi plant in Japan	3 tph	<a href="http://www.recoveredenergy.com">www.recoveredenergy.com</a>	
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	<a href="http://www.solenagroup.com">www.solenagroup.com</a>	
Plasma Arc Gasification	Startech Environmental Corporation	2001	Bristol, Connecticut	4.5 tpd (Demonstration Facility)	<a href="http://www.startech.net">www.startech.net</a>	
Plasma Arc Gasification	Sun Energy Group LLC	2011	New Orleans	n/a	<a href="http://www.sunenergygrp.com">www.sunenergygrp.com</a>	
Plasma Arc Gasification	US Plasma	n/a	n/a	n/a		
Plasma Arc Gasification	Westinghouse Plasma/GeoPlasma	2002	Utashinai & Mihama Mikata, Japan	n/a	<a href="http://www.westinghouse-plasma.com">www.westinghouse-plasma.com</a>	
<b>Pyrolysis</b>						
Pyrolysis	Balboa Pacific Corporation	n/a	n/a	n/a	<a href="http://www.balboa-pacific.com">www.balboa-pacific.com</a>	
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	<a href="http://www.conradind.com/to_tech_develop.asp">www.conradind.com/to_tech_develop.asp</a>	
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	<a href="http://www.energ.co.uk">www.energ.co.uk</a>	
Pyrolysis	Entech Renewable Energy	2006	Korea	60 tpd (MSW)	<a href="http://www.entech.net.au/ws1/">http://www.entech.net.au/ws1/</a>	
Pyrolysis	International Energy Solutions	2004	Romoland, California	16,500 tpy (MSW)	<a href="http://www.wastetopower.com">www.wastetopower.com</a>	
Pyrolysis	JND Thermal Process	n/a	Hamburg, Germany	Test Facility	<a href="http://www.jnd.co.uk">www.jnd.co.uk</a>	
Pyrolysis	Mitsui Babcock	2000	Yame Seibu, Japan	219 tpd	<a href="http://www.doosanbabcock.com">www.doosanbabcock.com</a>	
Pyrolysis	Mitsui R-21	2002	Toyohashi City, Japan	400 tpd	<a href="http://www.gec.jp/JSIM_DATA/WASTE/WASTE_3/html/Doc_436.html">http://www.gec.jp/JSIM_DATA/WASTE/WASTE_3/html/Doc_436.html</a>	
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	<a href="http://www.rcrinternational.com">www.rcrinternational.com</a>	
Pyrolysis	Splainex Ecosystems Ltd.	n/a	n/a	n/a	<a href="http://www.splainex.com">www.splainex.com</a>	
Pyrolysis	Takuma	2005	Kakegawa, Japan		<a href="http://www.takuma.co.jp/english/">www.takuma.co.jp/english/</a>	
Pyrolysis	Technip / Waste Gen	1987	Burgau, Germany	36,200 tpy	<a href="http://www.wastegen.com/alternative.htm">www.wastegen.com/alternative.htm</a>	
Pyrolysis amd Gasification	Techtrade	2002	Hamm, Germany	100,000 tpy	<a href="http://www.tech-trade.de/index.html">www.tech-trade.de/index.html</a>	RDF.
Pyrolysis	Thide/Hitachi	2003	Izumo, Japan	63,500 tpy		
Pyrolysis	TPF Group (Serpac Pyroflam)	2005	Keflavik, Iceland	41 tpd	<a href="http://www.tpf-bs.be">www.tpf-bs.be</a>	
Pyrolysis and Gasification	WasteGen (UK)	2000	Hamm, Germany	100,000 tpy	<a href="http://www.wastegen.com/wastegenuk.htm">www.wastegen.com/wastegenuk.htm</a>	

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	<a href="http://www.advancedplasmapower.com">www.advancedplasmapower.com</a>	
Thermal Cracking Technology						
Thermal Cracking Technology	GEM Waste to Energy Inc.	1998	Romsey, England	0.7 tph	<a href="http://www.gemcanadawaste.com/index2.html">www.gemcanadawaste.com/index2.html</a>	
Thermal Oxidation						
Thermal Oxidation	Zeros Technology Holding	No existing plant.			<a href="http://www.zerosinc.com">www.zerosinc.com</a>	
Waste to Fuel						
Waste to Fuel	BioEngineering Resources (BRI)	2003	Fayetteville, Arkansas	1.3 tpd (Pilot Plant)	<a href="http://www.brienergy.com">www.brienergy.com</a>	
Waste to Fuel	BlueFire Ethanol Inc.	2002	Izumi, Japan		<a href="http://bluefireethanol.com/production_plant/">http://bluefireethanol.com/production_plant/</a>	
Waste to Fuel	Changing World Technologies	1999	Philadelphia, PA	Test Facility	<a href="http://www.changingworldtech.com">www.changingworldtech.com</a>	
Waste to Fuel	Enerkem	2003	Sherbrooke, Quebec	5 tpd (MSW pellets)	<a href="http://www.enerkem.com">www.enerkem.com</a>	
Waste to Fuel	Enerkem (Novera)	To be constructed 2009	Edmonton, Alberta	100,000 tpy	<a href="http://www.enerkem.com">www.enerkem.com</a>	
Waste to Fuel	Genahol Inc.	2007	Lake County, Indiana	30 million gallons ethanol/year	<a href="#">Not constructed yet</a>	
Waste to Fuel	Indiana Ethanol Power	2008	Lake County, Indiana	1,500 tons per day	<a href="#">Not constructed yet</a>	
Waste to Fuel	Masada OxyNol	n/a	n/a	n/a		
Waste to Fuel	Power Ecalene Fuels	n/a	n/a	n/a	<a href="http://powerecalene.com">http://powerecalene.com</a>	Converts syngas to alcohol.
Waste to Fuel	Range Fuels Inc.	2008	Denver Colorado	5 oven dried tonnes	<a href="http://www.rangefuels.com">www.rangefuels.com</a>	
Other Methodologies						
Kearns Disintegrator	Quantum Solutions Technoogy Ventures Inc.	1983	Cape Breton Isaldn, Nova Scotia	Prototype	<a href="http://www.qstv.ca/qstv-about.html">www.qstv.ca/qstv-about.html</a>	
Steam Reforming Plant	Elementa	2007	Sault Ste. Marie	n/a	<a href="http://www.elementagroup.com/">http://www.elementagroup.com/</a>	

**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)

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## 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 (m<sup>3</sup>) 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/m<sup>3</sup>, 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/m<sup>3</sup>, 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/m<sup>3</sup>, 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/m<sup>3</sup> (0.5-h average) and 40 µg/m<sup>3</sup> (24-h average);
  - Sulphur Dioxide — 450 µg/m<sup>3</sup> (1-h average) and 160 µg/m<sup>3</sup> (24-h average); and
  - Nitrogen Oxides (measured as Nitrogen Dioxide) — 400 µg/m<sup>3</sup> (1-h average) and 200 µg/m<sup>3</sup> (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/m<sup>3</sup> corrected to 11% O<sub>2</sub> (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 m<sup>3</sup>/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% O<sub>2</sub>)

Contaminant	Limit	Averaging Period	Monitoring Method
Total Particulate	20 mg/m <sup>3</sup>	(1)	(2)
Carbon Monoxide	55 mg/m <sup>3</sup> (3)	4-hour rolling average	Continuous Monitoring
Sulphur Dioxide	250 mg/m <sup>3</sup>	(1)	(2)
Nitrogen Oxides (NO <sub>x</sub> as NO <sub>2</sub> )	350 mg/m <sup>3</sup>	(1)	(2)
Hydrogen Chloride	70 mg/m <sup>3</sup>	8-hour rolling average	Continuous Monitoring
Hydrogen Fluoride	3 mg/m <sup>3</sup>	(1)	(2)
Total Hydrocarbons (as Methane CH <sub>4</sub> )	40 mg/m <sup>3</sup>	(1)	(2)
Arsenic (4)	4 µg/m <sup>3</sup>	(1)	(2)
Cadmium (4)	100 µg/m <sup>3</sup>	(1)	(2)
Chromium (4)	10 µg/m <sup>3</sup>	(1)	(2)
Lead (4)	50 µg/m <sup>3</sup>	(1)	(2)
Mercury (4)	200 µg/m <sup>3</sup>	(1)	(2)
Chlorophenols	1 µg/m <sup>3</sup>	(1)	(2)
Chlorobenzenes	1 µg/m <sup>3</sup>	(1)	(2)
Polycyclicaromatic Hydrocarbons	5 µg/m <sup>3</sup>	(1)	(2)
Polychlorinated Biphenyls	1 µg/m <sup>3</sup>	(1)	(2)
Total PCDDs & PCDFs (6)	0.5 ng/m <sup>3</sup>	(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/m<sup>3</sup>.

(4) The concentration is total metal emitted as solid and vapour.

(5) For existing incinerators the limit shall be 200 µg/m<sup>3</sup>, 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 <sup>3</sup> @ 11% O <sub>2</sub> (4-h rolling average)	55 mg/m <sup>3</sup> @ 11% O <sub>2</sub> (4-h rolling average)	110 mg/m <sup>3</sup> @ 11% O <sub>2</sub> (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

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## **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.