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Development of guidelines on best available techniques and provisional guidance on best environmental practices relevant to the provisions of Article 5 and Annex C of the Stockholm Convention on Persistent Organic Pollutants

DRAFT GUIDELINES ON BAT AND BEP FOR MUNICIPAL WASTE INCINERATION

Note by the Secretariat

The attached was provided by Mr. Robert Kellam (United States of America) who coordinated its development. This note and its attachment have not been formally edited.

[1] UNEP/POPS/EGB.2/1.

Draft Guidelines on
Best Available Techniques (BAT) and Best Environmental Practices (BEP) for the Incineration of Municipal Waste

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Figures and Tables

1.0 Background

Although landfilling remains the principal means for the disposal of municipal solid waste (MSW), incineration and the subsequent landfilling of residues has become a common practice in many developed and industrializing countries. In the United States, for example, there are currently 130 municipal waste incinerators in operation, handling approximately one-sixth of the country's MSW. Where landfill space is scarce, or other factors such as a shallow water table restrict its use, the proportion of MSW incinerated may reach 75% or greater.

Municipal waste incineration is frequently accompanied by the recovery of energy in the form of steam or electricity generation. Incinerators can also be designed to accommodate processed forms of MSW known as refuse-derived fuels or RDF, as well as co-firing with fossil fuels. Municipal waste incinerators can range in size from small package units processing single batches of only a few tons per day to very large units with continuous daily feed capacities in excess of 250 tons. The capital investment costs of such facilities can range from tens of thousands to hundreds of millions of USD.

The primary benefit of waste incineration is a 70-90% reduction in the volume of the waste. Other benefits include the destruction of toxic materials, sterilization of pathogenic wastes, recovery of energy, and the re-use of some residues.

Large municipal waste incinerators are major industrial facilities and have the potential to be significant sources of environmental pollution. In addition to the release of acid gases (sulfur oxides, nitrogen oxides, hydrogen chloride) and particulate matter, poorly designed or operated incinerators can lead to the unintentional formation and release of persistent organic pollutants (dioxins and furans [PCDD/PCDF], and unintentionally produced polychlorinated biphenyls [PCBs] and hexachlorobenzene [HCB]).

The environmentally sound design and operation of municipal waste incinerators requires the use of best environmental practices and best available techniques to prevent or minimize the formation and release of the unintentional POPs. The purpose of this guidance is to identify such practices and techniques, summarize their effectiveness, and estimate their relative cost, for consideration by the Parties in the development of national action plans under the Stockholm Convention on Persistent Organic Pollutants.

2.0 Formation and Release of Unintentional POPs

Combustion research has led to the development of three theories for the formation and release of unintentional POPs from waste incinerators: (1) pass through, in which the POPs (e.g., dioxins and furans) are introduced into the combustor with the feed and pass through the system unchanged; (2) formation during the process of combustion; and 3) *de novo* synthesis in the post-combustion zone. Emission testing has confirmed that composition of the waste, furnace design, temperatures in the post-combustion zone, and the types of air pollution control devices (APCD) used to remove pollutants from the flue gases are important factors in determining the extent of POPs formation and release. Depending on the combination of these factors, POPs releases can vary over several orders of magnitude per ton of waste incinerated.

3.0 Municipal Waste Incinerator Design

Municipal waste incinerators can be divided into three major design categories: mass burn, modular, and refuse-derived fuel or RDF. The mass-burn and RDF technologies are more common in larger incinerators (greater than 250 metric tons per day of MSW) and modular technology dominates among smaller units. The major types are described below, along with the APCDs frequently used with these systems.

3.1 Incinerator Types

Mass Burn. The term "mass burn" was originally intended to describe incinerators that combust MSW as received (i.e., no preprocessing of the waste other than removal of items too large to go through the feed system). Currently, several types of incinerators are capable of burning unprocessed waste. Mass burn facilities can be distinguished in that they burn the waste in a single stationary combustion chamber. In a typical mass burn facility, MSW is placed on a grate that moves through the combustor. Combustion capacities of mass burn facilities typically range from 90 to 2700 metric tons of MSW per day. There are three principal subcategories of the mass burn technology.

- Mass burn refractory-walled (MB-REF) systems represent an older class of incinerators (available in the late 1970s to early 1980s) that were designed primarily to reduce by 70-90% the volume of waste disposed. These facilities usually lacked boilers to recover the combustion heat for energy purposes. In the mass burn refractory-walled design, the MSW is delivered to the combustion chamber by a traveling grate or a ram feeding system. Combustion air in excess of stoichiometric amounts (i.e., more oxygen than is needed for complete combustion) is supplied both below and above the grate. Few mass burn refractory-walled incinerators are currently operational in developed countries; almost all have closed or been dismantled.

- Mass burn waterwall (MB-WW) facilities offer enhanced combustion efficiency, compared with mass burn refractory-walled incinerators. Although it achieves similar volume reductions, the MB-WW incinerator design provides a more efficient delivery of combustion air, resulting in higher sustained temperatures. Figure 3-1 is a schematic of a typical MB-WW MWC. The term "waterwall" refers to a series of steel tubes that run vertically along the walls of the furnace through which water is pumped. Heat from the combustion of the waste produces steam, which is then used to drive an electrical turbine generator or for other energy needs. This transfer of energy is called energy recovery. MB-WW incinerators are the dominant form of incinerator found at large municipal waste combustion facilities.

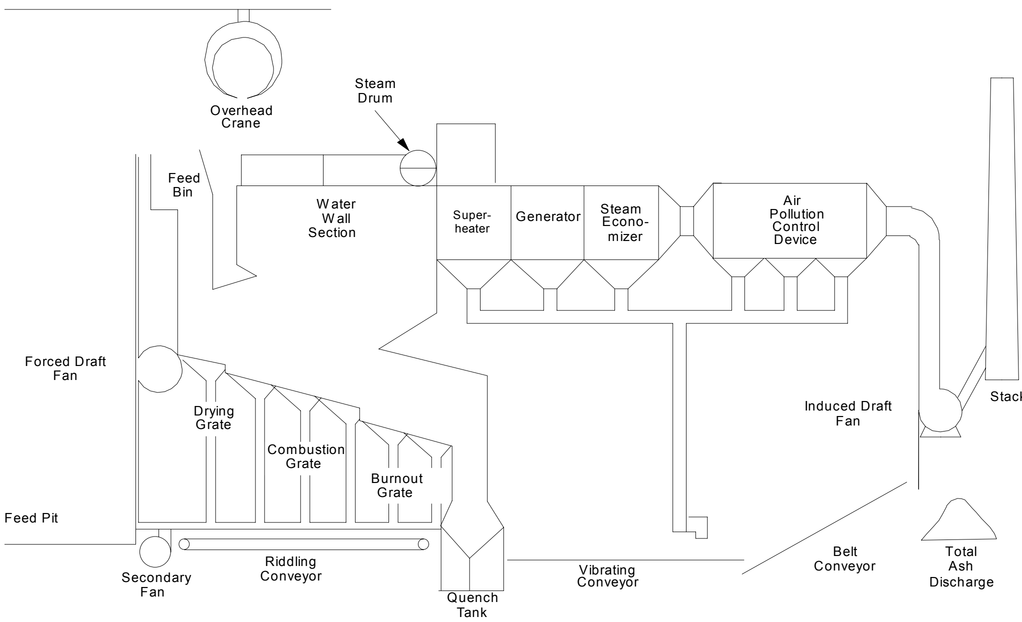

Figure 3.1 Mass Burn Waterwall MSW Incinerator

- Mass burn rotary kiln (MB-RK) incinerators use a water-cooled rotary combustor that consists of a rotating combustion barrel configuration mounted at a 15- to 20-degree angle of decline. The refuse is charged at the top of the rotating kiln by a hydraulic ram (Donnelly, 1992). Preheated combustion air is delivered to the kiln through various portals. The slow rotation of the kiln (10 to 20 rotations per hour) causes the MSW to tumble, thereby exposing more surface area for complete burnout of the waste. These systems are also equipped with boilers for energy recovery. Figure 3-2 provides a schematic view of a typical rotary kiln combustor.

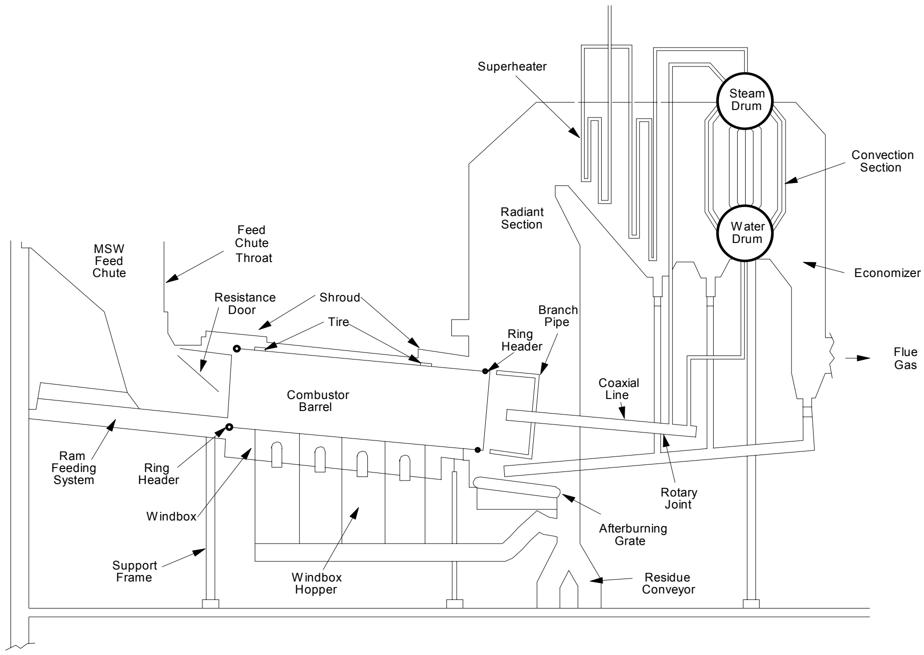

Figure 3.2 Mass Burn Rotary Kiln MSW Incinerator

Modular. This is a second general type of municipal solid waste incinerator used widely in the United States, Europe and Asia. As with the mass burn type, modular incinerators burn waste without preprocessing. Modular incinerators consist of two vertically mounted combustion chambers (a primary and secondary chamber). In modular configurations combustion capacity typically ranges from 4 to 270 metric tons per day, that is, predominately in the small-sized MWS incinerators. The two major types of modular systems, excess air and starved air, are described below.

- The modular excess air system consists of a primary and a secondary combustion chamber, both of which operate with air levels in excess of stoichiometric requirements (i.e., 100 to 250% excess air). Figure 3-3 illustrates a typical modular excess air MSW incinerator.

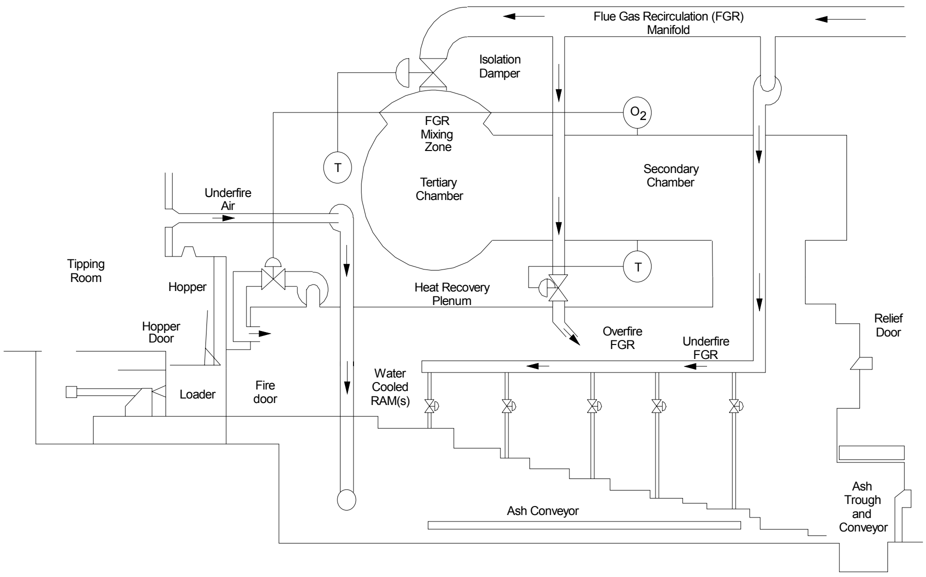

Figure 3.3 Modular Excess Air MSW Incinerator

- In the starved (or controlled) air type of modular system, air is supplied to the primary chamber at substoichiometric levels. The products of incomplete combustion entrain in the combustion gases that are formed in the primary combustion chamber and then pass into a secondary combustion chamber. Excess air is added to the secondary chamber, and combustion is completed by elevated temperatures sustained with auxiliary fuel (usually natural gas). The high, uniform temperature of the secondary chamber, combined with the turbulent mixing of the combustion gases, results in low levels of PM and organic contaminants being formed and emitted. Therefore, many existing modular units are not accompanied by post-combustion APCDs. Figure 3-4 is a schematic view of a modular starved-air MWC.

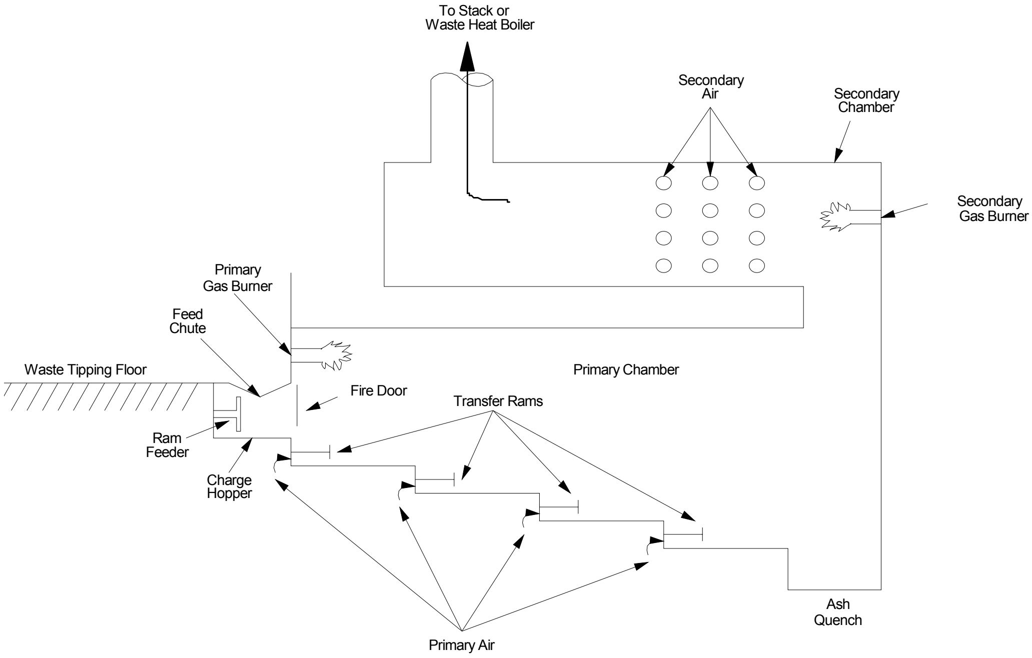

Figure 3.4 Modular Starved Air MSW Incinerator with Transfer Rams

Refuse-derived fuel. The third major type of MSW incinerator design involves the pre-processing of the MSW feed. This technology is generally applied only at very large MWC facilities. RDF is a general term that describes MSW from which relatively noncombustible items are removed, thereby enhancing the combustibility of the waste. RDF is commonly prepared by shredding, sorting, and separating out metals to create a dense MSW fuel in a pelletized form of uniform size. Three types of RDF systems are described below.

- The dedicated RDF system burns RDF exclusively. Figure 3-5 shows a typical dedicated RDF furnace using a spreader-stoker boiler. Pelletized RDF is fed into the combustor through a feed chute using air-swept distributors; this allows a portion of the feed to burn in suspension and the remainder to burn out after falling on a horizontal traveling grate. The traveling grate moves from the rear to the front of the furnace, and distributor settings are adjusted so that most of the waste lands on the rear two-thirds of the grate. This allows more time to complete combustion on the grate. Underfire and overfire air are introduced to enhance combustion, and these incinerators typically operate at 80 to 100% excess air. Waterwall tubes, a superheater, and an economizer are used to recover heat for production of steam or electricity. The dedicated RDF facilities range from 227 to 2720 metric tons per day total combustion capacity.

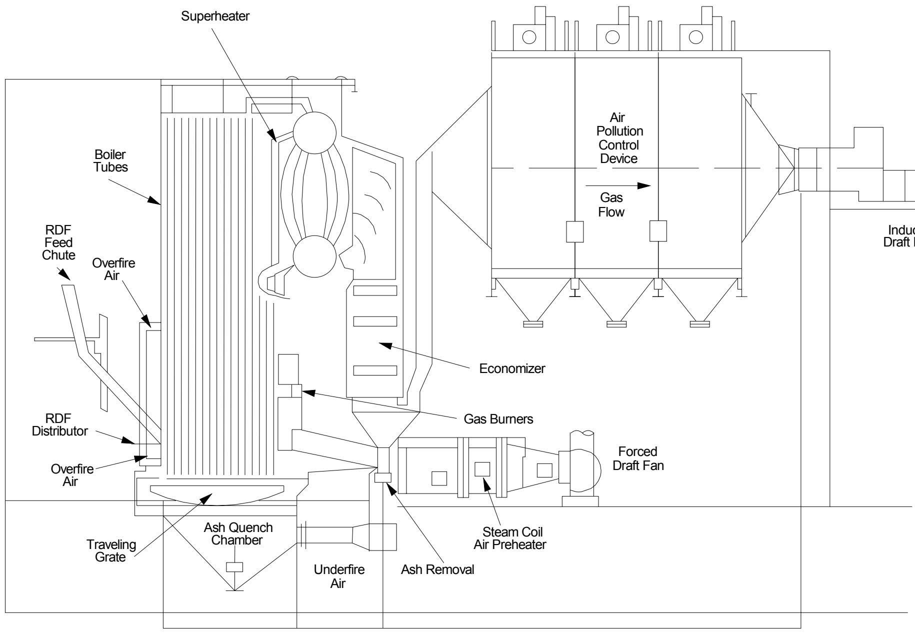

Figure 3.5 RDF-Fired Spreader Stoker MSW Incinerator

- Co-fired RDF incinerators burn either RDF or normal MSW, along with another fuel. RDF, because of its greater surface area, can support more catalytic reactions. Co-firing RDF with coal tends to reduce dioxin formation due to the inhibitory behavior of the sulfur content in the latter.

- The fluidized-bed RDF burns the waste in a turbulent and semisuspended bed of sand. The MSW may be fed into the incinerator either as unprocessed waste or as a form of RDF. The RDF may be injected into or above the bed through ports in the combustor wall. The sand bed is suspended during combustion by introducing underfire air at a high velocity, hence the term "fluidized." Overfire air at 100% of stoichiometric requirements is injected above the sand suspension. Waste-fired fluidized-bed RDFs typically operate at 30 to 100% excess air levels and at bed temperatures around 815 EC (1500 EF). A typical fluidized-bed RDF is represented in Figure 3-6. The technology has two basic designs: (1) a bubbling-bed incineration unit and (2) a circulating-bed incineration unit. Fluidized-bed MSW incinerators in the United States, for example, have capacities ranging from 184 to 920 metric tons per day. These systems are usually equipped with boilers to produce steam.

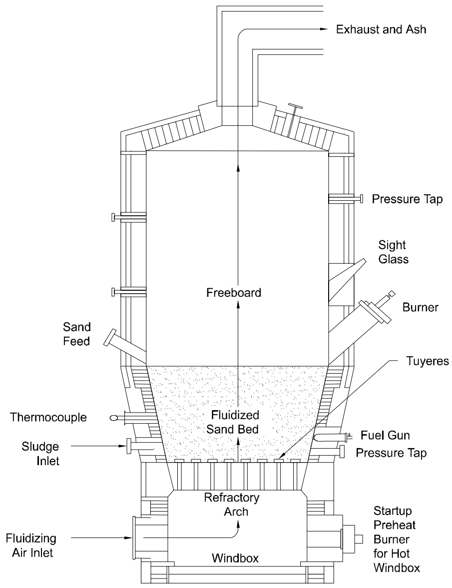

Figure 3.6 RDF Fluidized Bed MSW Incinerator

3.2 Air Pollution Control Devices (APCDs)

Municipal waste incinerators are commonly equipped with one or more post-combustion APCDs to remove various pollutants prior to release from the stack, such as PM, heavy metals, acid gases, and organic contaminants. Types of APCDs include:

- Electrostatic filters (precipitators) (ESP)
- Fabric filters (FF)
- Spray dry scrubbing systems (SD)
- Dry sorbent injection systems (DSI)
- Wet scrubbers (WS)

Electrostatic precipitator (ESP). The ESP (in Europe these systems are usually referred to as electrostatic filters) is generally used to collect and control particulate matter that evolves during MSW combustion by introducing a strong electrical field in the flue gas stream. This acts to charge the particles entrained in the combustion gases. Large collection plates receive an opposite charge to attract and collect the particles. **PCDD/PCDF formation can occur within the ESP at temperatures in the range of 200EC to about 450EC. Operating the ESP within this temperature range can lead to significant levels of PCDDs/PCDFs in the combustion gases released from the stack.** As temperatures at the inlet to the ESP increase from 200 to 300EC, PCDD/PCDF concentrations have been observed to increase by approximately a factor of 2 for each 30EC increase in temperature. As the temperature increases beyond 300EC, formation rates decline. ESPs that operate within this temperature range are referred to as 'Hot-Sided' ESPs.

Although ESPs in this temperature range efficiently remove most particulates and the associated PCDDs/PCDFs, the PCDD/PCDF formation that occurs can result in a net increase in emissions of these POPs. Cold-sided ESPs, which operate at or below 230EC, do not foster PCDD/PCDF formation. However, most ESPs have been replaced with better-performing and lower-cost fabric filter technology.

Fabric filter (FF). FFs are sometimes referred to as baghouses or dust filters. FFs are also particulate matter control devices that can effectively remove PCDDs and PCDFs that may be associated with particles and any vapors that adsorb to the particles in the exhaust gas stream. The filters are usually 16 to 20 cm diameter bags, 10 m long, made from woven fiberglass material, and arranged in series. An induction fan forces the combustion gases through the tightly woven fabric. The porosity of the fabric allows the bags to act as filter media and retain a broad range of particle sizes (down to less than 1 :m in diameter). The FF is sensitive to acid gas; therefore, it is usually operated in combination with spray dryer adsorption of acid gases.

Spray dry scrubbing system (SDSS). Spray dry scrubbing, also called spray dryer adsorption, involves the removal of both acid gas and particulate matter from the post-combustion gases. In a typical SDSS, hot combustion gases enter a scrubber reactor vessel. An atomized hydrated lime slurry (water plus lime) is injected into the reactor at a controlled velocity. The slurry rapidly mixes with the combustion gases within the reactor. The water in the slurry quickly evaporates, and the heat of evaporation causes the combustion gas temperature to rapidly decrease. The neutralizing capacity of hydrated lime reduces the acid gas constituents of the combustion gas (e.g., HCl and SO_2) by greater than 70%. A dry product consisting of PM and hydrated lime settles to the bottom of the reactor vessel.

SDSS technology is used in combination with ESPs and FFs. Spray drying reduces ESP inlet temperatures to create a cold-side ESP. In addition to acid gas, particulate matter, and metals control, SDSSs with FFs or ESPs typically achieve greater than 90% reduction in PCDD/PCDF release as well as better than 90% SO_2 and HCl control. PCDD/PCDF formation and release is substantially prevented by quenching combustion gases quickly to a temperature range that is unfavorable to the formation of PCDDs/PCDFs, and by the higher collection efficiency of the resulting particulate matter.

Dry sorbent injection (DSI). DSI is used to reduce acid gas emissions. By themselves, these units probably have little effect on unintentional POPs releases. In this system, dry hydrated lime or soda ash is injected directly into the combustion chamber or into the flue duct of the hot post-combustion gases. In either case, the reagent reacts with and neutralizes the acid gas constituents.

Wet scrubber (WS). WS devices are designed for acid gas removal and are common in MSW incinerators in Europe. Wet scrubbers also help reduce formation and release of PCDD/PCDF in both vapor and particle forms. The device consists of a two-stage scrubber. The first stage removes HCl through the introduction of water, and the second stage removes SO_2 by addition of caustic or hydrated lime.

Other types of APCDs. In addition to the APCDs described above, some less common types are also used in some municipal incinerators. One example is activated carbon injection (CI) technology. Activated carbon is injected into the flue gas prior to the gas reaching SDSSs with FFs (or ESP). PCDD/PCDF (and mercury) are absorbed onto the activated carbon, which is then captured by the FFs or ESP. The carbon injection technology improves capture of the unintentional POPs in the combustion gases by an additional 75% and is commonly referred to as flue gas polishing. Many APCDs have been retrofitted to include carbon injection, including more than 120 large municipal incinerators in the United States.

4.0 Best Environmental Practices for Municipal Waste Incineration

Well-maintained facilities, well-trained operators, continuous monitoring of operating parameters, and careful management of residues are all important factors in minimizing the formation and release of the unintentional POPs. In addition, effective waste management strategies (*e.g.,* waste minimization, source separation, and recycling), by altering the volume and character of the incoming waste, can also significantly impact releases.

4.1 Waste Management Practices

Waste Minimization. Reducing the overall magnitude of MSW for disposal serves to reduce both the releases and residues from MSW incinerators. Diversion of biodegradables to composting and initiatives to reduce the amount of packaging materials entering the MSW stream can significantly affect waste volumes.

Source Separation and Recycling. Curbside or centralized sorting and collection of recyclable materials (e.g., aluminum and other metals, glass, paper, recyclable plastics, construction & demolition waste) also reduces waste volume and removes some non-combustibles.

Removal of Non-combustibles at the Incinerator. The removal of both ferrous and non-ferrous metals on-site is a common practice.

4.2 Operating and Management Practices

Ensuring Good Combustion. To achieve optimal prevention of formation and capture of the unintentional POPs, proper care and control of both burn and exhaust parameters are necessary. In continuous feed units, the timing of waste introduction, control of burn conditions, and post burn management are important considerations.

Optimal burn conditions involve:

- mixing of fuel and air to minimize the existence of long-lived, fuel rich pockets of combustion products,
- attainment of sufficiently high temperatures in the presence of oxygen for the destruction of hydrocarbon species, and
- prevention of quench zones or low temperature pathways that will allow partially reacted fuel to exit the combustion chamber.

Proper management of time, temperature, and turbulence (the "3 T's"), as well as oxygen (air flow), by means of incinerator design and operation will help to ensure the above conditions. The recommended residence time of waste in the primary furnace is 2 seconds. Temperatures at or above 1,000°C are required for complete combustion in most technologies. Turbulence, through the mixing of fuel and air, helps prevent cold spots in the burn chamber and the buildup of carbon which can reduce combustion efficiency. Oxygen levels in the final combustion zone must be maintained above those necessary for complete oxidation.

Cold Starts, Upsets, and Shutdowns. These events are normally characterized by poor combustion, and consequently the conditions for unintentional POPs formation. For smaller, modular incinerators operating in batch mode, start-up and shutdown may be daily occurrences. Preheating the incinerator and initial co-firing with a fossil fuel will allow efficient combustion temperatures to be reached more quickly. Upsets can be avoided through periodic inspection and preventive maintenance.

Regular Inspections and Maintenance of the Facility. Routine inspections of the furnace and APCDs should be conducted to ensure system integrity and the proper performance of the incinerator and its components.

Monitoring. High efficiency combustion can be facilitated by establishing a monitoring regime of key operating parameters, such as carbon monoxide (CO). Low CO is associated with higher combustion efficiency in terms of the burnout of the MSW. Generally, if the CO concentration is kept to below 50 ppm by volume in the stack flue gases, this provides a general indication that high combustion efficiency is being maintained within the combustion chamber. Good combustion efficiency is related to the minimization of the formation of PCDD/PCDFs within the incinerator.

In addition to carbon monoxide, oxygen in the flue gas, air flows and temperatures, pressure drops, and pH in the flue gas can be routinely monitored at reasonable cost. While these measurements represent reasonably good surrogates for the potential for unintentional POPs formation and release, periodic measurement of PCDD/PCDF in the flue gas will aid in ensuring that releases are minimized.

Management of Residues. Bottom and fly ash from the incinerator must be properly handled, transported, and disposed of. Covered hauling and dedicated landfills are a common practice for managing these residues. If re-use of the residues is contemplated, an evaluation of the unintentional POPs content and potential environmental mobility is advisable.

Operator Training. Regular training of personnel is essential for proper operation of MSW incinerators.

5.0 Best Available Techniques

The demonstrated options for best available techniques applicable to MSW incinerators include several combinations of incinerator configurations and flue gas treatment that have been demonstrated to be highly effective in preventing formation and release of the unintentionally produced POPs. Table 1 displays incineration options on the basis of relative, expected PCDD/PCDF releases, reported as nanogram TEQ emitted per kg waste combusted, using the WHO TEF method. Techniques in the "Relatively Low to Moderate" category (0.1-10 ng TEQ/kg waste) would be considered as better candidates for BAT. Those in the "Relatively High to Very High" category should be avoided, particularly in the consideration of the design of a new source. As noted earlier, designs involving a "hot-sided" ESP invariably fall in the "relatively very high release" category and should definitely be avoided.

Table 1. Candidate Best Available Techniques for MSW Incinerators

	Range Of Relative Expected WHO_{DF}-TEQ PCDD/PCDF Emissions (ng TEQ/kg waste)			
	0.1 –1.0 (Relatively Low Releases)	1.0 – 10.0 (Relatively Moderate Releases)	10.0 – 100.0 (Relatively High Releases)	100.0 – 1000.0 (Relatively Very High Releases)
Massburn/WW				
DS/FF	X			
DS/CI/FF	X			
Cold-ESP		X		
Hot-ESP				X
Uncontrolled				X
Massburn/REF				
DS/FF	X			
DS/Cold-ESP		X		
Cold-ESP		X		
Hot-ESP				X
Uncontrolled				X
Massburn/RK				
DSFF	X			
Cold-ESP		X		
DSI-FF		X		
Hot-ESP				X
Uncontrolled				X
Modular/SA				
DSI/FF	X			
DS/FF	X			
FF		X		
Cold-ESP		X		
Hot-ESP			X	
WS		X		
Modular/EA				
DSI/FF	X			
DS/FF	X			
FF		X		
Cold-ESP		X		
Hot-ESP			X	
WS		X		
FB-RDF				
DS/FF	X			
Cold-ESP		X		
Hot-ESP				X

Source: Adapted from, *The Inventory of Sources and Environmental Releases of Dioxin-like Compounds in the United States: The Year 2000 Update*. National Center for Environmental Assessment, Office of Research and Development. United States Environmental Protection Agency, Washington DC**.** External Review Draft. EPA/600/P-03/002A, August, 2003

Key:

Massburn/WW = Massburn MWC units with waterwall tubes for heat recovery.
Massburn/REF = Massburn MWC units with refractory walls without heat recovery.
Massburn/RK = Massburn MWC unit having a rotary kiln without heat recovery.
Modular SA = Modular MWC unit with primary chamber operated under substochiometric condition (starved air)
Modular EA = Modular MWC unit with primary chamber operated under stochiometric condition (excess air).
FB-RFD = Fluidized bed MWC unit firing dedicated Refuse Derived Fuel (RDF)

Air pollution control device

C-ESP = Cold-sided electrostatic precipitator (<200^0C)
DS = Dry scrubber or spray dryer
DSI = Dry sorbent injection
FF = Fabric filter
H-ESP = Hot-sided electrostatic precipitator (>200^0C)
WS = Wet scrubber
CI = Carbon Injection

6.0 Management of Residues

Bottom ash from MSW incinerators tends to be very low in unintentional POPs content. These compounds are also generally tightly bound to the ash particles and resistant to leaching. For these reasons, bottom ash or slag can often be reused in construction and road-building material.

Unlike bottom ash, APCD residuals including fly ash and scrubber sludges may contain relatively high concentrations of heavy metals, organic pollutants (including PCDD/F), chlorides and sulfides. Their method of disposal, therefore, has to be well controlled. Wet scrubber systems in particular produce large quantities of acidic, contaminated liquid waste. Treatment methods include:

(a) The catalytic treatment of fabric filter dusts under conditions of low temperatures and lack of oxygen;

(b) The scrubbing of fabric filter dusts by the 3-R process (extraction of heavy metals by acids and combustion for destruction of organic matter);

(c) The vitrification of fabric filter dusts;

(d) Further methods of immobilization; and

(e) The application of plasma technology.

Fly ash and scrubber sludges are normally disposed of in landfills set aside for this purpose. Some countries include ash content limits for PCDD/PCDF in their incinerator standards. If the content exceeds the limit, the ash must be re-incinerated.

7.0 Economics of MSW Incineration

The construction of large state-of -the-art MSW incinerators requires major capital investment, often approaching hundreds of millions USD. Plants recover capital and operating costs through tipping fees and, in the case of waste-to-energy facilities, through the sale of steam or electricity to other industries and utilities. The ability to fully recover the costs of construction and operation is dependent on a number of factors including: the relative cost of alternative disposal methods (e.g., landfills); the availability of sufficient MSW within the local area; provisions for disposal of residues; and proper staffing, operation, and maintenance to maintain peak efficiency and minimize downtime.

Recycling and recovery programs to remove non-combustibles and other recyclable materials from the waste stream are economically compatible with large incinerator operations, provided these programs are incorporated into the planning and design of the facility.

Small waste incinerators, particularly the modular designs, require significantly lower capital investment but do not benefit from the economies of scale available to larger facilities. While modern designs can generally achieve high levels of combustion efficiency through starved air and secondary combustion chambers, the addition of APCDs to further reduce releases may be considered disproportionately expensive. There will be, however, situations in which smaller units may be the most feasible and cost effective incineration option. These could include: low population density; low waste generation; and the lack of transportation infrastructure.

8.0 New and Significantly Modified MSW Incinerators

The Stockholm Convention (Annex C, Part V, B, (b)) states that before Parties proceed with proposals to construct or significantly modify sources that release unintentional POPs, they should give "priority consideration" to "alternative processes, techniques or practices that have similar usefulness but which avoid the formation and release" of these compounds. In cases where such consideration results in a determination to proceed with construction or modification, the Convention provides a set of general reduction measures for consideration. While these general measures have been incorporated in the preceding discussion of best environmental practices and best available techniques for this category, there are additional factors that will be important in deciding whether it is feasible to construct or modify an MSW incinerator.

8.1 Additional Factors in the Siting of New MSW Incinerators

1. Do I have an accurate prediction of the MSW generation in the area to be served for the cost recovery period?
2. Does this prediction include appropriate waste minimization, recycling, and recovery programs?
3. Do I have the necessary transportation infrastructure to support collection and hauling?
4. Have I investigated the likelihood of intra- on interstate restrictions on waste transportation?
5. Do I have available markets for any on-site separated materials?
6. Do I have available markets for excess steam or electricity generated on-site (WTE)?
7. Do I have environmentally sound options for the disposal of residues?

8.2 Modification of Existing MSW Incinerators

Significant modifications to an existing MSW incinerator may be considered for several reasons. These could include: an expansion of capacity, the necessity of major repairs, enhancements to improve combustion efficiency and/or energy recovery, and the retrofitting of APCDs. Before undertaking such a modification, in addition to the "priority consideration" noted above, the following factors will be important to consider.

1. How will the modification affect the potential releases of unintentional POPs?
2. If the modification is the addition of an APCD, is it sized properly for the facility?
3. Is there sufficient space to install and operate it properly?
4. Will the retrofitted device operate in concert with the existing APCDs to minimize releases?

9.0 Emerging Technologies

The Convention defines the "available" in "best available techniques" as *"those techniques that are accessible to the operator and that are developed on a scale that allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages"*. Although the following technologies are not considered fully demonstrated on an industrial scale for the environmentally sound disposal of MSW, they warrant further study.

- **Pyrolysis and Gasification.** While incineration converts MSW into energy and ash, these processes limit conversion so that combustion does not take place. Instead, the waste is converted into intermediates that can be further processed for recycling and energy recovery. Many of these systems currently in use have been designed for a particular waste (e.g., discarded tires) or have only operated at a pilot scale. There is currently a lack of good data on true capital and operating costs.

- **Thermal Depolymerization.** This process mimics the natural processes that convert organic matter, under heat and pressure, into oil. The feedstock waste is shredded into fine particles and introduced into a kiln. Heat and pressure are applied in an anaerobic environment to obtain hydrocarbon oils, fatty acid oils, gas, solid carbon and minerals. Similar to pyrolysis, the process appears to work best when the waste stream is more homogeneous (e.g., turkey offal). For heterogeneous MSW, the result is more often an inconsistent and dirty oil/gas that is difficult to harvest and market.

- **Plasma Torch.** This technology employs a high temperature (10,000°C), high voltage direct current arc to atomize waste, breaking all chemical bonds. A variant of this technique relies on pyrolysis/gasification of materials by indirect exposure to plasma heat. In this process, MSW is exposed to temperatures of 1,800°C in an oxygen starved environment and the organic fraction is converted largely to hydrogen and carbon monoxide. Inorganic materials are reduced to a magma from which metals can be further separated. Proponents argue that there can be as much as a four-fold net energy recovery from the process. Combined with conventional APCDs, PCDD/PCDF levels can be held under conventional detection limits. A full scale application of this technology for MSW is currently under development in Japan.