MELIADINE GOLD PROJECT

Incineration Management Plan

APRIL 2015

VERSION 4

6513-MPS-01

ᓇᐃᓈᖅᓯᒪᔪᖅ

ᐊᓃᑯᒃᑯᑦ ᑕᓯᕐᔪᐊᕐᒥᑦ ᒎᓗᒧᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᓕᕆᕙᓪᓕᐊᔪᑦ (ᐱᓕᕆᐊᖅ), 25 ᑭᓛᒥᑕᒥᒃ ᐅᐊᖕᓇᖕᖓᓂᑦ ᐅᖕᖓᓯᒃᑎᒋᔪᖅ ᑲᖏᖅᖠᓂᕐᒥᑦ, ᐊᒻᒪ 80 ᑭᓛᒥᑕᒥᒃ ᓂᒋᖅᐸᓯᐊᓂᑦ ᐱᖕᖓᖕᓇᖅᐸᓯᐊᓂᑦ ᐅᖕᖓᓯᒃᑎᒋᔪᖅ ᐃᒡᓗᓕᒑᕐᔪᖕᒥᑦ ᑭᕙᓪᓕᕐᒥᑦ ᓄᓇᕗᒻᒥᑦ. ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒧᑦ ᐸᕐᓇᐅᑕᐅᔪᖅ ᐅᒃᑯᐃᖕᖓᔪᒥᒃ ᐊᒻᒪ ᓄᓇᐅᑉ ᐃᓗᐊᓂᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᖅᑲᕐᓂᐊᖅᑐᖅ ᐱᕙᓪᓕᐊᓂᕐᒧᑦ ᑎᑎᖓᓂᐊᖅ-ᒥᑦ ᒎᓗᓂᒃ ᐱᓂᕐᒧᑦ, ᒪᕐᖂᖕᓂᒃ ᐅᒃᑯᐃᖕᖓᔫᖕᓂᒃ ᓄᓇᒥᑦ (ᑎᑎᖓᓂᐊᖅ Pit 1 ᐊᒻᒪ ᑎᑎᖓᓂᐊᖅ Pit 2) ᐊᒻᒪ ᐊᑕᐅᓯᖅ ᓄᓇᐅᑉ ᐃᓗᐊᓂᑦ ᐅᔭᕋᖕᓂᐊᕐᓂᖅ.

ᑖᒻᓇ ᑎᑎᖅᑲᖅ ᐅᖅᑲᐅᓯᖅᑲᖅᑐᖅ ᐃᑯᐊᓪᓚᒃᑎᖓᓂᕐᒧᑦ ᐊᐅᓚᑦᑎᓂᕐᒥᒃ ᐸᕐᓇᐅᑎ ᐱᓕᕆᐊᒧᑦ ᐊᒻᒪ ᐃᓚᓕᐅᑎᑦᑎᑉᓗᓂ ᑎᑎᖅᑲᓂᒃ Type A ᐃᒪᕐᒧᑦ ᓚᐃᓴᓐᓯᒥᒃ ᑐᒃᓯᕋᐅᑎᒥᒃ. ᑖᒻᓇ ᐸᕐᓇᐅᑎ ᐱᓕᕆᐊᖑᓚᐅᖅᑐᖅ ᒪᓕᒡᓗᒋᑦ ᐱᐅᓛᑯᑦ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᐊᑐᖅᑕᐅᖃᑦᑕᖅᑐᓂᒃ ᐊᑐᖅᓗᓂ, ᑲᓇᑕᒥᑦ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ *ᑎᑎᖅᑲᖅ ᑲᑎᓯᒪᔪᓄᑦ ᐊᒃᑕᑯᐃᑦ ᐃᑯᐊᓪᓚᒃᑎᑕᐅᔪᑦ*, ᐊᒻᒪ ᒪᓕᒃᑕᐅᔭᓇᐊᖅᑲᖅᑐᑦ ᑎᓂᔭᐅᔪᑦ ᓄᓇᕗᒻᒥ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᕿᒥᕐᕈᔾᑯᖕᒋᓐᓄᑦ ᐱᓕᕆᐊᒧᑦ.

ᓯᑎᔪᑦ ᐊᒃᑕᑯᓂᒃ ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔾᔪᑎ ᐃᑭᑎᑦᑎᔾᔪᑏᓪᓗ ᒪᓕᒐᑎᒍᑦ ᐊᐅᓚᑕᐅᔪᑦ ᓄᓇᕗᒻᒥ ᒪᓕᒡᓗᒋᑦ *ᓄᓇᕗᒻᒥᑦ ᐃᓄᐃᑦ ᐋᓐᓂᐊᖅᑲᖅᑕᐃᓕᒪᓂᖕᒋᓐᓄᑦ ᐱᖁᔭᖅ, ᓄᓇᕗᒻᒥ ᐊᕙᑎᒥᒃ ᒥᐊᓂᖅᓯᓂᕐᒧᑦ ᐱᖁᔭᖅ*, ᐊᒻᒪ *ᐊᕙᑎᒥᒃ ᒥᐊᓂᖅᓯᓂᕐᒧᑦ ᐱᖁᔭᖅ*. ᐱᓕᕆᓂᕐᒧᑦ ᑭᒡᓕᐅᔪᑦ ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔾᔪᑎᒧᑦ ᐱᓕᕆᐊᒥᑦ ᒪᓕᖕᓂᐊᖅᑐᑦ ᐊᓂᐊᔪᓄᑦ ᒪᓕᒃᑕᐅᔭᓇᐊᓕᖕᓂᑦ ᐋᕿᒃᑕᐅᔪᑦ ᑲᓇᑕᒥᑦ ᑲᑎᒪᔨᖕᒥᑦ ᒥᓂᔅᑕᐅᔪᓄᑦ ᐊᕙᑎᒧᑦ. ᐳᔪᐃᑦ ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔾᔪᑎᒥᙱᓚᖅᑐᑦ ᐃᒋᑕᐅᓂᐊᖅᑐᑦ ᒪᓕᒡᓗᒋᑦ *ᓄᓇᕗᒻᒥ ᐊᕙᑎᒧᑦ ᒪᓕᒃᑕᐅᔪᒃᓴᐃᑦ ᐱᓕᕆᕕᒡᔪᐊᓂᑦ ᐊᒃᑕᑯᓄᑦ*.

ᐱᓕᕆᐊᖅ ᓂᕈᐊᕐᓂᐊᖅᑐᖅ ᐊᒻᒪ ᐊᐅᓛᖅᑎᓪᓗᒍ ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔾᔪᑎᖕᖓ ᒪᓕᒡᓗᒋᑦ ᑲᓇᑕᒥᑦ ᐊᕙᑎᓕᕆᔨᒃᑯᖕᒋᑦᑕ *ᑎᑎᖅᑲᖅ ᑲᑎᓯᒪᔪᓄᑦ ᐊᒃᑕᑯᐃᑦ ᐃᑯᐊᓪᓚᒃᑎᑕᐅᔪᑦ*. ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔾᔪᑎᒧᑦ ᐊᑐᖅᑐᓄᑦ ᐃᓚᒋᔭᐅᓂᐊᖅᑐᖅ, ᐊᑐᓕᖅᑎᑦᑎᓂᖅ ᐊᒃᑕᑯᐃ ᐊᕕᒃᑐᖅᑕᐅᓂᖕᒋᓐᓄᑦ ᑐᕌᖕᖓᔪᖅ ᑭᒡᓕᓕᐅᕐᓂᐊᖅᑐᖅ ᐊᓂᐊᔪᓂᒃ (ᓲᕐᓗ dioxins ᐊᒻᒪ furans, ᓄᖑᓯᐃᑐᖅ) ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔾᔪᑎᒥᑦ.

ᐊᑐᖅᑕᐅᖃᑦᑕᖅᑐᖅ ᐊᐅᓚᑦᑎᔪᖅ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑎᖕᓂᑦ, ᑲᑎᕐᒪᔪᑦ, ᒪᕐᖂᖕᓂᒃ ᐃᑲᐊᓪᓚᒃᑎᑦᑎᔾᔪᑎᖃᖅᑐᖅ ᐃᓕᓴᐅᓂᐊᖅᑐᖅ. ᐱᕙᓪᓕᐊᓂᕐᒧᑦ ᑭᒡᓕᐅᔪᑦ, ᓲᕐᓗ ᐆᓇᕐᓂᖕᖓ, ᐃᑯᐊᓪᓚᒃᑐᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᐸᑎᓐᓂᑦ ᐊᐅᓚᓂᖕᖓ, ᐊᒻᒪ ᐃᑯᐊᓪᓚᒍᑎ ᐊᓂᐊᓂᖕᖓ ᖃᓇᑕᐅᓴᒃᑯᑦ ᐊᐅᓚᑕᐅᓗᓂ ᐃᑭᐸᓪᓕᐊᔪᑦ ᐋᖅᑭᐅᒪᕐᑯᒧᑦ. ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔾᔪᑎ ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔪᖕᓇᖅᑲᑦᑕᕐᓂᐊᖅᑐᖅ 1,500 ᑭᓗᒍᕋᒻᓂᒃ ᐅᕐᑯᒪᐃᓂᓕᖕᓂᒃ ᐅᑉᓗᑕᒫᑦ ᐊᒃᑕᑯᐃᑦ ᐱᓕᕆᐊᒥᙱᓚᖅᑐᑦ ᐃᑭᑎᓐᓂᐊᕐᓗᒋᑦ. ᐊᒃᑕᑯᓄᑦ ᐊᐅᓚᑦᑎᕕᖕᒦᓐᓂᐊᖅᑐᖅ[1] ᐊᒻᒪ ᐊᐅᓚᑕᐅᓗᓂ ᐊᔪᕈᖕᓃᖅᓴᓯᒪᔪᓄᑦ ᐱᓕᕆᔨᓄᑦ.

[1] ᖃᐅᔨᒪᔭᐅᖕᒥᔪᖅ ᐃᑯᐊᓪᓚᒃᑎᑦᑎᕕᖕᒥᑦ.

ᖃᐅᔾᔨᒋᐊᖃᑦᑕᕐᓂᖅ ᐊᒻᒪ ᐆᒃᑐᕋᐃᓂᖅ ᐸᕐᓇᐅᑕᐅᓯᒪᔪᖅ ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔾᔪᑎᒥᑦ ᐳᔪᐃᑦ ᐊᓂᐊᔪᓄᑦ, ᐅᖅᓱᐊᓗᐃᑦ/ᐅᖅᓯᖅᑎᕈᑏᑦ ᐃᒋᑕᐅᔪᑦ ᐃᑭᑎᑕᐅᓗᑎᒃ ᐃᑯᐊᓪᓚᒃᑎᑦᑎᔾᔪᑎᒥᑦ, ᐊᒻᒪ ᑕᒡᕙᖕᖑᖅᑐᑦ ᐳᔪᐃᑦ.

ᑕᑯᒃᓴᐅᑎᖏᓐᓂᐊᕐᓗᒍ ᐋᕐᑭᐅᒪᓂᖓ ᑭᒡᓕᐅᔪᓄᑦ, ᐊᕐᕿᒍᑕᒫᑦ ᐃᑯᐊᓪᓚᒃᑎᑦᑎᓂᕐᒧᑦ ᐊᐅᓚᑦᑎᓂᕐᒥᒃ ᐅᓂᒃᑳᓕᐅᖃᑦᑕᕐᓂᐊᖅᑐᑦ ᑐᓂᐅᑕᐅᓗᑎᒡᓗ ᐃᓚᒌᔭᐅᓗᓂ ᐊᕐᕿᒍᑕᒫᑦ ᐅᓂᒃᑳᓕᐊᒧᑦ ᑐᓂᐅᑕᐅᔪᑦ ᐱᔪᙳᖅᑎᑦᑎᔾᔨᓄᑦ. ᖃᐸᓯᐅᓂᖏᑦ ᐊᒻᒪ ᖃᓄᐃᑦᑐᓂᖏᑦ ᐃᑭᑎᑕᐅᔪᑦ ᐱᓕᕆᐊᒥᑦ ᐊᐅᓛᖅᑎᓪᓗᒍ, ᑕᒪᐃᓂᒃ ᖃᓄᐃᖕᒐᓂᐅᔪᑦ ᐃᓱᐊᕿᔪᖅ ᐊᓂᐊᔪᑦ ᐊᒻᒪ ᐳᔪᐃᑦ ᖃᐅᔾᔨᒋᐊᖃᑦᑕᕐᓂᖅ, ᐃᓚᐅᓂᐊᖅᑐᖅ ᐊᕐᕿᒍᑕᒫᑦ ᐅᓂᒃᑳᓕᐊᒧᑦ. ᐅᓂᒃᑳᓕᐊᖅᑕᖃᕐᓂᐊᕐᒥᔪᖅ, ᐱᔭᕇᐊᖃᖅᐸᑦ, ᑲᓇᑕᒥᑦ ᐱᐅᖏᑦᑐᓂᒃ ᐊᓂᐊᑎᑦᑎᓂᕐᒧᑦ ᓈᓴᐃᔨᓄᑦ. ᑭᖑᓪᓕᖅᐹᖅ, ᐊᒡᓃᑯᒃᑯᑦ ᐱᓂᐊᕐᓂᖃᖅᑐᑦ ᐅᓂᒃᑳᓕᐅᕐᓂᕐᒥᒃ ᐳᔪᕐᓗᖕᓂᒃ ᐊᓂᐊᔪᓂᒃ ᐃᑲᔪᐃᓂᕐᒧᑦ ᑲᓇᑕᐅᑉ ᐃᓯᒪᖅᓱᖅᓱᕈᑎᒃ ᐆᒃᑐᖅᑐᓄᑦ ᑎᑎᕋᖅᓯᒪᔪᓄᑦ.

EXECUTIVE SUMMARY

Agnico Eagle Mines Limited (Agnico Eagle) is developing the Meliadine Gold Project (Project), located approximately 25 kilometres (km) north of Rankin Inlet, and 80 km southwest of Chesterfield Inlet in the Kivalliq Region of Nunavut. The mine plan proposes open pit and underground mining methods for the development of the Tiriganiaq gold deposit, with two open pits (Tiriganiaq Pit 1 and Tiriganiaq Pit 2) and one underground mine.

This document presents the Incineration Management Plan for the Project and forms a component of the documentation series produced for the Type A Water Licence Application. This Plan was prepared in accordance with best management practices, Environment Canada's *Technical Document for Batch Waste Incineration,* and guidelines issued by the Nunavut Impact Review Board for the Project.

Solid waste incinerators and waste oil burners are regulated in Nunavut under the *Nunavut Public Health Act*, the *Nunavut Environmental Protection Act,* and the federal *Environmental Protection Act*. Performance limits for the incinerator at the Project will be in accordance with the emission guidelines set out by the Canadian Council of Ministers of the Environment. Ash produced from the incineration process will be disposed of in accordance with the *Nunavut Environmental Guideline for Industrial Waste Discharges*.

The Project will select and operate its incinerator based on Environment Canada's *Technical Document for Batch Waste Incineration*. In addition to incinerator technology, the implementation of a waste segregation program will limit emissions (e.g., dioxins and furans, mercury) from the incinerator.

A typical modern controlled-air, batch, dual chamber incinerator will be installed. Critical process parameters, such as temperature, combustion air flow, and burner output will be computer-controlled to maintain optimal combustion conditions. The incinerator will have an incineration capacity of approximately 1,500 kilograms per day to accommodate predicted volumes of waste to be generated at the site. It will be located in the waste management building[2] and operated by appropriately trained personnel.

Monitoring and testing is planned for incinerator stack emissions, waste oil/fuel to be burned in the incinerator, as well as incinerator ash.

To demonstrate conformity with performance limits, an annual incineration management report will be prepared and submitted as part of annual reporting to authorizing agencies. The quantity and type of materials incinerated on-site during operation, together with results from periodic stack

[2] Also known as the incinerator building.

emission and ash monitoring, will be included in the annual report. A report will also be provided, if necessary, to the National Pollutant Release Inventory. Finally, Agnico Eagle is committed to reporting greenhouse gas emissions in support of Canada's Voluntary Challenge Registry.

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TABLES

DOCUMENT CONTROL

Version	Date	Section	Page	Revision	Author
1	October 2012			First draft of the Incineration Management Plan	John Witteman, Env. Consultant, Agnico Eagle
2	March 2013			DEIS re-submission; rebranding	
3	April 2014	7.4.2	15	Revision made to address review comments and commitments	John Witteman, Env. Consultant, Agnico Eagle
4	April 2015			First version of Supporting Documents for Type A Water Licence Application, submitted to Nunavut Water Board for review	John Witteman, Env. Consultant, Agnico Eagle

ACRONYMS

Agnico Eagle	Agnico Eagle Mines Limited
CCME	Canadian Council of Ministers of the Environment
CEPA	*Canadian Environmental Protection Act*
CWS	Canada-Wide Standards
EC	Environment Canada
GN	Government of Nunavut
IMP	Incinerator Management Plan

SECTION 1 • INTRODUCTION

Agnico Eagle Mines Limited (Agnico Eagle) is developing the Meliadine Gold Project (Project), located approximately 25 kilometres (km) north of Rankin Inlet, and 80 km southwest of Chesterfield Inlet in the Kivalliq Region of Nunavut. Situated on the western shore of Hudson Bay, the Project site is located on a peninsula between the east, south, and west basins of Meliadine Lake (63°1'23.8'' N, 92°13'6.42"W), on Inuit Owned Lands. The Project is located within the Meliadine Lake watershed of the Wilson Water Management Area (Nunavut Water Regulations Schedule 4).

The mine plan proposes open pit and underground mining methods for the development of the Tiriganiaq gold deposit, with two open pits (Tiriganiaq Pit 1 and Tiriganiaq Pit 2) and one underground mine. The proposed mine will produce approximately 12.1 million tonnes (Mt) of ore, 31.8 Mt of waste rock, 7.4 Mt of overburden waste, and 12.1 Mt of tailings. There are four phases to the development of Tiriganiaq: just over 4 years construction (Q4 Year -5 to Year -1), 8 years mine operation (Year 1 to Year 8), 3 years closure (Year 9 to Year 11), and post-closure (Year 11 forwards).

Mining facilities include a plant site and accommodation buildings; three ore stockpiles; a temporary overburden stockpile; a tailings storage facility (TSF); three waste rock storage facilities (WRSFs); a water management system that includes collection ponds, water diversion channels, and retention dikes/berms; and a Water Treatment Plant (WTP).

This document presents the Incineration Management Plan (IMP) to support the Type A Water Licence application for the Project. The Plan is divided into the following components:

- introductory section (Section 1);
- background and objectives (Section 2);
- summary of the regulatory setting (Section 3);
- description of the performance limits of the incinerator (Section 4);
- summary description of the incinerator operations (Section 5);
- outline of the waste management processes (Section 6);
- description of the proposed monitoring and testing (Section 7); and
- overview of the proposed reporting to the authorizing agencies (Section 8).

The purpose of the Plan is to provide consolidated information on the specifications, operations, management, monitoring, and reporting of the incinerator process proposed for the Project. This Plan will be reviewed and updated on a regular basis to reflect changes to the Project.

1.1 Concordance with Project Guidelines

This document was developed under the Guidelines for the Preparation of an Environmental Impact Statement for Agnico Eagle Mines Limited's Meliadine Project (the Guidelines) issued by the

Nunavut Impact Review Board for the Project (NIRB 2012), and specifically those relating to the presentation of the IMP in Section 9.4.9 of the Guidelines. In addition this IMP has been developed to be consistent with the guidance provided in the Environment Canada's (EC) Technical Document for Batch Waste Incineration (EC 2010). It is one in a series of environmental management plans that have been prepared for the Project. All are included under the umbrella Environmental Management and Protection Plan.

1.2 Linkages to Other Management Plans

Documents included in the application package of this Type A Water Licence, which support this Plan include the:

- Environmental Management and Protection Plan;
- Landfill and Waste Management Plan;
- Hazardous Materials Management Plan; and
- Preliminary Closure and Reclamation Plan.

The Occupational Health and Safety Plan, submitted with the FEIS also supports this IMP (Agnico Eagle 2014).

SECTION 2.0 • BACKGROUND INFORMATION

At the Project site, all wastes will be safely managed from the time they are produced to their final disposal. All waste will be segregated at the proposed mine site and will predominately be landfilled, incinerated, or recycled. Used oil burning will be maximised as much as possible using the second chamber of the incinerator. Remaining wastes, including hazardous waste[3], will be packaged for shipment to a certified waste management facility for treatment, recycling, and/or disposal.

Incineration is an essential part of waste management at the proposed mine site. The incineration of acceptable solid waste from the accommodation complex, kitchen, lunch rooms, shops, warehouses, and offices will divert waste from directly reporting to the on-site landfill. It will have the advantage of eliminating putrescible waste that could potentially attract wildlife to the landfill, thereby reducing possible dangerous interactions between humans and wildlife.

The objectives of this IMP are summarized as follows:

1) To understand the quantity and composition of the waste to be generated at the proposed mine site, and separate waste acceptable for incineration from waste that is not;
2) To select the proper batch waste incinerator based on the characteristics and quantity of waste, and to locate it in an appropriate building away from other site infrastructure;
3) To properly equip and install the incinerator;
4) To operate the incinerator for optimal combustion, and avoid the formation of dioxins and furans in the combustion process;
5) To safely handle and dispose of incinerator residues; and
6) To establish a record keeping system for managing the facility and for future reporting.

As a component of the Project Environmental Management System, the IMP will be updated prior to mine operation and periodically thereafter to ensure that site experience is reflected in the IMP and subsequently communicated to all parties. The Project Environment Superintendent will be responsible for managing and implementing the IMP.

2.1 Incinerator Location

The incinerator will be located in its own building on the south end of the infrastructure pad, down-wind of other mine infrastructure. The incinerator building will have sufficient floor space to manage all Project wastes in one convenient location.

[3] Please refer to the Hazardous Materials Management Plan for further information on the handling and management of hazardous waste.

SECTION 3 • REGULATORY SETTING

Solid waste incinerators and waste oil burners are regulated in Nunavut under the *Nunavut Public Health Act*, the *Nunavut Environmental Protection Act,* and the federal *Environmental Protection Act*. Various regulations and guidelines under these Acts, as well as guidelines developed by the Canada Council of Ministers of the Environment (CCME), were reviewed in preparing the IMP. They are as follows:

- *Canadian Environmental Protection Act* (CEPA)
    - Schedule 1: List of Toxic Substances
    - *Interprovincial Movement of Hazardous Waste Regulations*
    - *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*
- EC Technical Document for Batch Waste Incineration (EC 2010)
- Canada-Wide Standard for Dioxins and Furans (CCME 2001a)
- Canada-Wide Standard for Mercury (CCME 2000)
- Northwest Territories *Environmental Protection Act*
    - *Used Oil and Waste Fuel Management Regulations*
- Nunavut *Environmental Protection Act*
    - Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities (GN 2011b)
    - Environmental Guideline for the Burning and Incineration of Solid Waste (GN 2012)
    - Environmental Guideline for Ambient Air Quality (GN 2011)
    - Environmental Guideline for Mercury-Containing Products and Waste Mercury (GN 2010)
- Nunavut *Public Health Act*

Provincial and/or territorial regulations that pertain to emissions from incinerators were not found for Nunavut or the Northwest Territories. Therefore, performance limits for the incinerator at the Project will be in accordance with the emission guidelines set out by the CCME: Canada-Wide Standard for Dioxins and Furans (CCME 2001a), and Canada-Wide Standards for Mercury Emissions (CCME 2000).

The management of used oil is regulated in the Northwest Territories through the *Used Oil and Waste Fuel Management Regulations* (NWT 2012; Reg. 064-2003). In the absence of Nunavut guidelines/regulations pertaining to used oil and waste fuel, the Northwest Territories regulations will be followed for the Project.

Ash produced from the incineration process will be disposed of in accordance with the Nunavut Environmental Guideline for Industrial Waste Discharges (GN 2014).

SECTION 4 • BACKGROUND INFORMATION

4.1 Dioxins and Furans

Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans, commonly known as dioxins and furans, are toxic, persistent, and bioaccumulative chemicals. Their presence in the environment results predominantly from human activity. The biggest source of dioxins and furans in Canada is the large-scale burning of municipal and medical waste. Other major sources include:

- the production of iron and steel;
- backyard burning of household waste, especially plastics;
- fuel burning, including diesel fuel and fuel for agricultural purposes and home heating;
- wood burning, especially if the wood has been chemically treated;
- electrical power generation; and
- tobacco smoke.

Due to their environmental persistence and capacity ability to accumulate in biological tissues, dioxins and furans are slated for virtual elimination under the CEPA, the Environment Canada Toxic Substances Management Policy (EC 2004) and the CCME *Policy Statement for the Management of Toxic Substances* (CCME 1998).

4.2 Mercury

Mercury is a naturally occurring substance, which can be transformed through biological processes to methyl mercury, a persistent substance which bioaccumulates in the food chain and is particularly toxic to humans and wildlife. Mercury levels originate from a combination of naturally-occurring mercury and anthropogenically emitted mercury, essentially through combustion processes. Under a variety of regional, national, bi-national, and internal programs, treaties and agreements, mercury is being targeted for emissions reductions consistent with the CCME *Policy Statement for the Management of Toxic Substances* (CCME 1998), which identifies that mercury shall be managed through its lifecycle to minimize release.

4.3 Used Oil and Waste Fuel

The following definitions are provided in the *Used Oil and Waste Fuel Management Regulations*.

Used oil: Any oil, including lubrication oil, hydraulic fluids, metal working fluid, and insulating fluid, that is unsuitable for its intended purpose due to the presence of impurities or the loss of original properties, but does not include waste oil derived from animal or vegetable fat, a petroleum product spilled on land or water, or waste from a petroleum refining operation.

Waste fuel: A flammable or combustible petroleum hydrocarbon, with or without additives, that is unsuitable for its intended purpose due to the presence of contaminants or the loss of original properties, and includes gasoline, diesel fuel, aviation fuel, kerosene, naphtha, and fuel oil, but does not include paint, solvent, or propane.

SECTION 5 • PERFORMANCE LIMITS

5.1 Incinerator Selection

The Project will select and operate its incinerator based on Environment Canada's *Technical Document for Batch Waste Incineration*. The incinerator for the Project will be similar to the one installed at Agnico Eagle's Meadowbank Gold Mine. The Meadowbank incinerator is a camp waste incinerator (model no. ECO 1.75TN 1P MS 60L) from Eco-Waste Solutions, which is in keeping with Environment Canada's technical document. The incinerator complies with the guidelines listed in Table 5-1, where the maximum emissions are expressed as a concentration in the exhaust gas exiting the facility's stack. The specifications of a potential incinerator are available in Appendix A. In addition to incinerator technology, the implementation of a waste segregation program will limit emissions of dioxins and furans, and mercury from the incinerator.

Table 5-1 Emission Regulations for Solid Waste Incinerators

Emissions	Sector	Guideline (max)[a]	Units	Reference
Dioxins and Furans	Municipal Solid Waste[b]	80	pg I-TEQ/Rm^3	CCME 2001a
Dioxins and Furans	Sewage Sludge Incineration	80	pg I-TEQ/Rm^3	CCME 2001a
Mercury	Municipal Waste	20	µg/Rm^3	CCME 2000
Mercury	Sewage Sludge Incineration	70	µg/Rm^3	CCME 2000

[a] Stack concentrations are corrected for 11% oxygen.

[b] According to the Canada-Wide Standards (CWS), "municipal solid waste" includes any waste that might be disposed of in a non-secure landfill site if not incinerated (i.e., non-hazardous wastes regardless of origin), but does not include "clean" wood waste.

Compliance to these performance limits will be confirmed by periodic stack testing, normally on an annual basis.

5.2 Used Oil and Waste Fuel

Agnico Eagle will manage used oil and waste fuel according to the *Used Oil and Waste Fuel Management Regulations* (NWT 2012) as presented in Table 5-2.

Table 5-2 Summary of Used Oil and Waste Fuel Regulations

Activity	Summary of Regulations
Registration	• Waste oil burner shall be registered with the Chief Environmental Protection Officer.
Disposal	• Used oil/waste fuel will not be disposed of directly into the environment.
Storage	• Used oil/waste fuel will be stored in specifically designed container for hydrocarbons to minimize the risk of spills; • Used oil/waste fuel containers will be periodically inspected for leaks or potential leaks; and • Used oil/waste fuel will be stored as per the Hazardous Materials Management Plan.

Sampling and Analysis	• A sample of one month's feedstock of used oil/waste fuel is required to be tested at least once a year;
	• Used oil/waste fuel will be tested for:
	  ◦ Flash point; and
	  ◦ Existence and amount of each impurity Listed in Table 5-3.

Burning	• Used oil/waste fuel will not be openly burned; • Used oil will not be burned in accommodation areas; • Used oil with a flash point of less than 37.7°C will not be burned or blended with another used oil/waste fuel; • Used oil that exceeds guidelines will not be burned; and • A 14-day notice will be given for the burning of waste fuel.

Records	• The following will be recorded in association with the incineration of used oil/waste fuel:
	  ◦ Volume of used oil/waste fuel generated;
	  ◦ Volume of used oil/waste fuel incinerated/consumed;
	  ◦ Name and address of person in charge, management or control of the used oil;
	  ◦ Location of production of used oil/waste fuel;
	  ◦ A summary of maintenance performed on used oil/waste fuel burners or processing equipment; and
	  ◦ Volume and nature of the products produced from the used oil.

Table 5-3 summarizes the maximum level of contaminants in used oil that can be incinerated as stipulated in the *Used Oil and Waste Fuel Management Regulations* (NWT 2012). Under the regulations blending of used oil that exceeds one of more of the criteria listed in Table 5-3 is not allowed.

Table 5-3 Used Oil Impurity Limit

Impurity	Maximum Level Allowed in Used Oil (ppm)
Cadmium	2
Chromium	10
Lead	100
Total Organic Halogens (as Chlorine)	1,000
Polychlorinated Biphenyls	2

5.3 Incinerator Ash

Provided the materials that go into the incinerator are controlled to exclude all hazardous materials, the incinerator ash should be non-hazardous. Even small quantities of hazardous waste, such as batteries, should not be mixed with waste to be incinerated. An ash testing protocol developed by the Government of Nunavut will be implemented to ensure that the incinerator ash is suitable for disposal in the landfill. Ash not meeting the guidelines will be packaged in drums to be sent to a certified waste management facility for appropriate treatment, recycling, and/or disposal, or will be buried within the dry stacked tailings.

SECTION 6 • INCINERATOR SPECIFICATIONS AND OPERATION

The Project will select a dual chamber, high-temperature incinerator as the primary incinerator. The technical specifications of one possible brand to be installed are included in Appendix A. The incinerator will be housed inside a separate building that will have sufficient floor space to manage all Project wastes in one convenient location.

6.1 Incinerator Specifications

Typical modern, controlled-air, batch, dual chamber incinerators are design using the principles of pyrolysis (starved-air burning condition) in the primary chamber and complete oxidation (high temperature, excess oxygen, and sufficient combustion time) in the secondary chamber. The incineration system will be a two-stage process. In the first stage, waste will be converted to gas in the primary chamber at approximately 650 to 850 degrees Celsius (°C). This process will be self fueling until the volume is reduced by 90 %. Gasses from the primary chamber will enter the secondary chamber of oxygen-rich and turbulent conditions, which is typically at a higher temperature – around 1,000°C. Combustion will be complete after a retention time of about two seconds. The temperature of combustion gases exiting the stack is anticipated to exceed 700°C and to flash cool in the ambient air, thereby leaving little opportunity for the *de novo* synthesis of dioxins/furans. Heat capture will not be used on the exhaust gases.

Critical process parameters, such as temperature, air flow, and burner output will be computer-controlled to maintain optimal combustion conditions.

For an incinerator capacity suitable for the predicted volumes of waste to be generated at the Project, the total particulate matter generated is expected to be extremely low. Therefore, dust collection technologies, such as baghouse filters, will not be necessary, as very minor amount of fly ash will be generated. Ash residues generated in the primary chamber will be manually removed on a daily basis using a shovel emptied into a metal bin.

6.1.1 Operation Procedures

General operating procedures for the incinerator will include:

1. Sort the waste on the basis of origin and heating value. Food waste and waste that has been in contact with food will have priority for incineration.
2. Mix the waste to ensure a calorific value within the incinerator's specification and to achieve good combustion inside the primary chamber.
3. The operator will observe the start of the burn cycle to ensure the incinerator is operating correctly.
4. The door to the incinerator will only be opened after the burn cycle is complete and the unit cooled.

5. The ash will be removed from the incinerator before it is charged with the next load of waste to be incinerated.
6. The ash will be placed in drums or bags before disposal.
7. The ash will be disposed of in the on-site landfill. If the concentration of trace metals exceeds the Government of Nunavut's *Environmental Guideline for Industrial Waste Discharges* (GN 2014), ash will be either packaged and sent to an approved disposal facility or buried in the dry stack tailings.

The system will have a sizable front door for easy access to manually load/feed waste into the unit with a front-end loader. The proposed waste streams will be layered wherever possible during loading to ensure proper combustion.

A full set of operating procedures specifying how to operate the incinerator will be developed in consultation with the supplier/manufacturer prior to its use, and its operation will be conducted in accordance with the EC *Technical Document for Batch Waste Incineration* (EC 2010).

6.1.2 Emissions

The incinerator to be purchased for the Project will be designed to meet performance limits described in Section 5.1. Good engineering practices will be used to ensure required incineration temperatures and dispersion of gases meet applicable air quality standards/guidelines.

The incinerator stack design will incorporate appropriate sampling ports, with caps where necessary, at appropriate locations to allow for stack testing to be undertaken during incinerator operation.

6.1.3 Dust/Odour Control Measures

Modern incinerators are commonly designed such that the non-turbulent atmosphere in the primary burn chamber reduces the formation of particulate matter. Therefore, the need for additional dust and/or odour control measures is not anticipated. Organic/putrescible wastes will be given incineration priority to limit odours.

6.1.4 Staffing and Equipment

The computerized incinerator will typically require one operator to interact with the equipment for approximately 1 to 1.5 hour per day, largely for ash removal, loading, and start-up. Operators are not typically required to be in attendance during the rest of the operation, as it is normally a fully automated process. The incinerator will be designed, installed and operated so that the operators are not exposed to high temperatures during loading or ash removal due to complete cool down after the burn cycle. Also, the waste will not be allowed to combust until the chamber is sealed thus isolating the worker from smoke and high temperatures.

6.1.5 Operator Training

Operator training will be provided by an experienced technician from the incinerator supplier/manufacturer or from an associated company. Special emphasis will be given to system safety including identification of hazards that the operator should recognize. Environment staff will be provided with training and record keeping protocols.

6.1.6 Inspections

Weekly inspections will be undertaken of the incinerator building for cleanliness and the proper management of wastes delivered to the facility. The Environment Department will carry out the inspections.

6.2 Used Oil and Waste Fuel

The incinerator will be able to efficiently burn used oil and waste fuel. A quantity of about 365,000 litres of used oil and waste fuel should be incinerated per year. The quantity of waste fuel is expected to be small and will be dependent on the adherence to standard operating procedures. The goal is to avoid practices that could result in waste fuel. The principal sources of the used oil will be from oil changes on the mining equipment and light vehicles, as well as oil changes to mechanical gearboxes within the mill. Typical used oil and waste fuel furnaces include a storage tank and a filter to recover sludge prior to burning. Sludge collected in the filters will be drummed and shipped, as needed, to a certified waste management facility for treatment, recycling, and/or disposal.

6.3 Shipboard Incinerator

See Section 8 of the Shipping Management Plan (Agnico Eagle 2014).

6.4 Closure Plan

In accordance with the Preliminary Closure and Reclamation Plan, salvageable buildings and surface structures, including the incinerator and waste management building, will be dismantled and demobilized from the site.

SECTION 7 • WASTE MANAGEMENT

The amount of waste will be reduced through purchasing policies that focus on reduced packaging. Reduce, reuse, and recycle initiatives as well as a waste segregation program will be developed at the Project as per the Landfill and Waste Management Plan to minimize the quantity of waste incinerated or directed to the landfill.

7.1 Approach

A waste segregation program will be implemented at the site. This will allow materials that are unsuitable for incineration to be either landfilled on-site or shipped off-site to a certified waste management facility for treatment, recycling, and/or disposal. The waste segregation program will document the quantities and types of materials that are incinerated.

7.2 Acceptable Waste for Incineration

Acceptable wastes for incineration will include the following:

- organic matter including food;
- food containers and wrappings, including plastics that are contaminated by food;
- medical waste from the Health Care Station;
- paper, cardboard, and the like;
- hydrocarbon spill absorbents;
- plastic and Styrofoam except plastic containing chlorine;
- dead animals; and
- used oils and waste fuel.

7.3 Unacceptable Waste for Incineration

Materials that are not listed above would be unacceptable for incineration. These materials include, but are not limited to:

- chlorinated plastics;
- inert materials, such as concrete, bricks, ceramics, ash;
- bulky materials such as machinery parts or large metal goods such as appliances;
- radioactive materials, such as smoke detectors;
- potentially explosive materials, such as propane tanks, other pressurized vessels, unused or ineffective explosives;
- hazardous materials such as organic chemicals (pesticides), other toxic substances (arsenic, cyanide);
- electronics;
- batteries;
- asbestos;

- dry wall;
- vehicles and machinery;
- fluorescent light bulbs;
- whole tires;
- paint and solvents;
- any materials containing mercury;
- used oil or waste fuel that exceeds the maximum impurity limits for parameters listed in Table 5-3;
- waste oil and waste fuel with a flash point of less than 37.7°C; and
- propane.

7.4 Waste Volumes

7.4.1 Solid Waste and Incinerator Ash

The number of people working on-site and the activities occurring at the time have a direct bearing on the volume of waste destined for the landfill, the incinerator, and the amount removed from waste streams for reuse and recycling.

It has been assumed that each person will produce 1 tonne of refuse per year[4]. Mean camp populations of approximately 200 during construction, 680 during operation, and 50 during closure have been estimated. Fifty percent of the refuse by weight can be incinerated thereby reducing the mass by 70 %. Thus for 680 workers, the annual quantity of ash during 8 years of operations would be about 105 tonnes. Table 7-1 estimates the annual tonnes of ash resulting from incineration for each project phase, based on the number of people on site, and cumulatively over the life of mine.

Table 7-1 Estimation of Ash over the Life of the Project

Project Phase	Workers On-Site	Annual Tonnes of Waste Incinerated	Annual Tonnes of Ash	Numbers of Years	Cumulative Tonnes of Ash
Construction	200	100	30	4	120
Operation	680	340	102	8	816
Closure	50	25	7.5	3	22.5
Total					**958.5**

Incinerator ash will be packaged in drums or sacks before being preferentially disposed of in the on-site landfill, thus eliminating any wind-blown effects.

[4] Environment Canada's "State of the Environment InfoBase", Environmental Indicator Series 2003 (http://www.ec.gc.ca), indicates that the per capita non-hazardous solid waste generation in 2000 for Canada was almost 1 tonne per person per year.

7.4.2 Used Oil and Waste Fuel

The quantity of used oil anticipated to be generated from the servicing of machinery at the Project was estimated to be approximately 365,000 litres per year (based incineration's maximum capacity of 1,000 litres per day).

The quantity of waste fuel is expected to be small but may vary between years.

7.5 Waste Incineration Rate

Due to the predicted volumes of waste to be generated at the site, the incinerator will have an approximate incineration capacity of 1,500 kilogram per day. If this cannot be achieved due to a lower volume of waste, the primary chamber could be used as storage of wastes until the desired volume is reached. This will primarily be wastes associated with food and small amount of medical waste. The batch cycle will be 6 to 10 hours for the burn cycle, followed by a cool-down of 6 to 8 hours.

SECTION 8 • MONITORING AND TESTING

The following presents the monitoring and testing plan for the incinerator.

8.1 Incinerator Emissions Testing

The incinerator stack design will incorporate appropriate sampling ports at appropriate locations, in right angle configuration, to allow for stack testing to be undertaken during incinerator operation. Table 8-1 summarizes the frequency of testing that will be completed as per relevant guidelines (see also CCME 2001b).

Table 8-1 Summary of Incinerator Emissions Testing

	Frequency	**Number of Test Required**	**Reference**
Dioxins and Furans	Annual	3	CCME 2001a
Mercury	Annual	3	CCME 2000

8.2 Used Oil/Waste Fuel Testing

A sample of feedstock of used oil/waste fuel will be collected each month with one of the monthly samples being tested each year. Used oil/waste fuel not meeting impurity limits or having a flash point less than 37.7°C will be drummed and shipped to a certified management facility for re-refining, treatment, recycling, and/or disposal.

8.3 Ash Testing

Upon commissioning of the new incinerator at the Project, an ash testing protocol will be implemented to ensure that the incinerator ash is suitable for disposal in the landfill.

Three ash samples will be collected (one per month for the first 3 months of the incinerator in operation) and the leachate tested for metals content. The samples will be compared to the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* (GN 2011b) presented in Table 8-2. Following the initial testing, ash samples will be collected and tested annually, or upon a significant change in the source or type of material sent to the incinerator.

If monitoring indicates the ash is above the guidelines and not suitable for landfilling, an investigation will be undertaken to identify the cause and eliminate the source for the exceedance. If deemed necessary, the ash will be packaged in drums and sent to a certified waste management facility for treatment, recycling, and/or disposal.

Table 8-2 Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities

Parameter	Maximum Concentration (mg/L)
Arsenic	2.5
Barium	100
Cadmium	0.5
Chromium	5
Lead	5
Mercury	0.1
Selenium	1
Silver	5
Zinc	5

SECTION 9 • REPORTING

To demonstrate conformity with performance limits, an annual incineration management report will be prepared and submitted as part of annual reporting to authorizing agencies. The quantity and type of materials incinerated on-site during operations, together with results from periodic stack emissions and ash monitoring, will be included in the annual report.

9.1 National Pollutant Release Inventory

The National Pollutant Release Inventory is a Canadian database containing information on the annual on-site release of specific substances to the air, water, and land from industrial and institutional sources (EC 2012). The National Pollutant Release Inventory provides a list of tracked substances and requirements for reporting incinerator emissions. Table 9-1 lists the substances under the National Pollutant Release Inventory that the Project expects to report annually. In addition, there are certain substances, as indicated in Table 9-1 that may require reporting depending on the quantity of incinerator emissions. Whether or not reporting is necessary will depend on results of periodic stack emission testing data and the quantity of annual emission calculated with emissions factors.

Table 9-1 National Pollutant Release Inventory Incineration Reportable Substance List

Substance	Note
Hexachlorobenzene	Required to report
Dioxins and Furans	
Carbon Monoxide	Required to report if released to air from facility in a quantity of 20 tonnes or more per annum
Oxides of Nitrogen	
Sulphur Dioxide	
Total Particulate Matter with diameter <100 microns	
Particulate matter with diameter less than or equal to 10 microns (PM_{10})	Required to report if released to air from facility in a quantity of 0.5 tonne or more per annum
Particulate matter with diameter less than or equal to 2.5 microns ($PM_{2.5}$)	Required to report if released to air from facility in a quantity of 0.3 tonne or more per annum

9.2 Greenhouse Gas Emissions and Global Warming

Agnico Eagle is committed to reporting greenhouse gas emissions in support of Canada's Voluntary Challenge Registry (currently termed the Canadian GHG Challenge Registry). Agnico Eagle will develop a baseline and monitoring system for greenhouse gas to evaluate and report on progress in improving efficiency and reductions in greenhouse gas.

SECTION 10 • PLAN REVIEW AND ADAPTIVE MANAGEMENT

The IMP will be updated regularly to reflect the operating conditions at the Project during construction, operation, and closure. The IMP will be reviewed annually by the Project Management team and an updated version will be produced every two years of operation at a minimum.

The up-to-date IMP will be made available by Agnico Eagle at all times for review by the Government of Nunavut, Water Licence Inspectors, and EC.

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APPENDIX A • TECHNICAL SPECIFICATIONS OF THE PROPOSED INCINERATOR

Eco Waste Solutions (EWS) Quotation

Technical Overview, Technical Specifications
& Itemized Budgetary Quotation
For Batch Incineration Equipment

Prepared for:
BBA

Agnico Eagle's
Meliadine Feasibility Project

Submitted by:
Eco Waste Solutions ("EWS")

Quotation No: AEM-ECO 1.5 TN1P 100L

BBA RFQ 5287063-PM0014/6509

Quotation Date: August 25, 2014

Eco Burn Inc.

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Eco Waste Solutions is a manufacturer of innovative point-of-need waste systems. Our mission is to provide robust, reliable, thoughtfully-designed equipment that is environmentally responsible. We foster a climate of energy and engagement within our team and with our clients; and we rely on procedures and practices that evolve with input from our clients and participation of employees in a continuous improvement effort.

Eco Waste Solutions' goal is to be a world leader in sustainable waste management solutions for our planet.

INCINERATION AND WASTE MANAGEMENT

Eco Waste Solutions (EWS) is a Canadian environmental technology company focused on point-of-need waste management solutions. **EWS** incineration systems offer a sustainable waste management alternative for projects in remote locations and regions that are ecologically sensitive, where proponents want to avoid the environmental legacy of a landfill or other traditional disposal methods used in the past.

Why is incineration often the best solution for point-of-need waste management?

- Landfilling of waste, without prior treatment, is no longer an acceptable practice for domestic waste management. Many countries have banned the practice of landfilling without recovering to the maximum extent possible and treating the residual while recovering valuable energy.
- The construction of a landfill is the creation of a permanent feature that requires on-going monitoring and management.
- With land disposal there is always a risk of material and/or microbes migrating from the landfill via wind, animal or bird movement, or water run-off causing contamination far from the site of disposal.
- Shipping material to other communities or sites for disposal is now viewed as pushing the problem onto someone else to deal with.
- Transportation is also heavily dependent upon fossil fuels, impacts the air and contributes to greenhouse gases – shipping waste long distances has a high environmental cost.
- The potential for contamination and liability is greatly increased once waste leaves the generator's site. Shipping material away from the creation point can be risky, if the material is mishandled or there is an accident the waste can pose an uncontrolled threat to the population and/or the environment

How does incineration offer a better solution?

- Processing waste at the point-of-need reduces transportation impacts and lowers the risk of contamination to waterways and/or the land.
- The ash residual, even with the presence of metal and glass containers, will represent less than 10% of the original volume of waste. The process includes a long and thorough burn down of the material to an ash residual that has minimal unburned carbon, is non-leaching and essentially inert.
- Waste materials are exposed to the required temperatures for destruction of disease causing pathogens, an important consideration in communities because of the risk of home care medical waste which often ends up in the landfill. Pathogen destruction makes incineration a suitable means for disposing of dewatered sewage sludge.
- Modern incineration with good control and high temperatures ensures that there will be no smoke and/or odour – a huge improvement over the uncontrolled burning that often occurs at landfills. Packages can be supplied with integrated air pollution control scrubbers guaranteed to meet the strictest standards in the world.
- Incineration is a fully commercialized and trusted method of waste disposal. Experimental technologies such as gasification will take many years before they are fully commercialized, dependable methods of waste disposal that a community can be relied upon for their long-term waste management needs.

ECO WASTE INCINERATION EQUIPMENT: RUGGED AND FIELD-PROVEN

A modern advanced technology incinerator, like the **Eco Waste Solutions** system proposed in this document, can be the basis of a pollution prevention approach to waste management for a remote mining operation.

Having an incinerator at the point-of-need allows for immediate and full control of the disposal of waste. This cost-effective waste management solution turns waste into non-toxic, non-leaching ash residual that will represent less than 10% of the original volume of waste prior to incineration.

The **Eco Waste Solutions (EWS)** standard equipment packages are well known to be high quality and extremely robust. In 1995, **EWS** began supplying equipment to the Canadian Department of Defence (DND). The first contract with the DND was at Canada Forces Station Alert, the northern-most inhabited place in the world. The equipment deployed to Alert in 1995 is still serving this remote military post today.

The expectation of military ruggedness was influential in the early **EWS** equipment designs and remains the construction standard used by **EWS** today. **EWS** products are noticeably more robust than traditional incinerators. Materials of construction most notably the steel shell, refractory lining, electrical and controls are more advanced and higher grade than is traditionally available. These factors are strongly correlated with equipment durability and lifespan; factors that have led to the strong following **EWS** has earned among its very demanding clients in the mining and military industries. Considerable R&D investment and continuous product improvement have led to a thoughtful design that is more practical and reliable in the field.

EWS also uses the latest in control technology including PLC (Programmable Logic Controller) computer-based system automation and the latest communication protocols.

Finally, one of **EWS'** most distinguishing features is the higher standard of environmental integrity inherent in its products. **EWS** has proven its environmental performance through more independent third-party testing and verification than any other incinerator manufacturer.

How is Eco Waste Solutions Technology different?

- Our industry-leading equipment with computerized automation and comprehensive monitoring has become the benchmark for many new regulatory requirements
- The automated operation of the system minimizes the need for a highly technical operator and constant operator input
- Customer feedback has been the basis for many of the advancements that our technology has over traditional equipment. The product has developed with a focus on ease of use, safety and reduced labor.
- EWS has a patented incineration process with unique process control that minimizes harmful emissions particularly Dioxins and Furans

DESIGN SPECIFICATION CRITERIA

Reference

Eco Waste Solutions (EWS) technical and commercial proposal, presented in this document, is based on information provided by, and in response to a Request for Quotation (RFQ) issued by **BBA** on behalf of **Agnico-Eagle Meliadine Division** dated August 18, 2014.

The Project

The **Meliadine Mining** property is located near the western shore of Hudson Bay in the Kivalliq region of Nunavut. It is about 25 km northwest of Rankin Inlet and 290 km southeast of Agnico-Eagle`s Meadowbank Mine.

Waste Description

As per the RFQ, specifically in the datasheet provided, the waste materials to be processed in the incinerator are described as follows:

Acceptable Solid Waste for Incineration	
	Organic matter (including food)
	Food containers and wrappings (including plastic that is not contaminated by food)
	Paper
	Wood
	Sewage sludge --- max: 200 kg/day
	Waste oils (shall be used as fuel) --- approx. 1000 l/day

Waste Quantity

The “capacity” criteria in the datasheet provided, stipulates that the incinerator be designed to process up to **1500 kilograms** of waste materials per day, which includes **200 kilograms** of sewage sludge. Additionally, the design criteria states that the incinerator be able to process up to **1000 litres** of waste oil per day.

EWS Waste Assumptions

One of the most critical waste characteristics to consider when designing the most appropriate incinerator package is the waste density of the material to be processed. With almost any disposal method, waste density has a serious impact on the sizing of the incineration system.

DESIGN SPECIFICATION CRITERIA (CONT..)

Based on the description of the waste material, provided in datasheet, EWS has made the following assumptions on the waste characteristics:

Table 3: EWS Assumptions on Waste Characteristics

Description	Total Moisture Content	Average Waste Density Range	Average Heat Value
Mixed Solid Camp Waste Material	Up to 45%	10-15 lbs/ft^3 160-240 kg/m^3	5000 BTU/lb 11655 KJ/kg

Also, EWS has made these additional assumptions and clarifications:

- The sewage sludge available for processing must be de-watered (25-30% solid content) prior to incineration
- The de-watered sewage sludge will be added onto a layer of other wastes and will comprise no more than 20% of the batch by weight
- The solid waste and de-watered sludge will need to be co-mingled to ensure that any wet low heat value waste is mixed with the other drier higher value materials.
- Regardless of recycling programs that may or may not be available, it is assumed that the waste materials described is typical of domestic solid waste and will include some plastic packaging and containers. The waste is expected to be bagged or stored in skips/bins around the mine operation then brought to the incinerator by truck.
- It is important to note that inappropriate materials including, but not limited to, reactive/explosive chemicals and items containing heavy metals will not be processed in the incinerator proposed herein.
- If waste audit data is available, it would be beneficial for EWS to review the details of the waste streams at site, to confirm all waste material is deemed acceptable for processing in the incinerator packages proposed herein. For now, this proposal and EWS recommendations are based on EWS assumptions from past experiences at other mine sites.
- Please see Document: **EWS Acceptable and Unacceptable Waste Stream**s, for more information on what waste materials are deemed appropriate for incineration

DESIGN SPECIFICATION CRITERIA (CONT..)

Addressing Waste Oil

To address the need of disposing the waste oils generated at site, EWS recommends the purchase of the **High Output Waste Oil Burner (HWOB) & Piping Package,** which is integrated as part of the incinerator package.

This HWOB can utilize the waste oils available on site and function as a fuel source to operate the incinerator system, in lieu of diesel. This packaged burner will not only dispose of the waste oils in an environmentally sound manner, but it will also decrease the daily operating costs of the waste incinerator system.

Both the Primary and Secondary Chamber will be equipped with a diesel-fired burner. The burner on the Primary Chamber is only used for heating up the chamber and igniting the waste. Once the waste is ignited, the diesel-fired burner turns off and the burning process is self-fueling. Most of the fuel usage is in the Secondary Chamber, therefore only the Secondary Chamber is equipped with a HWOB.

EWS PRODUCT SELECTION

ECO Model Batch Incineration Equipment

EWS offers a range of products to accommodate point-of-need waste disposal. These incinerator systems can be combined with other components, as required or mandated by local environmental regulations, such as weigh scales, building enclosures, air pollution control systems (scrubbers), continuous emissions monitoring systems, heat recovery features, etc.

Based on the given waste description, waste quantity and waste assumptions; EWS proposes the ECO Model, specifically the **ECO 1.5 TN 1P 100L** system to treat the solid and waste oils generated at this site.

The **ECO 1.5TN1P 100L** package is designed to process up to 1500 kilograms of solid waste which also includes 200 kilograms of de-watered sewage waste and is equipped with a **High Output Waste Oil Burner & Piping Package** for processing up to 1000 litres/day of used waste oils, as described previously.

ECO 1.5TN1P 100 L Incinerator Package

	ECO 1.5TN1P 100L
Maximum Incinerator Processing Rate of Solid Waste	Up to 1500 kg/day
Maximum Incinerator Processing Rate of Waste Oil	Up to 1000 litres/day (100 LPH) (during the burn cycle only)
Hours of operation	Burn Cycle: 6-10 hours Cool Down Cycle: 6-8 hours

ECO WASTE SOLUTIONS BATCH INCINERATION TECHNOLOGY

Main System Components

1. Primary Chamber
2. Secondary Chamber
3. Main Control Panel

COMPONENT	FUNCTIONAL OVERVIEW
Primary Chamber	In the first stage, a diesel fired burner is used to elevate the temperature of the **Primary Chamber** to ignite the waste. Once the Chamber reaches a temperature of approximately 650-850°C, the burn process becomes self-fuelling and the burner will shut off. To save fuel and control temperatures, only when the energy contained within the waste is depleted, will the burner periodically turn on. At these operating temperatures, waste is allowed to fully combust and is rendered sterile. Waste is reduced in volume by over 90%. Independent tests have shown that the residual ash is non-hazardous, non-leaching and essentially inert. After enduring the combustion process, metals and glass remain intact. Preservation of metals and glass not only protects the refractory lining from damage caused by melted and fused metals and glass, but also allows for post-combustion recycling where possible.
Secondary Chamber	As waste burns in the Primary Chamber, gases containing the products of combustion enter the high temperature zone of the **Secondary Chamber** for cleansing. The **Secondary Chamber** is sized to retain the incoming gases for a minimum of 2 seconds at 1000°C. This chamber utilizes a packaged, high output, fully modulating diesel burner to maintain the required temperature (even in the absence of energy input from the first stage which is important when processing wet or low energy waste such as food). This stage employs a large blower, tightly controlled by the control system using a variable frequency drive on the motor. The blower creates the turbulence required to mix the gases and oxygenate them. This fosters the high efficiency combustion required to break hydrocarbon chains into carbon dioxide and water vapour.
Main Control Panel	There is one **Main Control Panel** for the incinerator package that controls all of the interconnecting modules. The Operator has one simple interface to start the equipment, view system status and change control settings if required. The system utilizes a PLC (programmable logic controller) to automate its functions. Incinerator critical process parameters such as temperature, combustion airflow, burner output are operated using EWS' patented system control program to maintain optimal combustion.

EWS BATCH SYSTEM OPERATING PHILOSOPHY

It is recommended that a heated and insulated building enclosure (provided by others) be installed on site to house the incinerator system proposed herein.

Generally speaking there is no need for pre-sorting of the waste if source separation is practiced to keep inappropriate materials out of the waste feed. The system operates in a batch style. As proposed, the system includes a full size front door for easy access to load the waste manually. It is expected that each day the **Primary Chamber** will be loaded to design capacity or at a minimum, to half capacity. If waste quantities are not sufficient to operate the machine daily, it can be used to store the waste until requirement is met.

The use of a weigh scale to confirm daily throughput and for record keeping is recommended and included in this proposal in the basic package, as it is an **Environment Canada's Technical Document for Batch Incineration (March 2009)** ***compliant*** *accessory*. Other scales (sizes and types) are available and some have been included as optional items for purchase, should the buyer wish to upgrade or downgrade from the weigh scale selected in the basic package.

Once loading is complete, the door is sealed shut and the **Secondary Chamber** is fired. The system is interlocked so that **Primary Chamber** waste is not allowed to combust until the **Secondary Chamber** is at operating temperature. Once this occurs, usually within the first 30 minutes of the cycle, the **Primary Chamber** cycle is initiated. During this phase, gaseous products of combustion produced from the solid waste burning in the **Primary Chamber** are burned off in the highly oxygenated, turbulent environment of the **Secondary Chamber** for a minimum of 2 seconds at a temperature of 1000℃ to complete the combustion reaction.

Typically, the Operator only remains present to load waste and supervise the beginning of the process, generally the first hour of the burn, and then is no longer required to be at the incinerator. The system will complete the burn-cycle and cool-down phases automatically. Based on the waste quantity and description, the burn-cycle is expected to occur over 6 to 10 hours, but could be longer depending on waste characteristics, to allow for thorough burn down. The cool-down phase that automatically follows is generally 6 to 8 hours. At completion, the operator will then be able to open the **Primary Chamber** door and clean out the ash. This is generally performed the next day prior to loading the **Primary Chamber** with another day's waste.

As available, waste oils such as waste crankcase, hydraulic and other lubricating oils can be burned in the **Secondary Chamber** of the incinerator system by utilizing the integrated **High Output Waste Oil Burner & Piping Package**. The heat value of the waste oil is significant and can reduce the amount of virgin fuel when they are being processed greatly reducing the system's operating costs and solving another waste problem on-site.

The entire process will be controlled by the PLC in the **Main Control Panel**. All key operating parameters will be controlled to factory pre-set settings using the integrated PLC. For simplicity of operation, the **Main Control Panel** comes with a full colour touch-screen user interface. The Operator can see the status of all of critical components and visual alarms for any malfunctions. The software also allows for logging and recording of system data, including historical trends.

EWS TECHNICAL SPECIFICATIONS: ECO MODEL INCINERATION SYSTEM

INCINERATOR COMPONENT	DETAILS
General Overview	• Custom sized, two-stage, controlled air, batch style incineration system • Shop assembled as packaged unit (including pre-piping and pre-wiring) • Tested before shipment and knocked down for transport purposes • Designed with lifting lugs for installation and maintenance purposes
Primary Chamber	• One (1) chamber to hold entire waste load • Capacity of chamber: up to 1500 kg/day • Batch cycle time: 6-10 hours (burn cycle) and 6-8 hours (cool-down) • Operating temperature of 650℃ to 850℃ Includes: • Manifold with air inlets (ports) for combustion air and blower for cooling • Viewing ports to permit safe observation of the combustion process during the burn cycle • Large front loading door for convenient manual loading of waste and for manual ash removal
Secondary Chamber	• Completely separate vessel from the Primary Chamber to expose gaseous products of combustion to high temperature • Operates at 1000℃ with a retention time of 2 seconds Includes: • Manifold air inlet (ports) for combustion and cooling air with excess air blower • Viewing ports to permit safe observation of the process • Access door for maintenance purposes
Outer Shell/Casing	• 6 mm (1/4" steel) thick carbon steel refractory lined, sand blasted, primed, painted with rust-inhibiting and heat resistant paint • The casing plate temperature will not exceed 200℉ (93℃) during operation

INCINERATOR COMPONENT	DETAILS
Refractory Lining	Combination of durable, resilient refractories as follows: Primary Chamber • Walls (6" thick ceramic fiber blocks), this refractory is held in place with a minimum Type 310SS (stainless steel) anchors • Floors (6" thick reinforced castable refractory) Secondary Chamber • Walls (6" thick ceramic fiber blocks), this refractory is held in place with a minimum Type 310SS (stainless steel) anchors • 18" firebrick walkway
Exhaust Stack	• Mild steel ¼" welded steel refractory lined stack in flanged sections for ease of on-site erection • Self-supporting and designed for local climatic conditions • Includes spark arrestor
Diesel Burner Package	• UL/CSA approved • General: Forced draft, pressure-mechanical atomizing, with built-in blower to supply combustion air, complete with silencer and damper, oil pump driven by blower motor, complete with integral relief valve and filter, pressure gauge, high voltage ignition transformer. • Control: electronic combustion control relay with scanner to control combustion and to supervise flame. Control to shut off fuel within 5 seconds upon flame failure or upon signal of a safety interlock and to ensure, when restarted, in sequence, ignition and supervision of burner operation. Main burner in the Secondary Chamber is fully modulating. **Please see *Items by Others* in this proposal for other accessories to be considered and included with diesel day tank.**
Integrated High Output Waste Oil Burner & Piping Package	Packaged supplementary specialty fuel burner (UL/CSA approved) for processing waste oils at a rate of up to 100 litres per hour Includes: • waste oil pump with integrated oil pressure gauge, relief valve and filter, blower and burner air/fuel and temperature controller • Interconnecting piping to burner (maximum 15 feet total distance), includes suction line filter and check valve **Please see *Items by Others* in this proposal for other accessories to be considered and included with waste oil day tank.**

INCINERATOR COMPONENT	DETAILS
Blowers	• One (1) in Primary Chamber • One (1) in Secondary Chamber for Oxidation, VFD controlled • One (1) as part of High Output Waste Oil Burner & Piping Package
Main Control Panel	Main Control Panel with motor starters, overloads and breakers for all components is housed in a NEMA 4 enclosure**:** Features include: • Variable Frequency Drive (VFD) controls the Secondary Combustion Fan • Single point electrical connection • Emergency stop button Integrated Allen Bradley Programmable Logic Controller (PLC) automatically monitors the process, and controls the following functions: • Temperature control, air/fuel modulation, system interlocks • **Environment Canada's Technical Document for Batch Incineration (March 2009) compliant monitoring and data acquisition system**. Equipment includes temperature sensors (primary, secondary and stack), differential pressure sensors with transmitter, monitoring of burner functions, auxiliary burner operation and fan amperage monitoring via current transducer, door position interlock monitoring, high temperature limit and interlock, low fuel level limit and interlock, air proving switch interlocks and integrated weigh scale to record the weight of waste prior to incineration • PLC designed to allow for remote diagnostics of incinerator with Vendor during trouble shooting operations, if desired
4G Control System	Touch-Screen Operator Control Panel Display makes system start up and operation visual and intuitive. The display also allows the Operator to view operating parameters (settings and signal outputs) during operation. • Pre-installed with EWS' user friendly easy to understand graphics customized to reflect the package's unique configuration and components. • Screens include graphic representation of the equipment with status of all major components, display of alarms or system faults and data trending using historical charts • All system inputs above are recorded and logged for record-keeping purposes • Data acquisition system allows for historical trending of key operating conditions • Logged data can be transferred to storage device using USB port on panel for easy transfer to PC and printing of reports using excel or other windows based programs • The system automatically records operations and data port allows for data transfer of data for easy record-keeping. This feature is also useful in managing data for submission to regulatory bodies

<table>
<tr><th>INCINERATOR COMPONENT</th><th>DETAILS</th></tr>
<tr>
<td>Process Monitoring

Environment Canada's Technical Document for Batch Incineration (March 2009) compliant accessory</td>
<td>The continuous process monitoring of the listed parameters are part of EWS standard scope of supply and are at no additional cost and will comply with Environment Canada's Technical Document for Batch Incineration (March 2009) and Nunavut requirements:
<table>
<tr><th>ELEMENT</th><th>DETAIL</th></tr>
<tr><td>Base System Parameters</td><td>Continuous Process Monitoring Includes:
Primary Chamber, Secondary Chamber and Stack Temperature;
System Pressure and Draft</td></tr>
<tr><td>Analyzer Type</td><td>Temperature: Thermo Kinetics thermocouple
Pressure Transmitter: Dwyer transmitter</td></tr>
<tr><td>Measurement Sensitivity</td><td>Temperature range: -250^{O}C to 2,750^{O}C
Pressure range: -2" WC to 2" WC</td></tr>
<tr><td>Data Acquisition System</td><td>Integrated into the Allen Bradley PLC and logged internally and displayed in historical trending graphs.</td></tr>
</table>
</td>
</tr>
</table>

<table>
<tr><th>INCINERATOR COMPONENT</th><th>DETAILS</th></tr>
<tr><td>Continuous Emissions Monitoring System (CEMS)

Environmental Guideline for Burning and Incineration of Solid Waste compliant accessory</td><td>Nunavut Department of Environment “ Environmental Guideline for Burning and Incineration of Solid Waste” section 4.3 “Commercial Camps” lists the monitoring and control systems required as “key operational parameters must be monitored using on-line instruments capable of continuously measuring the combustion process and stack emissions quality.”

<table>
<tr><td>Base System Parameters</td><td>Measures Opacity</td></tr>
<tr><td>Compliance</td><td>EPA PS-1</td></tr>
<tr><td>General</td><td>• Flanged mounting to stack ports
• Transceiver/Reflector
• Local control panel (standard specifications available, other specifications may be available)
• Air purge assembly</td></tr>
<tr><td>Calibration</td><td>Calibration kit with 3 standards and carrying case included (on-site calibration or RATA by others)</td></tr>
<tr><td>Data Acquisition System</td><td>Signal outputs sent to the incinerator PLC for display on the local HMI.</td></tr>
</table></td></tr>
<tr><td>Integrated Weigh Scale

Environment Canada’s Technical Document for Batch Incineration (March 2009) compliant accessory</td><td>Environment Canada’s Technical Document for Batch Incineration (March 2009) compliant accessory for measuring the weight of waste materials charged to the incinerator. It is recommended that this device is installed near to the incinerator loading door. This can be in a small enclosure or the extra shipping container can be converted to allow for the scale to be installed inside.

Weighing can be accomplished in one of two ways:

1) Weigh Scale Option 1 - simple light-duty portable electronic bench scale. The Operator would be required to manually log and total the weights for record-keeping.

2) Weigh Scale Option 2 and 3 - heavy duty fully integrated electronic scale. The package will be integrated with the incinerator so that it automatically logs and totals the weight and signals a cut-off when the maximum weight of waste has been reached.</td></tr>
</table>

INCINERATOR COMPONENT	DETAILS
Integrated Weigh Scale (cont..) ***Environment Canada's Technical Document for Batch Incineration (March 2009)* compliant accessory**	**Note: <u>Option 2</u> is included in EWS Base Package already**

	Option 1	Option 2	Option 3
Weighing Platform	Above ground 2' x 2'	Low profile above ground 4' x 4'	Low profile above ground or in-ground mounting 4' x 4'
Capacity	1000 lbs	5000 lbs	
Material of Construction	Mild Steel platform and base (stainless steel available if required)		
Load Cells	Standard load cells	Hermetically sealed (protection from dust, dirt and liquids)	
Weight Indicator	Wall-mountable local indicator with IBN (Improved Black Pneumatic) display and IP69 enclosure (rated for temperatures from minus 10^{O}C to plus 50^{O}C).		
Integration	None	Includes an analog output module (4-20mA) to send signal to the incinerator PLC. System HMI will display weigh scale data and weights will be logged automatically along with other incinerator functional parameters described herein.	
Coping/bumper frame to protect scale from damage	N/A	N/A	Included
Self-Alignment	N/A	N/A	Self-aligning ball bearing suspension of scale

EWS DOCUMENTATION PACKAGE

The following list defines the EWS standard documentation package.

However, additional documentation can be provided but must be agreed upon and defined in the contract. Also, additional documentation may result in increased costs to the Buyer.

Also, if required, final drawings can be signed and stamped by Professional Engineer, at an additional cost to the Buyer.

DOCUMENT NAME	FORMAT	QUANTITY
Production Schedule*	Electronic PDF file	1
ISO Quality Plan*	Electronic PDF file	1
ISO Inspection & Test Plan	Electronic PDF file	1
Installation, Operation, Maintenance & Training Operator Manual	Hardcopy in 3-ring binder and files on a compact disc	2 binders, 2 CDs In English
Equipment Layout Drawing – General Arrangement* with weights and dimensions	Electronic PDF file	1
Itemized Spare Parts Lists (if purchased)	Electronic PDF file	
Piping & Instrument Diagram*	Electronic PDF file	1
Electrical Wiring Diagram	Electronic PDF file	1

Note: Items highlighted with (*) above are typically included in the preliminary documentation package which will be submitted to client at 2ARO (Two Weeks After Receipt of Order).

EWS ITEMIZED BUDGETARY PRICING – BASIC PACKAGE

Item	Description	Unit Price $CAD
1	**Eco Waste Oxidizer System Model: ECO 1.5TN 1P** • As per technical specifications given herein • Includes EWS Documentation Package given herein • Includes Domestic Packaging as described herein • The bracing of incinerator components within the container • Loading the container onto Purchaser's nominated transportation supplier	$475,000
2	**Continuous Emissions Monitoring System (CEMS)**	$26,250
3	**Start-up & Training Package** • 1 Technician, 7 days on-site for system installation check, system start-up and operator training • This is performed once assembly has been completed and photos have been provided to EWS • $1500 per additional day on-site	$12,500
	Basic Package, EX Works Burlington, ON	**$513,750**

EWS ITEMIZED BUDGETARY PRICING – OPTIONAL ITEMS FOR PURCHASE

Item	Description	Unit Price $CAD
1	**Recommended Commissioning Spare Parts Package**	$4,109
2	**Recommended Special Tools for Commissioning**	$6,150
3	**Recommended Operating Spare Parts Package for One (1) Year**	$36,029
4	**Recommended Capital Spare Parts Package**	$23,800
5	**Weigh Scale Options** **Note:** Option 2 is already included in EWS Total Equipment Package Price. Should client prefer to select Option 1 (a downgrade) or Option 3 (an upgrade) instead, EWS Total Equipment Package Price will be adjusted accordingly. Options are described on page 12 of this quotation	**Option 2**: Included in Total Basic Price **Option 1**: Reduce Total Basic Price by $2877 **Option 3**: Increase Total Basic Price by $510
6	**EWS Installation and Assembly Supervision Service Package** • 1 Technician on-site 5 days to supervise equipment installation and assembly performed by buyer's local trades people • $1500 per additional day on-site	$10,000
7	**Domestic Transportation from Burlington, Ontario to Port Becancour, Quebec** • 2 flatbed trucks • to ship one (1) x 40' container from EWS shop • to ship 2 incinerator chambers as bulk freight (tarped)	$8,500

EWS TECHNICAL ASSISTANCES RATES

In-field Service & Training Rate	Price ($CAD)	Description
Standard Rate	$1,500.00	per day for standard ten (10) hour day (Monday to Friday)
Overtime Rate	$225.00	per hour for weekdays (Monday to Friday) in excess of ten (10) hour per day
Non Working Days	$225.00	per hour for Saturday ten (10) hour day
	$300.00	per hour for Sunday or Holidays ten (10) hour day
Non Working Days Overtime Rate	$450.00	per hour for Saturday, Sunday or Holidays in excess of ten (10) hours per day
Travel Time	$650.00	per day Monday through Sunday
Travel Costs	TBD	Travel expenses charged out at cost + 10%
Factory Training & Assistance Rate	**Price ($CAD)**	**Description**
Standard Rate	$900.00	per day for standard eight (8) hour day (Monday to Friday)
Overtime Rate	$150.00	per hour for weekdays (Monday to Friday) in excess of eight (8) hour per day
Non Working Days	$150.00	per hour for Saturday eight (8) hour day
	$200.00	per hour for Sunday or Holidays eight (8) hour day
Non Working Days Overtime Rate	$250.00	per hour for Saturday, Sunday or Holidays in excess of eight (8) hours per day

EWS MAINTENANCE PACKAGES

EWS is committed to working with our customers to ensure that they have reliable, well-maintained equipment.

Therefore, we offer Maintenance Packages to help manage the total cost of ownership. Planned and budgeted service and maintenance costs are considerably less expensive and less difficult to manage than emergency repairs or impromptu service calls. The cost of a Maintenance service contract is generally outweighed by the costs of any downtime with unplanned emergency service calls.

With the purchase of a Maintenance Package we can also offer discounted technical assistance rates and training rates. For more details please request a quotation for an EWS Maintenance Package.

EWS QUOTATION TERMS

1. Equipment quotation valid for 90 days
2. Excludes all applicable taxes, duties and tariffs
3. Subject to change in the event of errors and/or omissions
4. Budgetary Pricing is estimated at +/- 15%
5. Spare Parts Packages are *estimated* within this proposal. Upon receipt of signed Purchase Order and after completion of in-house detailed, engineering, EWS will provide itemized list with accurate pricing.
6. Domestic Transportation cost is *budgetary* and only *estimated* at this time. Upon receipt of signed Purchase Order and after completion of in-house detailed engineering, EWS will provide accurate domestic shipping costs.
7. EWS requires the full technical and commercial specifications to confirm compliance with all requirements. Upon review of full technical and commercial specifications, EWS will provide a list of any applicable exceptions and clarifications.

ITEMS BY OTHERS: (not included in equipment price)

1. Site preparation (including concrete pad or other suitable level surface)
2. Off-loading and field-installation and assembly of incinerator
3. Building Enclosure for incinerator package
4. Fuel Tank and Waste Oil Tank
5. Piping & Fuel/waste oil delivery fillings systems
6. Electrical wiring and external conduit to the equipment to control panel from the Main Power feed
7. Final electrical terminations and power to junction boxes
8. low level switch to shut burner off when HWOB tank is empty
9. low level switch to shut burner off when diesel tank is empty
10. immersion hear in HWOB tank
11. stir mixer in HWOB tank
12. Applicable duties and/or taxes
13. Environmental permits, testing, bonding, local permits
14. Freight of equipment and materials to site, crane and forklift for off-loading equipment
15. Mobilization to and from Jobsite by EWS technicians (air travel, taxi etc.) and Room and Board on-site. To be billed separately.
16. Time for site specific safety orientation or other safety requirements such as Medical Exam (if required)

EWS PAYMENT TERMS

Eco Burn Inc. o/a Eco Waste Solutions manufactures equipment on a custom order basis. Therefore, the Schedule of Payments is as follows:

- 15% Upon submission of deliverable: Documentation of Drawing Descriptions and anticipated submittal dates
- 35% Upon documented verification of placement of orders for major equipment
- 40% Following Purchaser Inspection and readiness to ship from Eco Waste Solutions Facility (Burlington, Ontario)
- 10% Systems commissioning or 90 days after readiness to ship whichever comes first.

Payment Terms are Net 30 days from Owner receipt of a correct and compliant invoice with required supporting documentation confirming achievement of milestone, where applicable.

EWS DELIVERY

The ECO Model typically requires 20 weeks from receipt of Purchase Order (PO) and down payment.

EWS ENVIRONMENTAL PERFORMANCE

Eco Waste Solutions (EWS) is a leader in providing environmentally responsible waste management equipment. EWS has certified air emissions test data proving that the equipment can reproducibly achieve the CCME (Canadian Council of the Ministers of the Environment) CWS (Canada Wide Standards). These limits can be met using the incinerator package, proposed herein, when processing the described waste in accordance, with factory recommended operating procedures.

Therefore, EWS will guarantee compliance of the Incinerator Package with the CCME emission limits for Dioxins and Furans specifically:

Pollutant	Limit
Dioxins & Furans	80 pg/ Rm3 TEQ

The incinerator package proposed herein, will also **comply with all requirements** contained in *Environment Canada: Technical Document for Batch Waste Incineration (March 2009).*

Please see datasheet for EWS explanation under sub-section "Emission Criteria".

The waste types to be processed are considered non-hazardous and it is assumed that any/all hazardous waste materials including batteries will be eliminated from the incinerator waste stream. The waste types to be processed are typical of camp waste and should not include any heavy metals or other problematic compounds.

However, to avoid exhaust emissions containing Mercury, materials that may contain heavy metals such as batteries MUST be eliminated from the incinerator waste stream. It is important that waste segregation and tracking procedures are in place whenever waste is to be incinerated and meet the regulations specified. Heavy metals in the exhaust emissions are not controlled by incinerator design but rather by waste control practices.

Therefore, **NO guarantee** is included herein, for any METALS (Mercury, Arsenic, Cobalt, Chromium, Copper, Manganese, Nickel, Cadmium, Lead and Thallium). All metals have been left out of the scope of the guarantee as they are not controlled by the equipment but rather a function of the waste input. If waste is properly segregated emissions will be well below those given as limits.

Note: If these waste-streams containing heavy metals, cannot be avoided, *Air Pollution Control equipment (Scrubber)* must be added to the incinerator package (pricing for this additional equipment can be provided, upon request).

Regardless, to ensure a high standard of performance from the incinerator package, it is important that the following practices are followed;

- waste segregation and tracking procedures are in place whenever waste is to be incinerated,
- operators are properly trained and follow all recommended operating procedures
- incinerator equipment is properly maintained.

Ultimately, the incinerator system operator is responsible to ensure that the correct waste is processed; the equipment is properly operated and maintained, according to recommended schedules, to avoid causing unwanted air emissions.

EWS ENVIRONMENTAL PERFORMANCE (CONTINUED…)

Air Emission Performance Conditions

1. The owner / operator is responsible for preventative measures to eliminate any waste from being fed into the incinerator that contain heavy metals.

2. The owner / operator is responsible to ensure that waste treated is only as per specified.

3. The unit must be operated within the rated operating ranges according to instructions and ensuring that the incinerator is not overloaded.

4. The owner / operator will ensure that each chamber is not charged with any load weighing greater than stated capacity or 75-80% of the chamber's internal capacity by volume per burn cycle (as indicated by the lowest aspect of the opening of the of the breech, or the burner port of the Primary Chamber). The chamber volumes are calculated to provide enough space for the total weight at the assumed density in the area below the burner port

5. The owner and/or operators are responsible for installing and operating the unit according to the manufacturer's instructions.

6. Operator must not create excess air and particulate emissions by stoking of the waste bed during burning or continuous feeding. Both actions are not acceptable.

7. The owner / operator is responsible for ensuring the safe operation of the unit, according to procedures outlined in the owner's manual and including good housekeeping practices such as ash cleanout prior to re-loading the unit.

8. The unit must be maintained according to the Eco Waste Maintenance Schedule. This should be documented fully including evidence of parts replacement.

9. Modification, abuse or other impairment of the unit voids all warranties and equipment performance obligations by Eco Waste Solutions.

If these conditions are not met Eco Waste Solutions (EWS) cannot assure the performance of the unit as designed.

If air emissions testing is required, the testing procedure is to be mutually agreed upon and performance testing to be performed within 60 days of start-up or 120 days after shipment, whichever occurs first. In the event that testing is delayed beyond this period through no fault of EWS, EWS shall be relieved from all obligations.

In the event that the equipment does not meet the performance targets EWS has committed to, EWS has the option at its own expense to make adjustments or additions to the equipment, to ensure that compliance can be met. The performance testing fees for the services of a certified testing lab and any costs associated with the testing (rental of equipment, or provision of an Eco Waste Technician to be present at testing etc.) are not included with the price of equipment or services.

EQUIPMENT WARRANTY

Equipment Warranty

To the original Purchaser, **EWS** warrants that the products and parts manufactured by the Corporation and supplied hereunder shall be free from defective workmanship and material for a period of 18 months from notice of ready to ship or 12 months from start-up at Purchaser's site, whichever is less. **EWS**' warranty is limited to **EWS** supplying the Purchaser with parts F.O.B. Purchaser site, replacement of any product or parts which shall be proved to the Corporation to be defective, provided that the Purchaser gives notice in writing within three (3) days after defect discovery.

To provide all labour related to **EWS** manufactured / warranted parts for 18 months from notice of ready to ship or 12 months from start-up whichever is less. In the case where **EWS** has purchased components from other vendors or suppliers, warranty will be limited to providing, render reasonable assistance to Purchaser when requested, in order to enable Purchaser to enforce such warranties and guarantees by third party manufacturers suppliers.

Equipment Covered by Warranty

Equipment supplied under a purchase order to **EWS** including:

- Primary and Secondary Chamber
- Connecting ductwork between Primary and Secondary Chambers (Breech Sections) and the Stack Sections
- Controls – Manual, Electronic and Electric

Extent of Warranty Coverage

All costs related to the repair or replacement of system components where failure is due to defect in material, workmanship or design is covered by **EWS** for one year from the date of repair or replacement.

Replacement due to abuse, misuse, and/or lack of maintenance or carelessness is not covered. Wear from normal use, or alternative disposal costs are not covered.

There is no warranty on the following parts and/or any consumables:

- All burner flame-front parts
- Thermocouple elements + protection tubes
- Electrodes, photocells
- Gaskets, Seals and tubing
- Fuses, light bulbs and glass assemblies
- Nozzles, filters
- Refractory Surface Cracks*
- Tubing

*Note: Normal in high temperature applications

Warranty Provisions and Exceptions

EWS does not guarantee or warrant, either expressly or implied, the materials and workmanship of supplies, materials, equipment or machinery manufactured by third parties and furnished and installed by **EWS** (outside of the scope of this proposal) in the performance of the Work, to the extent such supplies, materials, and equipment or machinery is itself an end product with its own customary warranty.

EWS shall endeavor to obtain from all such vendors and suppliers and assign to Purchaser the customary warranties and guarantees of such vendors and suppliers with respect thereto. **EWS** shall, at the sole expense to Purchaser, render reasonable assistance to Purchaser when requested in order to enable Purchaser to enforce such warranties and guarantees by third party manufacturer's suppliers.

EWS will not be liable for any consequential damages, loss or expense arising from any change in or alteration to equipment of its manufacturer such changes or alterations having been made by any persons other than personnel of **EWS** or its agents, in which event such agents must have written permission of **EWS** prior to making such changes or alterations.

EWS shall in no event, be liable for consequential damages as a result of any breach of this agreement by or for any other reason. This warranty shall not apply to products or parts not manufactured by **EWS** or to equipment parts which shall be subject negligence, accident or improper control, improper operation, maintenance, storage, or damage or circumstances beyond the control of **EWS** or to other than normal use or service. Regarding parts of the equipment purchased by **EWS**, no warranty is made other than that offered by the original equipment manufacturer.

THE ABOVE ARE **EWS**' SOLE WARRANTIES, AND THE REMEDIES SET FORTH ABOVE CONSTITUTE PURCHASER'S EXCLUSIVE REMEDIES IN THE EVENT SUCH WARRANTIES ARE BREACHED. WITH RESPECT TO THE CONSTRUCTION AND MECHANICAL FUNCTION OF THE PRODUCTS, EWS MAKES NO OTHER WARRANTIES OF ANY KIND WHATEVER, AND THESE WARRANTIES ARE IN LIEU OF ALL OTHER WARRANTIES OR GUARANTEES, WRITTEN OR ORAL, STATUTORY, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION THE WARRANTY OF MERCHANTABILITY AND THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE.

Acceptable Waste-Streams

The **Eco Waste Solutions Waste Oxidizer** can process a range of waste materials. The following list has some of the potential waste streams that can be effectively processed in our system. This list is only a guide and should not be assumed to be an exhaustive list of materials. Please contact EWS for more details.

Acceptable Waste Materials Suitable for Processing in Eco Waste Solutions Technology

Solid Waste	Description	Origin
Food Waste	Food, food packaging and containers, plastic and paper waste from food preparation	Kitchen and dining areas
Domestic waste	General refuse such as paper, plastics, cans, bottles, cardboard, newsprint	Dormitory areas, recreation facilities, office areas, warehouse, plant and production facilities
Packaging	Cardboard boxes, paper, plastic containers, plastic film, styrofoam, poly-weave bags	Inbound supplies to all work areas.
Wood waste	Skids, pallets, crates, including wood materials contaminated with chemical residues from Cyanide or explosives	Construction activity, inbound supplies, reagent and chemical packaging.
Absorbents	Rags, wipes, spill cleanup materials	From all work areas
Filters – Air and Fluid	Filters coated with fine particles and trapped solids, saturated with water or fluids (glycol, lube oils, fuel)	From water treatment facility, or generated at point of maintenance of vehicles, machinery and equipment
Medical Waste	Bandages, dressings, gloves, swabs, syringes, sharps	Medical clinic or first aid centre
Tires & Rubbers	Tires, belts, hoses	From vehicles and equipment maintenance shop
Low-level radioactive waste[1]	Personal protective equipment (gloves, overalls, etc.), pallets, packaging, rags, construction debris that have come in contact with radioactive elements.	From maintenance activities, operations and construction activities
Liquid Waste[2]	**Description**	**Origin**
Glycol	Used antifreeze	From vehicles and equipment maintenance shop
Used Oils	Used lubricating and hydraulic oils, including synthetics	From vehicles and equipment maintenance shop
Semi-solid Waste[3]	**Description**	**Origin**
Sewage sludge	Dry filter cakes	From sewage treatment plant dewatering equipment
Kitchen grease, oils	Solid kitchen fats, grease, used cooking oil	Kitchen grease traps, fryers

Note: the following items require special features and handling please consult with EWS for details

1. Processing of radioactive materials requires the inclusion of an air pollution control system.
2. Glycol can be blended with waste oil (up to 5%) – only with optional upgraded waste oil burner package.
3. Dewatered sewage sludge and kitchen grease can be comingled with waste – restrictions apply.

ECO WASTE SOLUTIONS

Unacceptable Waste-Streams

The following is a list of some of the waste-streams that should not be processed in the Eco Waste Oxidizer. This list is only a guide and should not be assumed to be an exhaustive list of materials. Please contact EWS for more details and to discuss your specific waste processing requirements.

A waste and procurement audit is highly recommended and encouraged to ensure that all sources of heavy metals are identified and diverted to other disposal methods. Small amounts of materials containing heavy metals may be acceptable if air pollution control equipment specially designed for metals removal is included with the package.

Unacceptable Waste Materials - NOT Suitable for Processing in Eco Waste Solutions Technology

Solid Waste	Description	Origin
Bulky Materials	Automotive or heavy equipment parts such as engine blocks and transmissions	From vehicles and equipment maintenance shop
Non-Combustible Materials	Drywall, asbestos, bricks, concrete, soils	Construction activity
Radioactive Materials	Smoke detectors, laboratory wastes	From Buildings, laboratories
Potentially Explosive Materials	Aerosol spray cans, large propane tanks, other pressurized vessels. Actual explosives	From warehouse, plant and production facilities
Heavy Metals	Items containing lead, mercury, cadmium, for example: batteries, electronic devices, fittings, old pipe work, fluorescent light bulbs, electrical switches, thermometers, PVC plastics, aluminum solder, photovoltaic cells	From maintenance activities, operations and construction activities
Liquid Waste	**Description**	**Origin**
High Alkaline or High Acid Materials	By-products of industrial processes, unrefined fuels	From warehouse, plant and production facilities
Solvents	Solvents such as acetone, xylene, methanol	From vehicles and equipment maintenance shop

ECO WASTE SOLUTIONS

Project: Meliadine Feasibility Study
Project No.: 5287063 - PM0014/6509
ECO 1.5TN1P

Commissioning Spare Parts

Qty	Part	Part No.*	EWS Spare CAD	EWS Spare Total CAD	Approx Lead Time (Weeks)
Insulation					
3	Blanket Refractory (50 sq ft)	502614	$250.00	$750.00	2-3
2	Super 3000 Mortar	SM 3000	$89.00	$178.00	2-3
Primary burner - RL 28/2					
2	Filter	3003082	$30.00	$60.00	2-3
4	Nozzle	C5222445	$15.00	$60.00	1
4	High Temperature Leads	3012995	$17.00	$68.00	1
Secondary Burner - RL 130/M					
4	Nozzles Modulating	C5220111	$85.00	$340.00	1
4	High Temperature Leads	3012959	$25.00	$100.00	1
Burners - Primary & Secondary					
8	Electrode	3003796	$29.00	$232.00	1
4	PE Cell	3006216	$210.00	$840.00	2-3
High Output Waste Oil Burner					
4	O'rings	JXPL Viton Extension	$4.00	$16.00	2-4
4	Washers	JPL 316 SS Rear Washer	$33.00	$132.00	2-4
4	Gaskets	JPL 316 SS Gasket	$33.00	$132.00	2-4
Fuse					
3	Class J 600V 30 Amp fuse	LPJ-30SP	$18.00	$54.00	1
3	Class J 600V 15 Amp fuse	LPJ-15SP	$11.00	$33.00	1
6	Class J 600V 10 Amp fuse	LPJ-10SP	$11.00	$66.00	1
3	Class J 600V 6 Amp fuse	LPJ-6SP	$11.00	$33.00	1
1	Class J 600V 5 Amp Fuse	LPJ-5SP	$11.00	$11.00	1
1	Class RK1 250V 25 Amp fuse	LPN-RK-25SP	$7.00	$7.00	1
2	Class RK1 250V 15 Amp fuse	LPN-RK-15SP	$7.00	$14.00	1
1	Class RK1 250V 10 Amp fuse	LPN-RK-10SP	$7.00	$7.00	1
2	Class RK1 250V 6 Amp fuse	LPN-RK-6SP	$7.00	$14.00	1
1	Class RK1 250V 5 Amp fuse	LPN-RK-5SP	$7.00	$7.00	1
1	Class RK1 250V 2 Amp fuse	LPN-RK-2SP	$7.00	$7.00	1
2	Class RK1 250V 1 Amp fuse	LPN-RK-1SP	$7.00	$14.00	1
Miscellaneous					
2	Type K Thermocouple element	TK-K08B-010.0-000	$30.00	$60.00	2-4
2	Inconel Protection Tube 10"	MP-60140-08-10.0	$155.00	$310.00	2-4
100	Thermocouple Wire (m)	Type K	$5.00	$500.00	1
1	Air Proving Switch	SML 8221210034	$64.00	$64.00	2-4
		Total	**$1,185.00**	**$4,109.00**	

*Part numbers and pricing subject to change upon detailed engineering.

Operating Spare Parts for 1 Year Opeartion

Qty	Part	Part No.*	EWS Spare CAD	EWS Spare Total CAD	Approx Lead Time (Weeks)
Insulation					
8	Module Refractory (boxes)	433026	$385.00	$3,080.00	2-3
50	Door Gasket	462007	$24.00	$1,200.00	1
Primary Burner - RL 28/2					
1	Fan Motor	3012994	$450.00	$450.00	3-4
10	Nozzle	C5222445	$15.00	$150.00	1
10	Electrode	3003796	$29.00	$290.00	1
2	Diffuser Disc	3003791	$62.00	$124.00	2-3
1	Supply Tube	3003821	$24.00	$24.00	2-3
1	Return Tube	3003822	$19.00	$19.00	2-3
1	Oil Pump	3013027	$257.00	$257.00	3-4
10	HT Leads	3012995	$25.00	$250.00	1
1	U-Bolts	3003495	$28.00	$28.00	2-3
1	Support	3003813	$20.00	$20.00	2-3
1	Coil	3006767	$51.00	$51.00	2-3
2	End Cone	3003807	$119.00	$238.00	2-3
1	Shutter	3003805	$55.00	$55.00	2-3
1	Nozzle Holder	3003814	$49.00	$49.00	2-3
1	PE Cell	3006216	$205.00	$205.00	2-3
Secondary Burner - RL 130/M					
1	Fan Motor	3012943	$844.00	$844.00	3-4
10	Nozzle	C5220111	$59.00	$590.00	1
10	Electrode	3003796	$23.00	$230.00	1
2	Diffuser Disc	3012463	$96.00	$192.00	2-3
1	Supply Tube	3012470	$79.00	$79.00	2-3
1	Return Tube	3012471	$79.00	$79.00	2-3
1	Oil Pump	3006369	$749.00	$749.00	3-4
10	HT Leads	3012959	$23.00	$230.00	1
1	U-Bolts	3003495	$28.00	$28.00	2-3
1	Support	3012461	$71.00	$71.00	2-3
1	Coil	3006767	$51.00	$51.00	2-3
1	Pressure Switch	3012948	$253.00	$253.00	2-3
2	End Cone	3012469	$198.00	$396.00	2-3
1	Shutter	3003984	$87.00	$87.00	2-3
1	Connector (nozzle holder)	3012096	$597.00	$597.00	2-3
1	PE Cell	3006216	$205.00	$205.00	2-3
High Output Waste Oil Burner					
1	Safety Relief Valves	VJ-3R 30-100	$506.00	$506.00	1
1	Liquid Level Switch	FS301-01	$920.00	$920.00	1
1	Pressure Switch	B724T 30 psi	$1,125.00	$1,125.00	2-3
1	Temperature Switch	ARR1264	$620.00	$620.00	2-3
1	Oil Pressure Gauge	0-60 psi	$93.00	$93.00	2-3
1	Ball Valves	#3080	$38.00	$38.00	3-4
1	Flow Control Valve	1813-02A-K	$861.00	$861.00	1
1	Back Pressure Regulator	98H-45	$4,238.00	$4,238.00	2-3

*Part numbers and pricing subject to change upon detailed engineering.

ECO WASTE SOLUTIONS

Project: Meliadine Feasibility Study
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Operating Spare Parts

1	Regulator	1115-8	$178.00	$178.00	2-3
8	Air Tubes	4-3684-2	$290.00	$2,320.00	2-3
1	Air Tube & Nozzle Assembly	3-6076-2	$1,290.00	$1,290.00	2-3
1	Mounting & Tile Assembly	3-6668-2	$1,960.00	$1,960.00	2-3
1	Oil Tube	3-2515-1	$575.00	$575.00	2-3
1	Oil Nozzle	3-6088-1	$1,580.00	$1,580.00	2-4
Starters					
1	9 Amp IEC Contactor	100-C09D10	$66.00	$66.00	2-4
1	Auxiliary Contact Block	100-FA40	$51.00	$51.00	2-4
Overloads					
1	IEC solid state overload relay range 1- 5 a	193-EECB	$76.00	$76.00	1-2
Relays					
1	Relay	700-HK36A1	$18.00	$18.00	1-2
1	Relay	700-HN121	$12.00	$12.00	1-2
Switches					
2	Limit Switch	802T-A	$133.00	$266.00	1-2
PLC					
1	16 Point AC Input Card	1769-IA16	$374.00	$374.00	2-3
1	16 Point AC Output Card	1769-OW16	$574.00	$574.00	2-3
1	4 Channel Analog Input Card	1769-IF4	$646.00	$646.00	2-3
1	6 Channel Thermocouple Input Card	1769-IT6	$1,311.00	$1,311.00	2-3
1	8 Channel Analog Output Card	1769-0F4	$1,933.00	$1,933.00	2-3
Miscellaneous					
10	Type K Thermocouple element	TK-K08B-010.0-000	$30.00	$300.00	2-3
10	Inconel Protection Tube 10"	MP-60140-08-10.0	$155.00	$1,550.00	2-3
1	Draft Transmitter	616KD-00	$134.00	$134.00	2-3
3	Air Proving Switch	SML 8221210034	$64.00	$192.00	2-3
1	Modutrol	M9184D4009	$962.00	$962.00	2-3
1	Resistor Kit	0-20 mA	$1.00	$1.00	2-3
1	Modutrol Transformers	50017460-001	$88.00	$88.00	2-3
		Total	**$26,161.00**	**$36,029.00**	

*Part numbers and pricing subject to change upon detailed engineering.

ECO WASTE SOLUTIONS

Project: Meliadine Feasibility Study
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Captial Spares

Capital Spare Parts

Qty	Part	Part No.*	EWS Spare CAD	EWS Spare Total CAD	Approx Lead Time (Weeks)
Primary Burner RL 28/2					
1	Primary Oil Burner	RL 28/2	$3,400.00	$3,400.00	3-4
Secondary Burner - RL 130/M					
1	Secondary Oil Burner	RL 130/M	$7,610.00	$7,610.00	3-4
High Output Waste Oil Burner					
1	Gear Pump	3HB1131-5TE32	$2,900.00	$2,900.00	3-4
1	10Hp Motor	CT10-D36	$3,200.00	$3,200.00	2-3
PLC					
1	**PLC Power Supply**	1769-PA2	$680.00	$680.00	2-4
1	Processor	1769-L32	$3,701.00	$3,701.00	2-4
DC Power Supply					
1	24 VDC 1.3 Amp Power Supply	PS5R-SC24	$59.00	$59.00	1-2
Frequency Drives					
1	480 volt 3 H.P. V.F.D.	22A-D6P0N104	$2,250.00	$2,250.00	2-4
			Total	**$23,800.00**	

*Part numbers and pricing subject to change upon detailed engineering.

ECO WASTE SOLUTIONS

Project: Meliadine Feasibility Study
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Special Tools

Qty	Part	Part No.*	EWS Spare CAD	EWS Spare Total CAD	Approx Lead Time (Weeks)
1	Stud Gun	STMOD	$ 5,175.00	$ 5,175.00	4-5
1	Incinerator Clean Out Kit	ECSS2344	$ 975.00	$ 975.00	4-5
			Total	**$ 6,150.00**	

*Part numbers and pricing subject to change upon detailed engineering.

*Part numbers and pricing subject to change upon detailed engineering.

BBA

MELIADINE FEASABILITY STUDY

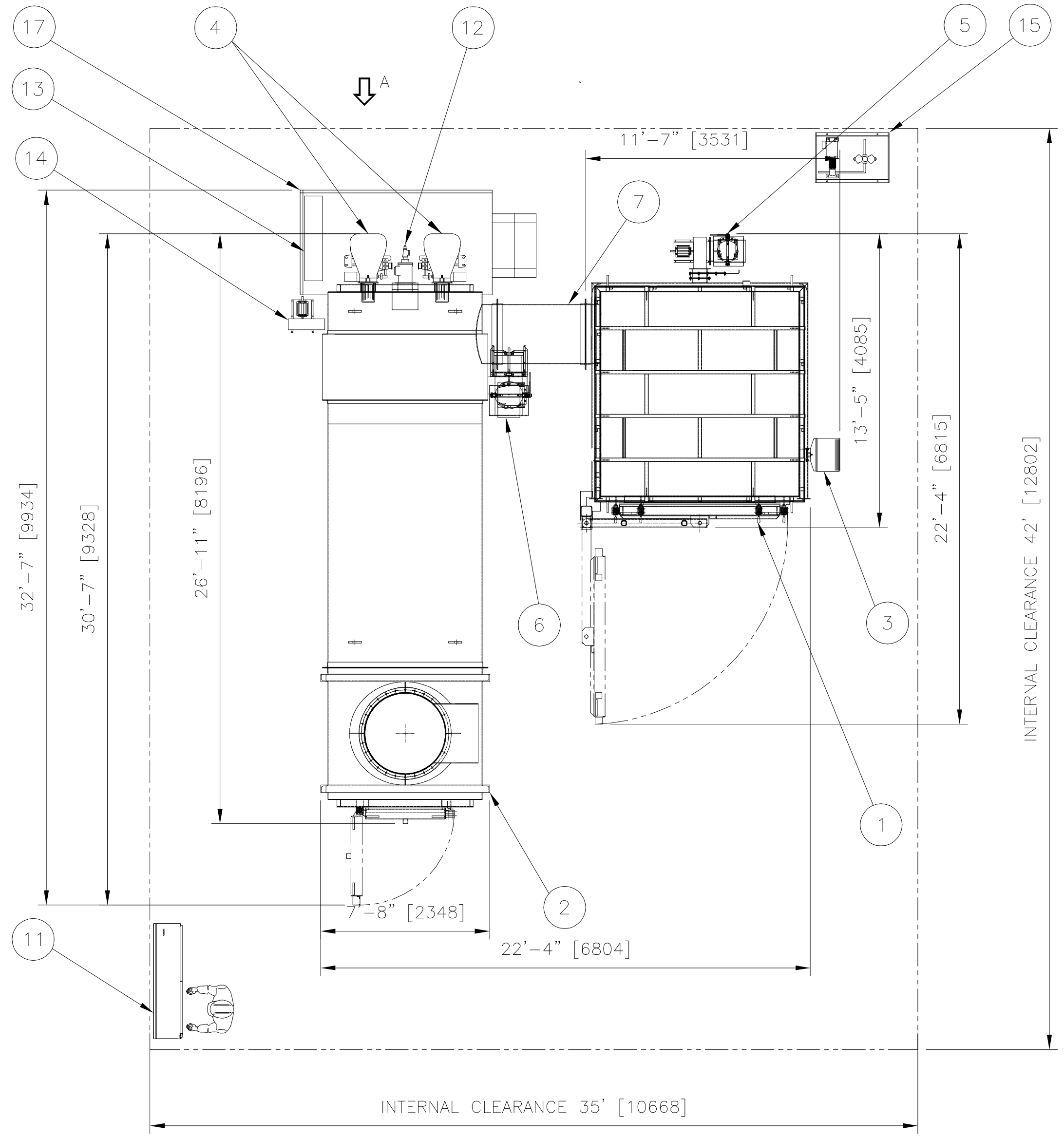
Technical Datasheet

Incinerator

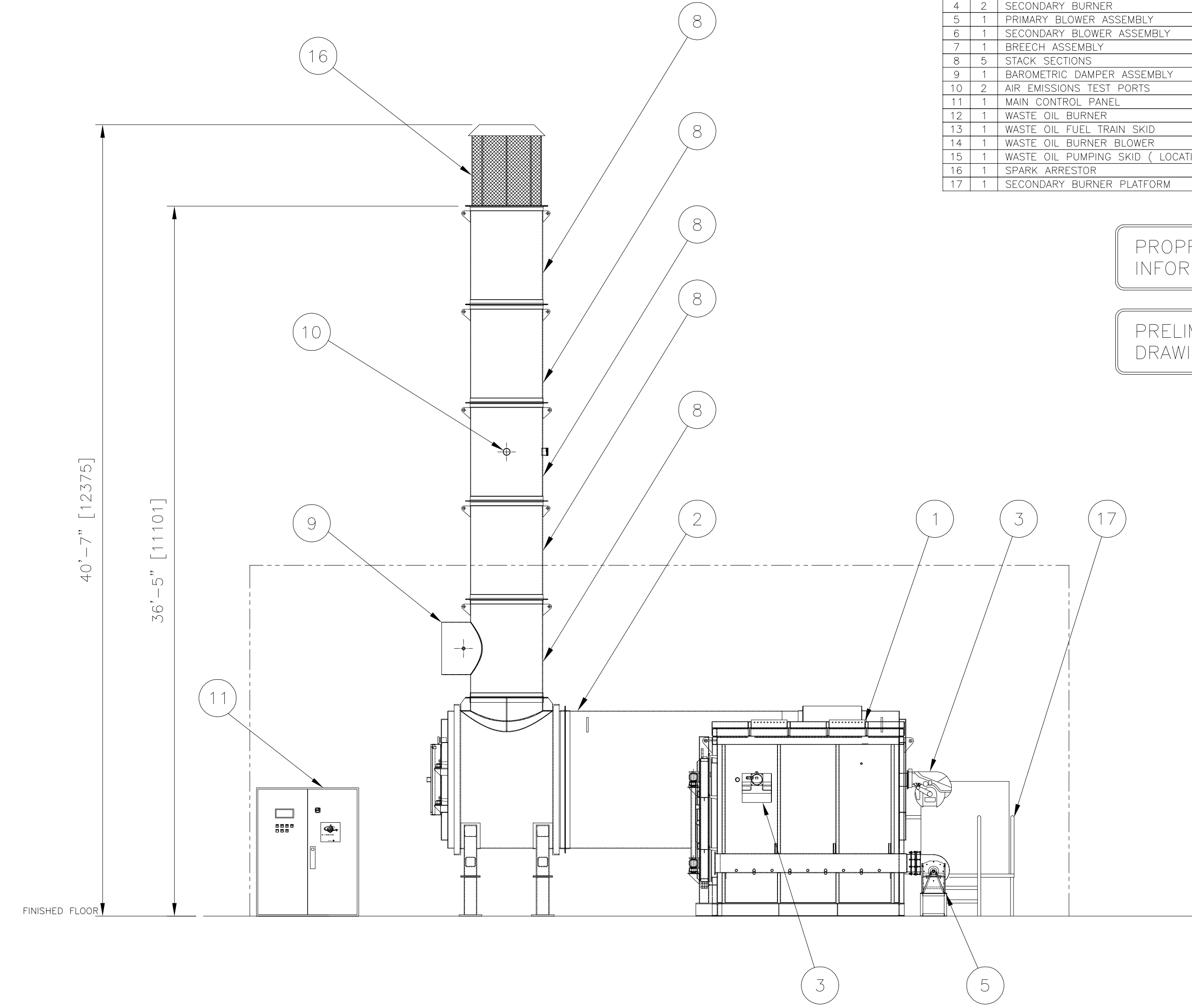
AGNICO EAGLE

	DESCRIPTION	UNITS	TECHNICAL DATA
Identification			
	Equipment name		Incinerator
	Equipment number		65FCA04001
General			
	Supplier		Eco Waste Solutions
	Manufacturer		Eco Waste Solutions
	Model number		ECO 1.5TN1P100L
Service Conditions			
	Location		Nunavut
	Altitude	m	62
	Design ambient temperature	℃	5 to 40 (inside building)
	Operation		7 days/week
Incinerator			
Design Criteria			
	Number of units		1
	Type		Dual Chamber
	Capacity	**kg / batch**	**1500**
	Productivity	batch / d	1
	Fuel type		Diesel, Winter Diesel and Waste Oils
	Primary chamber temperature	°C	~ 650 to 850
	Secondary chamber temperature	°C	> 1000
	Secondary chamber retention time	s	> 1
	Equipment weight	kg	24500
Acceptable Solid Waste for Incineration			
	Organic matter (including food)		
	Food containers and wrappings (including plastic that is not contaminated by food)		
	Paper		
	Wood		
	Sewage sludge --- max: 200 kg/day		
	Waste oils (shall be used as fuel) --- approx. 1000 l/day		
Components & Features			
	Refractory lining		EWS standard supply of refractory is a combination of durable resilient refractory (castable and ceramic modules) as this material is more reflective (thus saves fuel), cools down quickly and is not susceptible to thermal shock)
	Burners		Riello/ RL28/2, Riello/ RL100/M, Fives North American/6422
	Blowers		NY Blower/Junior 90, SWSI 15, Fives North American/CT10-D36T1SI
	Coupling & Guards		Shall be included
	Exhaust piping/stack system		Shall be included
	Stack		EWS standard supply for the stack is 1/4" mild steel welded and refractory lined - 11 m From Grate
	Spark arrester on incinerator stack		Shall be included
	Fuel supply system with day tank		Excluded
	Waste Oils day tank and supply system		Excluded
	Fuel train (including fuel control valve)		Shall be included (to FM standards)
	Paint		Heat resistant

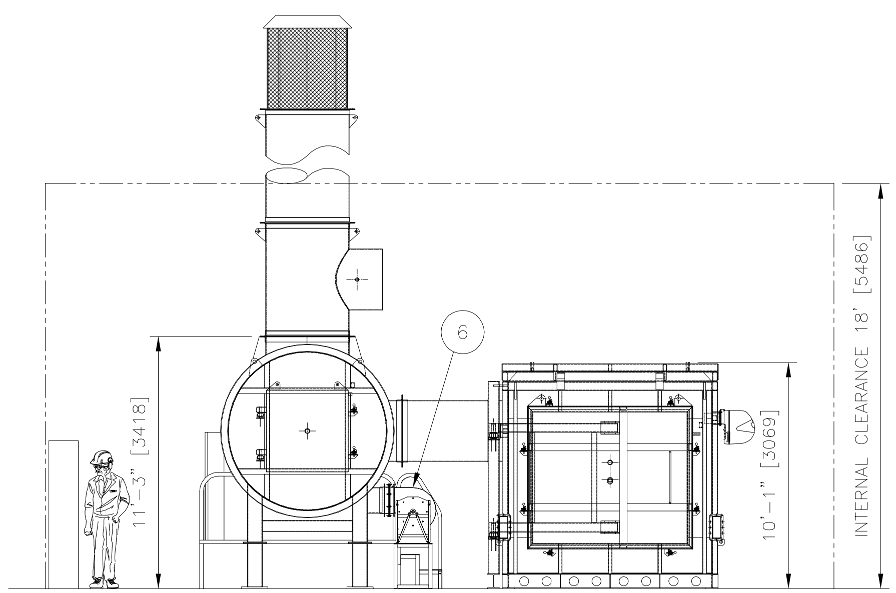
	DESCRIPTION	UNITS	TECHNICAL DATA
	Maintenance access doors		On each chamber there is an access door for maintenance purposes. The door on the Primary Chamber is used for loading material, removing ash and for maintenance purposes.
Emission Criteria (all emissions standardized at 11% O2)			
	Particulate matters	mg/Rm³	< 20 (the incinerator proposed can operate at this limit, however to provide an EWS Performance Guarantee, we recommend the purchase of an Air Pollution Control system to be integrated with the package.
	Dioxins & furans	pg / Rm³ TEQ	< 80
	Carbon monoxide (CO)	mg/Rm³	< 57
	NOx	mg/Rm³	< 500
	Opacity		< 5%
Electrical and Control Options			
	Power supply	V/ph/Hz	600 / 3 / 60
	Electrical load	kW	10.5
	Local control panel		NEMA 4
	Air/fuel modulation		Yes
	Temperature monitoring		Yes
	Temperature control system		Yes
	Safety shut-off on burner fail		Yes
	Monitoring /data acquisition system		Compliant with Environment Canada's Technical Document for Batch Incineration (March 2009). Please see document enclosed in EWS Submittal for full document.
	Remote I/O		EWS Standard Scope of Supply is a local control panel. All incinerator components are installed within 50' feet of the Main Control Panel. Buyer can use its Plant Control System to monitor the incinerator provided the exact same software is integrated (software purchase or upgrades may be required)
	Equipment operation		Local only



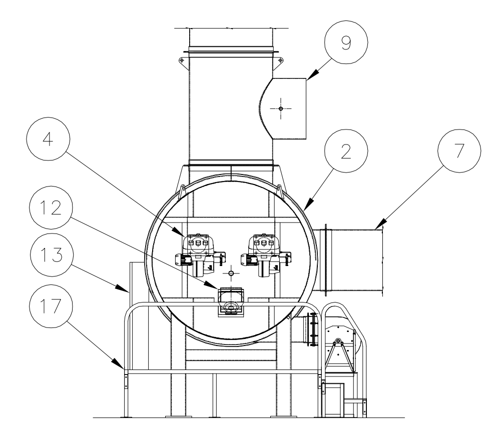
PLAN VIEW



RIGHT ELEVATION



FRONT ELEVATION



VIEW ON ⇨ A
(BACK VIEW)

BILL OF MATERIAL

ITEM	QTY.	DESCRIPTION	WEIGHT LB(Kg)
1	1	PRIMARY CHAMBER	22500(10206)
2	1	SECONDARY CHAMBER	18080(8200)
3	1	PRIMARY BURNER	88(40)
4	2	SECONDARY BURNER	176(80) x2
5	1	PRIMARY BLOWER ASSEMBLY	275(125)
6	1	SECONDARY BLOWER ASSEMBLY	551(250)
7	1	BREECH ASSEMBLY	1005(455)
8	5	STACK SECTIONS	1720(780) X5
9	1	BAROMETRIC DAMPER ASSEMBLY	480(218)
10	2	AIR EMISSIONS TEST PORTS	–
11	1	MAIN CONTROL PANEL	507(230)
12	1	WASTE OIL BURNER	–
13	1	WASTE OIL FUEL TRAIN SKID	–
14	1	WASTE OIL BURNER BLOWER	–
15	1	WASTE OIL PUMPING SKID (LOCATION TBD)	–
16	1	SPARK ARRESTOR	–
17	1	SECONDARY BURNER PLATFORM	–

PROPRIETARY INFORMATION

PRELIMINARY DRAWING

REV.	DATE	DESCRIPTION	BY	APPROVED

DRAWN: JX — DATE: 20 AUG 2014
CHECKED: KD — DATE: 21 AUG 2014

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: MELIADINE
CUSTOMER P.O.
PROJECT NUMBER:
CUSTOMER EQUIPMENT. # —

SCALE: 1:50
JOB NO.
TITLE: GENERAL ARRANGEMENT ECO 1.5TN1P100L
SH 1 OF 1
THIRD ANGLE
DWG. NO. ECO1.5TN1P100L-00
REV. A

Project Name: Meliadine Feasibility study

ECO WASTE SOLUTIONS

Estimated Shipping Dimensions Weights

ESTIMATED SHIPPING DIMENSIONS & W

SUPPLIER NAME: ECO WASTE SOLUTIONS

ITEM No.	ITEM DESCRIPTION	QUANTITY	EACH PIECE APPROXIMA					
			Length		Width		Height	
	ECO 1.5 TN 1P100L INCINERATOR	1						
1	Primary Chamber	1	12 3.6	FT M	10 3.2	FT M	10 3.07	FT M
2	Secondary Chamber	1	25 7.52	FT M	8 2.46	FT M	9 2.8	FT M
3	40' ISO Shipping Container, Including:	1	40	FT	8	FT	8	FT

ECO WASTE SOLUTIONS

EWS List of Incinerator Defaults Controls & Alarms

Incinerator's Default Controls:

1. Emergency Stop button (E-Stop)
2. Control Power On illuminated push button
3. HMI displays temperature readings, damper position, state(open-closed, on-off) of doors, blowers and burners.
4. HMI has Start / Stop push buttons for burn cycle and clear alarm button.
5. HMI displays historical logging of incinerator temperature.
6. HMI displays system alarms.

Default Alarms:

#	ALARM (System Fault)
1	The Primary Chamber Thermocouple is faulted
2	The Secondary Chamber thermocouple is faulted
3	The Secondary Stack Thermocouple is faulted
4	The primary burner is faulted
5	The secondary burner is faulted
6	The system has shut down due to primary blower low air flow.
7	The primary blower motor overload is tripped.
8	The system has shut down due to secondary blower low air flow
9	The Secondary blower variable frequency drive is faulted
10	Low burner fuel level

Environment Canada Environnement Canada

Technical Document for Batch Waste Incineration

Prepared for:

Environment Canada
Waste Reduction and Management Division

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Executive Summary

Incineration is recognized as an effective and environmentally sound disposal method for a wide range of wastes, and is used in facilities and jurisdictions across Canada. Waste generators located in remote areas may have limited options for cost-effective and environmentally sound waste management, and incineration may therefore be considered an appropriate waste management option. Remote commercial activities, such as exploration and development of natural resources, can create large volumes and varieties of wastes that must be managed appropriately. Residual wastes from industry, research activities, and the health care sector may require thermal treatment as an environmentally sound method to control the spread of disease from plants, animals or humans. Furthermore, there are certain locations in Canada where incinerating waste is an important means of avoiding potentially dangerous interactions between humans and wildlife. In all cases, reduction and diversion should be the primary waste management objectives, prior to considering any disposal option.

There are, however, some important potential environmental concerns associated with waste incineration that must be addressed through proper equipment selection, operation, maintenance and record keeping. These include potential releases of mercury, as well as dioxins and furans (PCDD/F), which are persistent organic pollutants (POPs). Mercury and POPs bio-accumulate in the environment and may cause adverse effects to human health and the environment. They can also be transported over long ranges; data from measurements in the North reveal concentrations far greater than what might be explained by local production. Dioxins/furans can be generated when inadequate incineration technology is used or when an incinerator is improperly operated. Mercury is not created in an incineration system; emissions are directly related to the presence of mercury in certain waste materials. Therefore, the best method to control mercury emissions is to limit the quantity of mercury in the waste fed to the incinerator.

The *Stockholm Convention on Persistent Organic Pollutants (POPs)* (which entered into force in May 2004 and to which Canada is a Party), identifies incineration as a potential source of POPs, and establishes a range of measures to reduce and, where feasible, eliminate their release. It also requires that the best available techniques (BAT) and best environmental practices (BEP) be applied for both new and substantially modified sources of POPs. Additionally, the Canadian Council of Ministers of the Environment (CCME) adopted the Canada-wide Standards for Dioxins and Furans in 2001, identifying incineration for action to reduce emissions, and adopting specific air emission standards. The CCME also adopted the Canada-wide Standards for Mercury Emissions in 2000 which include limits on mercury emissions from incinerators. Both mercury and dioxins/furans are on the List of Toxic Substances in Schedule 1 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999).

The Technical Document for Batch Waste Incineration was developed to provide guidance for owners and operators on proper system selection, operation, maintenance and record keeping, with the goals of achieving the intent of the Canada-wide Standards for dioxins/furans and mercury, and reducing releases of other toxic substances. The document includes:

- A discussion of the importance of reducing, reusing and recycling to divert wastes from disposal;
- Methods for the selection of appropriate incineration technologies to meet specific waste management requirements;

- Operational requirements that should allow batch incinerators to meet the intent of the Canada-wide Standards for dioxins/furans and mercury, and to reduce the release of other toxic substances; and
- Recommendations on record keeping and reporting.

This Technical Document focuses on minimizing dioxins/furans and mercury emissions from batch waste incinerator systems ranging in size from 50 kg to 3000 kg of waste/batch, the latter representing the largest batch incinerator currently in use in Canada. Batch waste incinerators are those that operate in a non-continuous manner (i.e. they are charged with waste prior to the initiation of the burn cycle, and the door remains closed until the ash has cooled inside the primary chamber). Air emission testing completed by Environment Canada in 2002 using a modern Canadian-built batch waste incinerator demonstrated that, when properly operated and maintained, these systems are capable of meeting the Canada-wide Standards for dioxins/furans (80 pg I-TEQ/Rm^3 @ 11% O_2) and mercury (20 μg/Rm^3 @ 11% O_2). Stack testing can be carried out as required by the regulatory authorities (e.g. federal, provincial/territorial) to verify that these standards are met.

The Technical Document recommends and describes a six-step process for batch waste incineration:

Step 1 – Understand Your Waste Stream

Step 2 – Select the Appropriate Incinerator (or Evaluate the Existing System)

Step 3 – Properly Equip and Install the Incinerator

Step 4 – Operate the Incinerator for Optimum Combustion

Step 5 – Safely Handle and Dispose of Incinerator Residues

Step 6 – Maintain Records and Report

This process will assist owners and operators of batch waste incinerators to achieve the intent of the Canada-wide Standards for dioxins/furans and mercury, and reduce the potential for releases of other toxic substances to the environment.

Overview of the Six-Step Process for Batch Waste Incineration

Step 1: Understand Your Waste Stream

The first step in managing waste is to understand the quantity and composition of the waste that is generated. A waste audit should be completed, where practical, to:

- Determine the quantity of waste generated in the various parts of an operation;
- Characterize the waste from each type of operation;
- Examine the waste stream to determine what opportunities exist for:
  - Reducing the quantity of waste generated;
  - Reusing materials; and
  - Recycling as much as possible before considering disposal.

Where waste audits are not practical, it is still necessary to develop an estimate of the waste quantities and characteristics before a strategy for waste diversion and disposal can be completed. Owners should investigate waste generation and diversion data from similar operations/facilities in order to estimate the waste types and quantities that will be generated at their own facilities. Sources of such information may include industry associations, waste industry consultants, provincial/territorial authorities and other regulatory bodies.

Based on the results of the waste audit/characterization, an assessment of appropriate disposal options should be undertaken. Where possible, disposal alternatives (other than incineration) for the residual waste stream (i.e. post 3Rs – Reduce, Reuse, Recycle) should be examined. When assessing disposal options, it is important to note that waste should neither be open-burned nor burned in a barrel. In both cases, the appropriate temperatures for a clean burn will not be achieved, and toxic contaminants, in particular dioxins and furans, will be released.

Step 2: Select the Appropriate Incinerator (or Evaluate the Existing System)

The characteristics of the residual waste stream destined for incineration should be incorporated into a call for proposals from incinerator manufacturers. Specifying the quantity and composition of the waste stream will ensure that proposals include suitable incinerators. It should be noted that incinerators built for a specific waste stream, such as animal carcasses, liquid wastes and hazardous wastes, are available and should be used as required.

For facilities with existing incinerators, owners/operators should reassess the suitability of the existing system to manage the current waste stream.

For facilities incinerating **more than 26 tonnes of waste per year,** dual chamber controlled air incinerators are the recommended configuration. These systems are capable of incinerating a wide range of wastes and, when properly maintained and operated, will achieve emissions of PCDD/F and mercury below the level of the Canada-wide Standards. These systems should be equipped with a large secondary chamber sized to provide a residence time of at least one second at a temperature higher than 1000^{O}C, to ensure complete combustion and minimize PCDD/F emissions.

For facilities incinerating **less than 26 tonnes of waste per year**, “determined efforts” as defined in the Canada-wide Standards for dioxins and furans[1] should be undertaken. Should circumstances restrict the ability to use a dual-chamber incinerator with a large secondary chamber, a single chamber incinerator with an afterburner should be used. It should be noted that such systems are less likely to be able to meet the emission standards than dual chamber incinerators.

Step 3: Properly Equip and Install the Incinerator

Building Considerations

- Incinerators should be installed inside a building to protect the equipment and the operators from weather conditions.
- In designing the installation site, care should be taken to maximize clearance between incinerator components, including the stack, and combustible construction materials.
- Insulation should be used to protect combustible building materials.
- The building should be equipped with sufficient fresh air inlet capacity for the incinerator. Both combustion air and dilution air for the barometric damper are required. Care should be taken to introduce air in a manner that does not lead to low-temperature operating problems.

Equipment Considerations

The incinerator system should come complete with the following equipment to monitor and record performance parameters:

- A scale to measure the weight of all materials charged to the incinerator; and
- A computerized process control and data acquisition system to store operating data from the incinerator.

Operational data should be collected and stored, at a minimum, every minute that the system is operating. The intent is to be able to summarize operating parameters during start-up, operation and cool-down for every cycle. If the required operating conditions are not achieved these data will allow the operators, the manufacturers and the regulator to identify the contributing factors for the failure. From this information, operating procedures can be adjusted to improve performance. Provisions should be made for the manufacturers to be able to remotely access and review the operating data for trouble shooting purposes.

It is highly recommended that batch incinerators not be equipped with heat recovery devices. The temperature of the stack gases in heat recovery systems will be lower than in systems without heat recovery, and may be in a temperature range that can lead to the formation of greater quantities of PCDD/F. Similarly, air pollution control systems are not recommended for batch waste incineration systems to control PCDD/F emissions. Stack gases should be released directly to the atmosphere at temperatures higher than 700^{O}C to reduce the chances of the inadvertent formation of PCDD/F through the *de novo* synthesis process.

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[1] Available on-line at: http://www.ccme.ca/ourwork/air.html?category_id=97

If it is necessary to introduce additional waste to the incinerator during the burn cycle, the incinerator should be equipped with a ram charge system to limit the disruption of combustion in the primary chamber during the waste charging process.

Step 4: Operate the Incinerator for Optimum Combustion

Operational Considerations

Wastes received at the incinerator building should be separated according to their heating value characteristics: wet or low-energy wastes (e.g. food waste); mixed wastes with average energy values; and other materials with high energy values, such as oily waste materials. To facilitate this separation, all waste should be collected in transparent bags. To further assist with separation, wastes could be collected in coloured-coded bags.

Batch incinerators are designed to accept wastes within a specified range of energy (i.e. calorific) values. The operator should select waste from each category and mix it to achieve the manufacturer's specified input calorific value. Each bag should be weighed, its source should be noted, and the total weight of each category should be tallied before completing the loading. This information should be recorded by the computerized data acquisition equipment installed with the incinerator. (Refer to step 6 for further record keeping requirements).

Batch incinerator systems have limited charging capacity (both in terms of waste quantity and the calorific value of the waste charge). To assist the operator with the charging task, particularly for smaller incinerators, several batches could be weighed and placed in their own containers prior to loading the incinerator. The same weighing and logging procedures should be used for each batch and, once recorded, the batch can be charged when appropriate.

When the incinerator is charged with the appropriate mix and quantity of waste, the operator should close the door, ensure all interlocks are engaged, and start the burn cycle. The operator should observe the burn for at least 15 minutes after ignition of the primary chamber burner to ensure the volatility of the waste charged is not creating too much gas for the secondary chamber to handle. The rate of combustion can be slowed by reducing the quantity of under-fired air. The primary chamber should be operated in the temperature range specified by the manufacturer (typically $500^{O}C$ to $800^{O}C$).

When satisfied that the burn is proceeding in a controlled manner, the operator may leave the incinerator area while the equipment completes the burn cycle.

The burn cycle should not be interrupted by opening the charging door until after the burn is complete and the unit has cooled down. No additional waste should be added to the primary chamber unless the incinerator is equipped with an appropriate ram feed device.

When the burn is complete and the unit has cooled, the operator should open the door only when wearing protective equipment such as gloves, dust mask, face shield and goggles.

The operator should remove the ash from the previous burn cycle before reloading the incinerator. Any unburned materials found in the ash should be recharged to the primary chamber after the operator has cleaned the air ports, and before putting a fresh charge into the incinerator.

Training Considerations

Operators should be properly trained by the incinerator manufacturer. The training course should include, as a minimum, the following elements:

- System safety including identification of hazards that the operator should recognize;
- Waste characterisation and how waste composition can affect operation;
- Loading limitations, including materials that should NOT be charged to the incinerator, and the allowable quantities of different types of wastes that can be charged;
- Start-up procedures for the incinerator and the normal operation cycle;
- Operation and adjustment of the incinerator to maximise performance;
- Clean out procedures at the end of the cycle;
- Troubleshooting procedures;
- Maintenance schedule; and
- Record keeping and reporting.

Managers should be involved in the training session so that continuity can be maintained with different operators.

Step 5: Safely Handle and Dispose of Incinerator Residues

Ash from the primary chamber of the incinerator can contain materials deleterious to the operator's health and the environment. Operators should use personal protective equipment when handling this material. The material should be carefully removed from the hearth and placed in covered metal containers suitable for transporting the ash to an approved disposal site. The operator should weigh, and maintain records of, the quantity of ash produced.

Step 6: Maintain Records and Report

To demonstrate appropriate operation and maintenance of the incinerator, the facility should maintain records and prepare an annual report containing at least the following information:

- A list of all staff who have been trained to operate the incinerator; type of training conducted and by whom; dates of the training; dates of any refresher courses;
- All preventative maintenance activities undertaken on the equipment;
- Records of operation of the incinerator - in electronic format with full data backup;
- Summarized annual auxiliary fuel usage;
- A list of all shipments of incinerator residues, including the weight transported and disposed of by type if necessary, and the location of the disposal site;
- Results of any emissions measurements or any ash sampling data collected during the period.

All raw data records from the operation of the incinerator should be retained for inspection by the appropriate authorities for the period designated by those authorities, or for at least 2 years. The owner should work with the incinerator manufacturer or supplier and the regulators to determine the appropriate level of summary data that should be sent to the regulatory body (e.g.

federal, provincial/territorial). The reports should be approved by the facility's senior management before submission.

1.0 Introduction

1.1 Purpose

This *Technical Document for Batch Waste Incineration* was developed to provide guidance for owners and operators of batch waste incinerators regarding proper system selection, operation, maintenance and record keeping, with the goals of assisting them in achieving the intent of the Canada-wide Standards (CWS) for dioxins/furans and mercury, and reducing releases of other toxic substances. This technical document focuses on batch waste incinerators ranging in size from 50 to 3,000 kg of waste/batch. Batch waste incinerators are those that operate in a non-continuous manner (i.e. they are charged with waste prior to the initiation of the burn cycle, and the door remains closed until the ash has cooled inside the primary chamber). Air emission testing completed by Environment Canada in 2002 using a modern Canadian-built batch waste incinerator revealed that, when properly operated and maintained, these systems are capable of meeting the CWS for dioxins/furans (80 pg I-TEQ/Rm^3 @ 11% O_2) and mercury. Stack testing can be carried out as required by the regulatory authorities in order to verify that these standards are met.

The document includes:

- A discussion on the importance of reducing, reusing and recycling to divert wastes from disposal;
- Methods for the selection of appropriate incineration technologies to meet specific waste management requirements;
- Operational requirements that should allow batch waste incinerators to meet the intent of the CWS for dioxins/furans and mercury, and to reduce the release of other toxic substances; and
- Recommendations on record keeping and reporting.

Owners and operators are advised to undertake a full review of relevant local legislation and consult with the appropriate regulators before proceeding with any waste management operation.

1.2 Background

Incineration is recognized as an effective and environmentally sound disposal method for a wide range of wastes, and is used in facilities and jurisdictions across Canada. Waste generators located in remote areas may have limited options for cost-effective and environmentally sound waste management, and incineration may therefore be considered an appropriate waste management option. Remote commercial activities, such as exploration and development of natural resources, can create large volumes and varieties of wastes that must be managed appropriately. Residual wastes from industry, research activities, and the health care sector may require thermal treatment as an environmentally sound method to control the spread of disease from plants, animals or humans. Furthermore, there are certain locations in Canada where incinerating waste is an important means of avoiding potentially dangerous interactions between humans and wildlife. In all cases, reduction and diversion should be the primary waste management objectives, prior to considering any disposal option.

This section provides background information on batch waste incineration, including: substances of concern; international and national initiatives; and provincial/territorial initiatives.

1.2.1 Substances of Concern

There are some important potential environmental concerns associated with waste incineration that can be addressed through proper equipment selection, operation, maintenance and record keeping. These include potential releases of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/F), which are persistent organic pollutants (POPs), and mercury.

Dioxins and Furans

Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDDD/F), commonly known as dioxins/furans (D/F), are toxic, persistent, bioaccumulative, and result predominantly from human activity.

Data from the measurement of dioxins/furans in the North shows that these chemicals are frequently found at concentrations far in excess of those that might be explained by local production. With the increased social and economic development in Canada's North, it is important to control these persistent chemicals.

Dioxins and furans can be generated from incomplete combustion resulting from the use of inadequate technology and/or operating the incinerator improperly.

Mercury

Another possible contaminant released from incinerators is mercury. Mercury bio-accumulates in the environment and, like POPs, is found in polar regions at higher concentrations than can be explained by local anthropogenic releases.

Mercury is not emitted from the incinerator unless items containing mercury are placed into the incinerator. The best method to control mercury releases is therefore to limit the amount of mercury in the waste fed to the incinerator.

1.2.2 International and National Initiatives

Over the years, Canada has participated in numerous initiatives to reduce dioxins and furans as well as mercury releases such as:

- Stockholm Convention on Persistent Organic Pollutants;
- CCME Policy for Management of Toxic Substances;
- Federal Toxics Substances Management Policy (TSMP),
- Canada Wide Standards for Dioxins and Furans;
- Canada Wide Standards for Mercury; and,
- Chemicals Management Plan.

Stockholm Convention on Persistent Organic Pollutants

Canada is a Party to the Stockholm Convention on Persistent Organic Pollutants (POPs), which entered into force in May 2004. The Stockholm Convention sets out a range of measures to reduce and, where feasible, eliminate POP releases[2].

Incineration was identified as a potential source of the POPs listed in Article 5 of the Stockholm Convention. Article 5 of the Convention requires Parties to take measures to reduce, and where feasible, eliminate releases of unintentionally produced POPs, including dioxins, furans, hexachlorobenzene (HCB) and dioxin-like polychlorinated biphenyls (PCBs) which are "*unintentionally formed and released from thermal processes involving organic matter and chlorine as a result of incomplete combustion or chemical reactions*".

Article 5 also requires that Best Available Techniques (BAT) and Best Environmental Practices (BEP) be applied for both new and substantially modified sources. "Best Available Techniques" are defined as using the most effective and advanced techniques that can be practically adopted to:

- *prevent or minimize* harmful emissions of by-product POPs and other environmental impacts; or,
- *reduce* by-product POPs releases to acceptable limits.

"Best Available Techniques" techniques can be applied by an operator to a specific facility since they have been developed to a state that they are economical and technically viable. Similarly, "best environmental practices" implies the application of the most appropriate combination of environmental control measures and strategies. Annex C states that for the purposes of the Convention there are a series of measures that are appropriate:

> *"Improvements in waste management with the aim of the cessation of open and other uncontrolled burning of wastes, including the burning of landfill sites. When considering proposals to construct new waste disposal facilities, consideration should be given to alternatives such as activities to minimize the generation of municipal and medical waste, including resource recovery, reuse, recycling, waste separation and promoting products that generate less waste."*

CCME Policy for Management of Toxic Substances and the Federal Toxics Substances Management Policy

Canada took steps to improve the management of POPs even before the Stockholm Convention was adopted. Polychlorinated dioxins-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) were designated as Track 1 substances and scheduled for virtual elimination from the Canadian environment under the 1995 federal *Toxic Substances Management Policy* [3] and the 1998 CCME *Policy for the Management of Toxic Substances*[4].

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[2] At the Conference of Plenipotentiaries on the Stockholm Convention on Persistent Organic Pollutants, held May 22 to 23 2001 in Stockholm, Sweden, the Convention was adopted and opened for Signature. It remained open for signature at the United Nations Headquarters, Treaty Section, in New York, until May 22, 2002. Available on-line at: http://chm.pops.int/

[3] Environment Canada, Toxic Substances Management Policy. 1995. Available at http://www.ec.gc.ca/toxics/TSMP/en/tsmp.pdf

[4] CCME, 1998. CCME Policy for the Management of Toxics Substances. January 29, 1998 Available at http://www.ccme.ca/assets/pdf/toxics_policy_e.pdf

PCDD/F are on the List of Toxic Substances in Schedule 1 of the *Canadian Environmental Protection Act, 1999*[5]

Under the federal 1995 *Toxic Substances Management Policy* and the 1998 *CCME Policy for Management of Toxic Substances*, mercury was designated as a Track 2 substance. As such, mercury must be managed through its life cycle to minimize releases. Mercury is on the List of Toxic Substances in Schedule 1 of the *Canadian Environmental Protection Act* (CEPA 1999).

Canada-wide Standards for Dioxins and Furans

The Canadian Council of Ministers of the Environment (CCME) examined the incidental release of dioxins and furans in emissions from various combustion systems. This led to the development of the *Canada-wide Standards for Dioxins and Furans*, which were adopted by the CCME in 2001. The standards identify incineration for action to reduce emissions, and include specific air emission standards.

In a 2007 review of the Dioxins and Furans Canada-wide Standards for waste incineration[6], a series of recommendations were made by the Dioxins and Furans Incineration Canada-wide Standards Review Group regarding batch incinerators in remote locations. These recommendations suggest that:

- The company/department should take appropriate measures to ensure good operation and provide adequate records of such operation;
- The company/department should only use incinerators that are equipped with monitoring equipment (temperature probes, differential pressure meters and auxiliary fuel flow) to ensure that proper operation is maintained. The monitoring equipment should be connected to a computer which will continuously log the data recorded;
- All installations should install weigh scales to record the weight of each load charged to the incinerator;
- All data from these systems should be available to inspectors;
- The computerized data acquisition equipment should be integrated with all the operating controls of the incinerator in a manner that would facilitate remote access to the data to enable the manufacturer to assist the operator with trouble shooting the operation;
- Operators should be trained, either through an appropriate site specific training program or through a certification program provided by a qualified body;
- Operators should be instructed to distinguish between broad categories of waste, in terms of their calorific value, and be given clear instructions on how much from each category is suitable for charging to the primary chamber for a given batch;
- All facilities should be required to file, with the appropriate regulatory authority, their annual waste throughput data. This filing should include details on the quantity and disposition of residues discharged from the facility.

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5 CEPA, 1999. Canadian Environmental Protection Act, 1999. 1999, c. 33 (Assented to September 14, 1999) Available at http://laws.justice.gc.ca/en/C-15.31/

6 Chandler, A.J., 2007. Review of Dioxins and Furans from Incineration In Support of a Canada-wide Standard Review A Report Prepared forThe Dioxins and Furans Incineration Review Group through a contract associated with CCME Project #390-2007. Available at: http://www.ccme.ca/assets/pdf/1395_d_f_review_chandler_e.pdf

Canada-wide Standards for Mercury

The Canada Wide Standards for Mercury Emissions were adopted in 2000 in order to reduce atmospheric emissions derived from both deliberate use of mercury and from incidental releases of mercury[7]. The standards include limits for mercury emissions from waste incinerators.

The Mercury Containing Product Stewardship: Manual for Federal Facilities[8] provides useful information on how to develop an inventory of mercury within a facility, reducing mercury through life-cycle management practices, and monitoring and reporting on mercury stewardship activities.

Chemicals Management Plan

Canada's efforts to improve the environment have also led to new measures under the Chemicals Management Plan (CMP)[9], which was first brought forward in 2006. The CMP develops measures to better protect human health and the environment from the risks posed by chemical substances. Since CEPA was adopted, all new chemicals have received rigorous pre-market assessments; however, approximately 23,000 "legacy" chemicals were in use in Canada before CEPA came into effect. The CMP identified a list of 193 substances as priority for action. Industry is required to provide Environment Canada and Health Canada with information regarding these substances on a quarterly basis within the next three years. The information that is received, along with that gathered from other sources, will be assessed and used to decide, if necessary, the appropriate actions required to protect the health of Canadians and the environment.

The Waste Sector has been identified as a sector under the CMP due to potential releases to the environment from incinerators and landfills.

1.2.3 Provincial / Territorial Initiatives

The CWS for both dioxins/furans and mercury have been incorporated into regulations related to new incinerators in various provinces. One example is the Ontario Guideline A-7[10] which incorporated the CWS emission values for new incinerators shortly after they were adopted and Guideline A-7[11] which clarified the approach for existing facilities in 2004. In many cases, the adoption of the CWS by provincial regulators has resulted in the closure of older incineration facilities. Some facilities have been upgraded to meet the new standards.

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7 Canadian Council of Ministers of the Environment (CCME). Canada-Wide Standard for Mercury Emissions, 2000. Available at: http://www.ccme

8 Mercury-containing Product Stewardship: Manual for Federal Facilities. (2004). Environment Canada. Available at http://www.ec.gc.ca/Mercury/ffmis-simif/Manual/index.aspx?lang=E

9 Chemicals Management Plan (CMP), 2006 Notice of intent to develop and implement measures to assess and manage the risks posed by certain substances to the health of Canadians and their environment. Under the *Canadian Environmental Protection Act*, 1999. http://www.chemicalsubstanceschimiques.gc.ca/en/index.html

10 Ontario Ministry of the Environment, 2004. GUIDELINE A-7 Combustion and Air Pollution Control Requirements for New Municipal Waste Incinerators. Legislative Authority: *Environmental Protection Act*, Part V, Section 27, and Part II, Section 9. Last revision February, 2004. Available at: http://www.ene.gov.on.ca/envision/gp/1746e.pdf

11 Ontario Ministry of the Environment, 2004. GUIDELINE A-8 Guideline for the Implementation of Canada-wide Standards for Emissions of Mercury and of Dioxins and Furans and Monitoring and Reporting Requirements for Municipal Waste Incinerators Biomedical Waste Incinerators Sewage Sludge Incinerators Hazardous Waste Incinerators Steel Manufacturing Electric Arc Furnaces Iron Sintering Plants. Legislative Authority: *Environmental Protection Act*, Part V, Section 27, and Part II, Section 9, August 19, 2004. Available at: http://www.ene.gov.on.ca/envision/gp/4450e.pdf

2.0 The Waste Incineration Process

This section provides background information on the waste incineration process in order to provide a basis for understanding the recommendations contained later in the report. This chapter discusses: controlling combustion and emissions; waste incineration technologies; and, general design and operation considerations.

2.1 Controlling Combustion

2.1.1 Overview of the Waste Incineration Process

Gases, liquids and solids containing carbon and hydrogen can be burned. The way each state of matter burns is different. In the context of this document, waste being incinerated is mostly in solid form as opposed to a liquid or a gas.

Most solid fuels contain both volatile materials and fixed carbon. During combustion, two different processes occur: the gaseous volatile materials are released and oxidised; and, the fixed carbon is oxidised.

In the first process, the volatile materials are released by pyrolysis reactions that convert the waste into gases consisting of hydrogen, carbon monoxide (CO), light hydrocarbons and tars. Once released in the high temperature environment, the hydrogen reacts instantaneously with oxygen to form water vapour. The CO oxidises to form carbon dioxide (CO_2) at a slightly slower rate. The hydrocarbons and tars react to form hydrogen and carbon, which in turn are oxidised. The gaseous reactions require oxygen and an elevated temperature. If the gases and the air are not well mixed some of the reactions do not go to completion and tars and other products of incomplete combustion, such as dioxins/furans, can also be released to the flue. Under these circumstances, the stack gases will be cooler and tars and other products of incomplete combustion will condense on the flue walls as soot or tar deposits.

In the second process, the remaining fixed carbon oxidizes and releases CO. This reaction takes longer than the release of the volatile materials because oxygen must diffuse to the material's surface where it can react. The rate of this reaction is proportional to the exposed surface area available.

Throughout the combustion process, the oxidation of CO to CO_2 occurs through reactions with hydroxyl (OH) radicals. If excessive air is present in the combustion zone, the combustion temperature and the concentration of hydroxyl radicals will be reduced and the CO oxidation reaction will be inhibited. This results in elevated concentrations of CO in the exhaust gases. Insufficient air can also lead to high CO concentration because there will be insufficient oxygen to oxidise the CO.

The burning of waste in an incinerator is essentially a rapid oxidation process that generates heat and converts the waste to the gaseous products of combustion, namely carbon dioxide and water vapour, which are released to the atmosphere. At the end of the burning process, there may be residual materials and ash that cannot burn.

2.1.2 Controlling Combustion

Controlling combustion during the waste incineration process is very important for in order to minimize the formation and release of products of incomplete combustion such as dioxins and furans. The intent is to ensure that the combustion process is as complete as possible, yielding residues with little carbon, and stack gases containing only carbon dioxide and water vapour.

Solid waste is generally characterized as heterogeneous, with materials that burn at different rates. The rate of burning is determined by the amount of air added to the waste. When burning waste in a well designed incinerator, air flows are controlled to ensure high temperatures and a clean burn.

Burning is an oxidation reaction that requires a precise amount of oxygen to mix with the material being burned. This is termed the stoichiometric oxygen requirement. There must be just enough oxygen molecules to combine with the carbon and hydrogen from the waste to create carbon dioxide and water. If the quantity of oxygen available is just enough, the temperature generated by the reactions will reach its maximum. If too little or too much oxygen is present, the temperature achieved in the system will be lower.

In batch incinerators, the waste sits stationary on a solid surface referred to as the hearth. The heterogeneous mix of waste on the hearth changes as the waste is reduced to ash through gasification and oxidation reactions. The initial heat required to ignite the waste is supplied by a burner that uses propane, natural gas or oil. Since the fuel supply to the burner is continuous, the burner can stay on indefinitely during the burn cycle. However, this would increase operating costs, and so the incinerator controls shut off the burner once the waste on the hearth has generated sufficient heat to allow the reactions to become self sustaining.

Air must be provided to sustain the combustion process. In batch incinerators, the air is supplied through holes in the incinerator walls. These holes are positioned so that the air is directed to the base of the hearth. In larger continuously operated incinerators, these air ports are under the fuel bed. In either case the air introduced in this manner is termed “under fired” air to denote where it is injected. Air must also be added above the hearth to burn the gases generated. This air also enters through air ports, and is referred to as “over fired” air. In dual chamber incinerators the over fired air is added in the secondary chamber. It is not sufficient just to add the over fired air, it must be well mixed with the volatile gases to ensure good combustion. This mixing is typically accomplished by passing the volatile gases through a “flame port” that is smaller than the primary chamber dimensions. Air can be added in the flame port or immediately after it. The flame port increases the gas velocity and introduces turbulence into the gas stream to promote mixing.

The oxidation reactions require a finite amount of time for completion, meaning that the duration of exposure at elevated temperatures must be controlled. Since batch incinerators typically lack any mechanism for agitating the waste, the temperature in the system must be maintained by re-igniting the primary burner. The combustion cycle for a batch waste incinerator is thus set to ensure maximum carbon reduction of the waste on the hearth.

The type of waste incinerated can have significant implications for the control of combustion. Paper and plastics have a higher energy value and require more air to complete the combustion process. Food wastes, with lower energy levels, require less air to complete the burning process. However, the moisture in food waste has to be evaporated before the carbon can sustain combustion. Thus, food wastes must be heated for longer periods before the combustion process commences and the primary burner can be shut off.

Combustion in the secondary chamber of a dual chamber incinerator will respond to the quantity of volatile gases present. As the volatile gas release rate drops, the temperature in the secondary chamber will also drop. To address this issue, most batch waste incinerators are equipped with secondary chamber auxiliary fuel burners. These burners maintain the desired temperature in the secondary chamber and assist with heating the incinerator during start up. The secondary chamber is typically sized to provide the gases with a one second residence time at $1000^{O}C$.

2.1.3 Reducing Dioxin and Furan Emissions

Emissions of air contaminants from batch waste incinerators are a function of the design and operation of the equipment, and the nature of the materials being processed. Heavy metals present in the waste will be released with the exhaust gases. If there is mercury in the waste, mercury will be found in the emissions. If no mercury enters the incinerator, it cannot exit the stack. However, the same approach cannot be used to reduce the emissions of POPs, and in particular, dioxins and furans (PCDD/F).

It is known that at temperatures in excess of $600^{O}C$, any PCDD/F pwill be destroyed. However, even in incinerators with good combustion there is a potential for PCDD/F formation due to *de novo* synthesis reactions. *De novo* reactions occur at temperatures in the 250 - $450^{O}C$ range when stack gases and fly ash are in contact for periods exceeding a few seconds. It has been postulated that residual carbon in the fly ash reacts with components in the exhaust gases to form PCDD/F. Given this behaviour, it should not be surprising that facilities with low temperatures have been identified as those having higher PCDD/F emissions.

Chemical reactions are driven by concentration gradients, so the higher the concentrations of carbon and fly ash the more likely the reaction will produce high emissions. Similarly, incinerators with higher concentrations of fly ash in zones with lower temperatures are anticipated to produce significantly more *de novo* reactions.

Carbon monoxyde (CO) concentrations in the exhaust gases are a good indicator of combustion efficiency. Most incinerators can be adjusted to give a minimum CO concentration. For batch waste incinerators, CO concentrations should be below 50ppm. If the incinerator is not operated appropriately (for instance, if the waste has a high calorific value and insufficient air is provided to complete the combustion process), CO levels will rise and black smoke will be released. Such smoke will contain large quantities of carbon that can react to produce higher PCDD/F emissions. Conversely, if the waste cannot create enough heat in the primary chamber to achieve the target temperatures, perhaps because too much air is leaking into the incinerator, there will be zones in the incinerator where temperatures could be in the *de novo* reaction range. The extra air can also entrain particulate matter from the hearth raising fly ash levels in the gas stream. The result will be higher PCDD/F concentrations than might be found in a properly operating system.

2.2 Waste Incineration Technologies

A waste incinerator is a system constructed to thermally treat (i.e. combust or pyrolyze) a waste for the purpose of reducing its volume, destroying a hazardous substances or pathogens present in the waste. There are two main types of waste incinerators: batch and continuous. Batch waste incinerators are loaded with waste through an open door which is then closed before the waste is ignited. The door remains closed until the ash residues remaining on the hearth have cooled and can be safely removed. The duration of a batch waste incinerator cycle is measured in hours. In comparison, continuously operated incinerators receive fresh waste and discharge ash residues periodically throughout their operation, which can last from weeks to months. This Technical Document focuses on minimizing dioxins/furans and mercury emissions from batch waste incinerator systems ranging in size from 50 to 3,000 kg of waste/batch.

For facilities incinerating more than 26 tonnes of waste per year (tpy), the preferred incinerator for new installations is the dual chamber controlled air incinerator. The dual chamber controlled air incinerator has two chambers and each chamber is equipped with air ports that allow the quantity of air added in various parts of the incinerator to be controlled. They are capable of achieving the higher operating temperatures required to minimize the emissions of POPs, and particularly dioxins/furans. Figures 2.2 and 2.3 illustrate the design of a typical dual chamber controlled air incinerator.

Batch waste incinerators have a zone where the waste is ignited and mixed with air to promote combustion, and a second zone where additional air is added to complete the combustion process. In large continuously operated incinerators, the energy available in the hot exhaust gas stream may be recovered in a heat recovery steam generator (HRSG) or hot water boiler. The steam generated can be used to produce electricity or it can be used for process or space heating. Heat recovery is not recommended for batch waste incinerators, as it lowers the gas temperatures in the system and can lead to *de novo* synthesis formation of PCDD/Fs.

Large continuously operated incinerators are equipped with air pollution control (APC) systems to treat the hot gases leaving the heat recovery system. The gases leaving the heat recovery system are cooled by a fine water mist to reduce the size of the required air pollution control equipment and to protect the incinerator from high gas temperatures. If a large continuously operated incinerator is not equipped with a heat recovery system, a rapid water quench system is used to achieve the desired gas temperatures. Such quenching will limit the potential for *de novo* synthesis of PCDD/Fs because the gases do not remain in the critical temperature range for sufficient time to allow the *de novo* reactions to proceed.

APC systems are not recommended for batch waste incineration systems to control PCDD/F emissions. Stack gases should be released directly to the atmosphere at temperatures in excess of 700^{O}C to reduce the chances of inadvertent formation of PCDD/F through the *de novo* synthesis process.

After the waste has been oxidized in the primary chamber, residues, generally referred to as bottom ash, must be removed. Bottom ash from well-operated incinerators has been shown to contain low PCDD/F concentrations (<20 pg TEQ/g of bottom ash). Solid residues deposited in the heat recovery system of large continuously operated incinerators typically have <50 pg TEQ/g of PCDD/F whereas residues from air pollution control systems typically have <300 pg TEQ/g of PCDD/F. The deposits from heat recovery systems and air pollution control systems are generally referred to as fly ash because the ash has travelled suspended in the exhaust gases. Because of low gas velocities, batch waste incinerators create much less fly ash than large continuously operated incinerators.

Figure 2.2 Typical Controlled Air Dual Chamber Incinerator

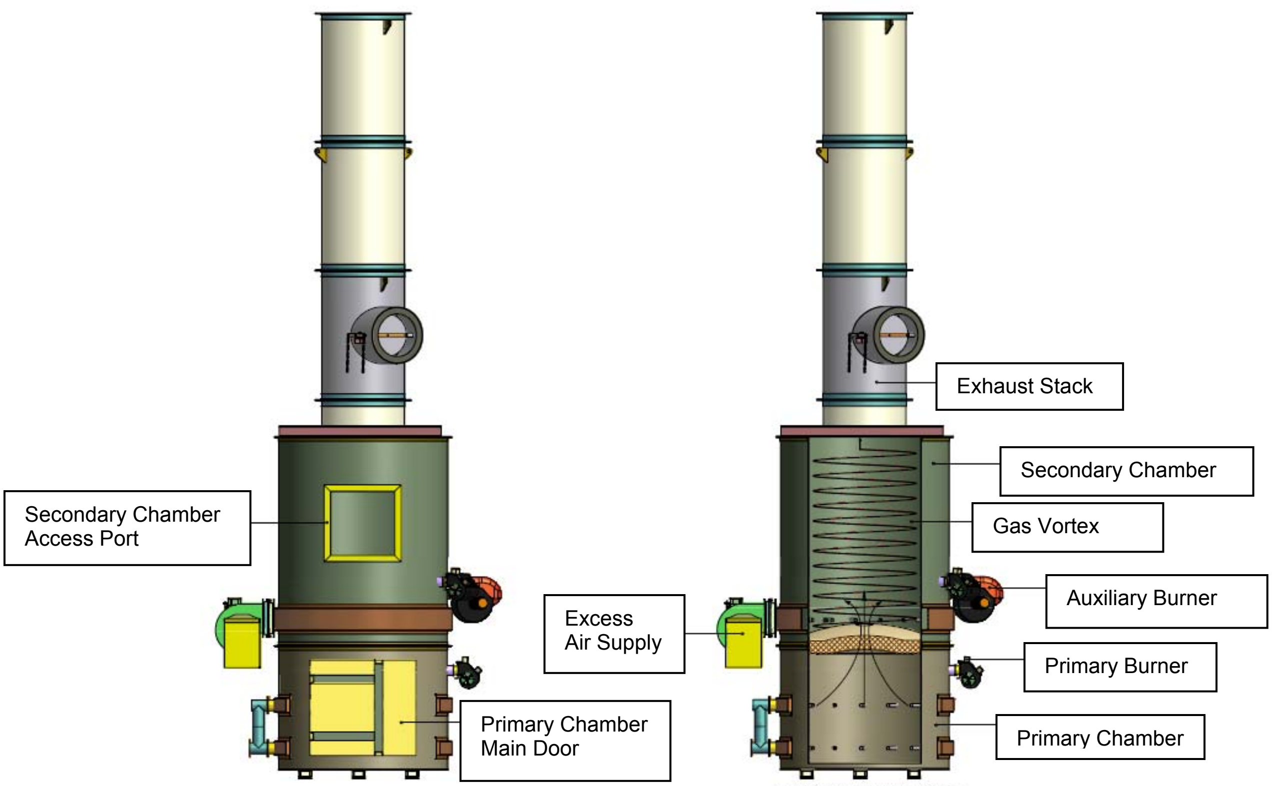

Figure 2.3 Schematic of Typical Controlled Air Dual Chamber Incinerator

2.3 General Design and Operation Considerations

2.3.1 Design and Operation

The design features addressed below are deemed to be most important for those contemplating buying a dual chamber controlled air batch incineration system. As mentioned previously, the emphasis is on batch waste incinerators that are capable of disposing of up to 3,000 kg of waste per batch.

The degree to which the combustion process is completed is a function of:

- the temperature the combusting gases reach;
- the length of time the gases remain at elevated temperatures;
- how well the air and the gases are mixed; and
- whether there is adequate oxygen to permit complete combustion.

Combustion temperatures downstream of the primary chamber and the residence time for gases at this temperature are frequently specified in regulations. In Ontario, for example, waste incinerators must provide a 1 second residence time for gases at 1,000^{O}C[12]. In the European Union, the requirements are two seconds at 850^{O}C[13]. These values reflect operating conditions in incinerators with low emissions.

The incinerator designer has more discretion in defining the temperatures in the primary chamber. Primary chambers are designed with consideration of the wastes that will be destroyed. Materials that are harder to burn require higher operating temperatures. The design temperature is governed by the rate at which heat is released in the primary chamber, which is known as the target volumetric heat release rate and expressed in MJ/m^3/hour. This value is based upon the calorific value of the waste in MJ/kg, the quantity of waste to be charged to the incinerator in kg/batch, and the volume of the primary chamber in cubic metres. The operating temperature in a system provides a limit for the volumetric heat release rate. For the typical dual chamber incinerator, the primary chamber should operate in the 500 – 800^{O}C range.

Since the temperatures achieved in a specific primary chamber are a function of the heat release rate and the waste mass, it is important that the incinerator be loaded with waste that matches its particular design characteristics. It should be remembered that by design, incinerators are heat release limited devices. Too little heat and the material will not burn properly; too much heat will lead to damage to the incinerator. When the appropriate amount of energy is introduced into the primary chamber, the primary chamber temperature in a batch waste incinerator can be controlled principally through adjusting the air to fuel ratio.

Air addition to the primary and secondary chambers of batch waste incinerators will result in exhaust oxygen concentrations in the range of 6 – 12%. Operation in this zone will minimize the release of CO and thus also minimize trace organic releases. This range can be reduced based upon testing of a given system to produce minimum CO levels. Maintaining oxygen

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12 Ontario Ministry of the Environment, 2004. GUIDELINE A-7 Combustion and Air Pollution Control Requirements for New Municipal Solid Waste Incinerators.

13 Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste. 2000.

concentrations within the manufacturer's recommended range will ensure that the system is operating at in the most efficient manner.

As noted, temperature control involves regulating the air to fuel ratio. To lower the temperature, more air is added, up to the maximum flow. Alternatively the auxiliary fuel flow rate can be reduced. The primary chamber of a batch waste incinerator is designed for a waste mass of a certain calorific value. The air supply system is sized to provide the appropriate level of excess air to control the temperature to the desired level, even if the heat input varies from design.

It is considered poor practice to introduce wastes at either extreme of the calorific value range if good combustion is the objective. In order to prevent any situation where the temperature might be damaging to the primary chamber, the quantity of high calorific waste in any charge must be limited. Wastes should be mixed to achieve a relatively uniform heating value close to the design point of the unit. If the operator controls the quality of the waste mix, any variability in the rate that the waste burns can usually be managed by the control systems of the incinerator.

2.3.2 Heat Recovery

In most cases, batch waste incinerators should not be equipped with heat recovery because this can lower temperatures and lead to *de novo* synthesis formation of PCDD/Fs.

2.3.3 Air Pollution Control Systems

Air Pollution Control (APC) systems with evaporative cooling towers and dry scrubbers are seldom recommended for small batch fed incinerators for two main reasons:

- Due to the non-continuous nature of batch waste incineration, gas temperatures will vary from ambient to operating levels as high as 1,200^{O}C each time the system is operated. When not at high temperature, condensation can occur and cause corrosion in the system. Furthermore, deposits remaining in the duct work during the cool down phase pass through the *de novo* synthesis temperature and can increase the production of PCDD/Fs.
- Since the non-continuous nature of batch waste incinerator operation generally makes it impractical to install a heat recovery system, there will be no initial cooling of the gas stream and higher temperatures will enter the APC system. To prevent equipment damage, some means of rapid gas cooling would need to be installed. This would require large volumes of water, some of which will collect hydrochloric acid and other acidic gases, and would require treatment or at the least re-circulation in the system. In certain areas of the country, obtaining the water and treating it could present significant challenges.

Adding an APC system to a batch waste incinerator will also increase the pressure drop across the system. This will result in the need for induced draft fans to exhaust the combustion gases. The induced draft fan and the air pollution control system will increase the energy requirements of the incinerator.

In most cases, APC systems are not recommended for batch incineration systems to control PCDD/F emissions. By ensuring good combustion control and exhaust gas temperatures in excess of 700^{O}C, there should be little opportunity for the formation of PCDD/F through *de novo* synthesis

However, in certain jurisdictions and/or operating conditions it may be necessary to employ an APC system. Owners and operators should consult with manufacturers and local regulatory authorities regarding any such requirements.

3.0 The Six-Step Process for Batch Waste Incineration

The recommended Six-Step Process for Batch Waste Incineration includes:

Step 1 – Understand Your Waste Stream

Step 2 – Select the Appropriate Incinerator (or Evaluate the Existing System)

Step 3 – Properly Equip and Install the Incinerator

Step 4 – Operate the Incinerator for Optimum Combustion

Step 5 – Safely Handle and Dispose of Incinerator Residues

Step 6 – Maintain Records and Report

The Six-Step Process will assist owners and operators of batch waste incinerators, ranging from 50 to 3,000 kg/batch, in achieving the intent of the CWS for dioxins/furans and mercury, and reducing the potential for releases of other toxic substances to the environment.

3.1 Step 1: Understand Your Waste Stream

The first step in managing waste is to understand the quantity and composition of the waste that is generated. A waste audit should be completed, where practical, to:

- Determine the quantity of waste generated in the various parts of an operation;
- Characterize the waste from each type of operation;
- Examine the waste stream to determine what opportunities exist for:
    - Reducing the quantity of waste generated;
    - Reusing materials; and
    - Recycling as much as possible before considering disposal.

Where waste audits are not practical, it is still necessary to develop an estimate of the waste quantities and characteristics before a strategy for waste diversion and disposal can be completed. Owners should investigate waste generation and diversion data from similar operations/facilities in order to estimate the waste types and quantities that will be generated at their own facilities. Sources of such information may include industry associations, waste industry consultants, provincial/territorial authorities and other regulatory bodies.

Based on the results of the waste audit/characterization, an assessment of appropriate disposal options should be undertaken. Where possible, disposal alternatives (other than incineration) for the residual waste stream (i.e. post 3Rs – Reduce, Reuse, Recycle) should be examined. When assessing disposal options, it is important to note that waste should neither be open-burned nor burned in a barrel. In both cases, the appropriate temperatures for a clean burn will not be achieved, and toxic contaminants, in particular dioxins and furans, will be released.

3.1.1 Conducting a Waste Audit or Estimating Waste Characteristics

A waste audit is the best way to define the waste stream at a given location. Ideally, an audit should account for seasonal variations in the waste generation rates, so it might have to be conducted in each season.

Performing a waste audit will provide an estimate of the total quantity of waste that could be generated, and allow the user to develop diversion activities that will reduce the amount of material requiring disposal. The residual waste remaining after diversion activities represents the waste requiring disposal. After other disposal options have been investigated, the characteristics of the remaining waste can be used to estimate the energy of the waste that will be charged to an incinerator. This information will be required to select an incinerator.

If the facility is only in the design stage a waste audit cannot be conducted. Even if a facility is operating, the cost of a waste audit could be seen as prohibitive. Where waste audits are not practical, it is still necessary to develop an estimate of the waste quantities and characteristics before a strategy for waste diversion and disposal can be finalized. Owners should investigate waste generation and diversion data from similar operations / facilities in order to develop an estimate of the waste types and quantities that will be generated at their facility. Sources of such information may include: industry associations; waste industry consultants; provincial / territorial authorities; and, other regulatory bodies.

3.1.2 Choosing Appropriate Waste Management Options

In all cases, reduction and diversion should be the primary waste management objectives, prior to considering any disposal option. Facilities should have a Waste Management Plan that outlines waste generation data and defines the acceptable recycling and disposal options. Hazardous waste and hazardous recyclable materials should be handled appropriately in accordance with local, provincial/territorial, and federal legislation.

3.2 Step 2: Select the Appropriate Incinerator (or Evaluate the Existing System)

The characteristics of the residual waste stream destined for incineration should be incorporated into a call for proposals from incinerator manufacturers. Specifying the quantity and composition of the waste stream will ensure that proposals include suitable incinerators. It should be noted that incinerators built for a specific waste stream, such as animal carcasses, liquid wastes and hazardous wastes, are available and should be used as required.

For facilities with existing incinerators, owners/operators should reassess the suitability of the existing system to manage the current waste stream.

For facilities incinerating **more than 26 tonnes of waste per year,** dual chamber controlled air incinerators are the recommended configuration. These systems are capable of incinerating a wide range of wastes and, when properly maintained and operated, will achieve emissions of PCDD/F and mercury below the level of the Canada-wide Standards. These systems should be equipped with a large secondary chamber sized to provide a residence time of at least one second at a temperature higher than $1000^{O}C$, to ensure complete combustion and minimize PCDD/F emissions.

For facilities incinerating **less than 26 tonnes of waste per year**, "determined efforts" as defined in the Canada-wide Standards for dioxins and furans[14] should be undertaken. Should circumstances restrict the ability to use a dual-chamber incinerator with a large secondary chamber, a single chamber incinerator with an afterburner should be used. It should be noted that such systems are less likely to be able to meet the emission standards than dual chamber incinerators.

The results of the waste audit conducted for the site should be provided to incinerator suppliers. Suppliers will be able to use these data to provide the appropriate type of incinerator. However, the owner should consider a number of issues when preparing the request for proposals. These include the type of incinerator that should be installed and the size of the incinerator. These issues are discussed in the following sections.

3.2.1 Classification of Batch Waste Incinerators

The emphasis in this report is on batch waste incinerators having a capacity of 50 to 3000 kg/batch. Even with this restriction there are various configurations of incinerators that could be used as noted in Table 2-2.

[14] Available on-line at: http://www.ccme.ca/ourwork/air.html?category_id=97

Table 3-2 Batch Waste Incinerator Types and Features

FEATURE	TYPE
A. Number of chambers	1. Single-chamber (with afterburner)
	2. Dual-chamber
	a. Excess air in primary chamber
	b. Starved air in primary chamber, excess in secondary chamber
B. Waste feeding mode	1. Batch (one load per cycle)
	2. Intermittent (with ram feeder)
C. Ash removal mode	1. Batch
D. Air Pollution Control	1. No
	2. Yes (variety of technologies)
E. Use of blowers and fans	1. Forced air (blower(s) to supply air to combustion chamber(s)
	2. Combination (blower(s) AND an induced draft fan, necessary for APC systems)
F. Heat Recovery System	1. No
	2. Yes

3.2.2 Incinerator Selection Considerations

New Incinerators

For facilities incinerating **more than 26 tonnes of waste per year (tpy), the preferred incinerator for new installations is the dual chamber controlled air incinerator**. This type of incinerator has two chambers and each chamber is equipped with air ports that allow the quantity of air added in various parts of the incinerator to be controlled. These incinerators are capable of achieving the higher operating temperatures required to minimize the emissions of POPs, and in particular dioxins and furans.

As noted in Table 3-2 there are single chamber incinerators on the market. Suppliers may offer single chamber units equipped with afterburners, but they are not desirable. They are unlikely to provide the low emissions levels achievable by properly sized dual chamber incinerators. A properly sized secondary chamber is required to accommodate the volatile gases that are released from the primary chamber. Small secondary chambers are unlikely to provide sufficient time at elevated temperatures to ensure destruction of volatile compounds.

Another important factor to consider is the frequency of operation of the incinerator. While operating procedures should minimize the release of unwanted contaminants to the atmosphere, even during start-up and shut-down, there is a higher probability of emissions during these transition conditions than during the normal steady-state operation.

Incinerators sized in a way that allow them to operate only on alternate days, or even only 2 or 3 times per week, will generate lower annual emissions than those operated frequently each day. For this reason, a larger incinerator which can be operated less frequently is preferred.

The designer undertakes detailed calculations to size the incinerator and the control systems. Manufacturers recognize that wastes will not be consistent day after day and provide a margin of safety in their instructions. While the manufacturers would prefer tighter control on the feed rate, it is not unusual to see instructions state that the primary chamber should only be half filled. Based on the waste audit data, the manufacturer assumes a density and heat value for the waste and specifies a safe quantity of material that can be burned in a given cycle.

Existing Incinerators

If an existing incinerator is still being used as originally intended (i.e. the nature of the waste has not changed over the intervening years, and the unit has been properly maintained), consideration could be given to the unit's continued operation. Stack testing of the emissions can determine the incinerator's emission performance and allow the status of the emissions to be compared to the Dioxins and Furans Canada-wide Standards for incinerators.

Annual Throughput Considerations

The Canada-wide Standards for Dioxins and Furans[15] distinguishes incinerators by their capacity and use, setting an annual throughput threshold of 26 tonnes.

Any system capable of handling greater than 26 tonnes per year should have a primary chamber and a large secondary chamber sized to match the nature of the waste characteristics developed from the waste audit.

If the unit is unlikely to process 26 tonnes of waste per year, and a smaller secondary chamber is chosen to facilitate transport, additional care must be taken in ensuring the correct types of wastes and volume of material are charged to the primary chamber. This will reduce the possibility of high PCDD/F emissions.

Special Waste

Special wastes such as liquid waste (e.g. waste oil), wet waste (e.g. kitchen wastes, sludges), and animal carcasses require special consideration when selecting an incinerator. Liquid and wet waste in small quantities can usually be mixed with other wastes, but large quantities of either material will require special provisions.

For instance, waste oil can be used as an auxiliary fuel in an incinerator. Should its use be contemplated to offset virgin oils in the incinerator, this strategy should be made known to the manufacturer. They will recommend appropriate systems to separate sludge and moisture from the used oils, and the installation of two burners in each chamber (one for waste oil and one for virgin oil). These are necessary steps to ensure that temperatures in the chambers can be maintained should operating problems arise with the waste oil burner. In the context of the batch waste incinerators addressed in this report, liquid hazardous wastes, other than oil, should not be injected into the incinerator.

The incinerator hearth should be designed to contain any free liquid anticipated in the waste stream. Free liquids can drain into air ports if they are situated below the liquid level in the incinerator. Liquid may also leak through the doors of a standard flat hearth incinerator and damage their seals. Leaks in other areas can lead to poor combustion performance.

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15 Available at: http://www.ccme.ca/assets/pdf/d_and_f_standard_e.pdf

Wet waste is challenging to handle unless the incinerator is properly designed. For example, it is strongly recommended that batch incinerators not be used to treat sewage waste, unless they have been designed specifically for this type of waste. If it is anticipated that the waste to be incinerated on a routine basis will contain wet wastes, the auxiliary burner may need to be larger to dry the waste in a reasonable amount of time.

Unlike sludges and liquids, animal carcasses should not cause liquid leaks from the primary chamber even though they contain high levels of moisture. They must be handled in incinerators that can accept this type of waste. Animal wastes should only be charged to an incinerator that is capable of completely calcining the bones in order to ensure that all pathogens are destroyed in the incinerator. Those anticipating the need to destroy animal carcasses should discuss their needs with regulators and the manufacturers of waste incinerators.

3.3 Step 3: Properly Equip and Install the Incinerator

Building Considerations

- Incinerators should be installed inside a building to protect the equipment and the operators from weather conditions.
- In designing the installation site, care should be taken to maximize clearance between incinerator components, including the stack, and combustible construction materials.
- Insulation should be used to protect combustible building materials.
- The building should be equipped with sufficient fresh air inlet capacity for the incinerator. Both combustion air and dilution air for the barometric damper are required. Care should be taken to introduce air in a manner that does not lead to low-temperature operating problems.

Equipment Considerations

The incinerator system should come complete with the following equipment to monitor and record performance parameters:

- A scale to measure the weight of all materials charged to the incinerator; and
- A computerized process control and data acquisition system to store operating data from the incinerator.

Operational data should be collected and stored, at a minimum, every minute that the system is operating. The intent is to be able to summarize operating parameters during start-up, operation and cool-down for every cycle. If the required operating conditions are not achieved these data will allow the operators, the manufacturers and the regulator to identify the contributing factors for the failure. From this information, operating procedures can be adjusted to improve performance. Provisions should be made for the manufacturers to be able to remotely access and review the operating data for trouble shooting purposes.

It is highly recommended that batch incinerators not be equipped with heat recovery devices. The temperature of the stack gases in heat recovery systems will be lower than in systems without heat recovery, and may be in a temperature range that can lead to the formation of greater quantities of PCDD/F. Similarly, air pollution control systems are not recommended for batch waste incineration systems to control PCDD/F emissions. Stack gases should be released directly to the atmosphere at temperatures higher than 700^{O}C to reduce the chances of the inadvertent formation of PCDD/F through the *de novo* synthesis process.

If it is necessary to introduce additional waste to the incinerator during the burn cycle, the incinerator should be equipped with a ram charge system to limit the disruption of combustion in the primary chamber during the waste charging process.

3.3.1 Building Considerations

The recommendation from the previous section that incinerators be over-sized so they can be operated on a less frequent basis implies that the facility will need to store waste between incinerator operation periods. The incinerator should be installed in a building with sufficient space for waste storage. Operating the unit in a building will ensure that the operators are more comfortable and thus spend more time ensuring proper operation and conducting the necessary maintenance on the system. Furthermore, it will protect the unit from weather conditions, extend its life, and make operation more reliable.

Care must be taken to avoid the exposure of combustible building material to the high temperatures on the surfaces of the incinerator and the stack. Suitable fire proof insulation and air gaps must be provided to avoid igniting the building structure.

Since combustion reactions require air, provisions should be made to ensure that sufficient fresh air is available in the vicinity of the incinerator. The air flow should be unimpeded by louvers or doors in the building. At the very least, if louvers are required to isolate the incinerator room during power outages, their status should be interlocked to the incinerator controls so the incinerator does not operate when the dampers are closed. The manufacturer's advice should be sought on the fresh air supply requirements for the incinerator. It should be remembered that in extremely cold climates, fresh air impinging upon fuel lines or other parts of the operating system can created operating problems so the air should be properly tempered to minimize equipment freezing and/or staff discomfort.

3.3.2 Equipment Considerations

The operation of the incinerator should be monitored at all times and this data should be recorded to provide a record of such operation. A list of monitoring equipment recommended for all installations follows:

- **Weigh Scale:** Every incinerator operation should have a weigh scale so that every load can be weighed and the results recorded.
- **Continuous Monitoring:** In order to confirm the status of the incinerator at all times, it is recommended that measurements of the parameters described below be continuous regardless of the operational status of the incinerator. Gaps in the readings could be interpreted as periods where the incinerator was not operating in an appropriate manner. Thus, continuous readings, once per minute, are the best way of proving that the system is operating in compliance with the various approvals and guidelines. The measurements should be captured in a computerized data acquisition system that logs the date and time of the readings as well as the readings themselves.
    - **Temperature:** The most basic of all measurements associated with incinerator operation is temperature. Temperature should be monitored in both the primary and secondary chamber and the stack at all times. The sampling location for the stack measurement should be above the barometric damper if one is installed. Such measurements will ensure that the system has achieved the desired temperature levels. Temperatures outside the normal range can serve to warn the operator that the system is not working as intended.
    - **Differential Pressure in the Primary Chamber:** A second operating parameter that is important is the differential pressures in the primary chamber. The primary chamber should operate at negative pressure. Should the differential

pressure track towards the positive, it is an indication that insufficient draft is present in the system and combustion fumes could be building in the system. The operator should be able to adjust this parameter either by changing the inlet flows or adjusting the barometric damper. If the pressure goes too negative, the combustion air fans may have failed, or the damper needs adjustment. The data acquisition system can be programmed to warn the operator of potential draft limitations in the system.

- **Auxiliary burner operation:** The auxiliary fuel burners in some incinerators are not reliable. This type of failure will likely be reflected in lower than desired temperatures in the incinerator. A combination of no fuel flow in the auxiliary burners and low temperatures in either chamber could indicate an auxiliary burner failure. The operator should be able to monitor the auxiliary burner operation.
- **Fan Amperage:** Failure of the combustion air fans will lead to inappropriate operating conditions. Recording the fan amperage will provide some indication that the fans are operating at their design loads.
- **Interlocks:** The data acquisition system should monitor the state of all interlocks on the system. Loading doors and other components of the system are frequently connected to the incinerator control system. Recording the status of sensors on various doors or dampers will assist in confirming the system is operating in the desired manner.

The type of data acquisition system described above can store data and can also be used as a means of allowing the manufacturer to look at operational data remotely to assist with trouble shooting the operation. In this manner, the operator can quickly obtain the assistance of the manufacturer. Owners should request that the manufacturer provide recommendations for the data acquisition system. This will likely open up a line of communication concerning what they can do to help operational staff adjust the incinerator if it is not operating correctly.

Other Considerations

Most batch incinerator systems are factory fabricated and shipped to the site where they are to be used. Larger systems may be shipped in sections to be assembled on the site. Typically the stack will be installed on the incinerator as one of the final steps. Stacks should be properly designed to ensure that emissions can freely disperse in the atmosphere and not be re-entrained into fresh air intakes on nearby buildings.

3.4 Step 4: Operate the Incinerator for Optimum Combustion

Operational Considerations

Wastes received at the incinerator building should be separated according to their heating value characteristics: wet or low-energy wastes (e.g. food waste); mixed wastes with average energy values; and other materials with high energy values, such as oily waste materials. To facilitate this separation, all waste should be collected in transparent bags. To further assist with separation, wastes could be collected in coloured-coded bags.

Batch incinerators are designed to accept wastes within a specified range of energy (i.e. calorific) values. The operator should select waste from each category and mix it to achieve the manufacturer's specified input calorific value. Each bag should be weighed, its source should be noted, and the total weight of each category should be tallied before completing the loading. This information should be recorded by the computerized data acquisition equipment installed with the incinerator. (Refer to step 6 for further record keeping requirements).

Batch incinerator systems have limited charging capacity (both in terms of waste quantity and the calorific value of the waste charge). To assist the operator with the charging task, particularly for smaller incinerators, several batches could be weighed and placed in their own containers prior to loading the incinerator. The same weighing and logging procedures should be used for each batch and, once recorded, the batch can be charged when appropriate.

When the incinerator is charged with the appropriate mix and quantity of waste, the operator should close the door, ensure all interlocks are engaged, and start the burn cycle. The operator should observe the burn for at least 15 minutes after ignition of the primary chamber burner to ensure the volatility of the waste charged is not creating too much gas for the secondary chamber to handle. The rate of combustion can be slowed by reducing the quantity of under-fired air. The primary chamber should be operated in the temperature range specified by the manufacturer (typically $500^{O}C$ to $800^{O}C$).

When satisfied that the burn is proceeding in a controlled manner, the operator may leave the incinerator area while the equipment completes the burn cycle.

The burn cycle should not be interrupted by opening the charging door until after the burn is complete and the unit has cooled down. No additional waste should be added to the primary chamber unless the incinerator is equipped with an appropriate ram feed device.

When the burn is complete and the unit has cooled, the operator should open the door only when wearing protective equipment such as gloves, dust mask, face shield and goggles.

The operator should remove the ash from the previous burn cycle before reloading the incinerator. Any unburned materials found in the ash should be recharged to the primary chamber after the operator has cleaned the air ports, and before putting a fresh charge into the incinerator.

Training Considerations

Operators should be properly trained by the incinerator manufacturer. The training course should include, as a minimum, the following elements:

- System safety including identification of hazards that the operator should recognize;
- Waste characterisation and how waste composition can affect operation;
- Loading limitations, including materials that should NOT be charged to the incinerator, and the allowable quantities of different types of wastes that can be charged;
- Start-up procedures for the incinerator and the normal operation cycle;
- Operation and adjustment of the incinerator to maximise performance;
- Clean out procedures at the end of the cycle;
- Troubleshooting procedures;
- Maintenance schedule; and
- Record keeping and reporting.

Managers should be involved in the training session so that continuity can be maintained with different operators.

3.4.1 Operation

3.4.1.1 General Batch Waste Incinerator Operation Considerations

Effect of Waste Characteristics

The characteristics of the waste loaded to the incinerator will affect the temperature profile in the various sections of the incinerator during the burn cycle. These variations will also influence the duration of auxiliary burner operation.

Wastes with a high percentage of volatile matter (e.g. paper >75%, plastics >85%) will release more volatile gases from the primary chamber than wastes with low percentage of volatile matter (e.g. vegetable wastes <20%). When mixed with additional air in the secondary chamber, the combustion of the volatile gases maintains the secondary chamber operating temperatures and limits the need for auxiliary fuel. At this point in the burn cycle, the temperature in the secondary chamber will be higher than that in the primary chamber. However, as the release of volatile gases from the primary chamber decreases, combustion in the primary shifts and begins to consume the fixed carbon. This results in a drop in temperature in the secondary chamber and an increase in temperature in the primary chamber. The secondary temperature can drop to the point where the secondary chamber auxiliary burner must come on to maintain the temperature at or above the required setpoint, typically 1000^{o}C.

Higher moisture levels in the waste require more auxiliary fuel to evaporate the moisture and allow the waste to burn. The moisture released in this way passes through the secondary chamber taking heat from that chamber as well. This could mean that the secondary burner must operate for longer periods during the early phases of the cycle.

The ash percentage in the waste can also influence auxiliary fuel consumption and overall cycle time. The ash must be heated to sufficient temperatures to drive off volatile gases and the fixed carbon. The ash remaining in the primary chamber retains heat and lengthens the time required for the incinerator to cool so it can be handled safely.

Incinerator Loading

To properly load the incinerator, the following steps need to be followed:

- Determine the source of the waste – kitchen, vehicle shop, bunkhouse area, etc.;
- Weigh the waste to determine how much must be disposed; and,
- Proportion the waste fed to the incinerator on the basis of the anticipated heating value.

The wastes from different operations in the facility would need to be designated, either by colour codes or in different waste containers. Each source would be assumed to produce waste that was similar in composition on a daily basis.

For batch waste incinerators with charge sizes between 50 kg and 200 kg, individual bags of waste can be weighed before they are put into the incinerator.

For larger batch incinerators it would likely be onerous to have to weigh each bag in a 1,000 kg charge and alternative approaches could be adopted. The incinerator building should have a tipping floor sized to allow segregation of the various types of waste streams. All waste arriving at the facility should be weighed before being placed in the appropriate area. Knowing the mass of waste in each pile, the incinerator could be loaded with the appropriate volume of a specific type of waste to create a mixed load that has an appropriate calorific input for the incinerator. Possible mixes could be developed from the waste characteristics so the operator has clear guidance on loading the incinerator. For instance adding some higher calorific value plastic waste to the kitchen waste could reduce the amount of auxiliary fuel needed to evaporate the moisture. It is important to segregate known high calorific value materials so that the quantity of these materials in a batch can be limited.

Controlling Air

Ideal combustion is achieved when the exact amount of air needed to oxidize the carbon and hydrogen in the waste is supplied to the incinerator. This stoichiometric air addition rate will result in the highest temperatures from burning a given batch of waste. If too little or too much air is supplied, the temperatures in the primary chamber will change. Indeed, controlling air is the basis of many batch waste incinerators.

The typical starved air incinerator operates by controlling the primary chamber air injection so that the primary chamber operates under sub-stoichiometric or pyrolytic conditions. The air added to the system is only sufficient for the primary chamber to reach pyrolysis temperatures. This is typically between 70% and 80% of the ideal amount of air needed to burn the waste.

The volatile gases from the primary chamber can be burned in the secondary chamber after being mixed with extra air. The amount of air in the secondary chamber is typically 140% to 200% of the amount required to complete the reaction in the secondary chamber. Part of this excess air is added to control temperatures in the secondary chamber as explained below.

If too little air is supplied to the primary chamber the temperature will drop because the waste cannot burn sufficiently to increase the temperature. The operating ideal is to allow the waste to burn at a rate that generates sufficient volatile gases to maintain the desired temperature in the secondary chamber. If too much air is added in the primary chamber the combustion rate is accelerated and much of the volatile gases will consumed before they get to the secondary chamber. This will lead to higher temperatures in the primary chamber, premature failure of refractory and potentially other damage to the incinerator. In turn, because insufficient volatile gases will pass to the secondary chamber, the temperature in the secondary chamber will be lower and the auxiliary burner will need to operate to maintain temperature. Adding additional air to the secondary chamber will decrease the temperature in the secondary chamber, while limiting air addition will raise the temperature. This is opposite to the temperature response to additional air in the primary.

Controlling the amount of air added to the incinerator can be done in a number of ways:

- Manually by the operator;
- Automatically based upon the temperatures in the primary and secondary chambers; and,
- Automatically based upon changes in the oxygen level in the gas stream.

The control methods represent an increasing level of complexity so oxygen sensors are usually found only on larger systems. The operator must understand the cause and effect when making changes to the system and should be present for the duration of the cycle if manually controlling the operation. For this reason, automatic temperature sensing controls are preferred for batch incinerators.

Controlling Temperature

The primary chamber should be operated in the appropriate temperature range (typically 500^{O}C to 800^{O}C) specified by the manufacturer.

During operation, the secondary chamber temperature is controlled by varying the amount of air introduced to the secondary chamber and by operating the secondary chamber burner. As discussed earlier, regulators usually specify the secondary chamber temperature set point in the range of 850 ^{O}C – 1000 ^{O}C. The secondary chamber temperature set point may vary by jurisdiction and according to the residence time in the secondary chamber. As noted above, adding air to the secondary chamber decreases its temperature, while decreasing the amount of air raises its temperature. A secondary chamber temperature sensor controls the operation of the secondary burner. This sensor has low and high temperature set points that govern burner operation on pre-heating of the secondary. If the temperature drops below the selected set point the burner comes back on to increase the temperature. To avoid having the air and burner control compete with each other, the set point for the air control system is usually set at least 40^{O}C above the burner's high temperature set point.

Typical Problems

Temperatures indicate how the combustion system is performing. Another way to judge the operation of the incinerator is to observe the colour of the flame in the two chambers. Hotter temperatures will drive the flame colour from dull red, through orange to yellow. In the primary chamber any colour brighter than dull red would suggest that too much air is being introduced into the system. In the secondary chamber, red flames indicate a temperature around 760^{O}C, which is generally considered to be too low. An orange flame will be seen in the 1,100^{O}C temperature range whereas at 1,200^{O}C yellow flames are an indication that the temperature is too high for normal waste destruction.

Typical operating problems with batch waste incinerators are:

- **High fuel consumption**

  High fuel consumption occurs when the operator is trying to burn extremely moist waste, or when too much air is added to the system.

  As noted earlier, water must be evaporated from the wet waste before volatilization can occur. Since heat is not released from the waste until it starts to volatilize, the auxiliary burner must supply the extra energy needed. To reduce energy consumption, one must limit high moisture waste in any particular load.

  If the combustion chambers have leaks, excess air will be introduced to the incinerator. Air could enter the incinerator through doors that have become warped due to over heating, or through deformed seals or holes in the incinerator due to corrosion. If excess air is introduced in the primary chamber, the volatile gases will be partially burned in the primary chamber and will not be available to heat the secondary chamber. If excess air enters the secondary chamber, temperatures will drop and the burner will operate for longer periods.

- **The formation of fused ash, or clinker, in the primary chamber**

  Clinkers form when localized temperatures of the ash bed lead to melting of the ash and fusing of the melted material. With municipal solid waste, this occurs at temperatures above 1,200^{O}C. While this should be far above the operating gas temperature of the primary chamber (typically 500^{O}C to 800^{O}C), localized bed temperatures can be higher than the gas temperature. Wherever air is introduced into the primary chamber, there will be zones where the stoichiometric amount of air is present for complete combustion. This air addition rate will result in the highest combustion temperatures possible (in excess of 1,500^{O}C). This condition is more likely to occur if a harsh jet of air is introduced into the primary chamber due to blocked air ports. If this occurs, the flames near the bed would be bright yellow. The operator needs to check the air ports and ensure that the air is evenly distributed throughout the primary chamber each time he removes ash from the incinerator. Cleaning the air injection ports will limit clinker formation.

- **Visible stack emissions**

  The appearance of the stack plume can also provide some indication of the adequacy of the combustion process. Typically stack emissions increase when there is one or a combination of the following situations occurring:

  - The high set point temperature in the secondary chamber is too low;
  - Excessive air infiltration;
  - Excessive negative draft;
  - Excessive primary air addition;
  - Excessive secondary air addition; or,
  - Waste characteristics that prevent the unit achieving design settings.

Plume Characteristics

Figure 3-2 shows different conditions that may be observed with malfunctioning dual chamber controlled air incinerators.

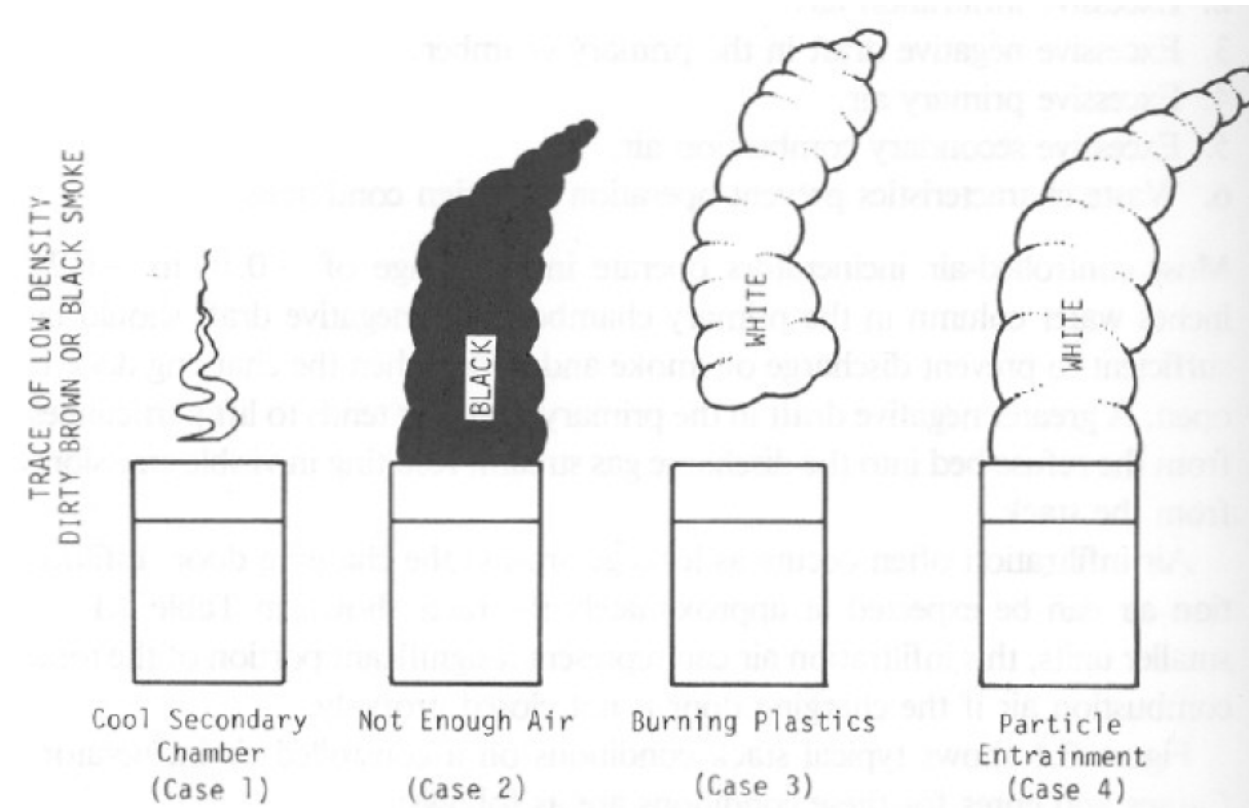

Figure 3-2 Plume Characteristics related to Operating Conditions [16]

Case 1, with traces of dirty brown or black smoke in a wispy plume, generally occurs when the secondary chamber set point temperature is too low. Raising the temperature in the secondary chamber should improve the situation. Secondary chamber temperatures could also be low due to burner failure. Incinerators should not be operated without functioning secondary chamber burners.

Case 2 is the classic "not enough air for the waste being burned" situation as black smoke indicates incomplete combustion. There are a series of steps that the operator should go through to rectify this situation:

- increase the air flow to the secondary chamber to the maximum;
- reduce the air flow to the primary chamber to reduce the rate of volatilisation; and/or
- temporarily increase the set point of the auxiliary burner to 1,200^{O}C to overcome the burning of a very high calorific waste charge.

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[16] Cross, F.R, and H.E. Hesketh, 1985. Controlled Air Incineration. Publishing by Technomic Publishing Company Inc. ISBN No. 87762-396-1

If the situation persists after these steps have been taken, check the charging capacity for the incinerator and the characteristics of the wastes being burned. If the energy content of the waste is very high, the amount of that waste charged to the incinerator will need to be reduced in the future.

Case 3 is a detached white plume that could be the result of burning chlorinated wastes. Hydrogen chloride can cause this type of plume in high concentrations. To rectify this situation, ensure that chlorinated plastics are segregated from the waste stream.

Case 4 is a white plume that persists for long distances downwind. It is indicative of high quantities of fine particulate matter in the stack gases. This can be caused by high rates of air addition to the primary chamber, or by the particular components in the waste stream. If reducing the primary air flow does not rectify this situation, the operator needs to determine the types of materials being burned and take steps to reduce or eliminate their introduction to the system.

High moisture levels in a plume, particularly when exhausting into cold air, will also appear to be white. Water vapour forms a mist as it comes out of the stack and takes on the appearance of a white plume. This plume dissipates rapidly as the plume travel downwind and as the saturated air mixes in the atmosphere reducing moisture levels. The difference between Case 3, Case 4 and a high moisture plume is that typically the moisture plume will only exist for a short distance downstream of the stack. Moreover, the high moisture plume will typically not be visible as the plume exits the stack, but rather appears to form some distance above the stack tip as the vapour condenses in the cold atmosphere.

3.4.1.2 DOs and DON'Ts of Incinerator Operation

It is important to ensure that the incinerator is operating properly according to its design purpose. The following figure provides some significant DOs and DON'Ts to consider when operating a batch waste incinerator.

Some Significant DOs and DON'Ts of Batch Waste Incineration

DO:

- Use specially designed incinerators to dispose of animal carcasses, sewage, liquid wastes, or hazardous waste materials.
- Develop a waste collection and handling program that will allow the operators to mix the waste to provide a uniform heat input to the incinerator;
- Use waste oil and waste fuel for other heating purposes where practical, rather than disposal through incineration;
- Limit the quantity of waste oil or waste fuel in any specific charge to the incinerator to ensure the energy contained in the waste charge is within the limits specified by the manufacturer;

DO NOT:

- Overload the incinerator.
- Put mercury containing waste (e.g. fluorescent lamps, thermometers, thermostats, dental amalgam, batteries) into the incinerator. Limiting the quantity of mercury placed in the incinerator is the most effective way to limit mercury emissions.
- Introduce metal and glass into the incinerator when alternative options exist (e.g. recycling, landfilling). These materials absorb energy from the furnace and increase the wear and tear on various incinerator components.
- Incinerate wastes containing heavy metals (e.g. mercury-containing wastes, wood treated with Chromated Copper Arsenate (CCA), lead paint).
- Incinerate asbestos waste.
- Introduce large quantities of plastics or high calorific wastes into incinerators designed for low calorific value wastes such as animal carcasses and food waste. Incinerators capable of disposing of low calorific value waste are not suited to burning large quantities of high calorific wastes.

3.4.1.3 Standard Operating Procedures

To ensure good operation of the incinerator, there are certain standard operating procedures that should be followed. The list below should serve as a starting point for building the site specific procedures. These procedures must be tailored to the individual facility, and all operators should be trained to follow the site specific version of these procedures.

Cleaning and Loading

- The primary chamber should be cleaned of all ash before any new charge is introduced. Operators should check to ensure that the previous cycle is complete and that the primary chamber has cooled to room temperature before commencing clean out.
- Turn OFF all power to the incinerator before opening the primary chamber door.
- Wear personal protective equipment (gloves, face shield, dust mask) and use appropriate equipment to remove the ash. Rake and shovel the ash from the hearth and place it in a metal container for transport to an approved disposal site.
- Material that was not completely reduced to ash should be placed into the primary chamber for the next burn cycle. If it is necessary to remove this material for inspection and maintenance of the chamber it should be placed in a metal container until it can be reloaded to the incinerator. If this material is still smouldering, it should be sprayed with water when in the metal container.
- Inspect the interior of the primary chamber for wear, or damage to refractory. Refractory that has failed should be replaced before using the incinerator for the next cycle.
- Clean all the air pipes into the primary chamber. Vacuum the pipes to remove fine materials and carefully chip away any slag around the tip of the air pipes, so as not to damage the air pipes.
- Inspect all the door seals to ensure that the door will maintain a tight seal upon closure. Clean any deposits from the seals. Replace seals that are damaged, worn or crushed.
- Clean the inspection view ports.
- Measure and record the weight of the materials to be combusted on the next burn cycle. Fill the primary chamber with the material to be combusted on the next burn cycle. Ensure waste loaded to the primary chamber does not block the burner. Follow the manufacturer's instructions concerning the mass or volume of waste that can be loaded.

Pre-Start Check

- Close and lock the primary chamber door. Ensure that all the latches are properly engaged and that the PRIMARY DOOR CLOSED safety switch is energized.
- Check that no alarms are displayed on the operating panel.
- Ensure that all the temperature set points are at the correct settings.
- Ensure that the cycle times are appropriate for the nature of the waste (volume, energy content, moisture, density, etc.). Typically the burn cycle will be 2 to 6 hours in duration with the cool down cycle being approximately 2 to 3 hours.
- If the incinerator is equipped with an EMERGENCY STOP BUTTON ensure that it is properly armed and that it is unlocked and pulled out.

- Ensure that primary and secondary manual air dampers are 100% open. Set all fuel valves to the open position.

Starting the Burn

Typically the operator will push the start button for the burn cycle and the control system will take over the operation of the incinerator. The operator should observe the operation during start-up to ensure that the following steps are completed.

- Starting the cycle will initiate an air purge of the chambers. This is followed by a purging of the secondary chamber burner prior to igniting. As the secondary burner operates, the temperature in that chamber will rise. When the temperature reaches the appropriate set point, the primary chamber burner will purge and ignite.
- If the secondary burner does not raise the temperature to the manufacturer's recommended set point, the operator should not override the controls and continue the burn. Any failures during the start-up should result in the incinerator shutting down. At this time the operator will need to commence fault identification procedures to overcome the deficiencies.
- The incinerator control system should maintain proper operating conditions throughout the timed burn cycle. Following the burn cycle, the system will go into a cool down mode. During this period air is introduced into the primary chamber to speed the cool down.
- Under no circumstances should the operator attempt to open the primary chamber doors when the system is operating. This practice can cause flashbacks that can injure personnel. The extra air entering the primary chamber will disrupt the combustion process, possibly leading to increased emissions.

3.4.1.4 Preventative Maintenance

All mechanical equipment requires routine preventative maintenance to operate efficiently. The operating conditions for the equipment dictate how frequently maintenance should be carried out. Incinerators have a service cycle that involves repeated heating to high temperatures followed by cooling. This can lead to refractory failures. Furthermore, moving waste and ash into and out of the incinerator creates wear on surfaces. Surfaces need to be refurbished on a routine basis and the seals around the openings require regular inspection and replacement as necessary.

Incinerators are waste disposal devices and should be managed in a manner similar to other disposal options. Incinerator owners need to recognize that money will be required to maintain the facility and to mitigate any unexpected events.

In addition, money should be set aside for routine maintenance. The cost of maintenance will be proportioned between labour, maintenance supplies, and equipment replacement. At least 3-5% of the capital cost of the unit should be set aside for annual maintenance and capital equipment replacement.

The maintenance budget should also include a capital reserve fund to cover repair and upgrades necessitated by unbudgeted circumstances. A suggested allowance for this would be 20% of the annual maintenance costs, labour and supplies, or about 1% of the capital cost.

The owner should consider establishing a service contract with the manufacturer (or a manufacturer-trained/ qualified local technician). These people should visit the site annually, and preferably quarterly if the incinerator is used daily. The owner should discuss the costs of such a program with the manufacturer and inquire about assistance the manufacturer can provide if the incinerator control and operating system can be accessed remotely.

Thus annual maintenance and capital reserve fund costs should be on the order of 4 - 6% of the original cost of the incinerator system.

3.4.2 Training

The cornerstone of ensuring good operation of any incinerator is that the staff understands how the system operates and takes appropriate steps to ensure the continued good operation of the equipment[17].

Every incinerator manufacturer has its own unique approach to designing incinerators. The control systems, while following the general logic of the previous section, are likely to differ as well. Any person who will be operating an incinerator should be trained by the manufacturer before being asked to operate it. It is not good practice to have operators train operators. The manufacturer and its agents are the people most familiar with good operating procedures that will ensure minimal emissions.

Management staff should be involved in the training sessions wherever possible. Management are likely to provide long-term continuity at most sites. They can assist operators with their tasks, and ensure that substitutes or replacements are suitably trained.

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17 Chandler, A.J., 2007. Review of Dioxins and Furans from Incineration In Support of a Canada-wide Standard Review. A Report Prepared for The Dioxins and Furans Incineration Review Group through a contract associated with CCME Project #390-2007. Available at: http://www.ccme.ca/assets/pdf/1395_d_f_review_chandler_e.pdf August 18, 2008.

3.5 Step 5: Safely Handle and Dispose of Incinerator Residues

Ash from the primary chamber of the incinerator can contain materials deleterious to the operator's health and the environment. Operators should use personal protective equipment when handling this material. The material should be carefully removed from the hearth and placed in covered metal containers suitable for transporting the ash to an approved disposal site. The operator should weigh, and maintain records of, the quantity of ash produced.

3.5.1 Residue Handling Practices

The quantity of ash (residues) generated by the facility should be documented, and the facility's weigh scale should be used to determine the mass of ash that is shipped from the facility to the disposal site.

For every 1000 kg of waste burned, approximately 300 kg of bottom ash is generated[18]. If the quantity of ash exceeds this amount, the material should be examined to determine whether the increased mass is due to the presence of non-combustible materials, or because there is a high quantity of unburnt carbon in the ash. If the latter situation is the case, operation of the incinerator should be adjusted to enhance the oxidation of carbon.

Representative samples of the bottom ash should be collected and forwarded to a laboratory for leachate toxicity testing. The International Ash Working Group provides guidance on sampling and analysis of ash[19]. At least 10 samples of ash are required to adequately characterise the material, and as a precaution it is recommended that testing on each sample be completed in triplicate. The results of the tests should be forwarded to the appropriate regulatory agency.

[18] International Ash Working Group, 1997. Municipal Solid Waste Incinerator Residues. Published by Elsevier, ISBN 0-444-82563-0.

[19] Ibid

3.6 Step 6: Maintain Records and Report

To demonstrate appropriate operation and maintenance of the incinerator, the facility should maintain records and prepare an annual report containing at least the following information:

- A list of all staff who have been trained to operate the incinerator; type of training conducted and by whom; dates of the training; dates of any refresher courses;
- All preventative maintenance activities undertaken on the equipment;
- Records of operation of the incinerator - in electronic format with full data backup;
- Summarized annual auxiliary fuel usage;
- A list of all shipments of incinerator residues, including the weight transported and disposed of by type if necessary, and the location of the disposal site;
- Results of any emissions measurements or any ash sampling data collected during the period.

All raw data records from the operation of the incinerator should be retained for inspection by the appropriate authorities for the period designated by those authorities, or for at least 2 years. The owner should work with the incinerator manufacturer or supplier and the regulators to determine the appropriate level of summary data that should be sent to the regulatory body (e.g. federal, provincial/territorial). The reports should be approved by the facility's senior management before submission.

Recording:

One of the most important records that should be available for review by the regulators is the maintenance log. This should record routine maintenance activities, date completed, by whom, and any problems encountered. This routine maintenance should correspond to the preventative maintenance recommendations provided by the manufacturer. A record should be kept of any upsets or equipment failures that necessitated special maintenance activities. The data for special maintenance activities should include the description of the issue being addressed, the date the work was completed, and who was responsible for that work. Most importantly, the operators/maintenance personnel should analyse the cause of the failure and ascertain if there are operating procedures that can avoid a repeat of the failure.

Continuous monitoring (once per minute) of incinerator operation should be recorded regardless of whether or not the incinerator is in use. To prevent any uncertainty about the waste disposal data, the information on the quantity of waste incinerated should be cross referenced by date and start time to the incinerator operating data. While some might question the usefulness of collecting operating data when the incinerator is not operating, a complete record for all 8760 hours of the year will validate the production data.

Reporting:

Licenses issued to waste disposal operators in all parts of Canada require some degree of reporting on operations to the appropriate authorities. There is some basic information that should be included in any report:

- **Quantity of Waste Incinerated:** Since the CWS for PCDD/F and Mercury both set limits on the amount of waste that can be burned before different levels of proof of compliance are required, the basic measurement for every incinerator site must be the quantity of waste charged to the incinerator during the year. Because the incinerator is limited to a fixed quantity of waste on every charge, each load should be recorded separately, and the quantities totaled for the year, and preferably weekly and monthly. Such data will also assist the owner in determining waste generation rates at the facility, and in turn, provide data on the effectiveness of diversion and reduction programs.

- **Operating Data:** Operating data that is important are temperatures, carbon monoxyde, and oxygen levels, along with other data such as differential pressures and auxiliary burner operating times. If the auxiliary burners are of fixed output, it would be satisfactory to record the signal controlling its operation. If the input is variable, motor amperage from the pump would provide some indication of the rate of fuel use. Raw one minute monitoring data should be preserved in electronic format for analysis.
- **Ash shipment weights:** The report should include ash shipment weights and the name of the operator for any particular load along with notes on observations or problems experienced with the load.
- **Auxiliary fuel receipt data:** Auxiliary oil receipt data should be recorded in the log book and receipts for the shipments should be kept for verification by regulators.
- **Training:** The report should contain records of the training received by the staff, who conducted the training and when.
- **Changes in Operation:** Any major changes to the operation should be noted in the annual report, as should the results of any testing undertaken on the stack emissions or ash.

It is important to note that waste any incinerators incinerating: $\geq$ 26 tonnes of non-hazardous solid waste per year, $\geq$ 26 tonnes of biomedical or hospital waste per year, hazardous waste, or sewage sludge must report emissions of PCDDF, hexachlorobenzene, and mercury under the National Pollution Release Inventory (NPRI). For more information, please see www.ec.gc.ca/inrp-npri/.