



**United Nations
Environment
Programme**

Distr.
GENERAL

UNEP/POPS/EGB.2/INF/9
23 October 2003

ENGLISH ONLY

EXPERT GROUP ON BEST AVAILABLE
TECHNIQUES AND BEST ENVIRONMENTAL
PRACTICES

Second session

Villarrica, Chile, 8-12 December 2003

Item 3 of the provisional agenda¹

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 MEDICAL WASTE INCINERATION

Note by the Secretariat

The attached was provided by Ms. Susana Eberhartinger (Austria) who coordinated its development. This note and its attachment have not been formally edited.

¹ UNEP/POPS/EGB.2/1.

Draft Guidelines on BAT and BEP for Medical Waste Incineration

List of Contents

| | |
|--|----|
| 1. Introduction..... | 2 |
| 2. Best Environmental Practices (BEP) concerning health-care waste management..... | 3 |
| 3. Alternative Techniques..... | 5 |
| 4. Best Available Techniques (BAT) for the incineration of health-care waste | 6 |
| Sources of unintentionally produced POPs..... | 6 |
| Process description..... | 6 |
| 5. Summary of Measures | 9 |
| 5.1 General guidance..... | 9 |
| 5.2 Health-care waste incineration - Firing technologies representing BAT | 9 |
| 5.3 Health-care waste incineration - General measures | 10 |
| 5.4 Primary measures and process optimization to reduce PCDD/F emissions | 11 |
| 5.5 Secondary measures | 11 |
| 5.6 Organisational measures | 13 |
| 5.7 General measures for management..... | 13 |
| 6. Performance Requirements based on BAT for new and existing health-care waste incineration plants..... | 14 |
| 7. References..... | 15 |

1. Introduction

This paper gives mainly information on the incineration of medical waste (in the following referred to as "health-care waste"), this being only one method of final disposal. Since the incineration of health-care waste can result in significant UPOPs emissions the main focus of the paper is on the best available techniques for the reduction of UPOPs emission due to incineration. Other possible techniques like e.g. the sterilization of infectious waste do not result in UPOPs emissions. The advantages and drawbacks as well as the applicability of these techniques are already described elsewhere and are not repeated here.

Hospitals generate large amounts of waste that falls into different categories (additionally, health-care waste can also originate from other sources like emergency medical care services, transfusion or dialysis centres, laboratories, animal research, blood banks etc.). Between 75 % and 90 % of the waste produced is non-risk or general health-care waste, which is comparable to domestic waste. It comes mostly from the administrative and housekeeping functions of health-care establishments and may also include waste generated during maintenance of health-care premises. The remaining 10-25 % of health-care waste is regarded as hazardous and may create a variety of health risks. Less than 10 % of this waste is of an infectious nature. Other types of waste include toxic chemicals, cytotoxic drugs, flammable and radioactive wastes. This paper is concerned almost exclusively with hazardous health-care waste; wastes comparable to domestic waste should be dealt with by the municipal waste disposal mechanisms.

Each hospital should develop a waste management plan that provides for a thorough segregation and treatment of waste. This can lower the costs of the ultimate disposal.

The main aims of hospital waste management are:

- minimizing risk for personnel, general public and environment
- minimizing the amounts of waste being generated
- providing for segregation and separation of wastes
- designation of deposit areas in the wards
- establishment of safe routes for the transportation of the waste
- establishment of a safe and proper area for the temporary storage
- proper waste treatment and disposal

Under the framework of the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal "**Technical Guidelines on the environmentally sound management of biomedical and health-care waste**"¹ have been published. It is strongly advised to use and apply these guidelines which provide detailed information on the hazards of health-care waste, safe management of health-care waste, the proper segregation and collection of wastes as well as treatment and disposal methods and capacity building.

Types of health-care waste

- infectious health-care waste (hazardous)
- chemical, toxic or pharmaceutical waste, including cytotoxic drugs (antineoplastics) (mostly hazardous)
- anatomical and pathological waste (body parts etc.)
- sharps (partly hazardous)
- radioactive waste
- other waste (glass, paper, packaging material etc.)

¹ Basel Convention on the control of transboundary movements of hazardous wastes and their disposal (adopted on 22 March 1989): Technical Guidelines on the environmentally sound management of biomedical and health-care waste, UNEP, Geneva 2002?

For the purpose of these guidelines, the following definitions are taken from the technical guidelines on the environmentally sound management of biomedical and health-care waste (Basel Convention):

Infectious health-care waste²

Discarded materials or equipment contaminated with blood and its derivatives, other body fluids or excreta from infected patients with hazardous communicable. Contaminated waste from patients known to have blood-borne infections undergoing haemodialysis (e.g. dialysis equipment such as tubing and filters, disposable sheets, linen, aprons, gloves or laboratory coats contaminated with blood);

Laboratory waste (cultures and stocks with any viable biological agents artificially cultivated to significantly elevated numbers, including dishes and devices used to transfer, inoculate and mix cultures of infectious agents and infected animals from laboratories).

Biological health-care waste

All body parts and other anatomical waste including blood and biological fluids and pathological waste that are recognizable by the public or the health-care staff and that demand, for ethical reasons, special disposal requirements.

Sharps

All biomedical and health-care waste with sharps or pointed parts able to cause an injury or an invasion of the skin barrier in the human body. Sharps from infected patients with hazardous communicable diseases, isolated wards or other pointed parts contaminated with the above-mentioned laboratory waste must be categorized as infectious waste.

2. Best Environmental Practices (BEP) concerning health-care waste management

In order to ensure an efficient and state of the art disposal or an incineration of the waste a number of practices prior to the final disposal method or the combustion of the waste itself is considered necessary. These practices are not directly linked to the reduction and avoidance of unintentionally produced POPs but represent general principles of which in consequence can influence the generation of waste fractions and which contribute to the safety of the personnel, the public and the environment. In this document only a brief overview of common best practices is given.

Segregation

Above all, segregation is the key to effective health-care waste management. It ensures that correct disposal routes are taken. Segregation should be carried out under the supervision of the waste producer and as close as possible to the point of generation. Segregation must therefore take place at source, that is, in the ward, at the bedside, in the theatre, in the laboratory, in the delivery room, etc., and must be carried out by the person generating the waste, for example the nurse, the doctor or the specialist, in order to secure the waste immediately and to avoid dangerous secondary sorting.

Waste minimization

The generation of hazardous wastes and other wastes within has to be reduced to a minimum. This can be achieved only if everyone who works in the health services sector

² The interpretation of the definition of infectious health-care waste varies according to national circumstances, policies and regulations. International organizations (WHO, the United Nations, etc.) have specific interpretations of the definition. Infectiousness is one of the hazardous characteristics listed in annex III to the Basel Convention and defined under class H6.2.

gives increased thought to this issue and takes action to ensure that the volume and hazardousness of wastes are minimized.

Preference should be given to environmentally sounder products and replacement of harmful or disposable products with reusable or alternative products, if these meet the relevant requirements in terms of hygiene and patient safety.

A noticeable reduction in waste volume can be achieved only if disposable products already in use are scrutinized as to their necessity. In principle, disposables such as disposable cutlery, disposable linen (including covering sheets), disposable instruments and equipment (scissors, scalpels, forceps) and disposable containers (kidney dishes, infusion bottles) should be replaced by reusable products and long-lived alternatives.

For more detailed information ample material concerning health-care waste management is available from different sources³.

The establishment of a proper health-care waste management involves to

- characterise the nature and amount of the different waste fractions
- identify option to avoid or reduce waste generation (package sizes, stockkeeping, evaluate work processes, reuse of equipment where feasible)
- draw up a list of rules how to handle the waste
- specify the suitable containers for collection, storage and transport
- lay down the responsibilities of the personnel
- describe the appropriate treatment options for the different waste fractions
- provide for proper documentation and control of the waste disposal
- describe the transport of the waste fraction to the final disposal location and the type of final treatment
- calculate the costs for the different activities

Training of personnel

The personnel should get thorough instructions about:

- risks connected with health-care waste
- classification and codes of the different waste fractions and their classification criteria
- costs of waste treatment
- illustration of the waste management from generation to disposal
- responsibilities
- effects of mistakes and mismanagement

Collection at the site of waste generation

- provide small bins for the disposal of the different waste fractions at suitable places
- proper packaging of the waste: Bags/containers for infectious waste and sharps should be puncture resistant and leak proof. Either solid drums or bags which are placed within an rigid or semi-rigid container having a capacity of 30 – 60 litres should be used. The containers may be recyclable (stainless steel) or single use (thick cardboard or rigid polyethylene). Plastic materials containing chlorine should be avoided if incineration takes place. Full containers should have a locking or sealing device.
- proper labelling of containers as infectious, cytotoxic etc. waste
- no overloading of containers
- Highly infectious waste should, whenever possible, be sterilized immediately by autoclaving. It therefore needs to be packaged in bags that are compatible with the proposed treatment process.

³ e.g. in "Handbook for safe management of wastes from health care activities", WHO, 2000; Basel Convention on the control of transboundary movements of hazardous wastes and their disposal (adopted on 22 March 1989): Technical Guidelines on the environmentally sound management of biomedical and health-care waste, UNEP, Geneva 2002?

Transport to the intermediate storage area

- Once the primary containers are full they must be taken to an intermediate storage area.
- establish a designated storage area (clean conditions, facilities for cleaning/washing/disinfecting of the containers) where access is only allowed for authorized personnel
- personnel handling the waste must wear protective clothing (gloves, shoes) during collection, transportation and storage
- clear transport routes and times
- no compression of waste containing sharps
- no manual sorting of infectious waste fractions

3. Alternative Techniques

When deciding on waste disposal from health-care activities, priority consideration should be given to alternate processes, techniques or practices that have similar usefulness but which avoid the formation and release of the identified substances.

The following alternative techniques do not result in the formation and release of UPOPs and are therefore considered suitable methods for their ultimate elimination. However, they might have advantages and drawbacks in other respects. For more information please see the "Technical Guidelines on the environmentally sound management of biomedical and health-care waste" elaborated under the framework of the Basel Convention.

Steam sterilization

Steam sterilizing or autoclaving is the exposure of waste to saturated steam under pressure in a pressure vessel or autoclave.

Dry heat sterilization

Dry heat sterilization is the exposure of the waste to heat at a temperature and for a time sufficient to ensure sterilization of the entire waste load.

Chemical disinfection/sterilization

This method involves the exposure of waste to chemical agents which possess antimicrobial activity. General disinfectants may not inactivate organisms such as spores, some fungi and viruses and should not be used as the principal treatment methods unless thermal procedures are inappropriate because of the nature of waste or contaminated material. Thermal sterilization should be given preference over chemical disinfection for reasons of efficiency and environmental considerations.

Landfill

Disposing of infectious wastes into a landfill greatly increases the risks to human health and the environment of exposure to infection from this source. If the waste is disturbed by any means, or not properly covered, further risks will arise. It is therefore not good practice to dispose of infectious waste directly into a landfill. To guard against these risks, where landfill is the only available option, infectious wastes should be treated in order to destroy/remove their infectivity, preferably at the site of generation of the waste. This can be done by using known effective techniques such as autoclaving, microwave treatment, dry heat sterilization or chemical disinfection.

4. Best Available Techniques (BAT) for the incineration of health-care waste

Sources of unintentionally produced POPs

Currently two major mechanisms for PCDD/F (dioxins and furans) formation during incineration of wastes are known:

- Formation of dioxins/furans in the presence of corresponding chlorinated precursors (such as PCBs, PCPs) by a homogenous gas phase reaction at temperatures between 300 and 800°C.
- De novo synthesis: The formation of PCDD/F will take place during cooling of the ex-haust gas under the following conditions:
 - Temperature range between some 200 and 500°C and adequate residence time in this temperature range.
 - Presence of a chlorine source.
 - Presence of oxygen in the exhaust gas.
 - Presence of dust containing heavy metals and carbon which acts as catalyst.

Emissions of organic pollutants and PCDD/F can be reduced by firing and plant specific measures (primary measures) and additionally by secondary measures.

Process description

Incineration is an important method for the treatment and decontamination of biomedical and health-care waste. This chapter gives guidance on the incineration of the following (mostly) hazardous waste fractions: infectious health-care waste, biological health-care waste and sharps.

Incineration is a high-temperature (850° C to 1100° C) dry oxidation process that reduces organic and combustible waste to inorganic, incombustible matter and results in a very significant reduction of waste volume and weight.

Semi-pyrolysis is a process of smoldering where thermal conversion occurs in an oxygen deficient atmosphere at a temperature between 500 and 600 °C.

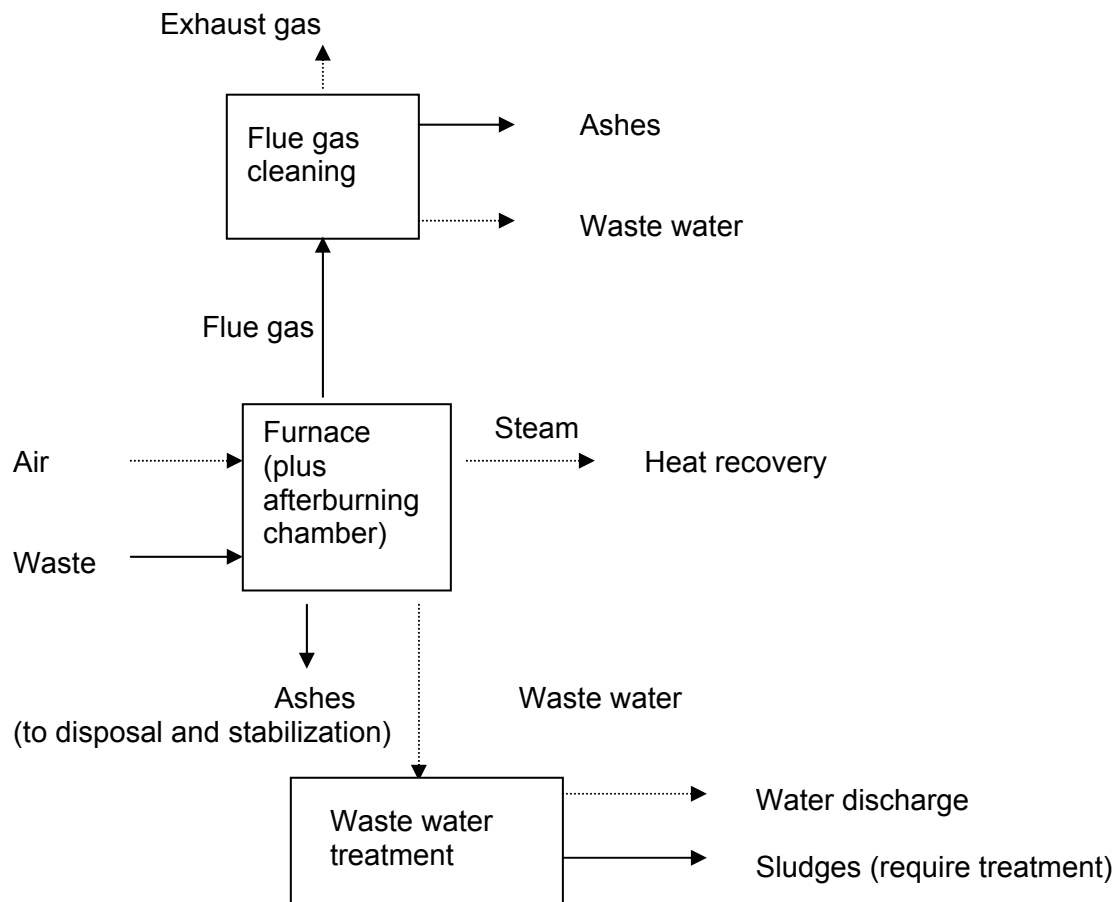
The incineration/pyrolysis should only be carried out in appropriate plants. The system should be designed to cope with the specific characteristics of hazardous health-care waste (high water content, high plastic content). As the following technologies are rather sophisticated only hazardous waste fractions should be burned in these plants. Other health-care waste which is similar to municipal waste should be segregated in advance and be subject to different waste treatment technologies. On-site facilities (i.e. in the hospital) are usually equipped with incinerators up to a capacity of 1 tonne/day.

If infectious waste is not burned immediately (during 48 hours) it must be deposited in a cooled storage room (10 °C max.). Working and storage areas should be designed to facilitate disinfection.

An incineration plant basically consists of the following units:

- furnace or kiln
- afterburning chamber
- dry, wet or catalytic flue gas cleaning devices
- waste water treatment plant

Simplified flow scheme of an incinerator:



The following firing technologies are considered **BAT options** for the thermal treatment of health-care waste:

- degassing and/or gasification of wastes (pyrolysis)
- rotary kiln
- (grate firing specially adapted for health-care waste⁴)

Single-chamber, drum and brick incinerators are **not considered as BAT**.

Pyrolytic incinerators

Pyrolysis plants with afterburning chambers are mainly used for smaller plants. These small plants usually operate in a discontinuous mode. For the purpose of health-care waste this is charged packed in barrels or bags. Larger plants should be equipped with automatic loading devices. At plants with degassing and/or gasification the processes drying, degassing and gasification take place in a reactor prior to combustion.

Waste is introduced discontinuously into a distillation chamber that is heated up to a sufficient temperature in order to distill the waste. Gases leaving the distillation chamber are mixed with a continuous airflow in the afterburning chamber and held at a temperature of about 900 °C by co-firing of natural gas. If the quantity of distilled gas is too high the volume of fired natural gas will be reduced automatically. Combustion gases leaving the afterburning chamber are cooled in a downstream hot water boiler and routed to a flue gas cleaning sys-

⁴ If the medical waste is to be burned in an municipal waste incinerator it has to be disinfected/sterilized beforehand.

tem. The boiler converts water into steam. The steam can be used to produce electricity to run a hospital, homes or businesses.

The smoldering process is done periodically. In order to ensure a sufficient burnout of the ash it is fired with gas burners before it is discharged from the distillation chamber.

At small plants fluctuations of the throughput and inhomogeneities of combusted waste are compensated by the auxiliary fuels.

As to pyrolysis plants the dust content of flue gases is small compared to conventional combustion systems. However, there is a great demand for additional fuels, so that consequently high volumes of flue gas are formed.

Typical incinerator capacities (on-site treatment): 200 kg to 10 tonnes/day

Rotary kiln

Another technology used is the rotary kiln. The combustion of health-care waste can be performed in either small rotary kilns (e.g. in the hospital) or, more common, in larger plants used for the combustion of several hazardous waste fractions.

Wastes are delivered from the bunker into the waste chute which is located in front of the firing using a crane.

In most cases a sluice is integrated into the chute where waste can directly be fed into the rotary kiln. Highly viscous and liquid wastes can be inserted through the front wall of the rotary kiln. As a result of the slope and the rotation of the rotary kiln, wastes are transported and circulated, which leads to intensive contact with primary air, that flows through the rotary kiln. In contrast to grate firings rotary kilns are closed systems. Therefore also liquid and highly viscous materials can be inserted.

Exhaust gases coming out of the rotary kiln are treated in an afterburning chamber. In order to assure high temperatures necessary for complete destruction of organic compounds (850 – 1200 °C depending on the waste) afterburning chambers are equipped with burners that automatically start when the temperature falls below the given value.

At the end of the rotary kiln slag arises either sintered or melted. By dropping into the water of the deslagging unit, granulated slag is formed. When the slag is sintered then this part of the plant is similar to that of a grate firing system.

Rotary kilns and afterburning chambers are in most cases constructed as adiabatic, ceramically lined combustion chambers. After the combustion chamber flue gases pass a void zone until a temperatur range of about 700 °C is reached. Subsequently heating bundles such as evaporators, superheaters and feedwater preheaters are arranged. Waste heat boiler and energy supply system is comparable to that of grate firing systems.

Incinerator capacities: 0.5 to 3 tonnes/hour (for health-care waste incineration)

Flue gas cleaning

Flue gases from incinerators contain fly ash (particulates) composed of heavy metals, dioxins, furans, thermally resistant organic compounds, and gases such as nitrogen oxides, sulfur oxides, carbon oxides and hydrogen halides. Flue gases resulting from uncontrolled batch mode (no flue gas cleaning) will contain around 2000 ng TEQ/m³ (source: UNEP Dioxin and Furan Toolkit).

The following flue gas cleaning measures have to be combined in a suitable manner to ensure the application of BAT:

- Separation of dust and non-volatile heavy metals: Fabric filters, electrostatic precipitators and fine wet scrubbers are used for dust separation. Precleaning of flue gases can be done with cyclones, that are efficient for separation of larger particles.
- HCl, HF, SO₂ and Hg removal: The removal of acid components and Hg can be reached by different dry or wet adsorption methods (adsorption on activated coke or lime) as well as by scrubbing (1- or 2-stage wet scrubbing).
- NO_x removal: Primary measures consist in the use of low-NO_x burners, staged combustion and recirculation of the flue gas, secondary measures are SNCR and SCR.

- The reduction of organic emissions and PCDD/F can be performed by primary measures (such as limitation of the de-novo synthesis, optimized combustion) and secondary measures like dust separation (see above), activated coke filter, flow injection with activated coke/furnace coke and lime hydrate, catalytic oxidation.

Due to the high investment and operational costs of the above equipment an economical plant operation seems often impossible. Therefore, centralised incineration units are preferred to decentralised on-site treatment of the health-care waste. Health-care waste incineration lines operated on the same site as other or municipal waste incineration will result in synergy effects and provide economic viability.

5. Summary of Measures

5.1 General guidance

| Measure | Description | Considerations | Other comments |
|--|--|---|--|
| Segregation of waste | Clear classification, segregation at source of health-care waste from other waste and within the health-care waste category to minimize the amount of waste to be treated | | not directly effective for UPOPs reduction but part of an integrated concept for the management of waste |
| Alternate Processes | In particular, if performance requirements cannot be met by the existing or planned facility priority consideration should be given to alternate processes with potentially less environmental impacts than waste incineration | Examples for alternate processes are: steam sterilization dry heat sterilization chemical disinfection/sterilization | |
| Performance Requirements for incineration plants | Health-care waste incineration plants should be permitted to achieve stringent performance and reporting requirements associated with best available techniques. | Consideration should be given to the primary and secondary measures listed in Chapter 5.4 below. | Performance requirements for achievement should include: <0.1 ng TEQ/m ³ for PCDD/PCDF |

5.2 Health-care waste incineration - Firing technologies representing BAT

| Technology | Considerations | Other comments |
|------------------------|---|--|
| Pyrolytic incinerator | suitable for smaller plants (200 kg/day to 10 tonnes/day) and on-site treatment | High investment and maintenance costs ¹ , well trained personnel required |
| Rotary kiln | suitable for medium sized plants (0,5 – 3 tonnes/hour) | High investment and maintenance costs, well trained personnel required, high energy consumption |
| Incinerator with grate | | Incineration in municipal waste incinerators requires special adaptations for health-care waste (e.g. automatic loading) |

¹ investment costs for a pyrolytic incinerator (with energy recovery and flue gas cleaning) in Europe (1 tonne/day): 4 million US\$ operating and maintenance costs: about 380 US\$ per tonne of waste incinerated (data from 1996)

5.3 Health-care waste incineration - General measures

| Management options | Release characteristics | Applicability | Other considerations |
|--|--|----------------------|---|
| No use of chlorinated plastic bags (such as PVC) and no burning of waste containing chlorinated compounds unless specific UPOP reduction measures are taken (secondary measures) | | | Be also aware of a possible heavy metal content in the waste and take the appropriate secondary measures |
| Appropriate transport, storage and security of health-care waste according to the needs of types of waste | not directly effective for UPOPs reduction but part of an integrated concept for the management of waste | | |
| Location of the plant: centralised incineration units are preferred to decentralised on-site treatment of hazardous health-care waste | | | Incineration lines for hazardous health-care waste operated on the same site as other hazardous waste incineration or municipal waste incineration will result in synergy effects and provide economic viability of BAT measures. |
| Incineration of health-care waste only in dedicated plants or in larger incinerators for hazardous waste | | | The characteristics of health-care waste (high water and plastics content) require special equipment |
| If not a dedicated health-care waste incinerator is used a separate charging system for infectious waste should be applied | not directly effective for UPOPs reduction but part of an integrated concept for the management of waste | | |
| Do not burn radioactive waste | no effects for UPOP reduction | | |

5.4 Primary measures and process optimization to reduce PCDD/F emissions

| Management options | Release characteristics | Other considerations |
|--|---|--|
| Optimization of combustion conditions: | The primary measures described here should be standard for all activities. By applying primary measures a performance around 200 ng TEQ/m ³ can be achieved (source: UNEP Dioxin and Furan Toolkit). | retrofitting of the whole process needed |
| Introduction of the waste in the combustion chamber only at temperatures of 850 °C; plants should have and operate an automatic system to prevent waste feed before the appropriate temperature is reached | | |
| Installation of auxiliary burners (for start-up and close-down operations) | | |
| In general, avoidance of start and stops of the incineration process | | |
| Avoidance of temperatures below 850°C and cold regions in flue gas | | |
| Sufficient oxygen content; control of oxygen input depending on the heating value and consistency of feed material | | average oxygen content: 6 Vol % |
| Sufficient residence time (minimum 2 sec) above 850°C (1100°C for highly chlorinated wastes, i.e. wastes with more than 1 % halogenated organic substances) and 6 % O ₂) | | sufficient residence time is required especially because of the plastic and water content of the waste |
| High turbulence of exhaust gases and reduction of air excess: e.g. injection of secondary air or recirculated flue gas, pre-heating of the air-streams, regulated air inflow | | optimized air inflow contributes to higher temperatures |
| (On-line) monitoring for combustion control (temperature, oxygen content, CO, dust), operation and regulation of the incineration from a central console | | |

As it is unlikely to meet a performance level lower than 0,1 ng TEQ/m³ with solely primary measures the below mentioned secondary measures⁵ should be considered.

5.5 Secondary measures

BAT for flue gas cleaning consists of a suitable combination of the options listed below (efficient dedusting assisted by equipment to reduce PCDD/F emissions):

⁵ which represent BAT in the European Union, Canada,

| Management options | Release characteristics | Applicability | Other considerations |
|--|--|---|---|
| Dedusting: | | | |
| Avoiding particle deposition by soot cleaners, mechanical rappers, sonic or steam soot blowers, frequent cleaning of sections which are passed by flue gas at the critical temperature range | | | Steam soot blowing can increase PCDD/F formation rates. |
| Effective dust removal by the following measures: | < 10 % remaining emission in comparison to uncontrolled mode | Medium | Removal of PCDD/F adsorbed onto particles |
| - Fabric filters | 1 - 0.1 % remaining emission | Higher | Use at temperatures < 260°C (depending on material) |
| - Ceramic filters | Low efficiency | | Use at temperatures 800-1000°C, not common for waste incinerators |
| - Cyclones (only for pre-cleaning of flue gases) | Low efficiency | Medium | only efficient for larger particles |
| - Electrostatic precipitation | Medium efficiency | | Use at a temperature of 450°C; promotion of the de novo synthesis of PCDD/F possible, low efficiency for fine particles, higher NO _x emissions, reduction of heat recovery. |
| - High-performance adsorption unit with added activated charcoal particles (electrodynamic venturi) | | | For fine dust removal |
| Reduction of UPOPs emissions by: | | | |
| Catalytic oxidation (SCR) | High efficiency (< 0.1 ng TEQ/m ³) | High investment and low operating costs | Only for gaseous compounds, previous removal of heavy metals and dust necessary, additional NO _x reduction if NH ₃ is added; high space demand, catalysts can be reprocessed by manufacturers in most cases, over-heating when too much CO present, higher energy consumption due to re-heating of flue gas; no solid residues. |
| Gas quenching | | | not common in waste incinerators |
| Fabric filter coated with catalyst | High efficiency (< 0.1 ng TEQ/m ³) | | e.g. made from PTFE, with parallel dedusting, lower contamination of filter dusts because of PCDD/F - destruction at the catalytic surface |

| Management options | Release characteristics | Applicability | Other considerations |
|--|-----------------------------|---|---|
| Different types of wet and dry adsorption methods with mixtures of activated charcoal, open-hearth coke, lime and limestone solutions in fixed bed, moving bed and fluidized bed reactors: | | | |
| - Fixed bed reactor, adsorption with activated charcoal or open-hearth coke | < 0.1 ng TEQ/m ³ | High investment, medium operating costs | High demand of space, disposal of solid residues from flue gas cleaning (=hazardous waste) necessary, permanent monitoring of CO necessary, increase of dust emissions due to aggregation with coal particles possible, consumption of open-hearth-coke in comparison with activated charcoal 2 to 5 times higher, incineration of used adsorption agent in the plant possible, fire/explosion risk |
| - Entrained flow or circulating fluidized bed reactor with added activated coke/lime or limestone solutions and subsequent fabric filter | < 0.1 ng TEQ/m ³ | Low investment, medium operating costs | not common for plants burning exclusively health-care waste, disposal of solid residues from flue gas cleaning (=hazardous waste) necessary, fire/explosion risk |
| Appropriate fly ash and waste water treatment | | | sludges from waste water treatment and from cooling of fly ash are hazardous waste |

5.6 Organisational measures

| Measure | Considerations |
|---|--|
| - Well-trained personnel - Operation and monitoring of the incinerator by periodic maintenance (cleaning of combustion chamber, declogging of air inflows and fuel burners, personnel should wear protective clothing); regular and/or continuous measurement of the relevant pollutants | Operation of incinerators requires qualified incinerator operators. It should be remembered that the availability of such operators in certain regions should be verified before purchasing high-technology incinerators. If qualified operators are not available, health-care establishments should either resort to alternative health-care waste disinfection technologies or contract the incineration out through a regional facility. |

5.7 General measures for management

- General infrastructure, paving, ventilation
- General control and monitoring of basic performance parameters
- Control and abatement of gross air emissions
- Development of environmental monitoring (establishing standard monitoring protocols)

- Development of audit and reporting systems
- Implementation of specific permit and audit systems for health-care waste incineration
- Demonstration by emission monitoring that a facility can achieve a given emission limit value

6. Performance Requirements based on BAT for new and existing health-care waste incineration plants

If incineration is the chosen disposal method for the health-care waste fraction the following performance standards are recommended:

| Type | Suggested Timeline | Emission Level ⁶ |
|----------|-------------------------------------|-----------------------------|
| New | Entry into force | <0.1 ng TEQ/m ³ |
| Existing | Within 10 years of entry into force | <0.1 ng TEQ/m ³ |

⁶ Based on the following: Canadian Council of Ministers of the Environment (CCME), *Canada-wide Standards for PCDD and Furans* ; European Directive 2000/76/EC on the incineration of waste

7. References

UNEP, Technical Guidelines on the environmentally sound management of biomedical and health-care waste, published under the framework of the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal (adopted on 22 March 1989), 2002, Geneva

UNEP, Standardized Toolkit for the identification of dioxin and furan releases, draft January 2001, Geneva

BMLFUW/Umweltbundesamt, State of the Art for Waste Incineration Plants, 2003, Vienna

WHO, Handbook for safe management of wastes from health care activities, 2000; http://www.who.int/water_sanitation_health/Documents/Healthcare_waste/Manual

European IPPC Bureau, BAT Reference Document Waste incineration, Draft May 2003, Seville

UNECE Protocol to the 1979 Convention on long-range transboundary air pollution on Persistent Organic Pollutants, 1998, New York and Geneva

Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste, OJ 18.12.2000, L 332/91

Canada-wide Standards for Dioxins and Furans for Incineration, http://www.ccme.ca/initiatives/standards.html?category_id=50#23

to be inserted: standards in other countries (USA, ...)

Institute for Environmental Medicine and Hospital Hygiene, University Clinical Centre Freiburg, Practical Guide for Optimising the Disposal of Hospital Waste: Reduction and Utilisation of Hospital Waste, with the Focus on Hazardous, Toxic and Infectious Waste (LIFE96ENV/D/10), 2000, Freiburg

E. Giroletti, L. Lodola, Medical waste treatment; Ispra courses waste treatment and management, 1993