Committee Bay Project

Comprehensive Waste Management Plan

Revision 1

North Country Gold Corp.
March 2015

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1.0 DOCUMENT CONTROL

Version	Date	Section	Pages	Revision
0	22/10/2014	all	all	Combination of former Waste Management Plan and Hazardous Waste Management Plan into single document. Updates to plan and incorporation of Technical Document for Batch Waste Incineration, and Environmental Guideline for the Burning and Incineration of Solid Waste.
1	16/03/2014	6.1.2	6	Section 6.1.2 *'Combustible wastes'* - Paragraph 3 – revision to clarify that open burning will only occur "...when authorization has been granted by the Nunavut Water Board."

2.0 COMPANY AND PROJECT BACKGROUND

North Country Gold Corp. (‘NCGC’) is a publically listed, Canadian based exploration company conducting mineral exploration within the Committee Bay area in the eastern portion of the Kitikmeot Region, Nunavut Territory, Canada.

The Committee Bay Project (‘CBP’) comprises mineral claims and leases located on both Crown Land and Inuit owned (surface rights) land pursuant to the Nunavut Land Claims Agreement. The project encompasses NCGC’s flagship Three Bluffs gold deposit, numerous gold occurrences, four exploration camps and a number of fuel and equipment caches.

Exploration work programs are generally undertaken as seasonal campaigns occurring between March and October in any given year, largely dictated by market conditions. Work activities comprise claim and lease staking, prospecting, geological mapping, rock, till and soil sampling, airborne and ground geophysics and drilling. Supplies, including fuel are airlifted to the CBP from various towns and cities in Nunavut, Manitoba and the Northwest Territories.

In 2011, NCGC initiated an upgrade of its primary camp, Hayes Camp. These upgrades were designed to increase the camp capacity to 100 people and improve the overall safety, working conditions and environmental impacts of ongoing work at the Three Bluffs gold deposit. Upgrades completed in 2011 comprised construction of additional camp accommodation, the installation of new washroom facilities, quonset structures, a dual chambered incinerator, waste water treatment system, and initiation of the construction of a 3000’ airstrip. NCGC intends to continue these camp upgrades and to construct an all-weather road from Hayes Camp to, and within, the Three Bluffs drilling area in coming years.

NCGC has the following permits and licences in place to support advanced exploration activity at the CBP.

Organization	Description	Permit/Licence #
Nunavut Impact Review Board	Project Reference Number	07EN021
Aboriginal Affairs and Northern Development Canada (AANDC)	Land Use Permit (Bullion camp)	N2014C0002
	Land Use Permit (Hayes camp)	N2014C0005
Kitikmeot Inuit Association	Land Use Licence for IOL (Ingot /Crater camps)	KTL314C003
Nunavut Water Board (NWB)	Water Licence	2BE-CRA1015
Aboriginal Affairs and Northern Development Canada (AANDC)	Commercial Leases	Lease 065J/11-1-2
		Lease 065J/12-1-2

3.0 INTRODUCTION

This Waste Management Plan was developed to document waste management practises employed on all NCGC exploration sites within the Committee Bay Project as part of the company's ongoing efforts to minimize pollution and protect the environment.

This document is designed to meet all regulatory requirements and combines and updates NCGC's existing *Waste Management Plan* and *Hazardous Waste Management Plan* into a single document. This document forms part of NCGC's Nunavut Water Boards ('NWB') 2015 Water Licence renewal application. Once approved, this document will remain in effect for the duration of NCGC's water licence. NCGC will conduct annual reviews of this document to address changes in technology and operational practises. Changes will be implemented upon approval from the NWB.

4.0 OBJECTIVES

The objectives of NCGC's *Comprehensive Waste Management Plan* are to:

- Minimize waste products generated by implementing Reduce-Reuse-Recycle best practises,
- Minimize and mitigate against any potential impacts to the environment by utilizing and employing best practise guidelines,
- Minimize hazardous waste products generated by seeking and utilizing non-hazardous alternatives,
- Ensure every effort is made to purchase products from suppliers that have programs or policies for return of empty containers or unused products,
- Comply with all Federal and Territorial legislation and Terms and Conditions stipulated within the company's water licence and land use licences.

5.0 SOURCES OF WASTE

Waste products generated during exploration activities at the CBP comprise:

- Camps (kitchen, offices and sleeping quarters):

  Food, recyclable containers, glass, plastic, cardboard, wood, batteries, scrap metals, aerosol cans, sewage, greywater, paint, construction debris.

- Equipment (Heavy equipment, snow machines, trucks, aircraft, generators):

Used oils, oil filters, air filters, antifreeze, hydraulic hoses, greases, batteries, absorbent pads, packaging, scrap metals, empty fuel drums.

- Drilling:

  Used oils, antifreeze, oil filters, air filters, hydraulic hoses, greases, batteries, absorbent pads, scrap metal, empty fuel drums

- General:

Waste petroleum products, empty fuel drums, empty chemical containers, contaminated soil, contaminated fuels and contaminated water.

6.0 <u>WASTE MANAGEMENT</u>

All wastes generated at the CBP will be separated and sorted as follows:

1. Non-Hazardous Wastes
    a. Combustible wastes
    b. Non-combustible wastes
        i. Reusable
        ii. Recyclable
        iii. For disposal

Non-hazardous waste includes food, wood, cardboard, plastic, rubber, glass, scrap metal, sewage waste and empty fuel drums.

2. Hazardous Wastes

Hazardous waste includes used oil and petroleum products, grease, antifreeze, oil filters, hydraulic hoses, paint, chemicals, aerosols[1] and rechargeable batteries.

[1] Aerosol cans will be avoided where alterative products exist.

6.1 Non-Hazardous Waste

6.1.1 *Greywater and sewage waste*

NCGC's Hayes Camp is equipped with a Sanitherm Inc. Membrane Bioreactor (MBR) Waste Water Treatment System[2] (WWTS) capable of treating greywater and sewage waste. This facility will be utilized to treat greywater and sewage waste for large scale programs where there is sufficient waste products generated. Bricks of pressed dry sludge produced by the WWTS will be incinerated as combustible waste.

In all other instances, and for satellite camps, NCGC will use conventional grease traps and small covered sumps for greywater, and pacto toilets (or latrine pits) for sewage waste. Pacto (sewage) bags will be incinerated as combustible waste in an incinerator designed to process this type of waste (details below).

6.1.2 *Combustible wastes*

Combustible wastes will be incinerated onsite in accordance with Environment Canada's "Technical Document for Batch Waste Incineration" (2009) and the Government of Nunavut's "Environmental Guideline for the Burning and Incineration of Solid Waste" (2012).

A Westland CY-50-CA diesel fired, dual chambered, controlled air, incinerator located at Hayes Camp will be used to incinerate material on a regular basis to prevent wildlife attraction. Material that will be incinerated will include paper, cardboard and untreated wood products, food waste, putrescible food packaging and pacto (sewage) bags[3] (when applicable). Recyclable materials, hazardous materials, materials containing mercury, lead or other heavy metals and plastic containing chlorine will not be incinerated.

Large pieces of untreated wood, cardboard and material comprised of natural fibres may be burned in a controlled open burn in accordance with the Government of Nunavut's Guideline for the burning and incineration of solid waste when authorization has been granted by the Nunavut Water Board.

All ash from incineration and burning will be collected in empty drums, sealed, labelled and shipped offsite to an approved disposal facility.

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[2] Please see NCG WWTS Management Plan

[3] Westland CY-50-CA is designed to incinerate sewage. Please see Appendix for design specifications.

6.1.3 <u>*Non-combustible wastes*</u>

6.1.3.1 Recyclables

Recyclable and reusable wastes will be collected, sorted and stored until they can be backhauled to an approved recycling facility. This includes plastic and aluminum drink containers, printer cartridges, plastics, and metals.

6.1.3.2 Non-combustible inert wastes

Non-combustible inert wastes will be collected, sorted and stored until they can be backhauled and included in recycling programs or disposed in an approved municipal landfill (as appropriate). This includes non-recyclable plastic, rubber, paint cans and sealed non-rechargeable ‘primary’ batteries.

6.1.3.3 Scrap Metal waste

Scrap metal waste will be collected, sorted and stored until such time as they can be backhauled and included in a scrap metal recycling program. This includes construction waste, equipment parts, and emptied and crushed 205 litre fuel drums.

6.2 Hazardous Waste

6.2.1 <u>*Hazardous waste generation*</u>

NCGC’s hazardous waste generator number is NUG100039.

6.2.2 <u>*Hazardous waste handling*</u>

All hazardous wastes generated at the CBP will be handled, sorted, packaged and labelled in accordance with applicable regulations. Personnel and contractors that handle hazardous wastes will be trained appropriately.

6.2.3 <u>*Hazardous Waste Storage*</u>

All hazardous materials will be clearly labelled in accordance with applicable regulations and stored in a safe manner inside secondary containment a minimum of 31 metres from the high water mark of any water body. Storage areas will be clearly identified and regularly inspected during operations.

MSDS sheets will be available for all hazardous materials and located inside the office or proximal to the storage area. MSDS sheets are also included in *NCG’s Spill Prevention and Contingency Plan.*

6.2.4 *<u>Hazardous Waste Transport</u>*

Hazardous material will be backhauled via aircraft and in some instances barge, rail and road to approved waste disposal facilities in either: Nunavut, the Northwest Territories or Manitoba. All waste products will be transported in accordance with the *Transport of Dangerous Goods Acts and Regulations (TDGA, TDGR)* administered by the Government of Nunavut and Transport Canada.

The TDGA and TDGR stipulate training, classification, packaging, labelling, and handling and transportation requirements for dangerous goods including hazardous wastes.

Dangerous good are divided into nine classes:

Class 1	Explosives
Class 2	Gases; compressed, deeply refrigerated, liquefied or dissolved under pressure
Class 3	Flammable and combustible liquids
Class 4	Flammable solids
Class 5	Oxidizing substances; organic peroxides
Class 6	Poisonous (toxic) and infectious substances
Class 7	Radioactive materials
Class 8	Corrosives
Class 9	Miscellaneous

The transportation of hazardous wastes is monitored by the Government of Nunavut by waste manifests. Suitably trained NCGC personnel will prepare a waste manifest on the appropriate form (issued by the Government of Nunavut – Environmental Protection Division). Waste Manifest will accompany all hazardous waste shipments whilst in transport from the CBP to the authorized hazardous waste receiver.

6.2.5 *<u>Waste Oils</u>*

NCGC intends to install a Clean Burn (or equivalent) waste oil furnace to provide heat to Quonset structures. This furnace will be fueled with waste oil products. (See Appendix 4 for specifications).

7.0 TRAINING

NCGC will ensure that personnel handling waste products are familiar with the NCGC *Comprehensive Waste Management Plan* and receive appropriate training.

8.0 RELEVANT LEGISLATION AND GUIDELINES

Other legislation, requirements and guidelines that apply to the storage, handling and transport of hazardous materials includes, but is not limited to:

8.1 Federal Legislation and guidelines

- National Fire Code of Canada
- Canadian Environmental Protection Act
- Federal Explosives Act and Regulations
- Fisheries Act
- Transportation of Dangerous Goods Act and Regulations
- Interprovincial Movement of Hazardous Wastes Regulations
- The Workplace Hazardous Materials Information Systems (WHMIS)

8.2 Provincial Legislation and guidelines

- Fire Prevention Act
- Nunavut Environmental Protection Act
- Government of Nunavut Environmental Guidelines
    - "General management of hazardous wastes"
    - "Waste batteries"
    - "Waste antifreeze"
    - "Waste solvent"
    - Disposal guidelines for fluorescent lamp tubes
- The Mine Health and Safety Act and Regulations
- Nunavut Safety Act and Regulations
- Public Health Act
- Nunavut Waters Act
- Nunavut Waters and Surface Rights Tribunal Act

9.0 CONTACTS

- Environmental Protection Division
  Department of Environment
  Inuksugait Plaza P.O. Box 1000, Station 1360
  Iqaluit, NU, X0A 0H0
  Phone: (867) 975-7729 Fax: (867) 975-7739

- Motor Vehicles Headquarters Division
  Department of Economic Development and Transportation
  Building 1104 A, Inuksugait Plaza
  PO Box 1000, Station 1500
  Iqaluit, NU, X0A 0H0
  Phone: (867) 975-7800 Fax: (867) 975-7870

- Workers' Safety and Compensation Commission
  P.O. Box 669, Baron Building/1091
  Iqaluit, NU, X0A 0H0
  Phone: 1-877-404-4407 (toll free) Fax: 1-866-979-8501

- Department of Community and Government Services (all Divisions)
  P.O. Box 1000, Station 700
  4th Floor, W.G. Brown Building
  Iqaluit, NU, X0A 0H0
  Phone: (867) 975-5400 Fax: (867) 975-5305

- Office of Chief Medical Health Officer of Health
  Department of Health and Social Services
  P.O. Box 1000, Station 1000
  Iqaluit, NU, X0A 0H0
  Phone: (867) 975-5774 Fax: (867) 975-5755

- NT-NU 24 Hour Spill Report Line
  Phone: (867) 920-8130 Fax: (867) 873-6924
  E-mail: spills@gov.nt.ca

- Nunavut Emergency Management – Emergency 24 hours
  Headquarters: (867) 979-6262 or 1-800-693-1666
  Kitikmeot: (867) 983-2542

- Office of the Fire Marshall (Nunavut Emergency Services Division)
  Department of Community Government and Transportation
  P.O. Box 1000, Station 700
  Iqaluit, NU, X0A 0H0
  Phone: 867-975-5315 Fax: 867-979-4221

10.0 <u>REVIEW</u>

NCGC will conduct annual reviews of this document to address changes in technology an operational practises. Changes will be implemented upon approval from the NWB.

APPENDIX 1

GOVERNMENT OF NUNAVUT
GUIDELINE FOR BURNING AND INCINERATION OF SOLID WASTE

Environmental Guideline for the
Burning and Incineration of Solid Waste

Department of Environment
Government of Nunavut

GUIDELINE: BURNING AND INCINERATION OF SOLID WASTE

Original: October 2010
Revised: January 2012

This Guideline has been prepared by the Department of Environment's Environmental Protection Division and approved by the Minister of Environment under the authority of Section 2.2 of the *Environmental Protection Act.*

This Guideline is not an official statement of the law and is provided for guidance only. Its intent is to increase the awareness and understanding of the risks, hazards and best management practices associated with the burning and incineration of solid waste. This Guideline does not replace the need for the owner or person in charge, management or control of a solid waste to comply with all applicable legislation and to consult with Nunavut's Department of Environment, other regulatory authorities and qualified persons with expertise in the management of solid waste.

Copies of this Guideline are available upon request from:

Department of Environment
Government of Nunavut
P.O. Box 1000, Station 1360, Iqaluit, NU, X0A 0H0
Electronic version of the Guideline is available at http://env.gov.nu.ca/programareas/environmentprotection

Cover Photos: Nunavut Department of Environment (left and bottom right), Aboriginal Affairs and Northern Development Canada (top right)

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Introduction

People living and working in Nunavut often have limited options available for cost effective and environmentally sound management of household and other solid waste. The widespread presence of permafrost, lack of adequate cover material and remote locations make open burning and incineration a common and widespread practice to reduce the volume of solid waste and make it less of an attractant to wildlife. A wide variety of combustion methods are used ranging from open burning on the ground to high temperature dual-chamber commercial incinerators. Generally, high temperature incinerators are more expensive to purchase and operate and cause less pollution than do the less expensive and lower temperature methods. However, high temperature incinerators can safely dispose of a wider variety of waste than can the lower temperature open burning methods.

The Guideline for the Burning and Incineration of Solid Waste (the Guideline) is not intended to promote or endorse the burning and incineration of solid waste. It is intended to be a resource for traditional, field and commercial camp operators, communities and others considering burning and incineration as an element of their solid waste management program. It examines waste burning and incineration methods that are used in Nunavut, their hazards and risks and outlines best management practices that can reduce impacts on the environment, reduce human-wildlife interactions and ensure worker and public health and safety. This Guideline does not address incineration of biomedical waste, hazardous waste and sewage sludge. The management of these wastes requires specific equipment, operational controls and training that are beyond the scope of the current document.

The *Environmental Protection Act* enables the Government of Nunavut to implement measures to preserve, protect and enhance the quality of the environment. Section 2.2 of the *Act* provides the Minister with authority to develop, coordinate, and administer the Guideline.

The Guideline is not an official statement of the law. For further information and guidance, the owner or person in charge, management or control of a solid waste is encouraged to review all applicable legislation and consult the Department of Environment, other regulatory agencies or qualified persons with expertise in the management of solid waste.

1.1 Definitions

Biomedical Waste	Any solid or liquid waste which may present a threat of infection to humans including non-liquid tissue, body parts, blood or blood products and body fluids, laboratory and veterinary waste which contains human disease-causing agents, and discarded sharps (i.e. syringes, needles, scalpel blades).
Bottom Ash	The course non-combustible and unburned material which remains at the burn site after burning is complete. This includes materials remaining in the burn chamber, exhaust piping and pollution control devices where such devices are used.
Burn Box	A large metal box used to burn solid waste. Combustion air is usually supplied passively through vents or holes cut above the bottom of the box. An exhaust pipe or stack may or may not be attached.

Commercial Camp	A temporary, seasonal or multi-year facility with a capacity greater than 15 people and which has been established for research, commercial or industrial purposes. A commercial camp does not include a traditional camp or field camp.
Commissioner's Land	Lands that have been transferred by Order-in-Council to the Government of Nunavut. This includes roadways and land subject to block land transfers. Most Commissioner's Land is located within municipalities.
Contaminant	Any noise, heat, vibration or substance and includes such other substance as the Minister may prescribe that, where discharged into the environment, (a) endangers the health, safety or welfare of persons, (b) interferes or is likely to interfere with the normal enjoyment of life or property, (c) endangers the health of animal life, or (d) causes or is likely to cause damage to plant life or to property.
Determined Effort	The ongoing review of opportunities for reductions and the implementation of changes or emission control upgrades that are technically and economically feasible and which result in on-going reductions in emissions. Determined efforts include the development and implementation of waste management planning which is focussed on pollution prevention.
De Novo Synthesis	The creation of complex molecules from simple molecules.
Environment	The components of the Earth and includes (a) air, land and water, (b) all layers of the atmosphere, (c) all organic and inorganic matter and living organisms, and (d) the interacting natural systems that include components referred to in paragraphs (a) to (c) above.
Field Camp	A temporary, seasonal or multi-year facility consisting of tents or other similar temporary structures with a capacity of 15 people or less and which has been established for research, commercial or industrial purposes. A field camp does not include a traditional camp or commercial camp.
Fly Ash	Unburned material that is emitted into the air in the form of smoke or fine particulate matter during the burning process.
Hazardous Waste	A contaminant that is a dangerous good and is no longer wanted or is unusable for its original intended purpose and is intended for storage, recycling, treatment or disposal.
Incineration	A treatment technology involving the destruction of waste by controlled burning at high temperatures.

Incinerator	A device or structure intended primarily to incinerate waste for the purpose of reducing its volume, destroying a hazardous substance in the waste or destroying an infectious substance in the waste. An incinerator has means to control the burning and ventilation processes.
Inspector	A person appointed under subsection 3(2) of the *Environmental Protection Act* and includes the Chief Environmental Protection Officer.
Modified Burn Barrel	A metal drum used to burn waste that has been affixed with devices or features which provide limited increased heat generation, heat retention and holding time.
Open Burning	Burning of waste with limited or no control of the burn process. For clarity, open burning includes burning on the open ground or using a burn box or unmodified or modified burn barrel.
Qualified Person	A person who has an appropriate level of knowledge and experience in all relevant aspects of waste management.
Responsible Party	The owner or person in charge, management or control of the waste.
Smoke	The gases, particulate matter and all other products of combustion emitted into the atmosphere when a substance or material is burned including dust, sparks, ash, soot, cinders and fumes.
Solid Waste	Unwanted solid materials discarded from a household (i.e. single or multiple residential dwellings, other similar permanent or temporary dwellings), institutional (i.e. schools, government facilities, hospitals and health centres), commercial (i.e. stores, restaurants) or industrial (i.e. mineral, oil and gas exploration and development) facility. For clarity, solid waste does not include biomedical waste, hazardous waste or sewage sludge.
Traditional Camp	A temporary or seasonal camp used primarily for camping, hunting, fishing or other traditional or cultural activities. A traditional camp does not include a field camp or commercial camp.
Unmodified Burn Barrel	A metal drum used to burn waste that has not been affixed with devices or features which provide for enhanced heat generation, heat retention and holding time.
Untreated Wood	Wood that has not been chemically impregnated, painted or similarly modified to improve resistance to insects or weathering.
Waste Audit	An inventory or study of the amount and type of waste that is produced at a location.

1.2 Roles and Responsibilities

1.2.1 Department of Environment

The Environmental Protection Division is the key environmental agency responsible for ensuring the proper management and disposal of solid waste and other contaminants on Commissioner's Land. Authority is derived from the *Environmental Protection Act*, which prohibits the discharge of contaminants to the environment and enables the Minister to undertake actions to ensure appropriate management measures are in place. Although programs and services are applied primarily to activities taking place on Commissioner's and municipal lands and to Government of Nunavut undertakings, the *Environmental Protection Act* may be applied to the whole of the territory where other controlling legislation, standards and guidelines do not exist. A complete listing of relevant legislation and guidelines can be obtained by contacting the Department of Environment or by visiting the web site at:

http://env.gov.nu.ca/programareas/environmentprotection.

The Wildlife Management Division is responsible for managing wildlife in Nunavut. Section 90 of the *Wildlife Act* prohibits the intentional feeding of wildlife and the placement of any food or garbage where there is a reasonable likelihood that it would attract wildlife. Once wildlife has been 'conditioned' to obtaining food associated with human activities, it can become dangerous and often will have to be destroyed. Further information on ways to reduce contact between wildlife and humans can be obtained by contacting the local Conservation Officer or by visiting the web site at:

http://env.gov.nu.ca/programareas/wildlife.

The Department of Environment will provide advice and guidance on the burning and incineration of solid waste. However, it remains the responsibility of the owner or person in charge, management or control of the solid waste to ensure continued compliance with all applicable statutes, regulations, standards, guidelines and local by-laws.

1.2.2 Generators of Solid Waste

The generator, or responsible party, is the owner or person in charge, management or control of the solid waste at the time it is produced or of the facility that produces the waste. The responsible party must ensure the waste is properly and safely managed from the time it is generated to its final disposal. This is referred to as managing the waste from cradle-to-grave.

Contractors may manage solid waste on behalf of the responsible party. However, the responsible party remains liable for ensuring the method of management complies with all applicable statutes, regulations, standards, guidelines and local by-laws. If the contractor does not comply with the requirements of the *Environmental Protection Act* or *Wildlife Act* and is charged with a violation while managing the waste, the responsible party may also be charged.

1.2.3 Other Regulatory Agencies

Other regulatory agencies may have to be consulted regarding the burning and incineration of solid waste as there may be other environmental or public and worker health and safety issues to consider.

Workers' Safety and Compensation Commission

The Workers' Safety and Compensation Commission is responsible for promoting and regulating worker and workplace health and safety in Nunavut. The Commission derives its authority from the *Workers' Compensation Act* and *Safety Act* which require an employer to maintain a safe workplace and ensure the safety and well being of workers.

Department of Community and Government Services

The Department of Community and Government Services is responsible under the *Commissioners' Lands Act* for the issuance of land leases, reserves, licenses and permits on Commissioner's Lands. The Department, in cooperation with communities, is also responsible for the planning and funding of municipal solid waste and sewage disposal facilities in most Nunavut communities.

The Office of the Fire Marshal is responsible for delivering fire and life safety programs including reviewing plans to ensure incinerators and other heating devices comply with all legislation, codes and standards. The Office of the Fire Marshal derives its authority from the *Fire Prevention Act*, *National Fire Code* and *National Building Code*.

Department of Health and Social Services

Activities related to the burning and incineration of solid waste may have an impact on public health. The Office of the Chief Medical Officer of Health and Regional Environmental Health Officers should be consulted regarding legislated requirements under the *Public Health Act.*

Environment Canada

Environment Canada is responsible for administering the *Canadian Environmental Protection Act* (CEPA) and Canada's Toxic Substances Management Policy. Many pollutants that are released into the atmosphere from the incomplete combustion of unsegregated, or mixed, solid waste are listed as Toxic Substances in Schedule I of CEPA, or are targeted for phase-out through the Toxic Substances Management Policy. Environment Canada is also responsible for administering the pollution prevention provisions of the federal *Fisheries Act* and for regulating the international and interprovincial movement of solid and liquid hazardous waste under the *Interprovincial Movement of Hazardous Waste Regulations* and *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*.

The Air Quality Research Division of Environment Canada is responsible for conducting research into atmospheric releases of chemicals in commercial use in Canada, measuring exhaust emissions from stationary and mobile sources and undertaking ambient air quality monitoring in partnership with provinces and territories.

Aboriginal Affairs and Northern Development Canada

Aboriginal Affairs and Northern Development Canada is responsible under the *Territorial Lands Act* and *Nunavut Waters and Nunavut Surface Rights Tribunal Act* for the management of federal lands and waters, including the impact solid waste may have on the quality of these lands and waters.

Local Municipal Governments

The role of municipal governments is important in the proper local management of solid waste. Under the Nunavut Land Claims Agreement, municipalities are entitled to control their own municipal disposal sites. Local environmental and safety standards are determined, in part, by how the land is designated under municipal government development plans (i.e. land use zoning). Solid waste may be deposited into municipal landfill sites only with the consent of the local government. The local fire department may also be called upon if a fire or other public safety issue is identified.

Co-management Boards and Agencies

Co-management boards and agencies established under the Nunavut Land Claims Agreement have broad authority for land use planning, environmental impact assessment and the administration of land and water. Activities involving the burning and incineration of solid waste may be controlled through the setting of terms and conditions in plans, permits and licenses issued by the Nunavut Water Board and other co-management boards and agencies.

Waste Burning and Incineration

2.1 The Combustion Process

The combustion, or burning, of solid waste proceeds through a series of stages. Water is first driven from the unburned waste by heat produced from material burning nearby or from an auxiliary burner. As the waste heats up, carbon and other substances are released and converted into burnable gases. This is referred to as gasification. These gases are then able to mix with oxygen. If the temperature inside the burn chamber is high enough and maintained for a long enough period of time, the hot gases are completely converted into water vapour and carbon dioxide, which is then released into the air. If the temperature inside the burn chamber is not high enough and the burn time is too short, complete conversion of the burnable gases does not occur and visible smoke is released into the air. Another result of burning at low temperatures is the creation of pollutants that were not originally present in the waste. This process is known as *de novo* synthesis. Dioxins, furans and other complex chemical pollutants can be formed through this process.

Ash produced from combustion takes the form of either fly ash or bottom ash. Fly ash is the fine particles carried away in the form of smoke while bottom ash is the course non-combustible and unburned material that remains after the burn is complete. The type and amount of pollutants in the fly and bottom ash depend upon what waste is burned and completeness of the combustion process.

The completeness of combustion is determined by all of the following factors:

Temperature

The temperature generated is a function of the heating value of the waste and auxiliary fuel, incinerator or burn unit design, air supply and combustion control. Complete combustion requires high temperatures. Generally, temperatures that exceed 650^{o}C with a holding time of 1-2 seconds will cause complete combustion of most food and other common household waste. Segregation of waste is required when using methods that don’t routinely achieve these temperatures. Dual chamber incinerators, which are designed to burn complex mixtures of waste, hazardous waste and biomedical waste, must provide a temperature higher than 1000^{o}C and a holding time of at least one second to ensure complete combustion and minimize dioxin and furan emissions. When these high temperatures and holding times are achieved, waste will be completely burned and ash, smoke and pollutant concentrations will be minimized.

Because exhaust gas temperatures vary from ambient to greater than 1000°C each time a batch waste incinerator is used, optional air pollution control systems with evaporative cooling towers and scrubbers are seldom recommended. However, it may be necessary to employ these systems with large continuous feed incinerators if additional cleaning of exhaust gas is required by regulatory authorities.

Holding Time

Complete combustion takes time. Holding time, otherwise known as retention or residence time, is the length of time available to ensure the complete mixing of air and fuel, and thus the complete burning of waste. Low temperatures, low heating values of the waste and reduced turbulence require that the holding time be increased to complete the combustion process.

Turbulence

The turbulent mixing of burnable gases with sufficient oxygen is needed to promote good contact between the burning waste and incoming air. This will help in achieving the high temperatures at which waste can be completely burned. The amount of mixing is influenced by the shape and size of the burn chamber and how the air is injected. Passive under-fire ventilation achieved during open burning does not result in sufficient turbulence for the burning of a wide variety of waste. Also, it is important not to overfill the burn chamber as airflow may be blocked and the amount of turbulence further reduced. The more advanced incineration designs provide effective turbulence through the forced introduction of air directly into hot zones.

Composition of the Waste

The heating value, wetness and chemical properties of the waste affect the combustion process and the pollutants that are contained in the resulting smoke and ash. The higher the burn temperature, holding time and turbulence that are achieved, the less effect the composition of the waste has on completeness of the burn.

2.2 Pollutants of Concern

Extreme care must be exercised when burning or incinerating solid waste. Open burning and the improper incineration of solid waste can result in environmental, health and safety hazards from the pollutants found in smoke and exhaust gases and in the bottom ash. These pollutants may either be found in the original waste itself, or may be created through *de novo* synthesis if sufficient temperature, holding time and turbulence is not achieved in the burn chamber.

Many different types of pollutants can be released during burning and incineration. A few of these pollutants include acid gases, trace metals, fine particulates, volatile organic compounds and semi-volatile organic compounds. Acid gases such as hydrogen chloride and sulphur oxides result from burning waste that has high levels of chlorine and sulphur (i.e. plastics). Mercury, lead and cadmium are examples of trace metals found in both fly and bottom ash when batteries, used lubricating oil and other metal-containing wastes are burned. Fine particulates are the very small particles found in smoke created by incomplete combustion and can cause respiratory irritation in humans and wildlife.

Dioxins and furans are pollutants that have drawn much attention in recent years because they have been linked to certain types of cancers, liver problems, impairment of the immune, endocrine and reproductive systems and effects on the fetal nervous system. These pollutants persist in the environment for long periods of time, bioaccumulate in plants and animals, result predominantly from human activity and have been identified for ‘virtual elimination’ in Canada under the federal Toxic Substances Management Policy. The incineration of solid waste accounts for almost 25% of the dioxin and furan emissions in Canada each year. They are formed in trace amounts by *de novo* synthesis during the low temperature burning of waste containing organic compounds and chlorine (i.e. chlorinated plastic, PVC pipe, marine driftwood).

The most effective way to reduce or minimize the release of pollutants is to segregate the waste before burning and achieve sufficiently high temperature, holding time and turbulence in the burn chamber. Open burning produces more smoke and pollutants, including dioxins and furans, than does an incinerator capable of achieving complete combustion.

2.3 Burning and Incineration Methods

The burning and incineration method used is a major factor in determining what type of waste can be safely and effectively disposed of. The methods commonly used in Nunavut include open burning on the ground, unmodified burn barrels and various mechanical incineration systems. Other useful methods include the use of burn boxes and modified burn barrels. Each method is discussed separately in the following sections.

2.3.1 Open Burning

Open burning means the burning of waste where limited or no control of the combustion process can be exercised by the operator. This method includes burning solid waste directly on the open ground or in burn boxes or burn barrels and often does not achieve the temperatures or holding time needed for complete combustion of the waste to occur. This results in the formation of potentially hazardous pollutants and ash, which are likely to impact nearby land and water. Food waste that is not completely burned through open burning can also be a powerful attractant for animals.

The various open burning methods can also present a risk of uncontrolled vegetation and tundra fires through the release of hot sparks or embers. The level of fire risk depends upon the type of open burning used, its location, the skill of the operator and the environmental conditions that exist at the time (i.e. dryness of the surrounding vegetation, wind).

The open burning of solid waste remains a common practice in Nunavut. It is the policy of the Department of Environment to eliminate or minimize open burning of mixed solid waste to the extent practicable and to encourage more acceptable methods of disposal and incineration.

Open Burning on the Ground

Open burning on the ground involves burning solid waste that has been piled directly on the surface of the ground or placed in a small open pit. Many large and small communities and camp operators in Nunavut continue to practice open burning on the ground as a means of reducing the volume of solid waste that must ultimately be disposed of. In general, open burning on the ground results in the incomplete combustion of waste and the release of various harmful pollutants to the air, can cause vegetation or tundra fires through the uncontrolled release of hot sparks and embers, and is actively discouraged by the Nunavut Department of Environment as a method for disposing of unsegregated or mixed solid waste.

Figure 1 – Open Burning on the Ground
Photo courtesy of Aboriginal Affairs and Northern Development Canada

Burn Boxes

There are two basic types of burn boxes. The *enclosed burn box* is constructed using heavy sheets of steel or other metal while the *open burn box* is constructed using expanded metal grating. The latter type is commonly referred to as a *burn cage*. These devices are not commercially-available in Nunavut, but can be constructed using locally available materials. For example, the enclosed metal burn box shown in Figure 2 is made from a dump truck bed and steel plating.

Figure 2 – Enclosed Metal Burn Box
Photo courtesy of Alaska Department of Environmental Conservation

Burn boxes are considered a modification of open burning. Combustion air is provided passively using a natural draft making electricity unnecessary. Burn boxes are single chambered units. Waste is raised off the bottom of the box by placing it on grates inside the unit. Unburned bottom ash falls through the grate during burning making removal easier once a sufficient amount has accumulated. Combustion air in enclosed burn boxes is typically provided by cutting holes near the bottom of the box allowing for better mixing with the burning waste.

Open burn boxes, or burn cages, are an improvement over enclosed burn boxes as the waste is exposed to natural drafts through the metal grating on all surfaces including the bottom. This enables air to better mix with burning waste and promotes more efficient combustion throughout the burning period. Both types of burn boxes are constructed with hinged tops to enable easier loading and cleaning.

Unlike open burning on the ground, burn boxes help to contain the burning waste within a specific location reducing the risk of fire spreading to other disposal areas or surrounding tundra, while still enabling moderate amounts of solid waste to be burned.

Figure 3 – Open Metal Burn Box
Photo courtesy of Alaska Department of Environmental Conservation

Burn Barrels

There are two basic types of burn barrels – the unmodified burn barrel and modified burn barrel.

The *unmodified burn barrel* is normally a 45 gallon, or 205 litre, metal fuel or oil drum with the top removed. These devices typically operate at a low temperature resulting in incomplete combustion of the waste and production of large volumes of smoke and fly ash.

A *modified burn barrel* is a 45 gallon metal fuel or oil drum that has been affixed with devices or features which result in higher burn temperatures, better mixing of the air and a longer holding time. These modifications include a 'metal mesh basket' insert or grate designed to suspend the burning waste. Evenly spaced vents or holes cut above the bottom of the barrel supply combustion air. These features provide for enhanced passive under-fire ventilation and promote better contact between the waste being burned and incoming air. The basket insert is topped with a hinged lid and a chimney port for attachment of an exhaust pipe or stack. The lid helps to increase heat retention and holding time inside the barrel while also allowing for easier loading and mixing of the waste. The removable mesh basket enables access to the unburned bottom ash.

Figure 4 – Modified Burn Barrel

Modified burn barrels can be built using commonly available materials. They can either be pre-built locally or transported to the site for assembly. Detailed construction plans are provided in Appendix 2.

Although modified burn barrels are designed to create an advantage over open burning on the ground, burn boxes and unmodified burn barrels through achieving higher burn temperatures and increased turbulence and holding time, incomplete combustion of waste and the release of pollutants to the atmosphere are still likely. In fact, emissions testing by Environment Canada on a modified burn barrel in April 2011 suggest that these devices do not provide any improvement over open burning on the ground in terms of emissions quality, particularly if wet food waste is added to the waste mixture. Other common problems include easily overfilling the unit and loading waste that should not be burned (refer to section 3.2). Wet or frozen masses of waste are particularly difficult to burn and the resulting partly burned food waste may still attract animals. The proper operation of modified burn barrels is critical to achieving the most efficient burn possible. Basic operating instructions are provided in section 4.1.

Burn barrels are capable of burning only small volumes of solid waste. Like burn boxes, they reduce the risk of fire spreading to vegetation and tundra by containing the burning waste to a specific location.

2.3.2 Incineration

Solid waste incinerators are engineered systems that are capable of routinely achieving burn temperatures in excess of 1000°C and a holding time of at least one second. Properly designed and operated incinerators are able to effectively and safely destroy a wide range of waste. Only incinerators designed for burning mixed municipal solid waste are discussed in the guideline. The incineration of hazardous and biomedical waste and sewage sludge requires specific equipment, operational controls and training that are beyond the scope of the current document.

There are four basic types of incinerators. They vary based upon the number of burn chambers they have, the amount of air provided to each chamber and how waste is fed into the primary burn chamber.

Dual-Chamber Starved Air System	The primary burn chamber receives less air than is needed to achieve full combustion. Gases from this incomplete combustion then pass into a second burn chamber where sufficient air is injected and complete combustion is achieved.
Single Chamber Excess Air System	More than a sufficient amount of air (as much as 50% more than the amount of air needed) is injected into the single burn chamber to achieve complete combustion of the waste.
Continuous Feed Incinerator	An incineration process that is in a continuous burn cycle. A continuous feed incinerator operates without interruption throughout the operating hours of the facility by having waste continually added to the primary burn chamber.
Batch Feed Incinerator	An incineration process that is not in a continuous or mass burning cycle. A batch feed incinerator is charged with a discrete quantity or single load of waste at the beginning of the burn cycle.

Batch feed dual-chamber controlled air incinerators currently operate at several remote industrial locations in northern Canada and Alaska. Although they are generally considered to have the highest qualities of all the incinerators and open burning methods mentioned, they must be designed for the type and quantity of waste to be burned. Too little heat and holding time will not allow waste to burn properly; too much heat will damage the incinerator.

Figure 5 illustrates the design of a typical batch feed dual-chamber controlled air incinerator. The main features of this type of incinerator are:

- Batch operation allows greater control of temperature and air throughout the burn process.
- Air turbulence can be reduced in the primary chamber so fewer particulates are released into the air from the stack.
- Although a wide range of wastes can be destroyed, waste may have to be segregated and remixed in order to achieve a uniform heating value close to the design point of the incinerator.
- Externally supplied fuel and electricity are needed for the burners and forced air ventilation.
- A properly operating dual-chamber controlled air system will reduce problems with animal attraction as the production of bottom and fly ash and smoke is minimized.

Section 2.3.2 is intended to provide the reader with a brief introduction to incinerators. It is not intended to provide information suitable for the design, selection or operation of an incineration system. Any person considering the purchase of an incineration system should first consult the system's manufacturer or other qualified persons with expertise in the incineration of solid waste.

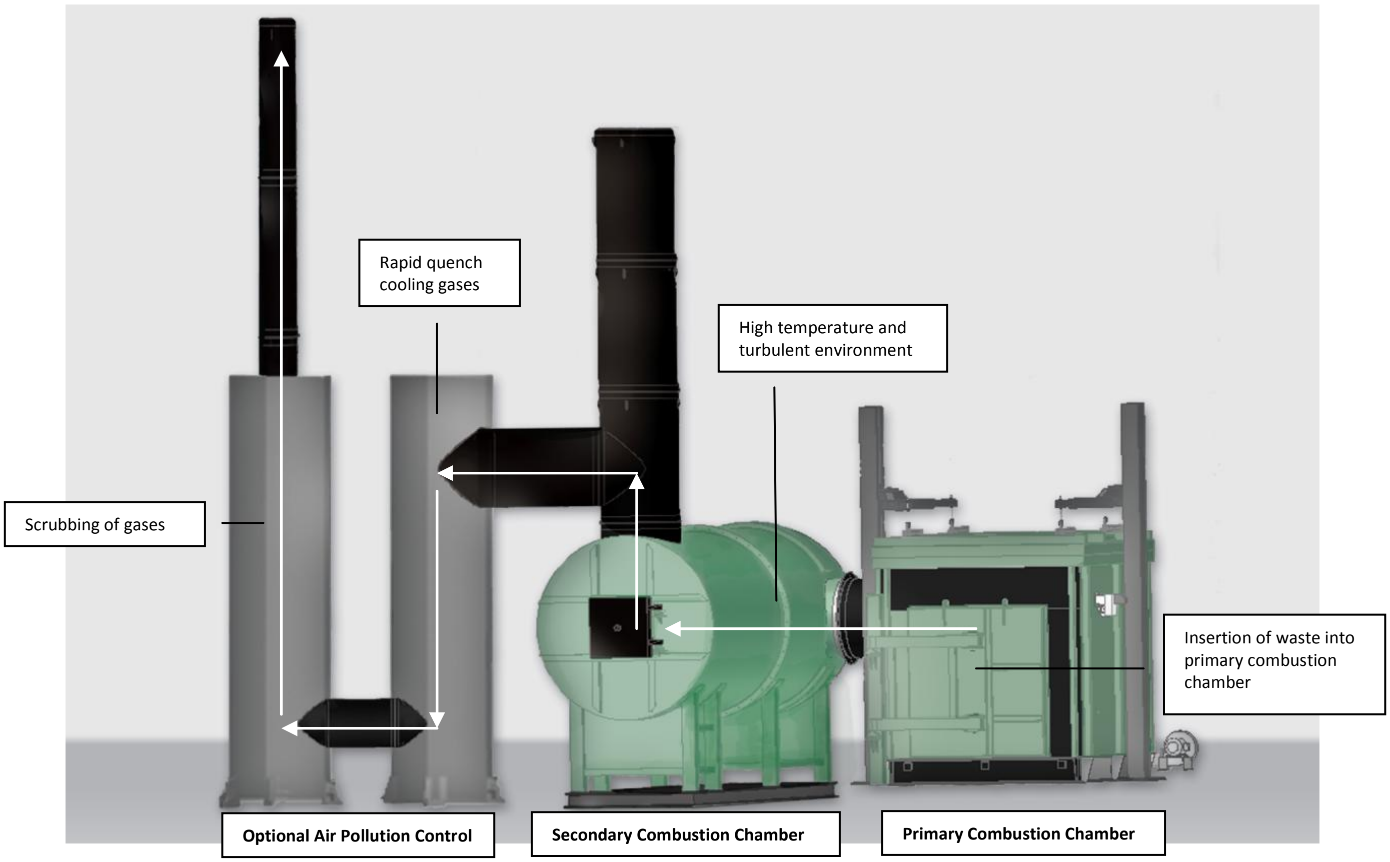

Figure 5 – Typical Batch Feed Dual-Chamber Controlled Air Incinerator with Optional Air Pollution Controls Illustration courtesy of Eco Waste Solutions

2.4 Environmental Standards

2.4.1 Air Emissions

Air emission standards establish limits on the amount of contaminants that can be released into the atmosphere. These standards are expressed as a concentration in the exhaust gases leaving the stack and are capable of being achieved using generally available incineration technology and waste diversion practices. The following emission standards[1] apply to existing, new or expanding solid waste incinerators operating in Nunavut and have been adopted from the Canadian Council of Ministers of the Environment (CCME) Canada-Wide Standards for Dioxins and Furans and Mercury Emissions, respectively. Similar standards for the open burning of solid waste have not been established.

[1] Stack concentrations are always corrected to 11% oxygen content for reporting purposes.

Table 1. Air Emission Standards for Solid Waste Incinerators

Parameter	Numeric Standard	Explanation
Dioxins and Furans	80 pg I-TEQ/cubic metre	Unit of measure is picograms of International Toxicity Equivalents per cubic metre of air
Mercury	20 µg/Rcubic metre	Unit of measure is micrograms per Reference cubic metre (the volume of gas adjusted to $25^{o}C$ and 101.3 kilopascals)

Opacity is the degree to which the exhaust gases reduce the transmission of light and obscure the view of any object in the background. It is expressed as a percentage representing the extent to which an object viewed through the gases is obscured. Although not an emission standard, opacity provides an indication of the general performance of the incinerator during normal operation[2]. Opacity in the incinerator stack should not exceed 5%. While it is not anticipated that opacity levels would exceed 1% to 2% under normal operation, values greater than 5% indicate the incinerator is not performing properly and additional performance evaluation and adjustment is required.

Less than 5% Opacity | 20%-30% Opacity | 90%-100% Opacity

Figure 6 - Examples of Smoke Opacity Ratings
The opacity ratings are estimates and are provided for illustrative purposes only
Centre and right photos courtesy of GNWT Department of Environment and Natural Resources

2.4.2 Bottom Ash

The *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* establishes criteria for determining whether process residuals[3] are suitable for disposal in landfill sites in Nunavut. For the purpose of this Guideline, process residuals include bottom ash from industrial and commercial incinerators. The Toxicity Characteristic Leaching Procedure Test method 1311 (US EPA) is the preferred method to analyze the residuals as this test is designed to simulate the processes a material would be subjected to if placed in a landfill.

Refer to the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* for additional information on the management of process residuals.

[2] The time during which optimum designed temperature is maintained in the burn chamber, and excludes ‘startup’ and ‘cool down’ operations.
[3] Process residuals are the solid, semi-solid or sludge waste resulting from industrial operations.

Best Management Practices

Best management practices are methods and techniques that have been shown to be effective in preventing or reducing pollution. They include policies, prohibitions of practices, maintenance and monitoring procedures and other practices adopted by the responsible party. Implementing best management practices together with using best available technology is an effective means of reducing costs, reducing pollution and reducing a parties' legal liabilities.

3.1 Waste Management Planning

The generator of a waste is responsible for its safe management from cradle-to-grave. Using raw materials efficiently and reducing the amount of waste generated is the most important step in waste management planning. For example, through improved waste management planning, it may be possible to reduce or eliminate the need to burn or incinerate waste altogether. Undertaking a waste audit will help to identify the type and amount of waste being generated, the costs of current management options and examine opportunities for better managing the waste. This information will also enable the generator to implement a waste management regime that is tailored to its own unique needs, location and circumstances.

Even with improved waste reduction measures in place there will be waste generated. Waste by its nature is usually a mixture of different unwanted materials. The segregation and diversion of different types of waste is an effective way to reduce the amount of waste requiring costly handling, storage, treatment and disposal. Segregation also enables the reuse of certain types of waste for a different purpose. Reuse activities may be undertaken either on-site or off-site.

Treatment and disposal is the last step in effective waste management and should be undertaken only after all other practical reduction and reuse options have been examined. A wide variety of treatment and disposal options exist and each must be examined before deciding on a final method, regardless of whether waste is to be treated and disposed of on-site or off-site. If burning and incineration is the method of choice, equipment must be designed and sized accordingly to accommodate the type and quantity of waste being produced. As described in the following section, open burning is capable of safely destroying a limited number of types of waste. While incinerators are capable of safely destroying a wider range of waste, many types of waste must still be diverted. Because of this, on-site segregation remains a critical component of any waste management plan.

Overall, the following principles should be used to guide responsible solid waste management planning:

- Know your waste by conducting a waste audit.
- Reduce the amount of solid waste produced by implementing strategic purchasing policies that focus on the substitution or reduction of purchased products as well as product design, composition and durability.
- Reuse waste where different purposes can be identified.
- Segregate and divert mixed waste streams enabling waste to be reused or recycled, thereby reducing the amount of waste to be disposed of.
- All practical disposal methods should be examined. Burning and incineration of waste should be considered only where other practical methods do not exist.

- If burning and incineration is used, the equipment chosen should be designed and sized to accommodate the waste produced, minimize fire hazard and result in the complete combustion of the waste.

3.2 Wastes That Can be Burned or Incinerated

Complete combustion converts waste into inert bottom ash with minimal creation of smoke, fly ash and hazardous gases. Several factors influence this process including the heating value, wetness and chemical composition of the waste itself, operating conditions in the burn chamber (i.e. temperature, holding time and turbulence) and operator skill.

The method used is important in determining what can safely be burned. Certain wastes can only be incinerated using equipment that has been specifically designed and equipped with sufficient air pollution controls and that achieve specific air emission standards. For example, waste containing chlorinated compounds (i.e. chlorinated solvents and plastics, PVC piping, wood treated with pentachlorophenol or PCB-amended paint, marine driftwood) must be separated from other waste as their burning will result in the *de novo* creation and emission of various dioxin and furan compounds. Waste containing mercury (i.e. batteries, thermostats and fluorescent light bulbs) and other heavy metals (i.e. lead acid batteries, wood treated with lead paint) should not be burned as the mercury and heavy metals will not be destroyed. Other waste that should not be burned unless using specially designed incinerators include used lubricating oil, hydrocarbon contaminated soil, biomedical waste, sewage sludge or any other waste specifically prohibited by the Department of Environment.

Table 2 provides a listing of common wastes that can be burned and those that require special consideration and treatment. Note that open burning and incineration are identified as separate columns in the table and that different restrictions apply depending upon which method is used. In general, more restrictions apply to the various methods of open burning because of the incomplete combustion achieved. Fewer restrictions apply to incineration because of the operator’s ability to control the combustion process.

Non-combustible materials such as metal and glass do not burn and will rob heat away from waste that can be destroyed by burning. Combustible waste should always be separated from non-combustible waste before being loaded into the burn chamber.

3.3 Keeping Waste Dry

Typical mixed garbage has a moisture content of less than 20% while the moisture content of food wastes can range up to 80%. Anything that can be done to reduce the moisture of waste burned will decrease the amount of smoke produced and increase the completeness of combustion. Waste should be covered or stored inside sheds or other secure buildings to keep rain and snow out of the waste. This will also lessen the opportunity for wildlife to access the waste. If wet waste must be burned, the wet waste should be mixed or layered with dry waste to reduce the overall moisture content of the waste burned. Mixing or layering waste in this manner is particularly important when loading wet solid waste into a burn box or modified burn barrel.

Table 2. Waste That Can be Burned or Incinerated

	Method	
Waste Type	**Open Burning[4]**	**Dual-Chamber Incinerator**
Paper products	✓	✓
Paperboard packing including boxboard and cardboard	✓	✓
Untreated wood including lumber and plywood	✓	✓
Food waste		✓
Food packaging		✓
Natural fiber textiles	✓	✓
Plastic and Styrofoam except plastic containing chlorine[5]		✓
Painted wood except wood painted with lead or PCB-amended paint		✓
Wood treated with creosote or tar oil		✓
Hydrocarbon spill absorbents		✓
Animal carcasses except those affected by disease-causing agents		✓

The following waste requires special consideration. It is not to be burned or incinerated unless the equipment used has sufficient air pollution controls, meets specific air emission standards and has been specifically designed to safely incinerate the waste product.

Hydrocarbon contaminated soil
Radioactive waste including smoke detectors
Organic compounds containing chlorine including plastics, solvents, PVC piping and marine driftwood
Pesticides
Items containing mercury, lead or other heavy metals including paint, computer equipment and fluorescent bulbs
Batteries
Explosives
Pressurized cans, cylinders or other containers that may explode when heated
Synthetic fiber textiles
Biomedical waste and animal carcasses affected by disease-causing agents
Wood treated with pentachlorophenol, inorganic preservatives, lead paint or PCB-amended paint
Sewage sludge
Rubber tires
Used lubricating oil
Waste fuel except limited quantities used solely as a starting fuel
Construction and demolition waste including roofing materials, electrical wire and insulation

3.4 Locating the Facility

Distance from sensitive areas (i.e. camp, work site, drinking water supply) and prevailing wind direction are important factors to consider when locating any facility that burns waste. The facility should be kept

[4] Includes open burning on the ground and the use of burn boxes, unmodified burn barrels and modified burn barrels.
[5] Chlorinated plastic materials are identified by the number "3" associated with the mobius loop symbol.

at least 100 metres from any surface water body. Although the objective is to minimize pollutants being released to the air, the site should be selected so that any resulting emissions are adequately dispersed. This includes locating the structure or facility away from areas or features that may trap smoke close to the ground (i.e. located in a valley). Avoid burning waste if people will be living or working within the plume of smoke. The facility should be located on stable and level ground. A gravel, rocky outcrop or other area free of combustible materials and vegetation should be chosen to avoid accidently starting a vegetation or tundra fire.

3.5 Maximizing Combustion Efficiency

More smoke and other pollutants are released into the air during the ‘start-up’ and ‘cool down’ phases of the burn cycle than during the ‘full burn phase’ when high temperatures are maintained. Low temperature smoldering fires should be avoided. Burn only dry feedstock and periodically add additional waste to the fire in order to maintain high burn temperatures until all waste has been destroyed. If waste is to be open burned on the ground, the use of deep or steep-walled ‘pits’ should be avoided as this will prevent the necessary turbulent mixing of oxygen with the burnable gases.

Desired operating temperature should be achieved as quickly as possible when operating any burning or incineration device. A rapid ‘start-up’ can be achieved by first loosely loading dry paper, paperboard packing and untreated wood into the bottom of the device. Dry, loosely loaded material will ignite more quickly and burn more evenly than a wet, tightly packed load. Wet waste should only be added after the fire is actively burning. Overfilling the burn chamber will prevent the turbulent mixing of burnable gases and oxygen, and should be avoided.

Modern batch feed incinerators are designed with primary and auxiliary burners to achieve and maintain the necessary high burn temperatures. Additional waste should only be added to these incinerators once the ‘cool down’ phase has been completed and it is safe to do so.

3.6 Ash Management

The management of bottom ash and other unburned residue is an integral part of sound waste management and the ash will need to be disposed of. Extreme care must be exercised when handling ash because of its physical (i.e. glass, nails) and chemical hazards. Use closed or covered containers when moving or transporting bottom ash from the burning device or incinerator to the approved disposal site. This will minimize physical contact with the ash and the release of fine ash particles to the environment.

Avoid handling bottom ash until it is completely cool. Hot ash and embers can cause painful skin burns and should never be buried or landfilled as they could cause unburned waste in the disposal area to catch fire.

Bottom ash from the open burning of paper, paperboard packing, untreated wood waste and natural fiber textiles is suitable for burial in a designated pit or municipal landfill. Because incinerators can be used to destroy a wide variety of waste and the subsequent ash may contain a wide variety of toxic residues, bottom ash from an incinerator is suitable for burial only where it meets the criteria set out in Table 1 of the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities*. Waste originating from outside a municipality and meeting the criteria may be deposited in municipal landfills only with the consent of the local government. Any bottom ash not meeting the criteria set out in the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* is considered to be a hazardous waste. This ash is not suitable for landfilling and its management must comply with the *Environmental Guideline for the General Management of Hazardous Waste*.

3.7 Monitoring and Record Keeping

Burn boxes, burn barrels and incinerators should be inspected for signs of damage, corrosion or other physical defects before each burn cycle. Repairs must be completed before the equipment is used again to ensure the health and safety of the operator, nearby people and the environment.

The various open burning methods tend to produce large quantities of smoke. Burning dry waste, high burn temperatures and sufficient air mixing with the burnable gases will reduce, but not eliminate, the amount of smoke and other pollutants that are generated. Large quantities of dark smoke indicate problems and inefficiencies with the combustion process and the generation of pollutants. Keep records of when, how much and what waste was burned, how the waste was loaded into the burning device or incinerator, the amount of smoke and bottom ash generated, how the fire was started and any other information that would help remind the operator of what worked well, and what didn't. These records would also assist the operator, Department of Environment and other regulatory agencies if complaints of nuisance smoke were to be received.

The operation of incinerators should be monitored using on-line instruments capable of continuously measuring the combustion process and stack emissions. The most basic measurement associated with the combustion process is temperature in both the primary and secondary burn chambers. Temperature readings outside of the normal range can warn the operator that the system is not working properly. In-stack monitoring provides the operator with additional information on the combustion process and on pollutants that may be released to the environment. A continuous opacity or particulate monitor should be installed in the incinerator stack to monitor emissions quantity. Additional combustion chamber and in-stack sampling and monitoring may be required depending upon the type and quantity of waste being incinerated. Each process and in-stack monitor should be equipped with visible and audible alarms to warn operators of poor incinerator operation. Refer to section 4.2 for additional information on incinerator monitoring requirements.

Written records should be kept by incinerator operators of what waste is burned, when and how much. Other record keeping requirements for incinerators may include:

- Operating data including readings from the process and emissions monitoring instruments.
- Weather conditions (i.e. air temperature and wind speed) at the time the incinerator is being operated.
- Repairs and maintenance performed on the incinerator and monitoring instruments.
- Major changes in operation.
- Quantity, condition and disposal location of the collected bottom ash.
- Operator training.

Records should be maintained on-site throughout the operational life of the facility and be made available to Inspectors and other regulatory officials upon request.

3.8 Operator Training

The cornerstone of ensuring proper and safe operation of any equipment is adequate operator training. Facility owners must ensure qualified operators are available and have been properly trained to operate the equipment under both normal and emergency conditions. This will help to ensure the continued operation and maintenance of the equipment and facility, protection of the environment and the continued health and safety of the operator and nearby people. In particular, operators of incinerators should be trained in the following areas:

- Physical and mechanical features of the equipment and facility.
- Operation and trouble-shooting procedures.
- Environmental and safety concerns related to operation of the facility.
- Spill and fire emergency response procedures.
- Emergency and accident reporting procedures including use of the NWT/Nunavut 24-Hour Spill Report Line at (867) 920-8130.

Every incinerator manufacturer has its own approach to designing and building incinerators. Operators should be qualified and trained to safely operate the specific make and model of incinerator they are expected to operate.

The Application of Open Burning and Incineration

The Department of Environment does not promote or endorse the burning and incineration of solid waste. This method of waste management should be implemented only after the owner or operator has made all reasonable and determined efforts to implement sound waste management planning and practices. Opportunities to reduce or eliminate the need for burning and incineration through changes in purchasing practices, reuse, recycling, segregation and diversion, and other changes or emission control upgrades that would result in emission reductions, must be reviewed periodically and implemented where practical. Refer to section 3 for additional information on best management practices.

This section provides guidance on the application of open burning and incineration of solid waste. In addition to the guidance and direction provided through the Guideline, the burning and incineration of solid waste may also be controlled through permits and licenses issued by Nunavut's co-management boards, Aboriginal Affairs and Northern Development Canada and other regulatory agencies. These permits and licenses must be complied with at all times.

4.1 Open Burning

Open burning is the burning of solid waste where limited or no control over the combustion process can be exercised by the operator. For the purposes of the Guideline, open burning includes burning waste that has been piled on the surface of the ground or placed in small open pits, or the use of a burn box, unmodified burn barrel or modified burn barrel. Open burning does not include the destruction of waste using a commercial or manufactured incinerator.

The open burning of unsegregated, or mixed, solid waste must not occur under any circumstances. Today's household, institutional, commercial and industrial garbage contains many materials which, when burned at low temperature, can result in the release of high levels of particulates, acid gases, heavy metals, carbon monoxide, dioxins, furans and other chemicals, some of which may cause cancer. The only solid wastes that may be disposed of through open burning are paper products, paperboard packing, untreated wood waste and natural fiber textiles (i.e. cotton, wool). Refer to section 3.2 for further information on what waste can and cannot be burned.

The open burning of solid waste remains a hazardous practice from a fire prevention and environmental management perspective. **Open burning on the ground** should not take place within a municipality without first obtaining authority to do so from the local community government. It should never occur at a municipal or industrial landfill because of the proximity of other combustible wastes within the working landfill. Where permission has been obtained and paper, paperboard packing, untreated wood waste and natural fiber textiles are open burned on the ground or in a small open pit, the activity must be attended and carefully monitored by a responsible adult at all times.

The preferred alternative to open burning on the ground is the use of an **enclosed burn box or burn cage**. These devices should be used when burning a moderate to large quantity of paper, paperboard packing, untreated wood waste and natural fiber textiles. They are designed to contain the waste while it is burning and reduce the likelihood of sparks or burning embers igniting adjacent vegetation and other combustible materials. When using a burn box or cage at a municipal or industrial landfill, extreme caution must be taken to ensure other areas of the working landfill are not ignited. Their proper operation includes loading the device with dry waste to about half its capacity before igniting the fire. Additional or wet waste can be added in small batches so as not to dampen the fire once the fire has developed into a good flame and it is safe to do so.

The following general conditions should be met whenever open burning on the ground or burning using an enclosed burn box or burn cage takes place:

- Only paper, paperboard packing, untreated wood waste and natural fiber textiles are burned.
- The waste is burned in a controlled manner and at a site which is separate from combustible vegetation and other materials.
- Burning takes place only on days when winds are light and blowing away from people.
- Waste is burned in manageable volumes so the fire does not get out of control.
- The fire is started, attended and monitored at all times by authorized and qualified personnel.
- The waste is kept dry or covered to the extent practicable prior to burning.
- Where applicable, authority is first obtained from the municipality or other regulatory agencies.

Modified or unmodified burn barrels should only be used to burn small quantities of paper, paperboard packing, untreated wood waste and natural fiber textiles at remote locations such as traditional camps and field camps. Food and food packaging waste, which make up a significant portion of kitchen garbage produced at these camps, should not be burned. These wastes should be segregated daily and stored in wildlife-proof containers for frequent removal to an approved disposal site.

It is important that burn barrels are properly constructed and operated to ensure safety of the operator and the environment. Appendix 2 provides detailed construction drawings for a modified burn barrel. The Department of Environment will consider other designs if they provide an equivalent level of environmental protection.

Below are some easy-to-do actions to ensure unmodified and modified burn barrels are operated safely and waste is burned to the greatest extent possible[6].

When locating and constructing a burn barrel:

- Locate the burn barrel in a place predominantly downwind of the camp site or burn only on days when the wind is light and blowing away from the camp.
- Ensure the burn barrel is located on gravel, rocky outcrop or other area free of combustible materials and vegetation to avoid accidently starting a tundra fire.
- Ensure the detailed plans provided in Appendix 2 are carefully followed when constructing a modified burn barrel. The ‘exhaust gas to combustion air’ ratio is particularly important to achieving the maximum burn rate. A 2:1 ratio of exhaust stack to air intake area consisting of a 6-inch exhaust port and three 2-inch air intake holes positioned equidistantly around the bottom of the barrel a few inches up from the base is preferred.

[6] Testing of a modified burn barrel was performed by Environment Canada’s Air Quality Research Division in April 2011 at the request of Nunavut’s Department of Environment. Ten trial burns were completed prior to emissions testing in order to optimize and standardize barrel design and operational procedures. Following the trial burns, four test runs were performed and air emission samples collected for analysis. Results of the emission testing program will be available from Nunavut’s Department of Environment. This list of recommended practices reflects the operational observations and measurements made during the testing program.

When operating a burn barrel:

- Inspect the barrel for any signs of leakage, corrosion or other physical defects before each burn cycle. Any necessary repairs must be completed before the equipment is used.
- Burn only dry waste. If wet waste must be burned, mix or batch the waste with other waste that has a low moisture content and high heating value (i.e. dry wood). This will help ensure the slow-burning wet waste is completely burned.
- Burn only paper, paperboard packing, untreated wood waste and natural fiber textiles. Food and food packaging waste should not be burned. Burning non-combustible waste (i.e. metal and glass) will rob the fire of valuable heat and should also be avoided. Food and food packaging, non-combustible and other waste that cannot be burned should be segregated and removed from the site for disposal on a regular basis.
- Do not overfill or densely pack waste into the burn barrel as air will be prevented from properly mixing with the waste. This will result in a smouldering, low temperature burn and smoke.
- Layering wet or slow burning waste with dry fast burning waste will help ensure more complete combustion of all waste.
- The burn barrel should not be used unless a responsible adult is available to monitor and watch over it until the fire has completely cooled.
- When using a modified burn barrel, the exhaust port on the 'metal basket insert' should be aligned between two of the 2-inch air intake holes in order to avoid short-circuiting of the combustion air directly through to the stack. Also, the spark arrest screen should be cleaned following each burn to ensure the stack does not become blocked with soot and other debris. If the barrel lid begins to 'puff' during a burn, inspect the screen to ensure it is not obstructing the flow of exhaust gases.

Care must be taken by the operator at all times to avoid skin contact with hot surfaces and avoid breathing smoke and other exhaust gases.

Written records of open burning should be kept by the operator. These record what was burned, when and how much, how waste was loaded into the device, how the fire was started, its location, weather conditions at the time and any other information that may help remind the operator of what worked well, and what didn't. These records are to be made available for review upon request by an Inspector.

Bottom ash from the open burning of paper, paperboard packing, untreated wood waste and natural fiber textiles is suitable for burial in a designated pit or municipal landfill site. Consent to use a municipal landfill should first be obtained from the local government. Bottom ash must be completely cooled before it can be safely handled and disposed of. Refer to section 3.6 for further information.

4.2 Incineration

Incinerators differ from the simpler methods of open burning as the operator has a higher degree of control over the burning process. The resulting higher temperatures, longer holding times and greater turbulence lead to more complete combustion of the waste. Although a wider range of wastes can be destroyed using high temperature single or dual-chambered incinerators, determined efforts should still be taken to reduce the quantity and type of waste generated and to implement other changes which would result in reductions in air emissions. Refer to section 3 for further information proper waste management practices and a listing of what waste can and cannot be incinerated.

The incinerator manufacturer's operating instructions must be followed at all times to ensure designed temperature, holding time and turbulence conditions are achieved and to avoid damage to the facility. When operating during winter months, additional care must be taken because cold air introduced into the primary and secondary chambers may make it difficult for normal operating temperatures to be achieved. Operators must be properly trained and qualified to operate the equipment under both normal and emergency conditions. Owners are strongly encouraged to consult system manufacturers or other qualified persons with expertise before purchasing an incinerator. Additional guidance on the selection of incinerator technologies and their operational requirements can be obtained by referring to Environment Canada's *Technical Document for Batch Waste Incineration*.

The installation and operation of monitoring and control systems is critical for the proper and safe operation of any incinerator. The design, installation, certification and operation of continuous emissions monitoring systems (CEMS) should comply with the principles described in Environment Canada's *Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation*. While the document is written for power generation facilities, the principles apply equally well to other types of facilities and continuous emissions monitoring systems. For incinerators operating in Nunavut, key operational parameters must be monitored at all times using on-line instruments capable of continuously measuring the combustion process and stack emissions quality. These instruments should be equipped with visible and audible alarms and be on-line whenever the incinerator is in operation, including 'start-up' and 'cool down' phases. Table 3 lists the monitoring and control system requirements.

Table 3. Incinerator Monitoring and Control System Requirements

System Description	Quantity of Waste to be Burned[7]	
	Less than 26 Tonnes per Year	**Greater than 26 Tonnes per Year**
Weight and composition of feedstock waste on a batch basis	✓	✓
Temperature in the primary and secondary combustion chambers	✓	✓
Opacity in the stack[8]	✓	✓
Initial Certificate of Operation[9]		✓

While not a specific requirement of the Guideline, additional one-time or continuous emissions monitoring may be required depending upon the type and quantity of waste to be incinerated. Examples include monitoring oxygen and carbon monoxide in the undiluted gases exiting the combustion chamber, such as a secondary chamber of a conventional dual-stage incinerator. Annual or periodic stack sampling for hydrogen chloride, dioxins and furans may also be required where the feedstock includes a significant quantity of organic materials that contain chlorine (i.e. chlorinated solvents and plastics, PVC piping, marine driftwood). The reader is encouraged to contact Nunavut's Department of Environment for guidance on additional emissions monitoring requirements.

[7] The CCME Canada-Wide Standard for Dioxins and Furans Emissions from Waste Incinerators and Coastal Pulp and Paper Boilers (2001) established a criterion of 26 tonnes per year to distinguish between a 'small facility' and 'large facility' incinerator.
[8] An acceptable alternative to monitoring opacity is to continuously monitor particulate matter in the stack.
[9] An initial Certificate of Operation includes satisfactory confirmation based on manufacturers' or third-party testing and certification that the unit is capable of complying with the requirements contained in the Guideline when operated in accordance with the manufacturer's recommendations and with minimal requirement for operator attention. The Certificate is to be provided to the Nunavut Department of Environment before the incinerator is placed into routine operational service.

Monitoring and control data should be recorded each time a burn cycle is completed. Records are to be maintained for the operational life of the incinerator and made available for review upon request by an Inspector. Refer to section 3.7 for additional information on monitoring and record keeping.

Bottom ash and other solid residue collected from the incinerator is suitable for burial where it meets the criteria set out in Table 1 of the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* or in accordance with land use permits and water licenses issued by Nunavut's co-management boards and Aboriginal Affairs and Northern Development Canada. Where bottom ash meets the criteria and is to be disposed of into a municipal landfill, the quantity transported off-site must be recorded and the consent of the local municipal government first be obtained. Bottom ash not meeting the criteria set out in the *Environmental Guideline for Industrial Waste Discharges into Municipal Solid Waste and Sewage Treatment Facilities* is considered to be a hazardous waste and must be managed in accordance with the *Environmental Guideline for the General Management of Hazardous Waste*.

Conclusion

This is a general introduction to the practice of burning and incinerating solid waste. It is not intended to promote or endorse the practice but to provide the reader with information on the risks, hazards and best management practices associated with this activity. It also provides specific guidance on the application of burning and incinerating solid waste should this practice be undertaken by municipalities and operators of traditional, field and commercial camps.

Familiarity with the Guideline does not replace the need for the owner or person in charge, management or control of the solid waste to comply with all applicable federal and territorial legislation and municipal by-laws. The burning and incineration of solid waste may be controlled through permits and licenses issued by Nunavut's co-management boards, Aboriginal Affairs and Northern Development Canada and other regulatory agencies. These permits and licenses must be complied with at all times.

For additional information on the management of solid waste, or to obtain a complete listing of available guidelines, contact the Department of Environment at:

Environmental Protection Division
Department of Environment
Government of Nunavut
Inuksugait Plaza, Box 1000, Station 1360
Iqaluit, Nunavut, X0A 0H0

Phone: (867) 975-7729
Fax: (867) 975-7739
Email: EnvironmentalProtection@gov.nu.ca
Website: http://env.gov.nu.ca/programareas/environmentprotection

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http://env.gov.nu.ca/node/82#Guideline Documents

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http://env.gov.nu.ca/node/82#Guideline Documents

APPENDICES

APPENDIX 1 - *ENVIRONMENTAL PROTECTION ACT*

The following are excerpts from the *Environmental Protection Act*

1. "Contaminant" means any noise, heat, vibration or substance and includes such other substance as the Minister may prescribe that, where discharged into the environment,
   (a) endangers the health, safety or welfare of persons,
   (b) interferes or is likely to interfere with normal enjoyment of life or property,
   (c) endangers the health of animal life, or
   (d) causes or is likely to cause damage to plant life or to property;

   "Discharge" includes, but not so as to limit the meaning, any pumping, pouring, throwing, dumping, emitting, burning, spraying, spreading, leaking, spilling, or escaping;

   "Environment" means the components of the Earth and includes
   (a) air, land and water,
   (b) all layers of the atmosphere,
   (c) all organic and inorganic matter and living organisms, and
   (d) the interacting natural systems that include components referred to in paragraphs (a) to (c).

   "Inspector" means a person appointed under subsection 3(2) and includes the Chief Environmental Protection Officer.

2.2 The Minister may
   (a) establish, operate and maintain stations to monitor the quality of the environment in the Territories;
   (b) conduct research studies, conferences and training programs relating to contaminants and to the preservation, protection or enhancement of the environment;
   (c) develop, co-ordinate and administer policies, standards, guidelines and codes of practice relating to the preservation, protection or enhancement of the environment;
   (d) collect, publish and distribute information relating to contaminants and to the preservation, protection or enhancement of the environment:

3. (1) The Minister shall appoint a Chief Environmental Protection Officer who shall administer and enforce this Act and the regulations.

   (2) The Chief Environmental Protection Officer may appoint inspectors and shall specify in the appointment the powers that may be exercised and the duties that may be performed by the inspector under this Act and regulations.

5. (1) Subject to subsection (3), no person shall discharge or permit the discharge of a contaminant into the environment.

   (3) Subsection (1) does not apply where the person who discharged the contaminant or permitted the discharge of the contaminant establishes that
   (a) the discharge is authorized by this Act or the regulations or by an order issued under this Act or the regulations;
   (b) the contaminant has been used solely for domestic purposes and was discharged from within a dwelling house;
   (c) the contaminant was discharged from the exhaust system of a vehicle;

(d) the discharge of the contaminant resulted from the burning of leaves, foliage, wood, crops or stubble for domestic or agricultural purposes;
(e) the discharge of the contaminant resulted from burning for land clearing or land grading;
(f) the discharge of the contaminant resulted from a fire set by a public official for habitat management of silviculture purposes;
(g) the contaminant was discharged for the purposes of combating a forest fire;
(h) the contaminant is a soil particle or grit discharged in the course of agriculture or horticulture; or
(i) the contaminant is a pesticide classified and labelled as "domestic" under the *Pest Control Products Regulations* (Canada).

(4) The exceptions set out in subsection (3) do not apply where a person discharges a contaminant that the inspector has reasonable grounds to believe is not usually associated with a discharge from the excepted activity.

5.1. Where a discharge of a contaminant into the environment in contravention of this Act or the regulations or the provisions of a permit or license issued under this Act or the regulations occurs or a reasonable likelihood of such a discharge exists, every person causing or contributing to the discharge or increasing the likelihood of such a discharge, and the owner or the person in charge, management or control of the contaminant before its discharge or likely discharge, shall immediately:
(a) subject to any regulations, report the discharge or likely discharge to the person or office designated by the regulations;
(b) take all reasonable measures consistent with public safety to stop the discharge, repair any damage caused by the discharge and prevent or eliminate any danger to life, health, property or the environment that results or may be reasonably expected to result from the discharge or likely discharge; and
(c) make a reasonable effort to notify every member of the public who may be adversely affected by the discharge or likely discharge.

6. (1) Where an inspector believes on reasonable grounds that a discharge of a contaminant in contravention of this Act or the regulations or a provision of a permit or license issued under this Act or the regulations has occurred or is occurring, the inspector may issue an order requiring any person causing or contributing to the discharge or the owner or the person in charge, management or control of the contaminant to stop the discharge by the date named in the order.

7. (1) Notwithstanding section 6, where a person discharges or permits the discharge of a contaminant into the environment, an inspector may order that person to repair or remedy any injury or damage to the environment that results from the discharge.

(2) Where a person fails or neglects to repair or remedy any injury or damage to the environment in accordance with an order made under subsection (1) or where immediate remedial measures are required to protect the environment, the Chief Environmental Protection Officer may cause to be carried out the measures that he or she considers necessary to repair or remedy an injury or damage to the environment that results from any discharge.

APPENDIX 2 – MODIFIED BURN BARREL DESIGN AND SPECIFICATIONS

A modified burn barrel is typically constructed from a 45 gallon metal fuel or oil drum. The modifications result in greater heat generation and retention, better mixing of the waste with incoming air and longer holding time inside the barrel. Together, these modifications result in more complete combustion of the solid waste than does open burning on the ground or in a pit.

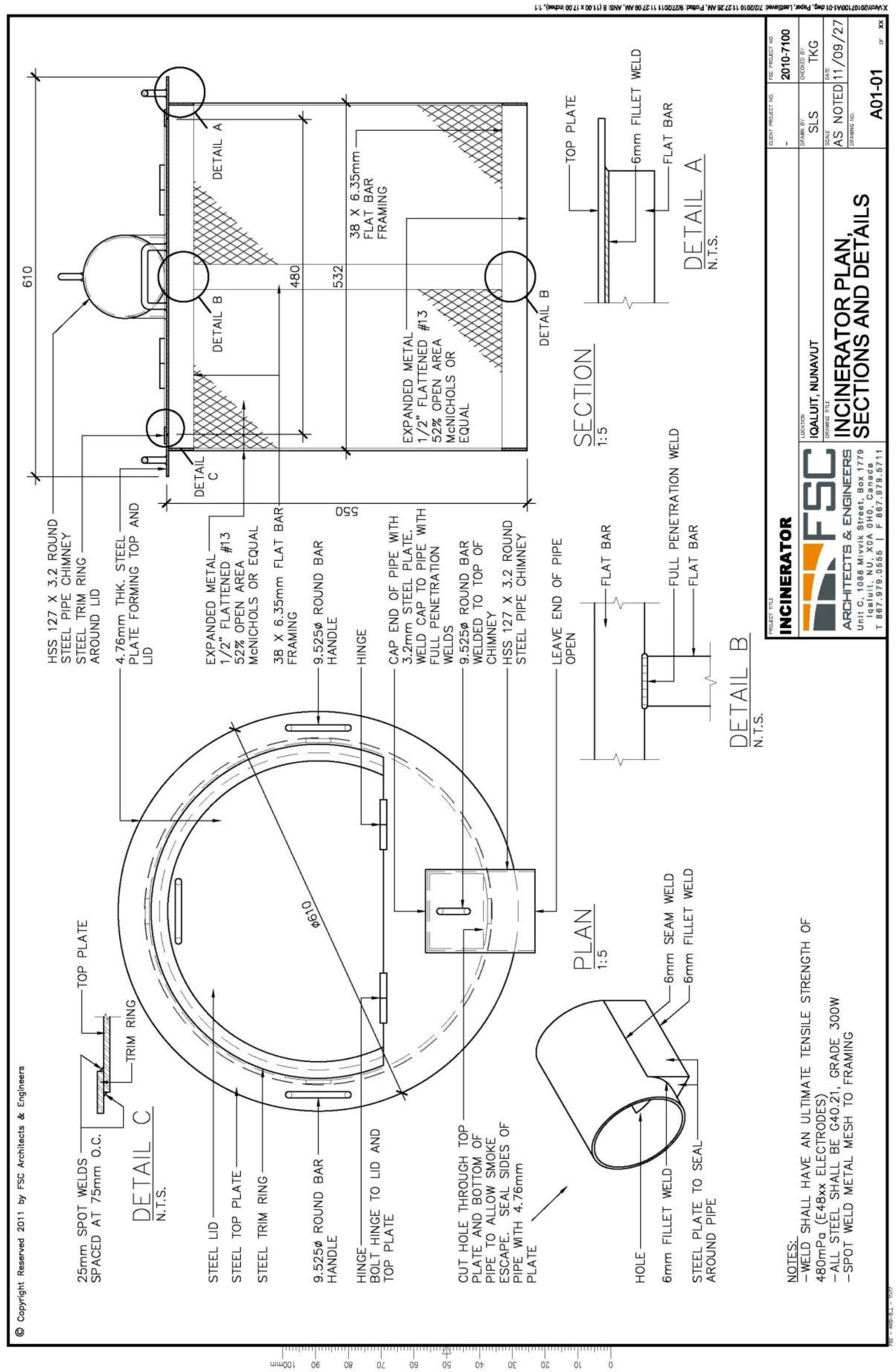
Placing a metal screen over the top of the exhaust pipe may be required to prevent sparks and hot ash from escaping. Care should be taken to ensure the screen does not become blocked with soot.

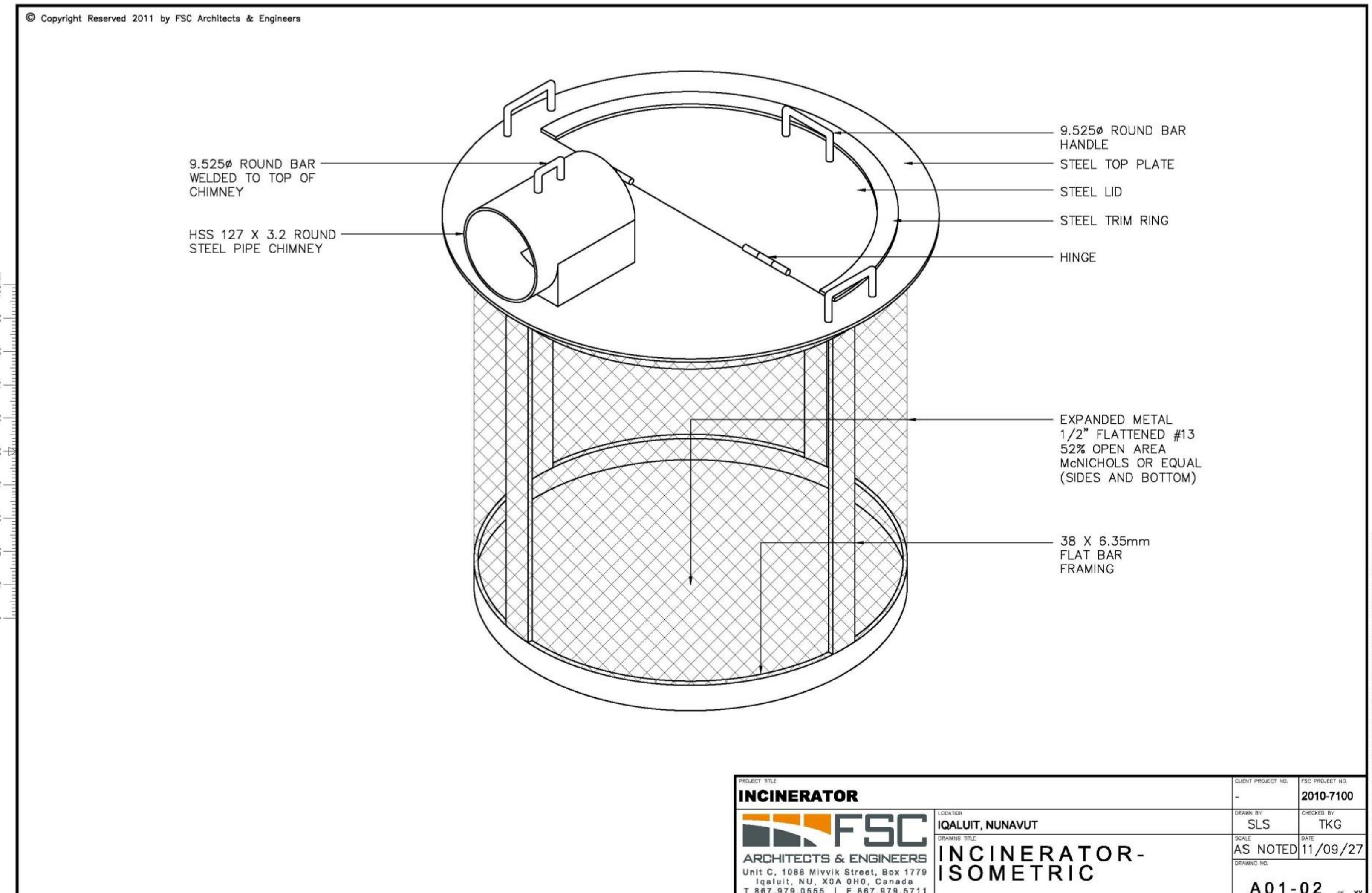
A hinged top helps to capture heat and enables easy loading and mixing of waste.

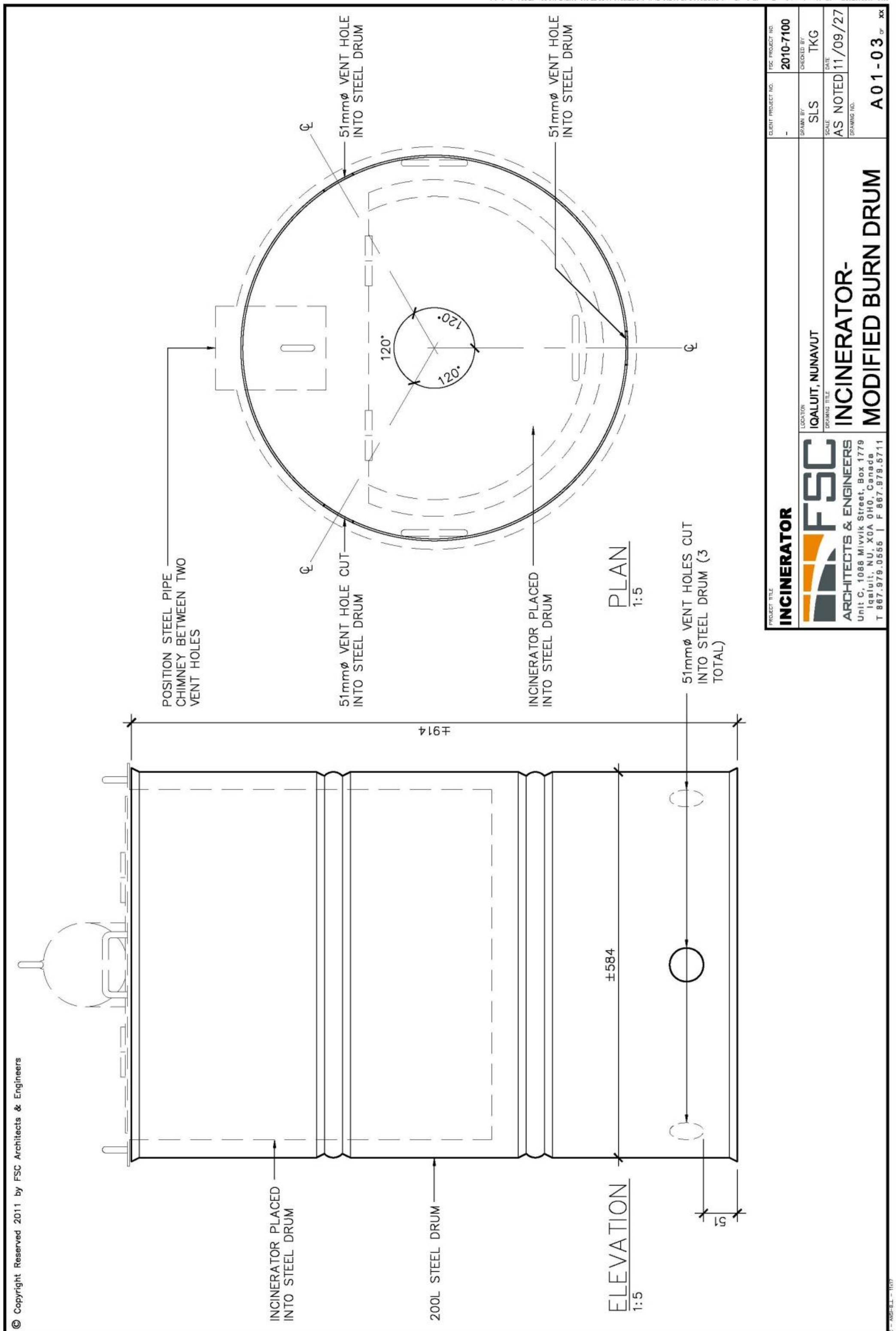
A stove pipe attached to the top of the barrel allows smoke to escape and creates an effective draft.

A metal basket or grate suspends the burning waste and enables mixing with the incoming air. The removable basket also enables access to any unburned ash that may collect in the bottom of the barrel.

Evenly spaced vents or holes cut above the bottom of the barrel enable fresh air to mix with waste inside the metal basket.


© Copyright Reserved 2011 by FSC Architects & Engineers
25mm SPOT WELDS SPACED AT 75mm O.C.
TOP PLATE
TRIM RING
DETAIL C
N.T.S.
STEEL LID
STEEL TOP PLATE
STEEL TRIM RING
9.525ø ROUND BAR HANDLE
HINGE-BOLT HINGE TO LID AND TOP PLATE
CUT HOLE THROUGH TOP PLATE AND BOTTOM OF PIPE TO ALLOW SMOKE ESCAPE. SEAL SIDES OF PIPE WITH 4.76mm PLATE
HOLE
6mm FILLET WELD
STEEL PLATE TO SEAL AROUND PIPE
6mm SEAM WELD
6mm FILLET WELD
ø610
PLAN
1:5
NOTES:
-WELD SHALL HAVE AN ULTIMATE TENSILE STRENGTH OF 480mPa (E48xx ELECTRODES)
-ALL STEEL SHALL BE G40.21, GRADE 300W
-SPOT WELD METAL MESH TO FRAMING
HSS 127 X 3.2 ROUND STEEL PIPE CHIMNEY
STEEL TRIM RING AROUND LID
4.76mm THK. STEEL PLATE FORMING TOP AND LID
EXPANDED METAL 1/2" FLATTENED #13 52% OPEN AREA McNICHOLS OR EQUAL
38 X 6.35mm FLAT BAR FRAMING
9.525ø ROUND BAR HANDLE
HINGE
CAP END OF PIPE WITH 3.2mm STEEL PLATE. WELD CAP TO PIPE WITH FULL PENETRATION WELDS
9.525ø ROUND BAR WELDED TO TOP OF CHIMNEY
HSS 127 X 3.2 ROUND STEEL PIPE CHIMNEY
LEAVE END OF PIPE OPEN
FLAT BAR
FULL PENETRATION WELD
FLAT BAR
DETAIL B
N.T.S.
610
480
532
550
DETAIL A
DETAIL B
DETAIL C
38 X 6.35mm FLAT BAR FRAMING
EXPANDED METAL 1/2" FLATTENED #13 52% OPEN AREA McNICHOLS OR EQUAL
SECTION
1:5
TOP PLATE
6mm FILLET WELD
FLAT BAR
DETAIL A
N.T.S.
INCINERATOR
FSC
ARCHITECTS & ENGINEERS
Unit C, 1088 Mivvik Street, Box 1779 Iqaluit, NU, X0A 0H0, Canada
T 867.979.0555 | F 867.979.5711
IQALUIT, NUNAVUT
INCINERATOR PLAN, SECTIONS AND DETAILS
2010-7100
SLS
TKG
AS NOTED
11/09/27
A01-01


© Copyright Reserved 2011 by FSC Architects & Engineers
9.525ø ROUND BAR WELDED TO TOP OF CHIMNEY
HSS 127 X 3.2 ROUND STEEL PIPE CHIMNEY
9.525ø ROUND BAR HANDLE
STEEL TOP PLATE
STEEL LID
STEEL TRIM RING
HINGE
EXPANDED METAL 1/2" FLATTENED #13 52% OPEN AREA McNICHOLS OR EQUAL (SIDES AND BOTTOM)
38 X 6.35mm FLAT BAR FRAMING
PROJECT TITLE
INCINERATOR
FSC
ARCHITECTS & ENGINEERS
Unit C, 1088 Mivvik Street, Box 1779
Iqaluit, NU, X0A 0H0, Canada
T 867.979.0555 | F 867.979.5711
LOCATION
IQALUIT, NUNAVUT
DRAWING TITLE
INCINERATOR-ISOMETRIC
CLIENT PROJECT NO.
-
FSC PROJECT NO.
2010-7100
DRAWN BY
SLS
CHECKED BY
TKG
SCALE
AS NOTED
DATE
11/09/27
DRAWING NO.
A01-02
OF XX


© Copyright Reserved 2011 by FSC Architects & Engineers
INCINERATOR PLACED INTO STEEL DRUM
200L STEEL DRUM
ELEVATION
1:5
51
±584
±914
POSITION STEEL PIPE CHIMNEY BETWEEN TWO VENT HOLES
51mmø VENT HOLE CUT INTO STEEL DRUM
INCINERATOR PLACED INTO STEEL DRUM
51mmø VENT HOLES CUT INTO STEEL DRUM (3 TOTAL)
PLAN
1:5
51mmø VENT HOLE INTO STEEL DRUM
51mmø VENT HOLE INTO STEEL DRUM
120°
120°
120°
INCINERATOR
FSC
ARCHITECTS & ENGINEERS
Unit C, 1088 Mivvik Street, Box 1779
Iqaluit, NU, X0A 0H0, Canada
T 867.979.0555 | F 867.979.6711
IQALUIT, NUNAVUT
INCINERATOR-
MODIFIED BURN DRUM
SLS
TKG
2010-7100
AS NOTED
11/09/27
A01-03

APPENDIX 2

ENVIRONMENT CANADA
TECHNICAL DOCUMENT FOR BATCH WASTE INCINERATION

Environment Canada Environnement Canada

Technical Document for Batch Waste Incineration

January 2010

Canada

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Aussi disponible en français.

Table of Contents

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.

[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.

5 CEPA, 1999. Canadian Environmental Protection Act, 1999. 1999, c. 33 (Assented to September 14, 1999). Available at http://www.ccme.ca/assets/pdf/mercury_emis_std_e1.pdf

6 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

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.ca/ourwork/air.html?category_id=87

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 will 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

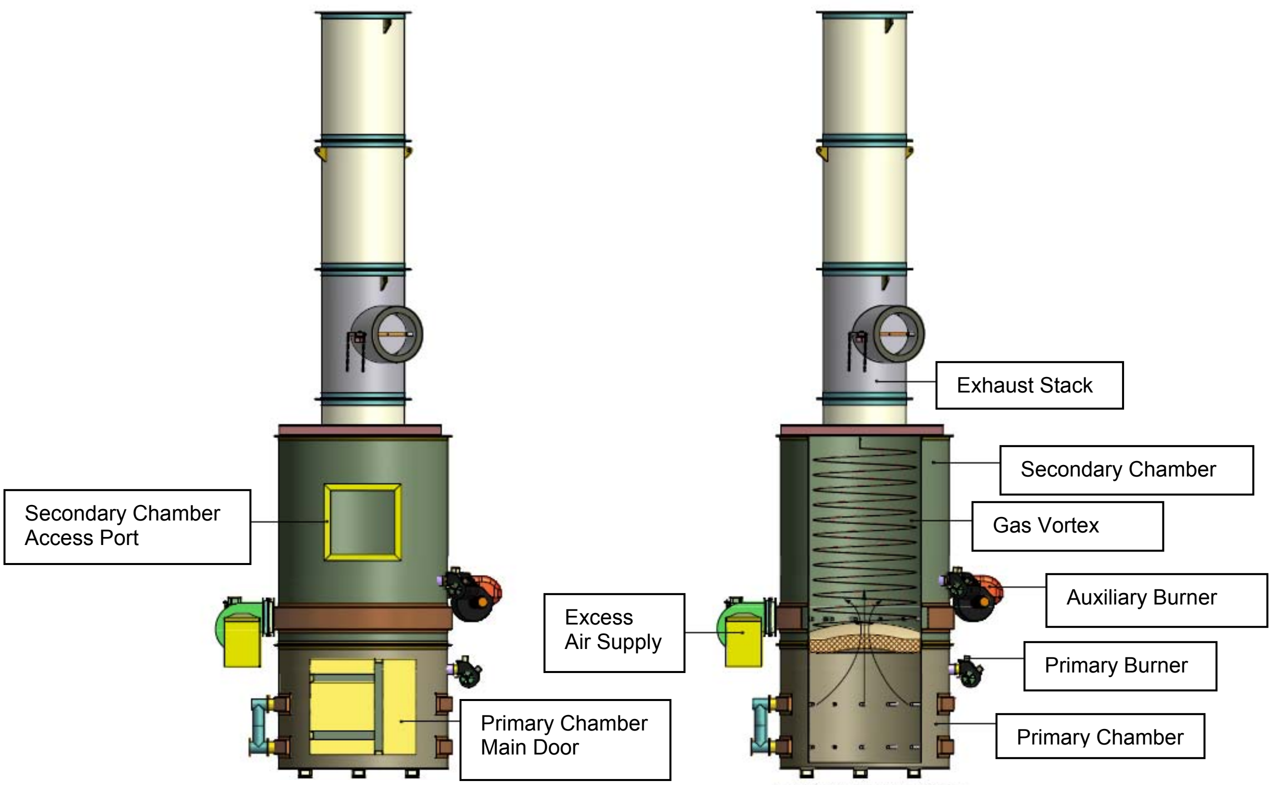

Figure 2.3 Schematic of Typical Controlled Air Dual Chamber Incinerator

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 3.2.

[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.

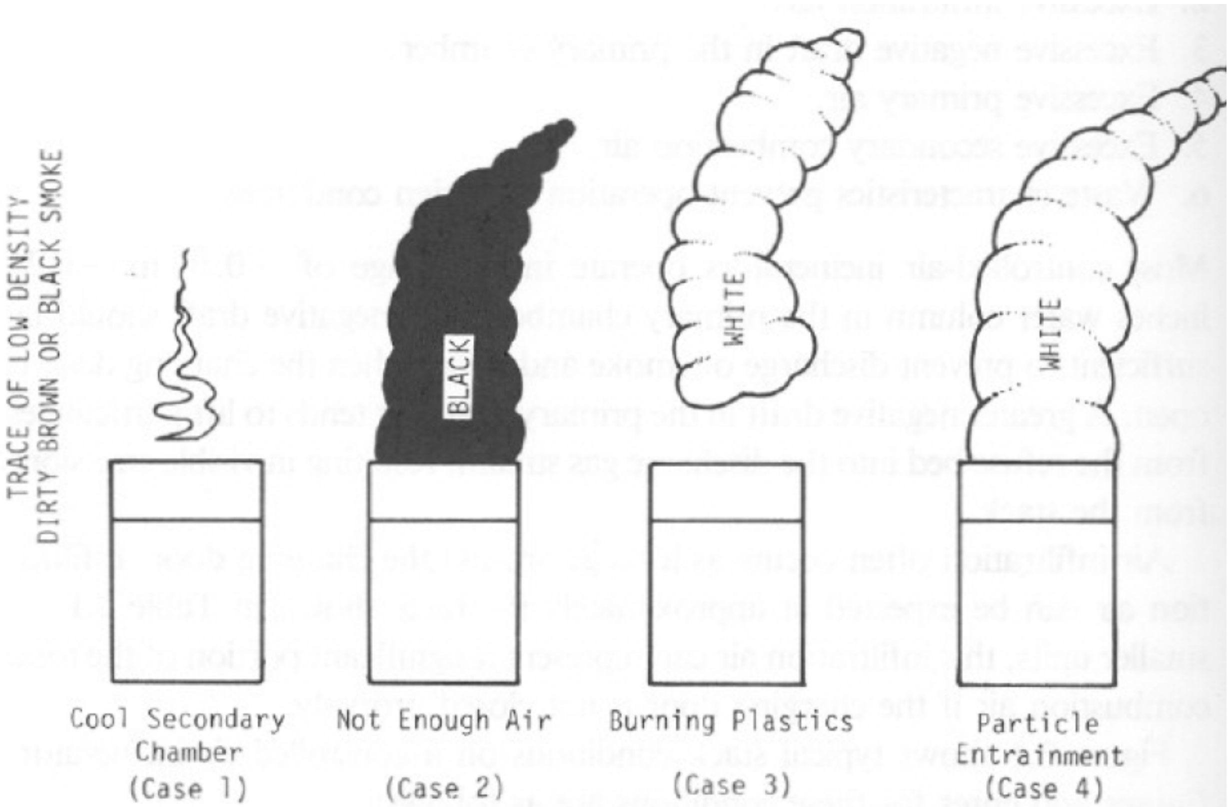

Figure 3.2 Plume Characteristics related to Operating Conditions [16]

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.

If the situation persists after these steps have been taken, check the charging capacity for the

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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

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/.

APPENDIX 3

WESTLAND ENVIRONMENTAL
CY50CA INCINERATOR SPECIFICATIONS

KETEK GROUP INC.
General Partner of Ketek Group LP

20204 – 110 Avenue
Edmonton, AB T5S 1X8
Phone: (780) 447-5050
Fax: (780) 447-4912
Toll Free: 1-855-447-5050
Email: info@ketek.ca

14 November 2014

Simeon Robinson
North Country Gold Corp.
220, 9797 45th Avenue
Edmonton AB,
T6E 5V8
E-mail: simeonr@northcountrygold.com

RE: Incineration of Sewage Sludge in Ketek/Westland Incinerator, CY-50-CA.

Dear Mr. Robinson,

Please find attached the specifications for the Ketek/Westland Incinerator, CY-50-CA. This incinerator is designed for Types-1, 2, 3 and 4 waste streams.

Limited quantities of sewage sludge can be incinerated in this unit along with other camp waste. However, the operators must be qualified and trained to operate the unit as per the manufacturer's specification including ensuring proper waste charging, air flow and temperatures in the primary and secondary chambers. The site must conduct a hazard assessment to ensure any OHS concerns including exposure to any bio-hazards have been addressed.

To ensure safe operation and continued environmental, health and safety compliance, it is recommended that the site develops a site specific waste management plan and Standard Operating Procedures for the incineration of sewage sludge along with the other camp waste. Periodic refresher training for the operators and inspection and preventive maintenance program for the incinerator shall be developed and implemented by the site.

Sincerely,

Dr. Yogendra Chaudhry, EP, CRSP
Ketek Group Inc.

Enclosure:

1. Specification sheet for CY50CA incinerator

KETEK MANUFACTURING
MEMBER OF KETEK GROUP INC.

ketek.ca

- Dual Chamber, Controlled Air Operation
- Built In Safety Features
- Meets Clean Air Guidelines in Most Areas
- "Load-and-Go" Operation
- Economical Operation
- Optional Dry Scrubber

INCINERATORS

CY-50-CA

CY-50-CA

Phone: (780) 447-5052
Fax: (780) 447-4912
info@ketek.ca

KETEK MANUFACTURING
MEMBER OF KETEK GROUP INC.

INCINERATORS

Designed for use in Permanent Locations for Types 1, 2, 3 and 4 Wastes

Capacity Combustion Chambers
• 1.63 m^3 Primary and Secondary Chambers

Power Requirements
• 125/250 V, 30A, 60 Hz

Stack
- 48 cm diameter
- 3.7 m high w/o spark arrester
- 4.3 m high w/ spark arrester
- Refractory lined stack
- Spark arrester

Casing
• 6.35mm gauge steel.
• Lining: high heat duty castable refractory over high temperature insulation.

Doors
• 1108 mm x 1108 mm Refractory lined, 6.35 mm steel plate c/w heavy duty toggle clamp
• 622 mm x 876 mm clear opening, Max waste size

Air Supply - Adjustable
• Forced air fan c/w ducts to secondary flame port air jets.

Auxiliary Burners
• 770,000 BTU for primary chamber; gun type, enclosed in protective steel housing.
• 1,600,000 BTU for secondary chamber; gun type, enclosed in protective steel housing.

Fuel Supply (Oil Fired Unit Only)
• 1000 l fuel storage tank* c/w filter and flexible hose type connection.
** Extra if required.*

Transporter
• Incinerator mounted on skid type frame,
L 6.1 m x W 2.1 m x H 2.3 m (Primary Chamber with skid)
• Secondary Chamber Crated Separate

Height
• 8.9 m tall with stack (crated separate)
Constructed of W200 x 31 I Beam

Weight
• 10,786 kg (23,780 lbs)

Auxiliary Fuel Options
• LPG Fired burners
• Diesel Fired burners
• Natural Gas Propane

Control System
• PLC controller
• "Load-and-Go", One-Button operation for batch operation
• Temperature controllers in primary and secondary chambers
• Real time data logging

Air Emissions
• Meets Environment Canada design draft guidelines for incinerator.
• Some waste streams may require the use of a scrubber
• Optional dry scrubber guaranteed to meet all emission standards.

CY-50-CA

CY-50-CA

ketek.ca

20204-110 Avenue, NW
Edmonton, Alberta
Canada T5S 1X8

APPENDIX 4

CLEAN BURN
WASTE OIL FURNACE SPECIFICATIONS

CLEAN BURN

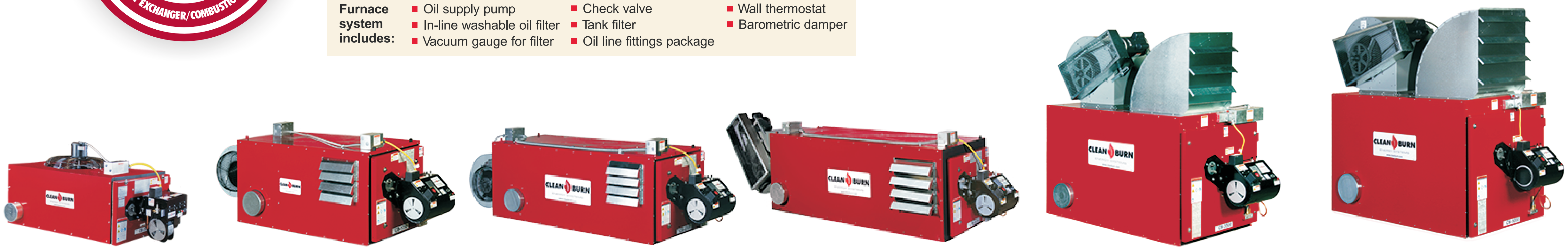
The #1 Waste Oil Furnace In Customer Satisfaction™

HASSLE FREE
CLEAN BURN
100% SATISFACTION
10 YEAR WARRANTY
(or 15,000 hours)
HEAT EXCHANGER/COMBUSTION CHAMBER

VERSATILE WASTE OIL HEATING TECHNOLOGY

Furnace system includes:
- Oil supply pump
- In-line washable oil filter
- Vacuum gauge for filter
- Check valve
- Tank filter
- Oil line fittings package
- Wall thermostat
- Barometric damper

6 ft. figure shown for scale



	CB-140	CB-1750	CB-2500	CB-3250	CB-3500	CB-5000
***Maximum BTU/hour**	140,000 (41 kW)	175,000 (51.25 kW)	250,000 (73 kW)	325,000 (95.3 kW)	350,000 (102 kW)	500,000 (146 kW)
***Maximum oil consumption**	1.0 GPH (3.8 L/h)	1.2 GPH (4.54 L/h)	1.7 GPH (6.4 L/h)	2.1 GPH (7.91 L/h)	2.5 GPH (9.5 L/h)	3.6 GPH (13.6 L/h)
Fuels	← **Used oils:** Crankcase, ATF, hydraulic **Fuel oils:** #2, #4, and #5 fuel oil →					
Air flow output (CFM)	Unit heater 2000 Axial fan Furnace cannot be ducted	Unit heater 1700 Central furnace (ducted) 0.25 SPWC (in.) 1500 0.30 SPWC (in.) 1400	Unit heater 2700 Central furnace (ducted) 0.25 SPWC (in.) 2500 0.40 SPWC (in.) 2400	Unit heater 3300 Central furnace (ducted) 0.25 SPWC (in.) 3150 0.40 SPWC (in.) 2900	Unit heater 4200 Central furnace (ducted) 0.25 SPWC (in.) 4000 0.40 SPWC (in.) 3900	Unit heater 5500 Central furnace (ducted) 0.25 SPWC (in.) 5200 0.40 SPWC (in.) 5100
***Air compressor req'd**	2.0 CFM @ 20 PSI (3.4 m^3/h @ 1.4 bar)	2.0 CFM @ 20 PSI (3.4 m^3/h @ 1.4 bar)	2.0 CFM @ 20 PSI (3.4 m^3/h @ 1.4 bar)	2.0 CFM @ 20 PSI (3.4 m^3/h @ 1.4 bar)	2.0 CFM @ 25 PSI (3.4 m^3/h @ 1.7 bar)	2.5 CFM @ 25 PSI (4.25 m^3/h @ 1.7 bar)
Stack size	6 inch dia. (152.4mm dia.)	8 inch dia. (203mm dia.)	8 inch dia. (203mm dia.)	8 inch dia.(203mm dia.)	8 inch dia. (203mm dia.)	10 inch dia. (254mm dia.)
Furnace dimensions, assembled L x W x H (inches) (millimeters)	45" L x 28 W x 20 H (1143 x 711.2 x 508)	83 x 29.25 x 31.5 (2190 x 743 x 787)	103.25 x 29.25 x 31.5 (2623 x 743 x 787)	121" L x 31.25 W x 35 H (3073 x 794 x 889)	74 x 35 x 61 (1880 x 889 x 1549)	78 x 38 x 73 (1981 x 965 x 1845)
Approx. weight (Uncrated furnace system)	300 pounds (136.07 kg)	406 pounds (182.7 kg)	509 pounds (229.1 kg)	641 pounds (288.7 kg)	836 pounds (376.2 kg)	1036 pounds (466.2 kg)
Electrical requirements	115 VAC 60 Hz, single phase 20 A circuit breaker	115 VAC 60 Hz, single phase 20 A circuit breaker	115 VAC 60 Hz, single phase 30 A circuit breaker	115 VAC 60 Hz,single phase 30 A circuit breaker -or- 230 VAC 60 Hz,single phase 20 A circuit breaker	230 VAC 60 Hz, single phase 30 A circuit breaker	230 VAC 60 Hz, single phase 30 A circuit breaker

* Values indicated above are nominal. Actual values will vary depending on fuel and installation.

Clean Burn, LLC. 4109 Capital Circle, Janesville, WI USA 53546 1-800-331-0183 Fax: 717-656-0952 **www.CleanBurn.com**