ENVIRONMENTAL COUNCIL OF ZAMBIA

Minimum Specifications for Health Care Waste Incineration

The Specifications have been developed in accordance with the Environmental Protection and Pollution Control Act (Amendment) No. 12 of 1999, the Hazardous Waste Management Regulations Statutory Instrument No. 125 of 2001 and shall be implemented in accordance with the afore cited legislation.

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Acronyms and Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
DHB	District Health Board
ECZ	Environmental Council of Zambia
EPPCA	Environmental Protection and Pollution Control Act
HCW	Health Care Waste
HCWM	Health Care Waste Management
HCF	Health Care Facilities
HIV	Human Immunodeficiency Virus
IP	Infection Prevention
SI	Statutory Instrument
MoH	Ministry of Health
NISIR	National Institute of Scientific and Industrial Research
TDAU	Technological Development Advisory Unit
UNZA	University of Zambia
ZANARA	Zambia National Response to HIV/AIDS

Definition of Key Terms

Disposal	Intentional burial, deposit, discharge, dumping, placing or release of any waste material into or on air, land or water. Disposal is undertaken without the intention of retrieval.
Encapsulation	Abstraction/act of enclosing substance in a capsule so that the included object is not apparent. E.g. filling a sharps container that is three quarters full with cement of clay, this, after hardening, can be disposed of safely in a municipal landfill.
Healthcare waste	All waste generated by health care facilities, research facilities, laboratories and that produced during undertakings in the home e.g. dialysis, insulin injections and home based care
Incineration	Controlled burning of solid, liquid or gaseous combustible wastes to produce gases and residues containing little or no burnable material.
Infectious waste	The part of health care waste that is capable of causing infectious disease.
Microorganism	Causative agent of infection (include bacteria, viruses, fungi and parasites)
Municipal waste	General waste for collection by local authorities (district, municipal or city councils) generated mainly by households, commercial activities and street sweeping.
Opacity	State/quality of a body that render it impervious to the rays of light; want of transparency; opaqueness.
Receptacle/container	Vessel in which waste is placed for handling, transportation, storage and/or eventual disposal.
Residence Time	Period of time spent by a particle in a particular place.
Sanitary landfill	Engineered method of disposing of solid waste on land in a manner that protects the environment.
Scavenging	Manual sorting of solid waste at landfills and removal of usable material.
Segregation	Systematic separation of solid waste into designated categories.
Sharps	Hypodermic needles, suture needles, scalpel blades, scissors, wire sutures, broken glass or any object that can cause a puncture or cut.
Treatment	A process that changes the physical, chemical or biological character of waste to reduce its environmental threat. Treatment can neutralize waste, recover energy or material resources from waste, render the waste less hazardous or make the waste safe to transport, store or dispose of.
Waste Management	All activities, administrative and operational, involved in the handling, treatment, conditioning, storage, transportation and disposal of waste.

Foreword

Quantities of health care waste generated monthly range from a few kilograms at remote health care facilities, to hundreds or possibly thousands of kg at central hospitals. Poorly disposed off health care waste such as syringes and needles may be scavenged and reused resulting in people being infected with hepatitis Band C, HIV and other blood-borne infections. The need for adequate and safe disposal of health care waste cannot be thus over emphasised. To avoid these serious health problems and the lack of minimum specifications for health care waste incinerators, the Environmental Council of Zambia (ECZ) and Ministry of Health (MoH), with the support of partner stakeholders, embarked on the development of these specifications for use by all health care facilities in the country.

Countrywide surveys of incinerator use, maintenance and management have revealed widespread deficiencies in the construction, siting, operation and management of these units. These deficiencies can result in poor performance of the incinerator, e.g. low temperatures, incomplete waste destruction, inappropriate ash disposal, high smoke emissions, fugitive emissions, etc. Still, user acceptance of incinerators appears generally high and the use of incinerators is preferable to the disposal of waste in unsecured pits or landfills, or (uncontrolled) burning in drums or pits. However, the combustion of health care waste can form particulate matter, dioxins, furans and other toxic air pollutants.

It is with the foregoing that these minimum specifications have been developed to ensure a sound management of the incineration process, disposal of health care waste, minimizing emissions, and reducing occupational exposures and other hazards. This will entail adherence to the following key elements:

(1) Effective waste reduction and waste segregation, ensuring that only the smallest quantity of appropriate waste types is incinerated.

(2) An engineered design, ensuring that combustion conditions are appropriate, e.g., sufficient residence time and temperatures to minimize products of incomplete combustion.

(3) Siting incinerators away from populated areas or where food is grown, thus minimizing exposures and risks.

(4) Construction following detailed drawings, thus avoiding flaws that can lead to incomplete destruction of waste, higher emissions, and premature failures of the incinerator.

(5) Proper operation, critical to achieving the desired combustion conditions and emissions, e.g., appropriate start-up and cool-down procedures; achievement and maintenance of a minimum temperature before waste is burned, use of appropriate loading/charging rates (both fuel and waste) to maintain appropriate temperatures, proper disposal of ash, and various actions and equipment to safeguard workers.

(6) Periodic maintenance to replace or repair defective components, e.g., including inspection, spare parts inventory, record keeping, etc.

(7) Enhanced training and management, possibly promoted by certification and inspection programs for operators, the availability of an operating and maintenance manual, management oversight, and maintenance programs.

Implementation of these minimum specifications and achieving the objectives will be reviewed at regular intervals, beginning with implementation process through workshops six months following adoption of these specifications.

These minimum specifications for health care waste incineration are intended to guide managers of health care facilities operators in the management of health care waste incineration. The development of these minimum specifications involved a participatory process that brought together ECZ, MoH and other stakeholders over an extended period.

Acknowledgments

On behalf of the Environmental Council of Zambia (ECZ), I would like to acknowledge the commitment and hard work and sincerely thank individuals and institutions that contributed directly or indirectly to the development of these Minimum Specifications for Health Care Waste Incineration in Zambia.

The preparation of these Minimum Specifications for Health Care Waste Incineration in Zambia has been undertaken by the Technical Committee on Development of Minimum Specifications for Health Care Waste Incineration upon which the following organisations were represented:

Lusaka City Council
Ministry of Health (Chair)
Zambia National Response to HIV/AIDS Project
Environmental Council of Zambia (Secretariat)

ECZ owes immense gratitude to the Norwegian Government for the financial support rendered to the development of these Minimum Specifications for Health Care Waste Incineration and Zambia National Response to HIV/AIDS (ZANARA) Project for its publication.

We count on every one to ensure implementation of these Minimum Specifications.

Edward Zulu
Director
Environmental Council of Zambia

1.0 INTRODUCTION

Health care waste management (HCWM) at all levels of health care provision is generally unsatisfactory in Zambia. Many health care facilities do not take due responsibility for the waste they generate to ensure safe, sustainable and environmentally acceptable methods for segregation, storage, collection, transportation, pre-treatment and final disposal both within and outside their premises.

With increasing population and a corresponding increase in number of health care facilities (HCF), the amount of waste generated has also gone up thereby exerting pressure on the available treatment and disposal facilities. These facilities are either inadequate, non-existent or the technology used is not appropriate. Many large hospitals have incinerators for disposing of health care waste (HCW) while rural-based facilities use pits or burning chambers for disposal. Many of these incinerators do not meet environmentally acceptable standards and legal requirements for air emissions or waste disposal. Untreated HCW has been seen at disposal designated for general waste where scavenging is practiced without taking necessary measures to control or abate it (CBoH, 2003).

Incineration is a common method of HCW disposal in Zambia. Incineration of HCW offers the benefits of sterilizing the waste, reducing the volume of waste, and rendering the waste unrecognizable. However, in recent years, public perception of incineration has been declining and environmental regulation of incineration is becoming increasingly more stringent.

The increasing number of companies and HCFs wishing to acquire incinerators and the lack of guidelines governing procurement, installation and operation of incinerators underscores the need for developing incinerator specifications.

1.2 Common Problems

The Environmental Council of Zambia (ECZ) has observed recurring problems with incinerators. Typical problems include inadequate or malfunctioning equipment, improper operation, and poor communication between operators and maintenance personnel.

1.2.1 Inappropriate Equipment

Often inappropriate incinerators are being used to burn HCW. This problem frequently occurs when incinerators that were designed to burn low moisture content waste are used to treat high moisture content HCW.

Pathological waste has very high moisture and a low volatile content; therefore can be completely combusted in an incinerator with a small secondary chamber. (Secondary chambers are specifically used to combust the volatile portion of the waste). On the other hand, HCW such as syringes, plastic catheters, drip set and urinary bags typically have a high volatile content and lower moisture content, due to the large quantity of plastics in the waste stream. Thus, this type of waste requires a larger secondary chamber to facilitate complete combustion of the volatile portion of the waste.

1.2.2 Poor Equipment Specifications

A poorly written equipment specification by HCFs is another incinerator problem. In the procurement contract, it is not always stated that the equipment must meet regulatory requirements, to include emission limits, residence times, training, etc. Incinerators and air pollution control devices are not ordered and delivered as a package during procurement.

1.2.3 Lack of Standard operating Procedures

It has been observed that few installations have formal written standard operating procedures for incinerators. Site-specific standard operating procedures provide a good reference for personnel associated with the incinerators and assist new personnel who are being trained to operate the incinerator.

1.2.4 Lack of Training for Incinerator Operator

The hospital housekeeping staff is frequently responsible for incinerator operation. These personnel are often given no formal training on how to operate the incinerator. An improperly operated incinerator can cause environmental regulation violations, equipment damage, and injury to the operator.

1.2.5 Lack of Waste Segregation Plans

Problems such as clogged air ports, damaged refractory and even explosions can occur if installations have not implemented waste segregation and employee training plans. Waste segregation has a direct effect on operator safety and equipment operation. The operator has no control over what is placed in the bags (See Annex-3). Certain materials can cause explosions or other damage to the incinerator. In addition, burning the wrong waste can reduce the life span of the incinerator and its associated equipment.

1.3 The Process of Incineration

Incineration is a high temperature dry oxidation process that reduces the volume and weight of waste. This process is usually selected to treat waste that cannot be recycled, reused, or disposed of in a landfill.

Health-care waste includes all waste generated by health care facilities, research facilities, laboratories and that produced in the course of health care undertaking in the home e.g. dialysis, insulin injections and home based care (needles, syringes, soiled bandages, disposable sheets, medical gloves, dialysis machine filters, plastic catheters and drip set, glass waste, urinary bags, expired medicines, medicine containers, pesticide containers, sanitary napkins, liquid waste and placenta). (WHO, 1998).

1.4 Requirements for complete combustion:

i. Oxygen in Air

Insufficient oxygen results in unburnt carbon (smoke) and malodorous hydrocarbons. If the waste burns too fast, there will be insufficient oxygen. Carbonaceous emissions due to a shortage of oxygen can be eliminated, if the rate of combustion (burning rate) is kept under control.

ii. Time

Combustion is a chemical reaction (oxidisation) requiring time for completion. Large combustion chambers retain the gases for sufficient time. If the waste burns too fast the gases (the volatiles) are pushed through too quickly. Control of the Rate of Combustion prevents this.

iii. Turbulence

Air, volatiles and heat must be thoroughly mixed. The flame port, mixing chamber and heated refractory screens are designed to produce turbulence. Optimum mixing is dependant on gas velocities, not obtained if the velocities are too high or too low. Control of the Rate of Combustion ensures correct gas velocities and optimum mixing.

iv. Temperature

High temperatures are needed in the secondary chambers to burn the carbon and hydrocarbons. Conversely, reduced temperatures are essential in the primary chamber and on the hearth to reduce and to trap the chemically formed compounds and to inhibit the rate of volatilisation. Temperatures have a direct effect on the Rate of Combustion and the Rate of Combustion has a direct effect on the temperatures.

1.5 Air pollutants from incinerators

Potential obnoxious emissions from incinerator chimneys can be divided into three main groups:

i) **Carbonaceous matter**

Includes hydrocarbons (many have of odour and/or acidic), carbon monoxide and pure carbon. Very fine particles of carbon constitute black smoke. Carbonaceous pollutants can be eliminated by complete combustion. Combustion breaks down hydrocarbons into carbon dioxide and water.

ii) **Entrained Ash**

Fine particles or flakes of incombustible material usually light in colour, are entrained in the gas stream. Visible flakes are called fly ash. Fine dust is called white smoke. They cannot be eliminated by combustion. Entrainment is reduced by controlling the volume and speed of volatiles leaving the fire bed. Entrained dust is removed from the gas stream in very large tertiary (settling) chambers, which also benefit from control of the speed and volume of the volatiles. The speed and volume of the volatiles is controlled by the rate of combustion.

a) **Heavy Metals:** Small amounts of lead, silver, chrome and cadmium may be oxidised and entrained. Oxidisation is drastically reduced or completely eliminated by controlled temperature and control of the Rate of Combustion.

b) **Mercury and chlorine:** React violently – so rapidly as to be almost explosive. Mercury-chloride salt is formed before the chlorine is neutralized. It is trapped in the ash from the incinerator and from the filter. This salt is insoluble in water and in weak acids. It can be safely deposited in a municipal tip without risk of contaminating ground water.

iii) **Chemically formed compounds**

Obnoxious, incombustible vapours and gases are sometimes liberated or formed. Many are completely invisible. Others condense to a visible plume on leaving the chimney. They cannot be completely eliminated by combustion. However, in most cases, the formation or liberation can be reduced by optimising combustion conditions.

The most common chemically formed emissions are:

a) **Nox:** These are formed at very high flame temperatures. Such high temperatures are prevented by control of the rate of combustion.

b) **SOx:** Sulphur burns to form SO_x. SO_x is neutralized by the same process that neutralizes the halogens. Typical domestic and health care wastes have relatively low sulphur contents so sulphur emissions from incinerators rarely cause concern.

c) **Salts:** Halogens include chlorine, fluorine, bromine and iodine. Polyvinyl chloride (PVC) and Polytetrafluoroethylene (PTFE) plastics are common sources of halogen. Ashes produced by wastes such as wood, paper and bones contain basic oxides. These oxides combine readily with halogens to form salts (chlorides, bromides etc). The salts are trapped in the ash. This process is most effective with a controlled rate of combustion.

d) **Dioxins and Furans:** The incomplete break down of complex hydrocarbons can result in the production of benzene, C_6H_6. A pair of benzene atoms may be linked by a single oxygen atom to form a furan or by a pair of oxygen atoms to form a dioxin.

e) Hydrogen atoms occupy the free corners of the dioxin and furan molecules. Halogens, chlorine and fluorine, can displace any one, or more of the hydrogen atoms. Any dioxin that has either Chlorine or Fluorine in positions 2, 3, 7 and 8 is said to be cytotoxic. In large doses it may cause cancer in human beings. If any one or more of the above four positions is not occupied by a halogen, the dioxin is not cytotoxic.

Furans are all significantly less toxic than dioxins – (about half). Dioxins with four chlorine atoms in positions 2, 3, 7, 8 are the most toxic. They are called 2, 3, 7,8-tetra-chlorinated biphenol dioxin. Dioxins with more than four halogens are progressively less toxic as the number of halogens increases.

2.0 INCINERATOR SPECIFICATIONS

Based on the history of the amount HCW generated across the country, incinerator specifications and or classification shall be as follows with respect to the amount of waste to be incinerated per hour:

i. Class 1 – $\geq$ 300 kg/hr
ii. Class 2 – 70 kg/hr
iii. Class 3 – 50 kg/hr
iv. Class 4 – $\leq$ 32 kg/hr

The following requirements shall govern incineration of HCW in Zambia.

2.1 Type of waste that shall not be incinerated

The HCW not to be incinerated shall have the following characteristics:

i. Pressurized gas containers
ii. Large amounts of reactive chemical waste.
iii. Silver salts and photographic or radioactive waste
iv. Halogenated plastics such as polyvinyl chloride (PVC) (blood bags, IV tubing or disposable syringes).
v. Waste with high mercury or cadmium content, such as broken thermometers, used batteries and lead-lined wooden panels
vi. Sealed ampoules or ampoules containing heavy metals
vii. Wastes chemically treated with any chlorinated disinfectant

2.2 Characteristics of waste to be incinerated

The HCW to be incinerated shall have the following characteristics:

i. Low heating value: above 2000kCal/kg (8370 kJ/kg) for single-chamber incinerators, and above 3500kCal/kg (14640kJ/kg) for pyrolytic double-chamber incinerators
ii. Content of combustible matter above 60%
iii. Moisture content below 30%
iv. Content of non-combustible fines below 20%
v. Content of non-combustible solids below 5%

2.3 Operating standards

All incinerators shall meet the following emission and operating standards:

i. Combustion efficiency (C.E.)shall be at least 99.0%
ii. The combustion efficiency shall be computed as follows:
$C.E = (CO_2 X\ 100) / (\%\ CO_2 + \%CO)$
iii. Suitably designed pollution control devices such as scrubbers, filters or electrostatic precipitators, shall be installed/retrofitted with the incinerator to achieve emission limits, if necessary.

2.4 Feeding

Controlled hygienic, mechanical or automatic feeding methods have to be used which will not negatively influence the air supply and temperature in the primary and secondary chambers of the incinerator.

No waste is to be fed into the incinerator:

i. At start up until the minimum combustion temperatures have been reached (see section 2.5 and 2.6);
ii. Whenever the minimum combustion temperatures are not maintained;
iii. Whenever the previous charge has not been completely combusted in the case of batch

loader;

iv. Until such times as the addition of more waste will not cause the design parameters of the incinerator to be exceeded.

2.5 Single chamber incinerators

The minimum temperature shall not be less than 1100°C

2.6 Double chamber incinerators

2.6.1 Primary combustion

i. The primary combustion chamber shall be accepted as the primary combustion zone and shall be equipped with a burner/s burning gas or low sulphur liquid fuel.
ii. Primary air supply is to be controlled efficiently.
iii. The minimum combustion temperature of the primary chamber shall not be less than 800 °C.

2.6.2 Secondary combustion

i. The secondary combustion chamber shall be accepted as the secondary combustion zone and shall be fitted with a burner/s burning gas or low sulphur liquid fuel.
ii. Secondary air supply is to be controlled efficiently.
iii. Flame contact with all the gases shall be achieved.
iv. The residence time in the secondary chamber shall not be less than two seconds.
v. The gas temperature as measured against the inside wall in the secondary chamber, not in the flame zone, shall not be less than 1100°C;
vi. The oxygen content of the emitted gases shall not be less than 11%.
vii. Both the primary and the secondary temperatures shall be maintained until all the waste has been completely combusted.

2.7 Chimney

The specifications below cover both single and double chamber incinerators.

i. The exhaust gas stack (chimney) shall extend above the general terrain in the immediate vicinity of the plant, in order to disperse the combustion gas products adequately.
ii. The chimney shall have a minimum height of nine (9) meters above ground level and clear the highest point of the building by not less than six (6) meters for flat roofs or 3 meters for pitched roofs. The topography and height of adjacent buildings (i.e. closer than 5 meters chimney height) shall be taken into account.
iii. If possible the chimney shall be visible to the operator from the stocking floor.
iv. The dilution of air after combustion in order to achieve the air pollution control standards is not allowed. (Refer to table 1 below)
v. The minimum exit velocity of the emissions shall not be less than 10 metres/second.
vi. The stack shall be insulated to maintain the maximum outlet temperature.
vii. The sampling platform and port for measurement of emissions shall be provided.

2.8 Temperature

i. The temperature shall be determined against the inside wall of the combustion chambers. Care shall be taken not to measure the burner flame temperature.
ii. An audible and visible alarm shall be installed to warn the operator when the secondary temperature drops to below the required temperature.
iii. The following instruments may also be required:

a) A carbon monoxide and/or oxygen meter/recorder
b) A smoke density meter/recorder
c) A gas flow meter/recorder

d) Any other instrument or measurement considered necessary

2.9 Siting

i. The proposed siting requirements shall address the impact of the facility on ambient air quality, visibility, soils, vegetation, and other factors that may be relevant in determining that the benefits of the proposed facility significantly outweigh the environmental and social costs imposed as a result of its location and construction.

ii. The incinerator shall be sited in accordance with the topography and be compatible with premises in the neighbourhood.

iii. The proposed site shall be duly approved by ECZ before installation.

iv. The incinerator shall be housed in a suitably ventilated enclosure.

v. The incinerator shall be sited in accordance with the relevant legislation (such as the Town and Country Planning Act, the Public Health Act and the Local Government Act).

Table 1: Guideline Limits for Ambient Air Pollutants

PARAMETER	REFERENCE TIME		GUIDELINE LIMIT
1. Sulphur dioxide (SO_2)	10 minutes		500 g/m^3
	1 hour		350 g/m^3
2. Sulphur dioxide (SO_2) in combination with Total Suspended Particles (TSP)*1) and PM_{10}	SO_2	24 hour	125 g/m3
		6 months	50 g/m^3
	TSP	24 hours	120 g/m^3
		6 months	50 g/m^3
	PM_{10}	24 hours	70 g/m^3
3. Respirable particulate matter PM_{10} *2)	PM_{10}	24 hours	70 g/m^3
4. Oxides of nitrogen (NO_X)	1 hour		400 g/m^3
As nitrogen dioxide (NO_2)	24 hours		150 g/m^3
5. Carbon monoxide (CO)	15 minutes		100 mg/m^3
	30 minutes		60 mg/m^3
	1 hour		30 mg/m^3
	8 hours		10 mg/m^3
6. Ambient Lead (Pb)	3 months		1.5 $\mu g/m^3$
	12 months		1.0 $\mu g/m^3$
7. Dust fall	30 days		7.5 tonnes/km^2
Source: Air Pollution Control Regulations, SI 141 of 1996			

*1) Total suspended particles (TSP) are particles with diameter less than 45 micrometers (m).

*2) Respirable particles (PM_{10}) are particles with diameter less than 10 micrometers (μm). These can penetrate to the anciliated regions of the deep lung.

NOTE: Reference times are the 98^{th} percentile averaging times.

The average dioxin and furan concentration in the emissions shall not exceed 80ng/m3 total dioxins and furans if measured for a period of 6 to 16 hours or 0.2 ng International Toxic Equivalent (I-TEQ/m3 or result in an excess cancer risk of 1:100000 on the basis of annual average exposure (ng – nanogram).

2.10 Residence time

i. The residence time for gaseous products in the combustion chamber will be designed to be at least 2 seconds to ensure complete combustion.
ii. Incinerators shall be equipped with temperature recording devices which will keep a continuous record of the temperatures in areas of interest such as the primary combustor, the air pollution control equipment, and the exhaust stack.

2.11 Fuel

i. The incineration chamber shall be designed to include an auxiliary gas or oil burner to be used as necessary to maintain the prescribed minimum combustion temperatures.
ii. Some dry solid waste which makes good fuel shall be held back in case of fuel shortage. This is typically cardboard or wooden scraps.
iii. Where diesel is used, low sulphur diesel shall be used as fuel in the incinerator.

2.12 Emission limits

i. Opacity of the smoke shall not exceed 20%.
ii. All the emissions to air other than steam or water vapour shall be odorless and free from mist, fume and droplets.
iii. All pollutants concentrations shall be expressed at 273K, (0°C) and 101.3kPa (1atmosphere) dry gas and 11% oxygen.
iv. ECZ shall require that the holder of a licence to emit air pollutants carries out tests to determine stack and/or ground level concentrations of the following substances:

a. Maximum of 0.05mg/m^3 (as measured in the chimney) for:

I. Cadmium and compounds
ii. Mercury
iii. Thallium

b. Maximum of 0.5mg/m^3 (as measured in the chimney) for:

i. Chromium
ii. Beryllium
iii. Arsenic
iv. Antimony
v. Barium
vi. Lead,
vii. Silver
viii. Cobalt
ix. Copper
x. Manganese
xi. Tin
xii. Vanadium
xiii. Nickel

2.13 Ash Processing

i. The ash processing system shall involve stabilizing the ash product with lime and cement so that it can safely be land filled or used in construction as fill material or construction blocks.
ii. Ash handling and processing shall be kept under roof and indoors so that it is not offensive to the neighbours and also so that operations may be conducted all year round.
iii. Incinerator ash and residues shall be disposed of in a special cell within an approved landfill unless handled otherwise in accordance with express permission from ECZ.
iv. Volatile organic compounds in ash shall not be more than 0.01%.
v. Wastewater from gas washing and quenching of ashes shall be neutralized to permissible statutory limits before being discharged. (Refer to Annex-2 and Trade Effluent Regulations)

3.0 INCINERATOR MANAGEMENT

3.1 Operation

i. Operating procedures with information on waste handling, waste storage, ash handling, incinerator operation, equipment maintenance, safety requirements, training requirements, and points of contact shall be provided.
ii. All employees shall be trained on waste segregation and proper waste handling and storage. Waste containers shall be labeled for easy identification and tracking.
iii. Preventive maintenance schedules shall be specified as well as maintenance points of contact. There shall be good communication between the medical department and the maintenance personnel. It is also important for the incinerator operator to know the chain of command and who is responsible for the incinerator.
iv. Materials destined for incineration shall be of known origin and composition.
v. The incinerator shall be preheated to working temperature before charging any waste.
vi. Overloading of the incinerator shall be avoided at all times.
vii. The incinerator shall be kept in good working order at all times and shall not be used if any component fails. Any malfunctioning shall be reported to the relevant control authority.
viii. The incinerator and its surroundings shall be kept in clean and sanitary conditions at all times.
ix. In cases where noxious or offensive particulates are emitted that cannot be destroyed by secondary combustion, additional control equipment e.g. scrubbers, bag filters or electrostatic precipitators will be required.
x. Access to the incinerator site shall be restricted to authorized personnel only and shall be controlled by means of a complete perimeter fence and lockable gates with clear warning signs.

3.2 Recordkeeping and Reporting

i. Owners of new or modified incinerators are required to submit notifications to competent authorities (ECZ, local authority) concerning construction and initial start up of the affected facility.
ii. Owners and operators are also required to maintain thorough records documenting the results of the annual performance tests, operating parameter monitoring data, output data, and quality assurance determinations.
iii. Records shall be kept of the mass and/or volume, the type and origin of the waste to be incinerated.
iv. Owners or operators of incinerators must submit a report to ECZ indicating any operating parameter limits that have not been met or any emissions that exceed applicable limits. These reports must be submitted biannually.
v. Information related to operator training/qualification requirements shall also be kept. This data includes all names and dates of personnel completing the operator training requirements; names and dates of personnel qualifying as incinerator operators; and the names and dates of personnel completing the review of the site-specific incinerator operating manual.
vi. All reports must be signed by the overall officer responsible for the incinerator. All documentation and records must be available for inspection by ECZ or any other competent authority upon request.

3.3 Operator Training and Qualifications

i. Personnel responsible for the operation of the incinerator shall be given formal training that includes the basic principles of waste handling, combustion, incinerator design, operation and controls, occupational health and safety, environmental regulations, maintenance, and associated problems.
ii. A fully trained and qualified incinerator operator is required to be on duty at the time of operating
iii. The training must be conducted by a qualified instructor and must include classroom and hands-on training.

iv. The training must include an examination, designed and administered by the instructor, and reference materials on course topics.

v. In addition to this training, a refresher course shall be required.

vi. The manufacturer/supplier shall install the equipment and provide training (training aspect shall be specified in the contract). The contract specifications shall require that at least three copies of any equipment operating manuals be provided.

vii. The owner of an affected facility must develop and annually update site-specific operating manual or standard operating practices. A system must be in place to ensure that incinerator operators review the manual regularly.

viii. The manual must be kept in a location that is easily accessible to personnel. This manual must be available for inspection by ECZ or any other relevant competent authority upon request.

4.0 MONITORING AND EVALUATION

4.1 Monitoring

Regular monitoring will be instituted to check on the progress in the implementation of the specifications.

a) HCFs will monitor their activities by themselves through internal audits etc.
b) Government through ECZ, and MoH will monitor activities of HCFs inspections and compliance monitoring.

4.2 Evaluation

The evaluation of the Minimum Specification for HCW incineration will focus on assessing the progress of implementing the required specifications, and how far the objectives are being achieved through government and Public sector as well as community involvement.

These improvements will be in the areas of producer responsibility, investments, service provision, public awareness and cost recovery. This review will be undertaken periodically, every 4-5 years.

5.0 IMPLEMENTATION OF THE SPECIFICATION

MoH and ECZ will spearhead and coordinate the implementation of the specifications in collaboration with the Ministry responsible for Local Government and Housing and other relevant stakeholders such as Institutions of learning and NGOs. The launch will be done by MoH who will ensure that the specifications are implemented. The implementation will include development of specific work plans from the broader targets provided within this specification and also taking into consideration specific time frames.

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7.0 LIST OF ANNEXES

7.1 Annex 1-Effluents and Waste Water Standards

THIRD SCHEDULE

(Regulation 5 (2))

TABLE OF STANDARDS (LIMITS) FOR EFFLUENTS AND WASTE WATER

Column 1 **PARAMETER**	***Column 2*** **EFFLUENT AND WASTE WATER INTO AQUATIC ENVIRONMENT**
A. Physical	
1. Temperature (Thermometer)	40 C at point of entry
2. Colour (Hazen Units)	20 Hazen units
3. Odour and Taste (Threshold odour number)	Must not cause any deterioration in taste or odour as compared with natural state
4. Turbidity (NTU scale)	15 Nephelometer turbidity units
5. Total suspended solids(Gravimetric method)	100 mg/L must not cause formation of sludge or scum in receiving water
6. Settleable matter sedimentation in 2 hours (Imhoff funnel)	0.5 mg/L in two hours. Must not cause formation of sludge in receiving water
7. Total Dissolved Solids (Evaporation at105 C and Gravimetric method)	3000 mg/L The TDS of waste water must not adversely affect surface water
8. Conductivity (Electrometric method)	4300 S/cm
B. Bacteriological	
9. Total Coliform/100 ml (Membrane Filtration method)	2500
10. Faecal Coliform/100ml (Membrane Filtration method)	5000
11. Algae /100 ml (Colony counter)	1000 cells
C. Chemical	
12. pH (0-14 scale) (Electro-metric method)	6.0 - 9.0
13. Dissolved oxygen mg Oxygen / Litre (Modified Winkler method and membrane electrode method)	5 mg/L after complete mixing extreme temperature may result in lower values

Column 1 **PARAMETER** **A. Physical**	**Column 2** **EFFLUENT AND WASTE WATER INTO AQUATIC ENVIRONMENT**
14. Chemical Oxygen Demand (COD) (Dichromat method)	*COD based on the limiting values for organic carbon 90 mg 02/L average for 24 hours*
15. Biochemical Oxygen Demand (BOD) (Modified Winkler method and Membrane Electrode method)	*50 mg 02/L (mean value over 24 hours period) According to circumstances in relation to the self cleaning capacity of waters*
16. Nitrates (NO3 as nitrogen) (Spectrophotometric method and electrometric method)	*The nitrates burden must be reduced as far as possible according to circumstances: water course 50 mg/L; Lakes 20 mg/L*
17. Nitrite (NO2 as nitrogen/L Spectrophotometric sulphanilamide)	*2.0 mg NO2 as N/L*
18. Organic Nitrogen (Spectro-photometric method N-Kjeldal)	*5.0 mg/L Mean* (* the % of nutrient elements for degradation of BOD should be 0,4 - 1 % for phosphorous (different for processes using algae)*
19. Ammonia and Ammonium (Total) (NH3 as N/L) (Nesslerization method and Electrometric method)	*The burden of ammonium salts must be reduced to 10 mg/L (depending upon temperature, pH and salinity)*
20. Cyanides (Spectrophoto-metric method)	*0.2 mg/L*
21. Phosphorous (Total) (PO4 as P/L) (Colori-metric method)	*Treatment installation located in the catchment area of lakes: 1.0 mg/L; located outside the catchment area: reduce the load of P as low as possible (PO4 = 6 mg/L*
22. Sulphates (Turbidimetric method)	*The Sulphate burden must be reduced to 1500 mg/L*
23. Sulfite (Iodometric method)	*0.1 mg/L (presence of Oxygen changes SO3 to SO4)*
24. Sulphide (Iodometric and electrometric method)	*0.1 mg/L (depending on temperature, pH and dissolved O2)*
25. Chlorides CI/L (Silver nitrate and Mercuric nitrate)	*Chloride levels must be 800 mg/L*
26. Active chloride Cl2/L (Iodometric method)	*0.5 mg/L*
27. Active Bromine (Br2/L)	*0.1 mg/L*
28. Fluorides F/L (Electro-metric method and Colori-metric method with distillation)	*2.0 mg/L*
C. Metals	
29. Aluminium compounds (Atomic Absorption method)	*2.5 mg/L*
30. Antimony (Atomic absorption method)	*0.5 mg/L*
31. Arsenic compounds (Atomic Absorption method)	*0.05 mg/L*
32. Barium compounds (water soluble concentration) (Atomic Absorption method)	*0.5 mg/L*
33. Beryllium salts and compounds (Atomic Absorption method)	*0.5 mg/L*

Column 1 PARAMETER	Column 2 EFFLUENT AND WASTE WATER INTO AQUATIC ENVIRONMENT	
A. Physical		
34. Boron compounds (Spectro photometric method-curcumin method)	0.5 mg/L	
35. Cadmium compounds (Atomic Absorption method)	0.5 mg/L	
36. Chromium Hexavelant,Trivalent (Atomic absorption method)	0.1 mg/L	
37. Cobalt compounds (Atomic Absorption method)	1.0 mg/L	
38. Copper compounds (Atomic Absorption method)	1.5 mg/L	
39. Iron Compounds (Atomic Absorption method)	2.0 mg/L	
40. Lead compounds (Atomic Absorption method)	0.5 mg/L	
41. Magnesium (Atomic Absorption method and flame photometric method)	500 mg/L	
42. Manganese (Atomic Absorp tion method)	1.0 mg/L	
43. Mercury (Atomic Absorption method)	0.002 mg/L	
44. Molybdenum (Atomic Absorption method)	5.0 mg/L	
45. Nickel (Atomic Absorption method)	0.5 mg/L	
46. Selenium (Atomic Absorption method)	0.02 mg/L	
47. Silver (Atomic Absorption method)	0.1 mg/L	
48. Thallium (Atomic Absorption method)	0.5 mg/L	
49. Tin compounds (Atomic Absorption method)	2.0 mg/L	
50. Vanadium compounds (Atomic Absorption method)	1.0 mg/L	
51. Zinc compounds (Atomic Absorption method)	10 mg/L	
D. Organics		
52. Total hydrocarbons (Chromatographic method)	10.0 mg/L	
53. Oils (Mineral and Crude) (Chromatographic method and Gravimetric method)	5.0 mg/L	
54. Phenols (steam distillable)	0.2 mg/L	
(Colorimetric method) (Non-steam distilled)	0.05 mg/L	
55. Fats and saponifiable oils (Gravimetric method and chromatographic method)	20 mg/L	
56. Detergents (Atomic) (Atomic Absorption Spectrophometric)	2.0 mg/L (Detergents should contain at least biodegradable compounds)	
57. Pesticides and PCB's (Total) (Chromatographic method)	0.5 mg/L	
58. Trihaloforms (Chromatographic)	0.5 mg/L	
E. Radioactive Materials		
58. Radioactive materials specified by International accepted Atomic Energy Agency	No discharge accepted	Not permitted

7.2 Annex 2-Colour Coding and Receptacles for various HCW types

Waste Type	Types of Waste	Colour Code	Type of Receptacle
A	General Waste	Black	Plastic bag of appropriate size
B	Infectious Waste		
B1	Sharps	Yellow	Puncture-resistant containers and plastic bags
B2	Patient Waste	Yellow	Plastic bags and containers
B3	Culture/Specimen	Yellow	Plastic bags and containers
C	Pathological/Organic Human Tissues	Yellow	• Plastic bags
D1	Pharmaceutical Waste	Brown	• Plastic bags and containers
D2	Photographic chemical Waste • Photographic developer • Fixer solution • X-ray photographic film	Brown	• Plastic containers To be recycled/reused • To be neutralised
D3	Radioactive Waste	Yellow	• Containers with radio-active symbol
	• Solid-combustible/compactable		Durable plastic bags which can be sealed
	• Non combustible/non-compactable		Puncture-resistant containers (metal)
	• Liquid-Aqueous		Thick walled polythene bottles or organic-glass containers but should have secondary container to prevent them from breaking
	• Spent sealed sources		Container in which the source was originally received.
D4	Laboratory Waste	Brown	• Containers with appropriate labels
D4.1	• Acids		Acid label
D4.2	• Alkalis		Alkali label
D4.3	• Solvents		Solvent label
D4.4	• Organic Substances		Organic substances label
D4.5	• Heavy metal (e.g. Mercury)		Heavy metal label
E	Incinerator Ash/Sludge	Yellow	• Metal containers labelled "Sludge" "Ash"
Source: WHO,1999			

7.3 Annex 3 - Incinerator Technical Specifications

	DESCRIPTION	Class 1	Class 2	Class 3	Class 4
CHIMNEY AND BREACHING	Standard top type – Self supporting				
PERFORMANCE	Capacity(kg/hr)	≥300	70	50	≤32
	Refuse	Health care Waste	Health care waste max. 15% plastic or dry paper	Heath care waste max. 15% plastic or dry paper	Health care waste max 15% plastic (or dry paper)
	Average Moisture (%)	15-25	15-20	15-20 on first one	
	Air pollution Std	SI 141 of 1996			
DIMENSIONS	High (mm)	3455	1785	1625	1502
	Length (mm)	3370	1540	1440	1080
	Width (mm)	3370	1610	1410	1060
	Loading door opening(mm x mm)	750x750	450 x 450	450 x 450	435 x 250
	Grate/Hearth area(m^2)	3.72	0.68	0.56	0.3
	Primary Chamber volume(m^3)	5.56	0.60	0.45	0.24
	Secondary Chamber total volume(m^3)	7.60	0.70	0.45	0.14
	Minimum stack diameter(mm)	933	394	324	226
	Approximate weight (kg)	25800	4400	3100	1800
MATERIALS	Casing	5.0mm mild steel plate	4.5mm mild steel plate	4.5mm mild steel plate	3.0mm &4.5mm mild steel

	DESCRIPTION	Class 1	Class 2	Class 3	Class 4
	Bracing	Mild steel	Mild steel	Mild steel	Mild steel
	Fire gate	High grade cast iron	High grade cast iron	High grade cast iron	High grade cast iron
	Ashing door	High grade cast iron	High grade cast iron	High grade cast iron	High grade cast iron
	Loading door	Heavy mild steel plate lined with castable refractory and insulation	Heavy mild steel plate lined with castable refractory and insulation	Heavy mild steel plate lined with castable refractory and insulation	Heavy mild steel plate lined with castable refractory and insulation
	Grate/Hearth support	Heavy mild steel sections	Heavy mild steel sections	Heavy mild steel sections	Heavy mild steel sections
	Refractory	High alumina monolithic	High alumina monolithic	High alumina monolithic	High alumina monolithic
	Insulation-walls	High temperature insulation bricks	High temperature insulation bricks	High temperature insulation bricks	High temperature insulation bricks
	Insulation- Roof	Calcium silicate boards and air traps	Calcium silicate boards and air traps	Calcium silicate boards and air traps	Calcium silicate boards and air traps
CONTROLS	Draught control	Natural induction and door operated draught reducer	Natural induction and door operated draught reducer	Natural induction and door operated draught reducer	
			Secondary /natural and venture induction	Secondary /natural and venture induction	
	Air supply	Primary- quarl induction,	Primary- quarl induction, vortex	Primary- quarl induction, vortex	Primary- quarl induction, vortex

	DESCRIPTION	Class 1	Class 2	Class 3	Class 4
		vortex interruption and door operated limiter Secondary – natural and venture induction	interruption and door operated limiter Secondary – natural and venture induction	interruption and door operated limiter Secondary – natural and venture induction	interruption and door operated limiter Secondary – natural and venture induction
	Electric	Control panels, relays isolator, contractors circuit breakers	Control panels, relays isolator, contractors circuit breakers	Control panels, relays isolator, contractors circuit breakers	Control panels, relays isolator, contractors circuit breakers
		Switches, digital indicating temperature controller, pilot light, pyrometer (indicating)	Switches, digital indicating temperature controller, pilot light, pyrometer (indicating)	Switches, digital indicating temperature controller, pilot light, pyrometer (indicating)	Switches, digital indicating temperature controller, pilot light, pyrometer (indicating)
AUXILIARY FIRING	Fuel	Diesel, Oil (or natural gas of LPG)	Diesel, Oil (or natural gas of LPG)	Diesel, Oil (or natural gas of LPG)	Diesel, Oil (or natural gas of LPG)
	Primary burner	RIELLO RG RL28 HILO or equivalent	RIELLO RG1 or equivalent	RIELLO RG2 or equivalent	RIELLO RG1 or equivalent
	Output	Max 332kW	Max 116kW		Max 116kW
	Secondary Burner	Photoelectric cell			
	Output	Max. 450kW		116kW	
	Flame monitoring	Photoelectric cell	Photoelectric cell	Photoelectric cell	Photoelectric cell

	DESCRIPTION	Class 1	Class 2	Class 3	Class 4
	Ignition	Auto spark after pre-purge	Auto spark after pre-purge	Auto spark after pre-purge	Auto spark after pre-purge
EMISSION CONTROL	System	Automatic regulation of air distribution, air quantity and rate of distribution	Automatic regulation of air distribution, air quantity and rate of distribution	Automatic regulation of air distribution, air quantity and rate of distribution	Automatic regulation of air distribution, air quantity and rate of distribution
	Particulate & fly ash	Heated refractory screen Low velocity grit settling Minimization of entrainment	Low velocity grit settling Minimization of entrainment	Low velocity grit settling Minimization of entrainment	Low velocity grit settling Minimization of entrainment
AUXILLARY EQUIPMENT	Firing tools	Rake, Straight poker	Rake, Straight poker	Rake, Straight poker	Rake, Straight poker
	Peepholes	Optional air cooled, glass fronted viewing point in loading door or rear wall	Optional air cooled, glass fronted viewing point in loading door or rear wall	Optional air cooled, glass fronted viewing point in loading door or rear wall	Optional air cooled, glass fronted viewing point in loading door or rear wall
PAINTING	Casting	Hammerite deep green	Hammerite deep green	Hammerite deep green	Hammerite deep green
	Roof	Hammerite silver grey	Hammerite silver grey	Hammerite silver grey	Hammerite silver grey
	Stack-mild Steel	Hammerite silver grey	Hammerite silver grey	Hammerite silver grey	Hammerite silver grey
	Stack- 3CR12	Pickled and passivated.	Pickled and passivated.	Pickled and passivated.	Pickled and passivated.

	DESCRIPTION	Class 1	Class 2	Class 3	Class 4
SITE REQUIREMENTS	Foundation	Flat and level concrete base under the incinerator	Flat and level concrete base under the incinerator	Flat and level concrete base under the incinerator	Flat and level concrete base under the incinerator
	Shelter	Weather protection over the incinerator in particular control panels and burner(s)	Weather protection over the incinerator in particular control panels and burner Optional chimney flashing by macrotech. Upstands around the hole in the roof by others	Weather protection over the incinerator in particular control panels and burner Optional chimney flashing by macrotech. Upstands around the hole in the roof by others	Weather protection over the incinerator in particular control panels and burner Optional chimney flashing by macrotech. Upstands around the hole in the roof by others
	Electric power	Single phase/220V/10 Amp/50hz to Isolator of controls.	Single phase/220V/10 Amp/50hz to Isolator in the controls panel.	Single phase/220V/10 Amp/50hz to Isolator in the controls panel.	Single phase/220V/10 Amp/50hz to Isolator in the controls panel.
	Fuel supply	10mm gravel feed connected to fire valve of incinerator	10mm gravel feed connected to fire valve of incinerator	10mm gravel feed connected to fire valve of incinerator	10mm gravel feed connected to fire valve of incinerator
	Access	Reasonable access to permit the entry of all components of the Incinerator and Chimney stack to be	Reasonable access to permit the entry of all components of the Incinerator and Chimney stack to be ensured by others.	Reasonable access to permit the entry of all components of the Incinerator and Chimney stack to be ensured by others.	Reasonable access to permit the entry of all components of the Incinerator and Chimney stack to be ensured by others.

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