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MUNICIPAL WASTE COMBUSTION ASSESSMENT: MEDICAL WASTE COMBUSTION PRACTICES AT MUNICIPAL WASTE COMBUSTION FACILITIES

Prepared for
Office of Air Quality Planning and Standards

Prepared by
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ABSTRACT

The EPA's Office of Air Quality Planning and Standards (OAQPS) is developing emission standards and guidelines for new and existing municipal waste combustors (MWCs) under sections 111(b) and 111(d) of the Clean Air Act. This report provides background information on the burning of medical waste in MWCs. The components of medical waste are defined and the potential air pollution emission impacts from burning medical waste in MWCs are discussed. MWCs in the U.S. which have reported burning medical waste are identified. The methods employed in handling and burning the medical waste at each facility are summarized. Important transportation, handling, and operating procedures which must be considered with respect to potential worker safety and health problems are discussed. Finally, current practices and regulations concerning the incineration of medical waste in Canada and Europe are summarized. Additional research and field tests are needed to fully evaluate the impacts of burning medical waste on the emission of acid gases, dioxin/furans, and trace metals. Further work is also needed to define combustion conditions necessary for the complete destruction of solvents, cytotoxic chemicals, and pathogens.

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FOREWORD

Based upon its analysis of Municipal Waste Combustors (MWCs), the Environmental Protection Agency (EPA) has determined that MWC emissions may reasonably be anticipated to contribute to the endangerment of public health and welfare and warrant further legislation. As a result, EPA's Office of Air Quality Planning and Standards is developing emission standards for new MWCs under Section 111(b) of the Clean Air Act (CAA) and guidelines for existing MWCs under Section 111(d) of the CAA.

In support of these regulatory development efforts, the Air and Energy Engineering Research Laboratory in EPA's Office of Research and Development has conducted an in-depth assessment of combustion control practices to minimize air emissions from MWCs. The results of this assessment are documented in the following reports:

Municipal Waste Combustion Assessment: Combustion Control at New Facilities, August 1989 (EPA-600/8-89-057)

Municipal Waste Combustion Assessment: Combustion Control at Existing Facilities, August 1989 (EPA-600/8-89-058)

Municipal Waste Combustion Assessment: Fossil Fuel Co-Firing, July 1989 (EPA-600/8-89-059)

Municipal Waste Combustion Assessment: Waste Co-Firing, July 1989 (EPA-600/8-89-060)

Municipal Waste Combustion Assessment: Fluidized Bed Combustion, July 1989 (EPA-600/8-89-061)

Municipal Waste Combustion Assessment: Medical Waste Combustion Practices at Municipal Waste Combustion Facilities, July 1989 (EPA-600/8-89-062)

Municipal Waste Combustion Assessment: Technical Basis for Good Combustion Practice, August 1989 (EPA-600/8-89-063)

Municipal Waste Combustion: Multi-pollutant Study. Emission Test Report, Maine Energy Recovery Company, Refuse-Derived Fuel Facility, Biddeford, Maine, Volume I, Summary of Results, July 1989 (EPA-600/8-89-064a)

Municipal Waste Combustion: Multi-Pollutant Study, Emission Test Report, Mass Burn Refractory Incinerator, Montgomery County South, Ohio, Volume I, Summary of Results, August 1989 (EPA-600/8-89-065a)

The specific objectives of this report, "Municipal Waste Combustion Assessment: Medical Waste Combustion Practices at MWC Facilities", were to examine and define the practice of incinerating medical waste in MWCs and to identify the potential air pollution emission impacts, as well as potential worker safety and health problems associated with this practice.

CONTENTS

TABLES

1.0 INTRODUCTION

The U.S. EPA is currently developing air emission standards for new and existing municipal waste combustors (MWCs) under Section 111 of the Clean Air Act. In addition, as part of the Medical Waste Tracking Act of 1988, EPA must prepare a comprehensive report to Congress identifying sources, handling procedures, transportation, treatment, and disposal of medical waste. This report must also include an assessment of the present and potential threat that medical waste represents to human health and the environment. It was determined in the MWC information gathering effort that a number of MWCs burn medical waste. The impacts of this practice on air emissions are currently not known. Based on these uncertainties, a study was conducted to examine and define the practice of incinerating medical waste in MWCs and identify potential air pollution emission impacts, as well as the potential worker safety and health problems associated with this practice. Section 2.0 of this report defines and characterizes types of medical waste. Section 3.0 discusses possible impacts of burning medical waste on combustor emissions, and Section 4.0 outlines important handling and operating considerations. Facility-specific design, handling, and operating practices are discussed in Section 5.0 for those U.S. MWCs that reportedly accept medical waste. Section 6.0 outlines European and Canadian medical waste incineration practices in MWCs. Section 7.0 discusses the handling and operating guidelines and philosophies of U.S. and European MWC manufacturers regarding medical waste incineration. Section 8.0 concludes the report with a discussion of preliminary findings, recommendations, and research needs.

2.0 MEDICAL WASTE

Medical waste is defined as any type of waste generated by a biomedical institution, including hospitals, medical laboratories, animal experimentation units, and clinics. Two features of medical waste are of key importance. First, the physical and chemical characteristics of the waste are highly variable. The heat content of the waste can vary from a low of 1000 Btu/lb (2.326×10^6 J/kg) for human tissues, organs, and body parts to a high of over 15,000 Btu/lb (3.489×10^7 J/kg) for plastic containers and disposable equipment.[1,2] In addition to heat content, the ash, moisture, chlorine, and metals contents can also vary significantly from one batch of waste to another.

Second, some of the components of medical waste require special attention. These components are:

- Cytotoxic chemicals
- Hazardous chemicals
- Pathogens
- Toxic metals
- Radioactive materials

Although medical waste may contain components from one or more of the above categories, it may also consist primarily of general refuse similar to commercial and household waste. This general refuse often makes up the bulk of a particular medical waste.

2.1 Cytotoxic Chemicals

Cytotoxic chemicals are substances capable of impairing, injuring, or killing cells. These hazardous pharmaceuticals are used in chemotherapy. Available information indicates that these agents may not be effectively destroyed at temperatures below 1800°F (982°C).[3]

2.2 Hazardous Chemicals

A number of laboratory solvents found in medical waste are listed as hazardous under the Resource Conservation and Recovery Act (RCRA). Included among these hazardous solvents are:

Acetone	Ethyl alcohol	Petroleum ether
2-Butanol	Heptane	2-propanol
Butyl alcohol	Hexane	Sec-butyl alcohol
Cyclohexane	Methyl alcohol	Tert-butyl alcohol
Diethyl ether	Methyl cellosolve	Tetrahydrofuran
Ethyl acetate	Pentane	Xylene

These compounds present concerns due to their own hazardous characteristics, and in addition, some serve as potential dioxin precursors.

2.3 Pathogens

Infectious waste is defined as medical waste which is capable of producing infectious disease due to the presence of pathogens of sufficient virulence and exposure routes to the host. (Examples: isolation waste, cultures and infectious agents, human blood, and body parts.) Pathogens are defined as agents capable of causing disease, such as bacteria or viruses. Infectious waste represents about 10 percent of the total medical waste stream and generally can be completely destroyed in a well designed and operated incinerator. The destruction of infectious waste is one of the primary reasons incineration is recommended for medical waste.

2.4 Toxic Chemicals

Medical waste contains toxic metals such as lead, cadmium, and mercury. These metals may be emitted into the air or may be leached from the solid residuals into groundwater. The principal mechanisms for the emission of metals are entrainment of metal-bearing particles or vaporization of the metal and transport in the gas phase from the combustion device. The vaporization escape mechanism is particularly important because the vapor condenses into a fine fume which may be difficult to capture with some air pollution control devices.

2.5 Radioactive Materials

Low level radioactive waste can be present in medical waste. The Nuclear Regulatory Commission (NRC) considers incineration to be an excellent means of disposing of radioactive medical waste.[3] Medical waste materials deregulated by the NRC include scintillation vials and research animal carcasses with less than 0.05 microcuries of tritium or carbon-14 per gram. Hazardous waste sites have been reluctant to accept this deregulated material, and incineration has been seen as an important alternative to shallow land burial.

MWCs burning even small percentages of medical waste must be able to accommodate highly variable waste compositions and heat content as well as many of the components discussed above.

3.0 IMPACT OF MEDICAL WASTE ON COMBUSTOR EMISSIONS

Limited information is available on the emission impacts associated with combustion of medical waste in MWC facilities. However, these impacts can be qualitatively discussed based on the composition of medical waste and emissions data from medical waste incinerators.

Halogenated polymers and copolymers make up a significant fraction of medical waste. Plastic items commonly found in medical waste include disposable instruments, syringes, petri dishes, plasticized paperware, cutlery, plastic containers, packaging, bedpans, urine bags, respiratory devices, and dialysis equipment. The high chlorine content of these materials will increase the production of HCl. Baseline HCl emissions from MWCs burning municipal waste may range from 100 to 1000 ppm. Co-firing large amounts of medical waste may increase baseline HCl emissions.

Medical waste incinerators have been found to emit dioxins at about the same concentrations as typical municipal waste incinerators (100-2000 ng/dscm).[4] Although dioxin formation is more strongly correlated with system design and operation, dioxin emissions may also be affected to some extent by waste characteristics. Medical waste has a number of characteristics that could lead to dioxin formation. A significant amount of aromatic compounds are present that may serve as dioxin precursors. These compounds include cytotoxins, laboratory wastes such as xylene, and components of various packing materials. Medical waste also contains a high concentration of chlorinated plastics and is highly non-homogeneous. Some components of the waste have high moisture contents. These materials may create localized low temperature zones within the waste bed, resulting in fuel-rich pockets that may escape complete destruction in the furnace.

Medical waste contains such toxic metals as mercury, cadmium, and arsenic. These metals are volatile and may vaporize in the incinerator. The metal vapors would then be carried away in the exhaust gases. As the exhaust gases cool, the metals would be adsorbed on the surface of particles or condense to form small particles which are difficult to capture. A significant fraction of the fine condensed particles may be emitted to the atmosphere. Mercury, cadmium, and arsenic have been detected in hospital waste incinerator exhausts.[2,5]

4.0 IMPORTANT CONSIDERATIONS

Beyond emissions concerns, a number of other factors must be considered when burning medical waste in MWCs. Transportation and handling is an important factor when medical waste is incinerated off-site as compared to an on-site hospital incinerator. Incinerator operation characteristics such as temperature, and time at a given temperature are also important factors relating to pathogen and cytotoxic chemical destruction. Ash handling and disposal are important as well due to potential pathogen survival, radioactivity, and metals content of the ash.

4.1 Waste Transportation and Handling

The transportation of medical waste to municipal waste combustors and the subsequent handling of the waste at the combustor site are areas of significant concern. As mentioned earlier, a number of medical waste components are extremely dangerous and must not be allowed to enter the environment. Precautions must be taken to ensure that none of the waste materials escape during transportation. These precautions include placing the waste in sealed, secure containers and employing procedures to deal with accidental releases such as those that may occur during a traffic accident. A truck itself is not considered a suitable containment system; rather it is a transport mechanism only. All medical waste should be placed in rigid or semi-rigid leakproof containers before being loaded onto a truck.[6]

Storage time and temperature are important considerations. Microbial growth and putrefaction rates increase with temperature, resulting in increased potency. In addition, unpleasant odors associated with decaying organic matter are produced. Storage times should be kept as short as possible.[6]

Once the waste is on site, transport containers must not be opened or breached until they are either in the combustor or in a secure environment. Medical waste cannot be preprocessed because of the resulting increased chance of exposure. All personnel handling medical waste should be aware of its nature and take proper precautions. However, if the integrity of the containers has not been compromised, it is unlikely that specialized clothing or respirators would be needed. All equipment used to handle waste containers should be sterilized periodically.[6]

4.2 Operation

When medical waste is burned in municipal waste incinerators, several operational precautions must be observed. It is generally believed that temperatures above 1800°F (982°C) are required to destroy cytotoxic compounds.[3] In addition, temperatures must be maintained at sufficient levels to ensure the complete destruction of all pathogens in the waste. However, one current study indicates that typical MSW operating conditions may be sufficient to accomplish this.[7] One final requirement is that medical waste be rendered "unrecognizable." That is, one should not be able to recognize body parts and medical equipment in the residual ash. This essentially requires good burnout of all incoming waste types. This is challenging because some materials (hospital gowns) are treated with flame retardant for safety reasons during their normal use.

4.3 Ash Handling

The primary concern in handling the ash from an incinerator burning medical waste is to ensure that all infectious agents have been destroyed. In general, the conditions found in a municipal waste incinerator will be sufficient to destroy most pathogens. However, additional concerns exist with regard to the ability of some viruses to survive incineration. Although some pathogen testing has been conducted on ash from both medical and municipal waste combustors, a standardized, generally accepted test that demonstrates the destruction of infectious agents has not yet been developed.

A second concern stems from the fact that radioactive materials may be present in medical waste. Radioactive materials may be concentrated in the ash, producing a material that cannot be placed in a municipal landfill. The radioactive nature of the waste must be carefully monitored to ensure that it does not exceed acceptable levels.

The metals present in medical waste are a third area of concern. Studies of the ash from hospital incinerators indicate that relatively large quantities of cadmium and lead are present.[8] These metals may potentially leach from the ash into groundwater reservoirs. The metals content of MSW ash is currently an important issue. Therefore, the impact on the metals content of the ash produced by an MWC also burning medical waste presents a definite concern as well.

5.0 CURRENT PRACTICES - U.S. MWCS

Medical waste is routinely fired in at least 12 MWC facilities, including three mass burn waterwall, one mass burn refractory, five modular starved air, and three modular excess air combustors. Medical waste comprises less than 5 percent by weight of the total feed for 11 of these systems and 50 percent by weight for 1 of the modular starved air units. Three additional MWC facilities--two mass burn refractory and one fluidized bed combustor--previously accepted medical waste but have ceased this practice. Design and operating characteristics of these 15 facilities are summarized in Table 5-1. The waste types, handling procedures, and reported problems are summarized in Table 5-2. A more detailed description of each of the facilities is outlined in the following sections.

5.1 Mass Burn Waterwall MWCs

The Walter B. Hall Resource Recovery facility in Tulsa, OK and the Ogden Martin Systems facility in Marion County, OR are both mass burn waterwall combustors supplied by Ogden Martin Systems, Inc.[9,10] Martin Gmbh manufactured the grates, and Zurn supplied the boilers. The Tulsa facility comprises three units, each with 375 tpd (340 tonnes/day) capacity. The Marion County facility includes two units rated at 275 tpd (249 tonnes/day) each. Both plants are state-of-the-art combustors, with only minor differences in design and operation. Tulsa reports firing 0.2 percent by weight medical waste and Marion County reports firing less than 1 percent. Both facilities have ram feeders. Feed rates are automatically controlled according to steam demand and excess oxygen levels. Five underfire air plenums supply 60-80 percent of the total combustion air. Three rows of overfire air jets supply the remaining portion of air to the primary combustor. Only the underfire air is preheated. Marion uses natural gas as auxiliary fuel to achieve temperatures of 1800°F (982°C) at the top of the furnace prior to waste feed during start-up and until all the waste is burned off the grate during shutdown. Tulsa does not use auxiliary fuel. The Tulsa units are equipped with three-field ESPs with typical operating inlet gas temperatures ranging from 375 to 505°F (190 to 263°C). Marion County is equipped with spray dryers and fabric filters.

The Tulsa facility receives medical waste from commercial haulers. A significantly higher tipping fee is charged for the medical waste than for

Table 5-1. Design and Operating Procedures of MWCs Accepting Medical Waste

	PLANT	# OF UNITS	INDIVIDUAL UNIT CAPACITY (tpd)	(tonnes/day)	COMBUSTION TYPE	MEDICAL WASTE MASS INPUT (%, average)	AIR POLLUTION CONTROL DEVICE
1	Tulsa, OK	3	375	340	Mass burn waterwall	0.2	ESP
2	Marion County, OR	2	275	249	Mass burn waterwall	<1	SD/FF
3	Olmstead County, MN	2	100	90	Mass burn waterwall	<1	ESP
4	Washington, DC	4	250	227	Mass burn refractory	1	ESP
5	Sheboygan, WI*	2	120	109	Mass burn refractory	<1	Water sprays
6	Louisville, KY*	4	250	227	Mass burn refractory	0.4	Wet scrubber
7	Bellingham, WA	2	50	45	Modular starved air	0-5	ESP
8	Windham, CT	3	36	33	Modular starved air	≤2	Fabric filter
9	Fort Dix, NJ	4	20	18	Modular starved air	<1	Fabric filter, wet scrubber, packed tower
10	Hampton, SC	3	90	82	Modular starved air	50	Dry injection/ESP
11	Cattaraugus, NY	3	38	34	Modular starved air	≤1	None
12	Pascagoula, MS	2	75	68	Modular excess air	2	ESP
13	Sitka, AK	2	25	23	Modular excess air	<1	ESP
14	Clebourne, TX	3	38	34	Modular excess air	1	ESP
15	Duluth, MN*	2	105-120	95-109	FBC	5	Venturi

* No longer accepting medical waste.

Table 5-2. Waste Types, Handling Procedures, and Reported Problems in MWCs Accepting Medical Waste

FACILITY		WASTE TYPE ACCEPTED											PROBLEMS EXPERIENCED					HANDLING
		REFUSE	CULTURES AND STOCKS	PATHOLOGICAL	BLOOD AND BLOOD PRODUCTS	USED SHARPS	ANIMAL CARCASSES	ISOLATION WASTES	UNUSED SHARPS	RADIOACTIVE	CYTOXIC	HAZARDOUS	SHARPS FALL THROUGH	INCOMPLETE BURNOUT	TEMPERATURE CONTROL	CONTAMINATION	REDUCED THROUGHPUT	
Mass Burn Waterwall	1	X	X		X	X		X	X				X					Hauler places in grapple
	2	X	X		X	X		X	X		X		X					Separate in pit
	3	X	X	X	X	X		X	X		X							Hauler places on conveyor
Mass Burn Refractory	4	X		X	X			X			X					X		Hauler places in crane
	5*	X	X	X	X	X	X	X	X		X		X	X				Separate in pit
	6*	X	X	X	X	X	X	X	X		X		X	X	X	X	X	Hauler places in hopper
Modular Starved Air	7	X	X		X	X		X	X		X							Hauler places in hopper
	8	X	X		X	X	X	X	X		X							Hauler places in hopper
	9	X	X			X		X	X		X		X					Hauler places in hopper
	11	X	X	X	X	X	X	X	X		X							Hauler places in loader
Modular Excess Air	12	X	X			X		X	X								X	Separate in pit
	13	X	X	X	X	X	X	X	X		X			X	X		X	Hauler places in crane
FBC	15*	X	X	X	X	X		X	X		X							Shredded

* No longer accepting medical waste

municipal waste.[11] No body parts, animal carcasses, or radioactive wastes are accepted. Sharps are accepted. The waste is delivered in lined boxes. The haulers manually load the boxes into a closed grapple which is unloaded directly to the charging hopper. The medical waste is mixed with municipal waste in the hopper in approximately equal amounts and incinerated immediately. The crane is cleaned after every load and the haulers are responsible for cleaning any spill from broken boxes. Coveralls, dust masks, and gloves are worn at all times by facility personnel. Facility personnel, as well as the haulers, receive training in the handling and operating procedures required by the facility.

The Marion County facility also receives medical waste from commercial haulers.[11] Prior to the end of January 1989, 70 tons/month (63 tonnes/month) of medical waste were being delivered from out of state at a tipping fee of $300/ton ($331/tonne). This contract expired at the end of the month with no plans for its renewal. The facility plans to continue receiving 15-20 tons/month (14-18 tonnes/month) of medical waste from within the county for $26/ton ($29/tonne), the same amount charged for municipal waste. Like Tulsa, no body parts, animal carcasses, cytotoxic wastes, or radioactive wastes are accepted. Sharps are accepted. Before the expiration of the out-of-state contract, the waste was delivered in sealed boxes, unloaded to a conveyor, and transported directly to the hopper. The in-county medical waste is delivered in red plastic bags and dumped into a separate area in the pit. An overhead crane is used to transport the red bags from the pit to the hopper. The crane sometimes penetrates the bags and plant personnel are presently in the process of requesting that all medical waste be delivered in sealed boxes. The medical waste is mixed with municipal waste in alternating layers in the hopper and incinerated immediately after delivery. The conveyor is cleaned after every load. The tipping floor and edges of the pit are decontaminated periodically and the crane is cleaned prior to maintenance. Surgical gloves, goggles, and respirators are available if any close contact or exposure to medical waste is required. Personnel training includes instruction from local medical professionals regarding infectious disease transmission, decontamination procedures, and precautions.

Both Tulsa and Marion County report good burnout and routinely test the bottom ash for pathogens.[11] The test results reportedly have always been negative. Neither facility reported any combustion problems or increased HCl or metals emission attributed to the medical waste. Reportedly, mixing the medical waste with the municipal waste prior to combustion eliminates any potential problems associated with the widely variable heat content of the medical waste. Both facilities did report that sharps occasionally fall through the grate system into the riddlings hoppers. Facility personnel are specifically instructed not to reach into this area with their hands during maintenance to avoid injury.

The Olmstead County Waste-to-Energy Facility in Rochester, MN comprises two 100 tpd (95 tonnes/day) mass burn waterwall combustors and reportedly fires less than 1 percent by weight medical waste.[12] A ram feed system is used. The underfire air is preheated. Natural gas is used to maintain 1800°F (982°C) measured 54 feet (16 m) above the combustion grate prior to waste feed for start-up and until waste is burned off the grate during shutdown. During continuous operation, the furnace exit gas temperature is maintained at 1700°F (927°C). Steam is generated at a rate of 25,000 lb/hr (11,340 kg/hr). The Olmstead County facility is equipped with a three-field ESP.

Commercial haulers deliver medical waste from a prison hospital and a county hospital.[11] Sharps are accepted, but animal carcasses are not. A significantly higher tipping fee is charged for medical waste as compared to municipal waste. The medical waste is delivered in plastic bags contained in plastic or cardboard drums which are carried up in an elevator and emptied into the feed hopper. The drums are reusable. The medical waste is mixed with the municipal waste in the hopper. No combustion problems were reported due to the small amount of medical waste received. No increase in HCl emissions was observed. Sharps pass through the combustor intact. The bottom ash is tested for metals, but no increase was attributed to the medical waste. The medical waste handling procedures were evaluated and approved by an industrial hygienist. In addition, a medical doctor discussed infectious disease transmission and precautions, and provided Hepatitis-B vaccines to all facility personnel coming in contact with the medical waste. Full respirators, dust masks, gloves, and paper suits are available. However, the biggest problem associated with accepting medical waste is reportedly personnel concerns over handling the waste due to potential health risks. For this reason, the Olmstead County facility will eventually discontinue accepting medical waste. The waste will then be sent to a new infectious waste incinerator to be operated by the Mayo Clinic in Rochester, MN.

5.2 Mass Burn Refractory MWCs

There are three mass burn refractory facilities that report firing medical waste along with MSW: the Solid Waste Reduction Center in Washington, DC, the Sheboygan, WI facility, and the Louisville Refuse Incinerator of Kentucky. The Washington, DC facility consists of four 250-tpd (227 tonnes/day) rectangular refractory wall combustors with rocking grates manufactured by Flynn and Emrich.[13] The waste is gravity fed. Medical waste reportedly contributes 1 percent of the total waste feed. The feed rate is controlled automatically by the furnace exit temperature and manually adjusted based on waste characteristics and overall waste volume reduction. The furnace exit temperature ranges from 1400 to 1800°F (760 to 982°C). Combustion air is not preheated and no auxiliary fuel is used. There is no heat recovery. The air pollution control devices include a water quench chamber for temperature reduction and two-field ESPs for particulate control. The ESP inlet gas temperature is 500°F (260°C).

Commercial haulers deliver approximately 300 boxes of medical waste per day to the Washington, DC facility.[11] No radioactive waste, body parts, animal carcasses, or sharps are accepted at the plant. The tipping fee for medical waste is more than twice the municipal waste fee. Haulers unload the boxes to a conveyor which transports the waste directly to the charging hopper, as opposed to the municipal waste which is dumped into a pit and loaded into the hopper with an overhead crane. Boxes occasionally fall off the conveyor exposing the contents, in which case the hauler is responsible for cleaning and decontaminating the area. Washington, DC does not provide facility personnel with any special training or protective clothing or equipment since the commercial haulers are totally responsible for waste handling. Washington, DC facility personnel did not report any combustion problems or emission increases attributed to the medical waste. Reportedly, the medical waste helped to maintain temperatures in the combustor and good burnout is achieved. Neither the stack emissions nor the bottom ash have reportedly been tested for pathogens.

Prior to the passage of recent state medical waste regulations, the Sheboygan, WI facility fired less than 1 percent medical waste in two rectangular refractory-wall combustors that utilize three rocking grate sections per combustor.[14] Each unit has a firing capacity of 120 tpd (109 tonnes/day) of MSW. In light of these regulations, the facility is no longer accepting medical waste. In addition to burning MSW, the plant also burns skimmings from the sewage treatment plant. A total of 417 tons (378 tonnes) of sludge was reportedly burned in 1986. Waste is charged from a holding pit into a water-cooled hopper which feeds each combustor by gravity. The feed rate is controlled by varying the speed of the first (drying) grate section. The majority of the burning takes place on the second grate section, and burnout is completed on the third (finishing) grate. Bottom ash is discharged from the finishing grate to a wet quench. A drag chain conveyor transports the ash to a truck for disposal in a nearby landfill.

Underfire air is supplied by forced-draft fans (one per combustor). Siftings hoppers are located beneath the drying grate. Separate forced-draft fans (one per combustor) located adjacent to the underfire air fans supply overfire air. All adjustments in air flow are made manually based on visual observation of the burning bed and flame patterns. Grate speeds are also varied manually by controls on the side of the combustor. The speed of each grate section can be independently set and varied.

There are no auxiliary fuel burners in either combustor. The combustor is started up by establishing a bed of waste on the first grate section and igniting the waste by hand. Plant operators reported that during start-up it takes approximately 1 to 2 hours to achieve a temperature of 1400°F (760°C) in the combustion chamber. When this temperature is achieved, the overfire air is introduced and the furnace temperature is established at 1700 to 1800°F (927 to 982°C).

Combustion products leaving the active burning region flow through a three-pass wet baffle system which both cools the hot flue gases and reduces particulate matter (PM) emissions. After passing through the wet baffle system, flue gases from both combustion trains are combined in a short run of ducting to the stack. Water and PM collected in the baffle system flow to a concrete lagoon where the ash settles out from the water. Every 3 to 4 months this ash is dredged out and disposed of at a nearby landfill.

During the period in which the Sheboygan facility was receiving medical waste, no radioactive waste was accepted.[11] Pathological waste, animal carcasses from the humane society, and sharps were accepted. Commercial haulers delivered the waste in red plastic bags and sharps in rigid boxes. The haulers manually placed the medical waste into the crane bucket or carried the waste up in an elevator and dumped the waste directly into the charging chute. The medical waste was then immediately incinerated. Some medical waste believed to be from doctors' or dentists' offices was also mixed in with the municipal waste. No combustion problems were attributed to the widely variable heat content of the waste because of the small amount of medical waste received. Likewise, no increase in HCl or metals emissions was noted. Neither the stack emissions nor the bottom ash were ever tested for pathogens. The two main problems attributed to medical waste were sharps and animal carcasses. Needles fell through the grates into the riddlings hopper creating potential hazards for maintenance personnel. Also, needles were caught in the front end loader used to transport municipal waste and were discovered during maintenance. Animal carcasses also caused problems because of poor burnout and recognizability after the combustion process.

Prior to the expiration of a special permit, Louisville, KY was firing 0.4 percent by weight medical waste. However, due to operational problems attributed to the medical waste, the facility did not seek permit renewal and no longer accepts medical waste.[11,15] The Louisville facility consists of four split-flow rotary kiln mass burn refractory combustors each with a capacity of 250 tpd (227 tonnes/day). The waste is gravity fed. There are two grate sections, drying grates, and ignition grates prior to the rotary kiln. Preheated underfire air is supplied to the ignition grate section. No auxiliary fuel is used. The combustor gas temperature is maintained at 2000°F (1093°C) at the exit of the ignition chamber and 1800°F (982°C) at the exit of the mixing chamber. There is no heat recovery. The facility is equipped with a water spray chamber and a venturi scrubber.

During the period in which Louisville was receiving medical waste, no radioactive waste was accepted. Pathological waste and sharps were accepted. Commercial haulers were required to deliver medical waste between 6 and 8 AM so as not to interfere with municipal waste deliveries. A slightly higher tipping fee was charged for medical waste than for municipal waste. Medical waste was delivered in red plastic bags and rigid sharps containers. The waste was dumped into a separate area in the pit and loaded into the hopper by an overhead crane. Louisville did not provide facility personnel with any special training or protective equipment since the commercial haulers were responsible for all handling of medical waste. Many problems were attributed to the medical waste including increased temperature due to the high Btu content, reduced throughput, increased HCl emissions, sharps falling through the grates, and poor burnout. No pathogen testing was ever conducted on the stack emissions or the bottom ash.

5.3 Modular Starved Air Systems

There are five modular starved air facilities that fire medical waste along with MSW. The Bellingham, WA facility includes two Consumat units with design capacities of 50 tpd (45 tonnes/day) each.[16] The Windham, CT facility has three Consumat units designed to fire 36 tpd (33 tonnes/day) each.[17] For both facilities, the feed rate is manually adjusted based on the primary chamber temperature. Exit gas temperatures are typically 1200-1600°F (649-871°C) from the primary chamber and 1800-2000°F (982-1093°C) from the secondary (upper) chamber. Natural gas is used at Bellingham for start-up. The units are required to achieve 700°F (371°C) in the upper chamber prior to initiating waste feed. Auxiliary fuel is not used for shutdowns. Windham has auxiliary oil burners available, although they are not used for start-up or shutdown. Both facilities have heat recovery and generate 25,000 lb/hr (11,340 kg/hr) and 20,000 lb/hr (9072 kg/hr) of steam, respectively, per unit. Bellingham is equipped with a two-field ESP which operates at an inlet gas temperature of 526°F (274°C). Windham is equipped with a fabric filter.

A commercial hauler delivers 5 tpd (4.5 tonnes/day) of medical waste to Bellingham in heavy cardboard boxes with plastic liners and rigid leakproof plastic sharps containers.[11] No radioactive waste, body parts, or sharps are accepted. A higher tipping fee is charged for the medical waste than for the municipal waste. The boxes are first unloaded to the tipping floor in an area separate from the municipal waste and then manually loaded into hoppers where it is mixed with municipal waste. Since all containers are leakproof, no routine decontamination procedures are followed; however, in case of a spill, any exposed area is decontaminated immediately. Facility personnel receive special training and are provided protective clothing and equipment for medical waste handling. Bellingham does not report any combustion problems or increased HCl or metals emissions attributed to the medical waste. Good burnout is reportedly achieved with no recognizability of the ash. Neither the stack emissions nor the bottom ash is tested for pathogens. Reportedly, mixing the medical waste with the municipal waste prior to combustion eliminates any potential problems associated with the widely variable heat content of the medical waste.

Commercial haulers deliver 1 to 2 tons per week (0.9 to 1.8 tonnes/week) of medical waste to the Windham facility in plastic bags and boxes.[11] A slightly higher tipping fee is charged for the medical waste. No radioactive waste or body parts are accepted. The haulers manually place the medical waste in the hoppers and it is incinerated immediately. Facility personnel are not provided any special training, clothing, or equipment since the commercial haulers are totally responsible for medical waste handling. No combustion problems or increased HCl or metals emissions were attributed to the medical waste. Good burnout is reportedly achieved. The facility does not test the stack emissions or the bottom ash for pathogens.

The Fort Dix, NJ facility consists of four Clear Air units rated at 20 tpd (18 tonnes/day) each and reportedly fires less than 1 percent by weight medical waste.[18] A ram waste feed system is used. There is no air preheat. Natural gas is used during start-up to attain a temperature of 1500°F (816°C) measured at the secondary chamber outlet before waste feeding is initiated. Natural gas is also used during shutdown, although no specific temperature is required. The gas temperature is maintained at 1750 to 1850°F (954 to 1010°C) at the exit of the primary chamber and 1800 to 2000°F (982 to 1093°C) at the exit of the secondary chamber. Steam is produced in each unit at a rate of 7000 lb/hr (3175 kg/hr). The air pollution control devices include a fabric filter, a wet scrubber, and a packed tower.

Fort Dix receives approximately 20 boxes per day of medical waste.[11] No radioactive waste, body parts, carcasses, or liquids are accepted. Commercial haulers manually place the boxes into the hopper separate from the municipal waste. The boxes are not allowed to touch the tipping floor. The hopper is checked daily for spills or leaks from the boxes and decontaminated if necessary. Facility personnel routinely wear respirators while on the tipping floor. No combustion problems or increased HCl or metals emissions were attributed to the medical waste. An increase in operating temperature was reported for the medical waste as compared to the municipal waste but was not viewed as a problem. Due to the small amount of medical waste being incinerated, the combustion control system responded adequately to the increased temperature. Good burnout is reportedly achieved. No pathogen testing has been conducted. Reportedly, needles occasionally fall through the grate system to the riddlings hopper, but no injuries have ever resulted.

The Hampton, SC facility, consisting of three units rated at 90 tpd (82 tonnes/day) each, fires 50 percent by weight medical waste and utilizes dry sorbent (sodium bicarbonate) injection with an ESP for air pollution control. All other design and operating characteristics have been declared confidential business information by the facility owner/operator.

The Cattaraugus, NY facility consists of three Clear Air units each with a 38-tpd (34 tonnes/day) capacity and reportedly fires less than 1 percent by weight medical waste.[19] A ram waste feed system is used. There is no air preheat. Natural gas is used for start-up so that 1800°F (982°C) is achieved in the secondary chamber prior to waste feed. The gas temperature is maintained at 1600-1800°F (871-982°C) at the exit of the primary chamber and 1800-2000°F (982-1093°C) at the exit of the secondary chamber. Steam is produced at a rate of 10,000 lb/hr (4536 kg/hr). Cattaraugus is not equipped with an air pollution control device.

Cattaraugus was receiving autoclaved medical waste in red plastic bags mixed in with municipal waste since, at that time, state regulations allowed autoclaved medical waste to be treated exactly like municipal waste.[11] This was not acceptable to the facility personnel because of safety concerns and because they had no way of knowing if the waste had in fact been autoclaved. Therefore, the facility implemented their own medical waste handling procedures. The autoclaved medical waste must be delivered separately from municipal waste. The hauler is required to manually place the bags into a front end loader whose operator is required to wear a respirator and protective coveralls. The waste is unloaded to the hopper where it is mixed with municipal waste and incinerated immediately. The coveralls are incinerated and the front end loader is steam cleaned after every load. No sharps or radioactive wastes are accepted and an extremely high tipping fee is charged. Since implementing these changes, no medical waste has been delivered to the facility and no operating information is available. The facility does not plan to implement any pathogen testing since only autoclaved medical waste is accepted.

5.4 Modular Excess Air Systems

Three modular excess air facilities reportedly fire medical waste along with MSW. Two facilities use combustion technology supplied by Sigoure Freres: Pascagoula, MS and Sitka, AK. The third facility is in Cleburne, TX and the combustion technology was supplied by Cadoux International. Pascagoula has two rotating annular hearths with capacities of 75 tpd (68 tonnes/day) each.[20] The hearths intermittently rotate on a horizontal plane about a vertical shaft. The waste is gravity fed. Automatic pokers stoke the fuel bed at regular intervals when the hearth is at rest. The combustion chamber temperature is maintained at 1850°F (1010°C). The combustion gases leave the rotary annular hearth and are tangentially fired into a cyclonic secondary chamber which serves the dual purposes of providing initial particulate matter separation and a high degree of mixing. The secondary chamber exit gas temperature is maintained at 1800°F (982°C). The ash is discharged from the hearth by a fixed plow into a water quench tank. Pascagoula has waste heat boilers that generate 16,000 lb/hr (7258 kg/hr) of steam per unit. Oil is used as auxiliary fuel during start-up in order to achieve a boiler exit temperature of 320°F (160°C) prior to initiating waste feed. Auxiliary fuel is reportedly not used for shutdown although a temperature of 700°F (371°C) is maintained in the secondary chamber until all the waste is burned off the grate. Pascagoula is equipped with two-field ESPs which operate at an inlet gas temperature of 550-650°F (288-342°C).

Commercial haulers deliver boxed medical waste from a local hospital to the Pascagoula facility.[11] The hospital incinerator is used for disposing of pathological waste, cytotoxic chemicals, and fluid-filled containers. All other medical wastes, except radioactive and hazardous wastes, are delivered to the Pascagoula facility. Sharps are sterilized prior to delivery. A higher tipping fee is not currently charged for the medical waste but is being considered. The boxed medical waste is dumped into a separate area of the pit and loaded into the hopper by an overhead crane which occasionally penetrates the boxes. The medical waste is incinerated immediately in the presence of the delivery personnel who must verify that all of the medical waste was in fact incinerated. Occasionally, if temperatures become too high, operators will mix the medical waste with municipal waste. Throughput is reduced considerably to ensure good burnout. No increase in HCl or metals emissions is attributed to the medical waste. No pathogen testing has been conducted. Due to the small "pin hole" design of the grate system, there are no reported problems of sharps falling through into riddlings hoppers.

The Sitka, AK facility consists of two 25-tpd (23 tonnes/day) Sigoure Freres modular excess air combustors with waste heat boilers and ESP controls.[21] The plant has been operating commercially since May 1985, and the normal operating schedule is 24 hours per day. 5 days per week. Sitka fires less than 1 percent medical waste as well as 8 percent sewage sludge. A feed pump transfers the sludge to the combustor charging hopper where it is metered into the MSW feed. The waste is fed by a charging ram and is moved through the unit by a series of pneumatically driven pokers. The combustor operates with nearly 115 percent excess air and combustion takes place on stepped hearths in the primary combustion chamber, where the temperature reportedly averages 1700°F (927°C). The flue gas flows to a post-combustion chamber where average temperatures are reportedly near 1900°F (1038°C). There is no air injection in the secondary chamber; combustion air control is achieved by an induced draft (ID) fan. The flue gases flow from the combustor through the firetube boilers and ESPs, which are designed to operate at 450°F (232°C). The ESP plates are constructed of Corten steel to reduce corrosion effects. Each ESP has one field. The units include oil burners which are used during start-up and shutdown conditions. The ash is co-disposed of in a lined landfill with leachate collection.

Commercial haulers deliver red plastic bags and boxes of medical waste to the Sitka facility.[11] Radioactive waste is not accepted. There is not a higher tipping fee for medical waste. The haulers manually place the medical waste into the crane, which is unloaded into hoppers and the medical waste is incinerated immediately. Facility personnel are not provided any special training, protective clothing, or equipment since the commercial haulers are totally responsible for all medical waste handling. The medical waste is not mixed with municipal waste. Resulting higher temperatures are controlled by reducing throughput. Reportedly, animal carcasses are occasionally recognizable in the ash. The ash has been tested for pathogens, although not routinely, with negative results. No increase in HCl or metals emissions is attributed to medical waste.

The Cleburne, TX facility reportedly fires 1 percent medical waste in three 38-tpd (34 tonnes/day) units each equipped with a ram feed system.[22] There is no air preheat. The average gas temperatures exiting the primary and secondary chambers are 2000°F (1093°C) and 1500°F (815°C), respectively. Each boiler produces steam at a rate of 7100 lb/hr (3220 kg/hr). Natural gas is used as auxiliary fuel for start-up to attain a temperature of 400°F (204°C) at the top of the primary chamber prior to initiating waste feed. Auxiliary fuel is also used for shutdown although there is no requirement to maintain a specific temperature until all of the waste is burned off the grate. Cleburne is equipped with a two-field ESP which operates at an inlet gas temperature of 450°F (232°C).

Reportedly. the Cleburne facility receives medical waste mixed in with the municipal waste; the medical waste is believed to be generated by doctors' and dentists' offices.[11] The facility is currently retrofitting one of their three units to burn only medical waste. Facility personnel were not willing to discuss any of the details of the retrofit or medical waste handling and operating procedures.

5.5 Fluidized Bed Combustors (FBCs)

The Western Lake Superior Sanitary District (WLSSD) facility in Duluth, MN combusts a mixture of sewage sludge and refuse derived fuel (RDF) in two Copeland Systems FBCs.[23] The units were primarily designed as sewage sludge incinerators that use RDF as a cheap auxiliary fuel. The WLSSD facility consists of two identical bubbling bed FBCs with individual waste heat boilers. The combustors are each 45 ft (14 m) high and the reactor vessels have an inside diameter of 34 ft (10 m) at the freeboard. Each combustor is capable of firing 120 tons/day (109 tonnes/day) of fluff-RDF and 345 tons/day (313 tonnes/day) of sewage sludge (18 percent solids); thus, RDF represents approximately 26 percent of the total waste input at full load. RDF is produced at the WLSSD facility 8 hours/day, 5 days/week. Input waste to the processing plant consists of approximately 60 percent residential, 25 percent commercial, 10 percent industrial, and 5 percent medical waste. RDF is pneumatically injected into the bed through four ports which extend approximately 5 feet (1.5 m) from the reactor wall about 18 in (0.46 m) above the gas distribution plate. The feed ports are angled downward at the ends to introduce the RDF low in the bed. Sewage sludge is pumped through a nozzle which penetrates the top of the reactor vessel and extends approximately 12 ft (3.7 m) below the roof. Each 160 x 10^6 Btu/hr (169 x 10^9 J/hr) boiler can provide 49,000 lb/hr (22,226 kg/hr) of steam, and all steam is used on site. Wood chips are fired as a supplemental fuel whenever sufficient heat input cannot be derived from RDF. Usually, wood is required only when all of the RDF feeding tubes plug simultaneously or when the RDF supply is occasionally exhausted at the end of the weekend. Wood chips account for about 7.5 percent of the facility heat input on an annual basis. Oil is fired for cold start-ups and as a second supplemental fuel; the boilers can be fired at up to 100 percent load using oil. The sewage sludge provides less heat input than is required to dry it and is, therefore, not considered a fuel by the facility. At typical operating conditions, the FBC has a bed temperature of about 1475°F (802°C) and a freeboard (furnace exit gas temperature, or FEGT) of about 1650°F (899°C). Typically all of the combustion air is supplied as underfire air. Although the FBCs are configured for overfire air injection, it is seldom used. The flue gas has 5 to 7 seconds residence time between the combustor and the boiler entrance, and the gas temperature at the entrance to the first convective section is about 1400°F (760°C). Each of the units is equipped with a venturi scrubber, a quench tower, and a demister.

The WLSSD facility is no longer accepting medical waste because of the potential hazards associated with shredding in RDF processing.[11] WLSSD assigned one employee to work with the area hospitals to ensure that only general refuse and no medical waste was sent to the MWC facility.

6.0 CURRENT PRACTICES - EUROPEAN AND CANADIAN MWCS

Several European and the Canadian environmental protection agencies were contacted regarding medical waste incineration practices in municipal waste combustors. Appendix A contains the agency addresses. The following sections summarize the responses.

6.1 Austria

According to the Umweltbundesamt in Vienna, Austria (EPA equivalent), federal medical waste disposal regulations have been in place since March 1, 1988. These regulations, known as ÕNORM S 2104, "Wastes from Medical Institutions", overlap with ÕNORM S 2100, "Catalogue for Special and Hazardous Waste", and ÕNORM S 2101, "Hazardous Wastes Requiring Supervision." Medical waste is classified into three categories:

- Wastes without infectious risks which need not be treated in a special way.

- Wastes which can be infectious or which represent an injury risk only within the medical center. They do not need special treatment outside of the medical area.

- Wastes representing danger inside and outside of the medical area. They must be treated in a special way. This category includes also hazardous waste (ÕNORM S 2100) and hazardous waste requiring supervision (ÕNORM S 2101), e.g. batteries, clinical thermometers, used medicine, solvents.

According to these regulations, body parts, organs, experimental animal carcasses, and certain hazardous wastes, if incinerated, must be done so in a hazardous waste combustor. Other medical waste types can be combusted in an MWC.

Reportedly, there is only one hazardous waste combustor in Austria, and this facility has emission limits as shown in Table 6-1. There are currently only two MWC facilities in operation: the Wels MWC facility in Oberösterrich and the Flötzersteig MWC facility in Vienna. The emissions standards for existing MWCs with boilers are set in the Clean Air Act for Steam Boilers as

Table 6-1. Emission Limits for Austrian Hazardous Waste Combustors

SUBSTANCE	mg/m3 (11% O2, dry)
Particles	10
Gaseous Substances	
Chloric acid, as Cl-	15
Fluoric acid, as F-	0.1
Sulfur dioxide, as SO2	100
Nitrogen oxides, as NO2	350
Heavy metals (gaseous and particles)	
Pb	0.5
Zn	0.8
Cd	0.05
Cr	0.2
Ni	0.2
Cu	0.1
As	0.2
Hg	0.05

shown in Table 6-2. New MWC facilities are regulated under the Ordinance to the Clean Air Act for Steam Boilers as outlined in Table 6-3.

6.2 Canada

Although no response was received from the Waste Management Division of Environment Canada regarding federal regulations, recent developments in the province of Alberta seem to suggest that medical waste issues may be handled by the provinces.

In Alberta, a task force on infectious waste disposal has been formed and is trying to create a long-term plan for disposing of the province's infectious and medical waste. According to the Environmental Health Services for the Alberta Ministry of Health, the task force is considering three options: upgrading existing hospital incinerators; creating seven regional incineration facilities; or disposing of all the province's infectious wastes at a state-of-the-art hazardous waste incineration facility.

Reportedly, medical wastes have not been a problem for Alberta, but due to public concerns, the province wants to create a long-term plan for handling medical waste. The province generates approximately 90 to 130 tons (82 to 118 tonnes) of infectious wastes per day. Current Alberta medical wastes regulations make it illegal to dispose of non-treated wastes in a landfill. Treated infectious wastes may go to a landfill and be buried in a separate cell, but the province discourages this. Incineration is the preferred method of disposal.

6.3 Denmark

According to the National Agency of Environmental Protection (NAEP), Denmark has about 30 relatively small facilities burning a mixture of municipal waste and what is termed "special hospital waste." These combustors burn approximately 20,000 tonnes (22,046 tons) per year including between 3,000 and 6,000 tonnes (3307 to 6614 tons) of special hospital waste.

In 1984, the NAEP issued a guideline defining the following types of waste as "special hospital waste": waste from hospitals, nursing homes, maternity clinics, other treatment and health care institutions, clinics of

Table 6-2. Emission Standards for Existing Austrian MWCs with Boilers

SUBSTANCE	SMALL FACILITY (mg/m3)	LARGE FACILITY (mg/m3)
Particles	50	25
Gases:		
Cl-	30	15
F-	0.7	0.7
SO2	-	100
CO	100	100
NO2	-	100
Heavy Metals (gases and particles)		
Pb, Zn, Cr combined	5	4
As, Co, Ni combined	1	1
Cd	0.1	0.1
Hg	0.1	0.1
Organic Matter (as total carbon)	20	20

Table 6-3. Emission Standards for New Austrian MWCs with Boilers

SUBSTANCE	SMALL FACILITY	MEDIUM FACILITY (mg/m3)	LARGE FACILITY
Particles	50	20	15
Gases			
Cl-	30	15	10
F-	0.7	0.7	0.7
SO2	-	100	50
CO	100	50	50
NO2	-	300	100
Heavy Metals (gases and particles)			
Pb, Zn, Cr combined	5.0	3.0	2.0
As, Co, Ni combined	1.0	0.7	0.5
Cd	0.1	0.05	0.05
Hg	0.1	0.1	0.05
Organic Matter (as total carbon)	20	20	20

general practitioners and dentists, which are either infectious or biological waste. Infectious or biological waste includes:

- all wastes from patients with infectious diseases, for instance waste from patients in epidemical wards, dialysis wards and isolation wards, and some types of waste from patients treated with special medicine

- all pointed or sharp objects: needles, knives, drop equipment from infusion apparatus and the like

- infectious wastes from clinical/microbiological laboratories (not autoclaved)

- infectious waste from some clinical/chemical laboratories and blood bank laboratories (not autoclaved)

- biological waste from surgery, delivery room, autopsy rooms and the like

- biological waste from animal bedding, etc.

According to the guideline, the special hospital waste shall be burned in combustors designed for that purpose. The combustor must have two chambers with the secondary chamber temperature at least 850°C (1562°F) with a minimum residence time of 0.5 sec. Also, the first chamber must have a solid floor so that needles and glass cannot fall through.

6.4 Federal Republic of Germany

According to the federal environmental agency (Umweltbundesamt), there are at least seven MWCs in the Federal Republic of Germany that accept medical waste. At least two of those facilities use separate combustion chambers for the medical waste. The combustors firing municipal and medical wastes, and in some cases sewage sludge, range in size from 10 to 20 tons/hr (9 to 18 tonnes). The separate medical waste combustion chambers are 0.375 and 1.7 tons/hr (0.34 to 1.5 tonnes). The design and operating characteristics of these facilities are summarized in Table 6-4.

Table 6-4. Medical Waste Incineration Practices in Municipal Waste Combustors in the Federal Republic of Germany

LOCATION	MANUFACTURER STOKER/BOILER	# OF UNITS	UNIT SIZE (tons /hr)	UNIT SIZE (tonnes /hr)	WASTE TYPES	TONS/YR	TONNES/YR	YEAR OF START-UP	APCD
Bielefeld	Widmer & Ernst Baumgarte	3	16	14.5	Municipal Sewage Sludge	230,000 19,900	208,655 18,053	1981	ESP
	Frohling-Siegota	3	1.7	1.5	Medical	2,600	2,359	1989	---
Coburg	Martin/Werle	2	11	10	Municipal Sewage Sludge	140,000 2,600	127,007 2,359	1988	Fabric Filter, ESP
	---	1	.375	.340	Medical	---	---	---	---
Goppingen	VKW/VKW	2	12	11	Municipal Sewage Sludge Medical	145,700 11,000 2,650	132,178 9,979 2,404	1975	Cyclone, ESP
Kassel	Balcke-Durr/ Balcke-Durr	2	10	9	Municipal Medical	120,000 (Total)	108,863	1968	Fabric Filter
Krefeld	VKW/VKW	3	12	11	Municipal Sewage Sludge Medical	210,000 (Total)	190,511	1974	ESP
Leverhusen	Von Roll/MAN	2	10	9	Municipal Medical	153,000	138,801	1970	ESP
	K&K/Lentjes	1	12	11	(Total in all three units)			1986	ESP
Munchen	Martin/VKW	2	20	18	Municipal Sewage Sludge Medical	228,000 (Total)	206,840	1964	Cyclone

6.5 Norway

The State Pollution Control Authority (SPCA) in Oslo, Norway divides medical waste into two categories: "household type" waste and "hazardous" waste. The "hazardous" waste category is further sub-divided into three categories: infectious, sharps, and biological (pathological) wastes. Most hospitals in Norway have on-site incinerators. Some hospitals burn all generated wastes on site; however, some hospitals burn only the "hazardous" portion on site and send the "household type" waste to a municipal waste combustor. For those hospitals that do not have on-site incinerators, the "household type" waste, sharps, and infectious wastes can be sent to an MWC. The SPCA believes that MWCs are not well suited for biological waste incineration as they do not provide sufficient residence times to ensure complete combustion. The Norwegian MWCs that do incinerate medical waste are the Oslo Renholdsverk in Oslo, the Tafjord Kraftselskap in Alesund, the Trondheim Elektrisitetsverk in Trondheim, and the Fredrickstad og Omegn Avløpsanlegg in Fredrikstad.

6.6 Spain

The Ministry of Public Works and Town Planning in Madrid, Spain reports that there is only one MWC in the entire country. This facility does accept some types of medical waste and is located in Valdemingomez, Spain.

6.7 Sweden

The National Environmental Protection Board in Solna, Sweden reports three MWCs that incinerate medical waste for which there are no special requirements. The facilities are the SYSAV in Malmo, the UEAB in Uppsala, and the Tekniska Verken in Linköping.

6.8 Switzerland

According to the Federal Office of the Environment, Forests and Landscape in Bern, Switzerland, municipal waste and sterilized infectious waste can be incinerated in MWCs. Non-sterilized infectious waste and pathological waste must be incinerated in hazardous waste or infectious waste incinerators with flue gas cleaning devices.

7.0 MWC MANUFACTURERS'/SYSTEM SUPPLIERS' RECOMMENDATIONS

In addition to contacting MWC facilities, several MWC manufacturers/system suppliers were also contacted to determine whether any special design and operating recommendations are made to facilities that accept medical waste. The U.S. manufacturers/system suppliers contacted include Sigoure U.S. Associates; Cadoux, Inc.; Consumat Systems, Inc.; and Ogden Martin Systems, Inc. The European manufacturers contacted include Von Roll, Deutsche Babcock, Volund, Martin, and Steinmuller.

7.1 U.S. Manufacturers/System Suppliers

7.1.1 Sigoure U.S. Associates

Sigoure U.S. Associates are the U.S. supplier of the French Sigoure Freres MWC systems. The two known U.S. MWC facilities supplied by Sigoure that accept medical waste are Pascagoula, MS and Sitka, AK. According to a Sigoure representative, as well as plant personnel from both facilities, Sigoure does not make any special recommendations regarding the incineration of medical waste in their MWCs.

7.1.2 Cadoux, Inc.

Cadoux, Inc. is the U.S. supplier of the French Cadoux International MWC systems. The only known U.S. MWC facility supplied by Cadoux that accepts medical waste is the Cleburne, TX facility. According to Cadoux, Inc. representative, no special recommendations are made to MWCs accepting medical waste. Facility personnel indicated that Cadoux did not participate in the retrofit of their facility to accommodate medical waste.

7.1.3 Consumat Systems, Inc.

Consumat Systems, Inc. is the manufacturer of the modular MWC system accepting medical waste in Hampton, SC. Consumat did not provide any guidelines or special recommendations to the Hampton, SC facility.

7.1.4 Ogden Martin Systems, Inc.

Ogden Martin Systems, Inc. is the U.S supplier of the grate technology developed by Martin GMBH in Germany. Both the Tulsa, OK and the Marion County, OR facilities are owned and operated by Ogden Martin. Therefore, the current practices of these facilities discussed in Section 5.0 is representative of Ogden Martin's recommendations regarding medical waste incineration in MWCs.

7.2 European Manufacturers/System Suppliers

No responses were received from Von Roll, Deutsche Babcock, Volund, or Steinmuller regarding handling and operating guidelines for medical waste incineration in their systems. Due to the infectious and hazardous nature of medical waste, Martin GMBH in München, FRG, feels that hazardous waste incinerators are more appropriate to handle medical waste than MWCs. One problem noted by Martin is that frequently, when incinerating medical waste in MWCs, all of the medical waste is incinerated in separate batches. In these cases, the MWC is essentially being used as an infectious waste incinerator. Because the system was not designed for medical waste and in some cases the facility personnel have not been trained to handle medical waste, handling and operating problems may arise.

8.0 PRELIMINARY RECOMMENDATIONS AND RESEARCH NEEDS

The 15 municipal waste combustors in the U.S. that have previously accepted or are currently accepting medical waste include a variety of combustor design types. The amount of medical waste burned in these units ranges from less than 1 percent by weight to 50 percent. Some of the major concerns regarding medical waste incineration in MWCs include waste handling procedures prior to combustion, identification of appropriate waste types to be burned in MWCs, and evaluation of potential problems associated with residue handling, including ash and effluent streams. Based on the preliminary findings, it appears that sharps pose a potential problem in MWCs with grate systems. Sharps in the ash represent potential worker safety and health problems to facility personnel or landfill operators handling the ash. Animal carcasses also represent a significant problem if poor burnout does not result in complete destruction of the carcasses. Prior to incineration, attention must be given to the medical waste handling procedures to prevent penetration of containers and exposure of containerized wastes. For example, it is recommended that medical waste not be processed into refuse derived fuel. There are very limited data available on the emission impacts associated with combustion of medical waste in MWCs. More research is needed to fully evaluate the potential impacts of burning medical waste on the emissions of acid gas, dioxin, and metals. Also, further studies and field tests are needed to determine the design and operating requirements for complete destruction of solvents, cytotoxic chemicals, and pathogens.

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9. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on June 7, 1988 by Z. Semanyshyn, Senior Operations Engineer, Ogden Martin Systems of Tulsa, Tulsa, OK.

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11. V.J. Landrum, Energy and Environmental Research Corporation, telecon with facility personnel. January 20, 1989 to February 23, 1989.

12. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on May 16, 1988 by Michael T. Cousino, P.E., Public Works Director, Olmstead County, Rochester, Minnesota.

13. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on June 1, 1988 by Sylvestre K. Yorrick, Facility Manager,

District of Columbia Government, D.C. Department of Public Works, Washington, DC.

14. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on May 16, 1988 by Frank Calco, Superintendent, City of Sheboygan, Sheboygan, Wisconsin.

15. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on May 9, 1988 by Dennis Minks, Technical Operations Manager, City of Louisville, Louisville, Kentucky.

16. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on July 12, 1988 by James R. Anderson, President, Thermal Reduction Co., Inc., Ferndale, Washington.

17. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on July 11, 1988 by Donald E. White, Plant Superintendent, Windham Energy Recovery Facility, Town of Windham, Willimantic, Connecticut.

18. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on April 29, 1988 by Alan D. Gibson, Environmental Engineer, USATC and Fort Dix, Directorate of Engineering and Housing, Fort Dix, New Jersey.

19. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on May 25, 1988 by Todd Dobmeier, Plant Manager, Cattaraugus County Waste-to-Energy Plant, Cuba, New York.

20. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on June 3, 1988 by Lloyd J. Compton, P.E., President, Compton Engineering, PA, Pascagoula, Mississippi.

21. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on May 23, 1988 by Larry Harmon, City Engineer, City and Borough of Sitka, Alaska.

22. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on July 15, 1988 by Fred Watson, Sanitation Superintendent, City of Cleburne, Cleburne, Texas.

23. Clean Air Act Section 114 and Resource Conservation and Recovery Act Section 3007 Municipal Waste Combustion Information Request, provided to U.S. EPA on May 16, 1988 by Gary Baker, Manager of Operations, Western Lake Superior Sanitary District, Duluth, Minnesota.

Appendix A. Foreign Environmental Protection Agencies

Umweltbundesamt
Biberstrasse 11
A-1010 Vienna
AUSTRIA

Environment Canada
Mr. J. Myslicki, Chief
Waste Management Division
Industrial Programmes Branch
351 St. Joseph Boulevard, 13th Floor
Ottawa, Ontario K1A 0H3
CANADA

National Agency for Environmental Protection
Strandgade 29
DK 1401 Copenhagen K
DENMARK

Unweltbundesamt
President: Dr. Heinrich Freiherr von Lersner
Bismarckplatz 1
1000 Berlin 33
FEDERAL REPUBLIC OF GERMANY

The Ministry of Environment
Pollution Control Department
Box 8013, Dep. 0030, Oslo 1
NORWAY

Ministerio de Obras Publicas y Urbanismo
Direccion General del Medio Ambiente
Nuevos Ministerios - Paseo de la Castellana
Madrid, SPAIN

Federal Office for Environmental Protection
BUS
Hallwylstrasse 4
3003 Bern
SWITZERLAND

The Swedish Ministry of the Environment and Energy
(Miljo- och Energidepartementet)
Stockholm
SWEDEN

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(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES AEERL project officer is James D. Kilgroe, Mail Drop 65, 919/541-2854.

16. ABSTRACT The report defines and characterizes types of medical waste, discusses the impacts of burning medical waste on combustor emissions, and outlines important handling and operating considerations. Facility-specific design, handling, and operating practices are also discussed for municipal waste combustors (MWCs) that reportedly accept medical waste in the U.S., Europe, and Canada. Only very limited data are available on the emission impacts associated with the combustion of medical waste in MWCs. Especially lacking is information needed to fully evaluate the impacts on acid gas, dioxin, and metals emissions, as well as the design and operating requirements for complete destruction of solvents, cytotoxic chemicals, and pathogens. The EPA's Office of Air Quality Planning and Standards is developing emission standards and guidelines for new and existing MWCs under Sections 111(b) and 111(d) of the Clean Air Act. In support of these regulatory development efforts, the Air and Energy Engineering Research Laboratory in EPA's Office of Research and Development has conducted an assessment to examine the incineration of medical waste in MWCs from an emission standpoint. Potential worker safety and health problems associated with handling of medical wastes and residues were also identified.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Metals	Pollution Control	13B	11F, 07B
Assessments	Toxicity	Stationary Sources	14B	06T
Combustion	Solvents	Medical Waste	21B	11K
Medical Equipment	Pathology	Municipal Waste Combustion	06L	06E
Waste Disposal			05E	
Emission		Cytotoxicity	14G	

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