



THE INCINERATOR GUIDEBOOK

A practical guide for selecting, purchasing, installing, operating and maintaining small-scale incinerators in low-resource settings



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Disclaimer

The author's views expressed in this publication do not necessarily reflect the views of the Office of the Global AIDS Coordinator (OGAC), the CDC, USAID or the United States Government.

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Acronyms and Abbreviations

HCWM	Health care waste management
JSI	John Snow, Inc.
WHO	World Health Organization
CDC	Centers for Disease Control and Prevention
AED	Academy for Educational Development
USAID	United States Agency for International Development
HCW	Health care waste
PQS	Performance, quality, and safety
WDU	Waste disposal unit
Btu/kg	British thermal units per kilogram
EPA	Environmental Protection Agency
EU	European Union
PVC	Polyvinyl chloride

I. Introduction

Purpose and approach

This guidebook is intended to be a practical guide for selecting, purchasing, installing, operating, and maintaining small-scale incinerators in low-resource settings. Small-scale refers to incinerators with a capacity to destroy approximately 12 to 100 kilograms of waste per hour. For the duration of this document, the term incinerator will refer to small-scale incinerators. This guide was designed to help program planners address the challenges of safe management of health care waste (HCW).

Every country and health setting faces different challenges to managing HCW safely. There is no one solution or technology that meets all needs. Programs must spend time to effectively plan and introduce any treatment solutions. The following information has been gathered to assist with this process.

This resource approaches the challenge of final disposal by providing key information on the following areas:

- Understanding incinerator performance.
- Available technologies.
- Selecting an appropriate incinerator.
- Best practices for procurement of small-scale incinerators.
- Installation.
- Training and supervision.
- Operation and safety.
- Maintenance and repair.

To date, developing countries have had more experience with brick incinerators and this guide reflects that experience. As more, lower-cost incinerator technologies become available and are introduced in low-resource settings, it will be important to publish and share these experiences with the global community.

Background

Developing countries face an urgent need for affordable, safe, and appropriate solutions for treating infectious waste. Without treatment by heat, steam, or chemicals, used needles and syringes (i.e., “sharps”) can cause infection and injury. Untreated safety boxes filled with used sharps pile up outside health facilities, allowing easy access by curious children or animals. Even if immunization programs specify that safety boxes must be treated according to national policies and standards, programs in low-resource countries may be forced to resort to whatever means are available to dispose of infectious waste. One common approach is burning infectious waste in a shallow pit, which generates toxic emissions and leaves behind melted plastic as well as needles that are often still sharp and infectious. Additional risks include environmental impacts to air and water quality.

Managing infectious medical waste in developing countries has become an increasingly complex issue. Global standards for acceptable performance of health care waste management (HCWM) do not exist. At the national level, policies are often lacking. Technological solutions are limited. In an attempt to address the dangers, products, needs, and environments are often mismatched. Appropriate technology combined with support and increased awareness has the immediate potential to substantially improve waste management practices in many countries.

The World Health Organization (WHO) advocates for a relative risk approach to waste treatment—that is, weighing the health risks from environmental exposures against the risks posed by accidental infection from poorly managed infectious waste (particularly sharps). WHO has indicated that until the infrastructure and resources are available, there is a need for immediate

improved solutions for waste treatment that are appropriate for low-resource settings. WHO also recognizes the need to identify feasible and cost-effective approaches that minimize environmental damage.

The trend in the developed world has been toward environmentally friendlier waste treatment solutions such as autoclaving and shredding of sharps, which destroys pathogens, prevents the potential for reuse, and reduces waste volumes. However, the higher cost of these technologies, lack of durable designs, and the lack of reliable electrical supplies in many developing countries has prevented these technologies from being widely used.

The role of incineration

Until now, appropriate, non-incineration technologies that respond to infrastructure and cost limitations are identified, incineration is a valuable, medium-term solution for safely treating and disposing of infectious waste including sharps in many resource-limited settings.

Incineration uses combustion to make infectious medical waste harmless and reduce the waste mass and volume by more than 90 percent. Proper incineration can convert certain wastes into gases and incombustible solid residues (e.g., ash) that are relatively harmless. A dual-chamber incinerator operated within the optimal temperature range of 650° to 1,000°C results in a lower level of emissions. The gases from incineration are released into the atmosphere (with or without gas cleaning). Residue ash from proper incineration can be encapsulated in designated ash pits or controlled landfills without any major risk. However, when the conditions are not adequate—for example, when the waste is not properly segregated or the incinerator is not properly constructed or operated—toxic compounds can be found in the unburned waste, and harmful gases can be released into the atmosphere. Good planning, technical oversight, and sustained supportive supervision of incinerator systems are critical to ensuring safe incineration.

Large-capacity, cleaner-burning incinerators usually rely on electricity and fossil fuels to maintain their emission standards. These technologies are often installed in large cities where electric power is available. The units can also be used as part of a collection and transport system. However, such systems are limited in many settings, especially when the roads are impassible or in poor condition as they often are during the rainy months. In addition, such centralized systems put a budgetary strain on governments, and they may fail for lack of fuel, power, and spare parts.

Small-scale incinerators that meet minimum performance parameters can significantly improve current waste treatment practices, particularly in the short and medium term.¹ Although WHO has not issued performance, quality, and safety (PQS) standards for small-scale incinerators, small-scale brick incinerators, such as the De Montfort and Waste Disposal Unit (WDUs), have been purchased and constructed for immunization campaigns and in some curative health settings.² Experiences with small-scale incinerators in developing countries over the past ten years point to several performance criteria that reduce emissions and improve incinerator quality and safety. Although the WHO policy paper on safe HCWM does not identify clear performance criteria for small-scale incinerators, evaluations have determined that several factors improve performance.¹ Ideally, small-scale incinerators should operate within a temperature range of 650° to 1,000°C, have at least two incinerator chambers, and have a minimum of one second of smoke-residence time.² Clear, practical

¹ World Health Organization (WHO). *Policy Paper: Safe Health Care Waste Management*. Geneva: WHO; 2004. Available at: http://www.who.int/immunization_safety/publications/waste_management/en/HCWM_policy_paper_E.pdf. Accessed March 12, 2010.

² Batterman S. *Assessment of Small-Scale Incinerators for Health Care Waste*. Ann Arbor: University of Michigan, Environmental Health Sciences; 2004. On consultancy for WHO.

performance guidelines are needed to assist countries, donors, and programs to procure acceptable, improved treatment methods for infectious waste from immunization and other health programs.

Practical challenges

A four-country survey and assessment of small-scale incinerators for health care waste conducted by Stuart Batterman in 2004 confirmed widespread deficiencies in the design, construction, placement, operation, and management of the units.² Such deficiencies can result in poor performance of the incinerator (e.g., low temperatures, incomplete waste destruction, inappropriate ash disposal, high smoke emissions, or fugitive emissions). Still, user acceptance of small-scale incinerators appears generally high, and the use of incinerators is preferred over waste disposal in unsecured pits or landfills, or uncontrolled burning of waste in drums or pits. The following were recommendations from Batterman's survey:

Best practices for small-scale incineration²

- Effective waste reduction and waste segregation.
- Installation of an engineered design, ensuring that combustion conditions are appropriate (residence time and temperatures that minimize incomplete combustion).
- Construction adherence to detailed dimensional plans to avoid common flaws that cause incomplete destruction of waste, higher emissions, and premature failures of the incinerator.
- Training of incinerator operators on appropriate start-up and cool-down procedures, maintenance of optimal operating temperatures, visible emission monitoring, appropriate loading/charging rates, proper ash disposal, recordkeeping to track quantities of waste destroyed and auxiliary fuel used, and occupational safety.
- Periodic maintenance to replace or repair defective components (e.g., inspection and spare parts inventory).
- Placement of incinerators away from populated areas or where food is grown.
- 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.

II. Understanding Incinerator Performance

The following section will provide a general overview of how incinerators work, including a description of their key performance indicators.

There are two main types of incinerators: auto-combustion incinerators and fuel-assisted incinerators. It is important to consider the factors outlined above when determining which of the two is most appropriate for the intended use scenario.

Some types of waste have enough heat value to support their own combustion (auto-combustion), and additional fuel such as wood or kerosene is only necessary for the initial ignition. In other cases, the heat value of the waste is too low and additional fuel is required to maintain combustion (fuel-assisted). The composition of the waste to be destroyed as well as the design of the incinerator must be considered when selecting the appropriate incinerator type. For low-income countries it is often necessary that incinerator designs are selected which support auto-combustion in order to reduce the operational costs.

Wastes containing halogens, phosphorus, sulphur, or nitrogen can generate noxious by-products when burnt, thus they require a more sophisticated technology than do wastes which only contain carbon, hydrogen, and oxygen. Therefore, the choice of incinerators and their potential gas-cleaning system will depend on the waste itself. Some wastes are not suitable at all for incineration (such as highly explosive and/or radioactive materials).

Combustion 101

Good combustion requires the right combination of carbon and oxygen. The important factors of oxygen supply in an incinerator design are:

1. Air inlets must be the right size and in the correct location to allow a good mixture of air (oxygen) with the waste (gasses).
2. Chimney diameter and length must be carefully designed (not too short and not too long) in order to control draught.
3. Incinerator itself should be located away from obstacles like buildings and trees.
4. Ashes and other residues that block the free passage of air (oxygen) must be removed routinely.

An incinerator, when operated, should have low or zero visible emissions and should not emit solid particulate matter from the stack. Thick black smoke should never be emitted; if it is, this is a sign that the incinerator is either inadequate or is not being operated properly.

Auto-combustion incinerators

In an auto-combustion system, the incinerator is preheated using dry wood and/or other agricultural residues (e.g., coconut shells, charcoal, etc.). At some point, the waste itself generates the heat for continued combustion during the waste disposal process. Auto-combustion incinerators are substantially cheaper to operate than fuel-assisted incinerators, however auto-combustion incinerators are not suited to destroy placenta or anatomic waste unless anatomic waste is interspersed with safety boxes, dry wood, or charcoal in a ratio of 1 kilogram of anatomic waste to 3 kilograms or more of plastic, wood or charcoal.

Auto-combustion incinerators are able to destroy non-sharps infectious waste if the ratio by weight of safety boxes, wood, or charcoal to non-sharps waste is 2:1 or greater. In consideration of the amount of plastic waste generated by injections, it is important that incinerator technologies which can destroy 50 to 100 percent plastic in the waste load without causing damage to the refractory materials are selected. It is important that metalwork in the incinerator is stainless steel or cast iron if incinerator equipment is expected to be operational for more than three years without replacement.

Fuel-assisted incinerators

Fuel-assisted incinerators require a fossil fuel (diesel or gas) and a continuous electrical power supply to operate. Fuel-assisted incinerators are sometimes prone to damage if an electrical power failure occurs during operation.

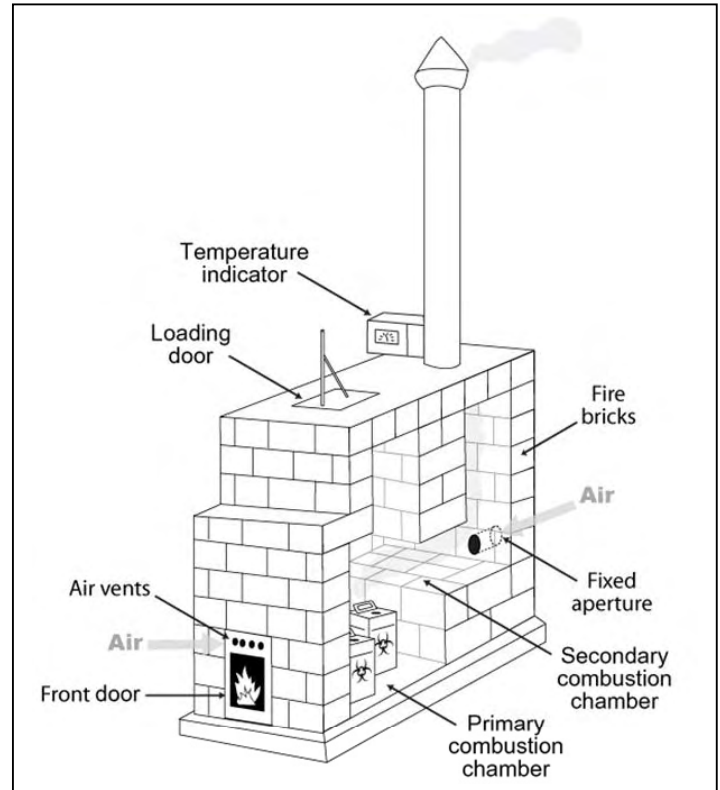
The better-designed fuel-assisted incinerators control the fuel supply in order to maintain constant combustion temperatures and to economize on fuel consumption. Fuel is injected into both the primary and secondary chambers, along with auxiliary air through blowers.

Most fuel-assisted incinerators with a capacity to destroy 100 to 150 kilograms of waste per day consume 5 to 8 liters per hour of fuel (4 to 6.5 kilograms of gas). It is important to note that some fuel-assisted incinerators cannot destroy more than 15 to 25 percent of plastic per load because of the high caloric value of plastics and the damage that can be caused to the refractory lining.

Temperature

An incinerator should operate in the temperature range of 800° to 1200°C when medical waste is incinerated. Toxic fumes including furans and dioxins are emitted at temperatures below 600°C if polyvinyl chloride or certain other materials are incinerated.

Figure 1. Standard components of a small-scale incinerator.



Residence time

The gas-residence period should not be less than one second. The gas residence period is the amount of time that the gases take to travel through the incinerator. The gases should travel through the incinerator as slowly as possible, a process that greatly reduces the toxicity of the fumes emitted.

Fuel to waste ratio

In principle, all products containing enough carbon, hydrogen, and oxygen will burn well as long as there is a low water (moisture) content. The different heating values of products found in health care waste can be expressed in British thermal units per kilogram (btu/kg).

Some types of waste have enough heat value to support their own combustion (auto-combustion), and additional fuel such as wood or kerosene is only necessary for the initial ignition. The heat value of other types of waste will be too low for auto-combustion and will require additional fuel in order to maintain combustion (fuel-assisted.) The composition of the waste to be destroyed must be considered when selecting an incinerator.

Lifecycle

An incinerator should be corrosion resistant. An auto-combustion system should have a 5-year lifecycle; a fuel-assisted system should have a 10-year lifecycle.

The stack height of an incinerator must be superior to 4 meters so that the stack emissions are not in contact with operators or others in the immediate proximity. Any incinerator selected should be purchased complete with sufficient consumable parts (i.e., fuel filters, burner nozzles, etc.) and replacement parts (i.e., grates, refractory liners, temperatures sensors, etc.) to ensure operation of the incinerator for its planned life cycle.

III. Selecting an Appropriate Incinerator

The following are key steps to follow when selecting the appropriate incinerator for HCWM to meet country and programmatic needs. Whether selecting one incinerator for one health facility or selecting several for a country, following the steps below will help ensure that the appropriate technologies are procured to meet the HCWM system needs.

When planning for a large-scale procurement of multiple units, the selection process will take considerable effort but is a necessity when investing a large amount of money into the system. Even when procuring one incinerator, following these steps will take time.

This guidebook provides general information about each step in the procurement process and the questions that need to be addressed in order to guide country-level planning and decision-making. A resource developed by PATH, *Planning for Safe Syringe Disposal*, may be a useful reference for this process. This document can be found at http://www.path.org/files/TS_syringe_disposal_plan.pdf.

Key steps to selecting an incinerator design

1. Determine your health system needs for HCWM treatment and disposal solutions.
2. Assess the infrastructure of the area.
3. Determine availability of local resources to support construction and operation.
4. Assess policy environment.
5. Develop cost estimates.
6. Identify lead candidate incinerator designs and determine which units to procure.

Key steps for selecting an incinerator design

1. Determine your health system needs for HCWM treatment and disposal solutions.

In order to determine what type of incineration technology would best fit your health system needs, it is important to undertake the following:

- *Map existing HCWM infrastructure.* Where is the closest functioning incinerator or other treatment facility? Is transport of HCW possible? Will other facilities be interested in bringing HCW to this facility for disposal? If an incinerator does not exist, what is the best location to situate a centralized incinerator in a service area?
- *Characterize waste.* What types of HCW are produced in your facility/service area? What types require treatment by incineration?
- *Quantify waste.* How many safety boxes and bags of infectious waste are filled each day in your facility/service area? What other waste will need to be incinerated? Is there an effective segregation system in place already to minimize quantities of waste that require treatment?

2. Assess the infrastructure of the area.

What condition are the roads near the facilities where incinerators are needed? Is power available? Is there land available on facility grounds to construct an incinerator (including an ash pit)?

3. Determine availability of local resources to support construction and operation.

- *Determine availability of skilled engineers for installation.* Are there skilled engineers to manage proper construction and provide ongoing support once the unit is installed?
- *Determine availability of quality materials.* If constructing a unit such as a De Montfort and the project proposes procuring materials locally, are quality refractory bricks available? What about high-quality metal components?

4. Assess policy environment.

- *Determine if incineration technologies meet current environmental standards/policies.*

- *Determine if existing HCWM practices are aligned with national guidelines.*
- *Determine if facility placement and incinerator technologies are aligned with current national HCWM planning efforts.*
- *Document attitudes and public awareness about incineration.*

5. Develop cost estimates.

For each of the candidate incineration technologies, document all of the predicted costs including capital, operation, and maintenance costs. Be sure to include transport costs if planning to use a centralized approach. More detail on cost considerations are included below.

6. Identify lead candidate incinerator designs and determine which unit(s) to procure

Based on the information gathered through the steps outlined above, conduct an analysis to determine which incinerator technologies meet the health system needs and budgets. Again, multiple types of incinerators may need to be purchased depending on the HCWM system needs.

Budgeting for capital, operational, and recurrent costs

Fuel costs

A regular supply of fuel—whether for auto-combustion incinerators, fuel-assisted incinerators, or transportation of waste—is essential. Likewise, a system of monitoring and control of the use of fuels is equally important. Adequate budgetary provisions for fuel supply is essential. Facilities equipped with incineration equipment are encouraged to serve as a disposal facility for other facilities nearby on an as-needed basis for a fee. This would increase the waste throughput of the disposal unit, render its investment more economical, and cost-share its operation with other facilities.

Fuels used for auto-combustion incinerators are typically dry wood, charcoal, or coconut husks. Agricultural residues such as straw, corn husks, etc. do not generate sufficient heat to be used effectively as preheating and booster fuels. Fuel used in fuel-assisted incinerators is typically fuel oil, waste vegetable oil, liquefied petroleum gas, compressed natural gas, and methane, as well as electricity to power pumps, spark igniters, and control circuitry. Special attention should be paid when selecting fuel-assisted incinerators to ensure that the financial implications of installation, maintenance, and operation are fully understood and budgeted.

Lifecycle costs

The destruction capacity over the estimated life of the system is also important and is critical in the determination of life-cycle costs.

Procurement agencies frequently select equipment based upon the equipment capital investment costs. True equipment costs relate to the life-cycle costs and not just their capital cost.

Life-cycle costs include: accessories; shipping and insurance; electrical; civil and mechanical works associated with the installation; installation; cost of associated civil works such as ash pit, needle

Lessons learned: incinerator selection in Haiti

In Haiti, US\$1M in funding was received from donors and used to purchase 17 diesel-electric incinerators and 20 biomass-assisted incinerators.

The original technical specification was not followed by the donor agency and consequently one of the models chosen was inadequate for incineration of safety boxes due to design of the grate system. The second model had no temperature gauge and required additional biomass to be added throughout the burn cycle.

The civil work expenses for the installations were 4 times the capital cost of the incinerators: a US\$5,000 incinerator cost US\$25,000 installed. Once the incinerators were installed, it was determined the country would need more than US\$300,000 annual to cover fuel costs to operate the diesel-electric incinerators.

pit, placenta pit, rinsing station, protective enclosures; fuel supply and electricity through the period of operation; salaries of operators; supervisory and management time; training of operators and supervisors; service; and maintenance and spare parts. All of these cost elements should be taken into consideration when comparing the costs of incinerators.

Comparing costs

The table below is an illustrative example of how costs/capacity could be compared side by side including installation costs and life-cycle costs. Note that when considering the purchase of a WDU kit vs. installing a De Montfort-style locally manufactured unit, determine the availability of high-quality materials (including refractory bricks and metal parts) as well as skilled engineers to ensure the design is appropriate and the unit is installed correctly.

Table 1. Comparison of installed small-scale, auto-combustion incinerators currently in use.

Characteristics	CREATE* waste disposal unit (WDU)	De Montfort-style locally manufactured unit
Materials	\$5,000	\$2,000
Installation (including labor)	\$4,500	\$4,000
Days required to install	9	18
Annual maintenance costs	\$150	\$1,000
Average life span (years)	5–10	2–3
Capacity (day)	20–30 kg/day	15–20 kg/day

*CREATE=Centre for Renewable Energy, Appropriate Technology, and Environment.

**All amounts are in US dollars.

IV. Best Practices for Procurement of Small-Scale Incinerators

Ensuring the procurement of quality small-scale incinerators is integral to strengthening HCWM systems and supporting safe final disposal of HCW. An effective procurement for small-scale incinerators should:

- Meet the needs of the health system.
- Obtain a good quality incinerator at a fair and reasonable price.
- Arrange timely installation of the incinerator.
- Ensure supplier reliability with respect to service and quality.

Table 2. Procurement cycles for incinerators.³

Phases	Elements
I. Program planning	A. Defining incinerator requirements
	B. Setting specifications
	C. Selecting equipment
	D. Budgeting and planning for funding
II. Procurement	A. Planning for procurement
	B. Developing tender documents and inviting offers
	C. Selecting suppliers
	D. Entering a contract
III. Performance	A. Contracting performance monitoring and maintenance

Program planning

Defining incinerator requirements

Estimating requirements is the first step in program planning and is an opportunity to efficiently utilize resources. This step involves quantifying the number of incinerators required at a national, district, or a facility level. Depending on the type and size of the facility, multiple small-scale incinerators may be purchased; alternatively, single larger units may be purchased instead.

The involvement of personnel in this step will vary depending on the scope of the procurement planned. If a country is planning to procure incinerators at a national level, this will require the engagement of a group of people such as procurement personnel, technical experts, and field program personnel who are familiar with the types of facilities in need of incinerators as well as the catchment area that those facilities serve. An incinerator in a second-level facility can also be useful for a number of primary health facilities in the surrounding areas, given that waste transport is an option.

Setting specifications

Technical specifications are one of the most important elements of procurement because they provide detailed information to suppliers about the requirements of the incinerators to be purchased, and they also form the basis for the contractual obligation of the supplier to the purchaser.³ Technical specifications must be clear, accurate, and complete; otherwise the procurement process will be delayed or may even need to be cancelled.

³ Adapted from the Procurement Capacity Tool Kit: Tool and resources for procurement of reproductive health supplies. November 2009. Available at: http://www.path.org/files/RH_proc_cap_toolkit_v2.pdf. Accessed March 15, 2010

Whether fuel-assisted or auto-combustion, the choice of incinerator technology should be in accordance with technical requirements of each country. Key specifications for any small-scale incinerator model should be based upon the following:

1. Product information

Architecture

Basic architectural requirements should include:

- A minimum of two burning chambers: one to combust solids and one to combust gases.
- A temperature or visual indicator to display heat status of equipment.
- A durable refractory wall or liner capable of withstanding heat generated by waste loads of 100% plastic.
- A stack with a minimum height of 4 meters.

The architecture of the site should also include a secure enclosure for the incinerator, an ash and needle pit, arrangement for destruction of vials and glass syringes, a washing facility for reusable items, and a secure storage facility for waste. If a maternity ward is located onsite, a placenta pit may also need to be provided, if appropriate.

Performance

Any incinerator selected should:

- Operate in the range of 600°–900°C when destroying medical waste.
- Emit clear or near-to-clear (non-visible) emissions from the stack when destroying medical waste that has been properly segregated and loaded.
- Reduce the weight of waste by 95% or more once destroyed.

Durability

Any selected incinerator should:

- Be capable of destroying medical waste where the plastic waste content is greater than 50% by weight of the total load.
- Be constructed of corrosion-resistant materials (all components stainless steel or cast iron).
- Be simple in design and operation, with minimal electronic components.
- Have a lifespan of at least 5 years if auto-combustion type or 10 years if fuel-assisted (when used under normal conditions).

Health centers must have access to the required technical capacity to install, maintain, repair, and operate the system. Systems installed in remote areas should be robust and reliable. Operating costs of systems should be considered when budgeting for procurement. If budget is not available, systems will not be operated and waste will not be destroyed properly. Systems should be easy to start, operate, and clean, and ash should be readily disposed of (including glass vials if mistakenly loaded).

Manufacturer

The profile and reputation of the manufacturer or supplier is critical. The manufacturer must support their product so that reliable and good-quality service or support can be assured in the event of system defect or failure. Specifications should ensure that:

- Warranties and guarantees are provided for the expected life of the system.
- The terms and conditions for technical support are clearly defined.
- Training in installation, operation, and routine service is provided as an integral part of the supply agreement.
- Maintenance and repair support is provided for a predetermined amount of time.

- The experience and track record of the supplier is known.
- Installation manuals with civil works drawings as well as service and operator manuals are provided as part of the supply agreement. Manuals should be provided in the national language and must be simple and explicit.

Rate of disposal of waste or daily quantities to be disposed

The destruction capacity of incinerators—in terms of quantity of waste destroyed as well as their capacity to burn waste of different compositions—varies greatly among models. Daily destruction capacity is also related to the number of hours each day that an incinerator can operate. Limitations of operation may be related either to the technical capacity of the equipment or to program limitations such as working hours of staff or directions of prevailing winds.

Plastic waste as a percentage of total waste to be destroyed

Many incinerators have a limited capacity for destroying plastics. Auto-combustion incinerators also frequently have a limited capacity for destroying non-sharps infectious waste.

Registration requirements

Manufacturers of small-scale incinerators should meet specific requirements that guarantee the quality of their product. These requirements include a certificate of license in country of manufacture, as well as licensing and quality of materials.

2. Regulations

It is important to follow international standards and national guidelines for gas emission control of incinerators used for medical waste disposal. WHO has not developed a guideline value for emissions from a single source such as incinerators.⁴ However, there are other guidelines, such as those from the Environmental Protection Agency (EPA) and the European Union (EU), which can also be applied to a developing-country situation to ensure that the incinerator built or purchased is meeting proper requirements for gas emission control.

Regulatory guidelines for reference

- 74 FR 51367: US Environmental Protection Agency. Standards of Performance for New Stationary Sources and Emissions Guidelines for Existing Sources: Hospital/Medical/Infectious Waste Incinerators; Final Rule. October 6, 2009.⁵
- Directive 2000/76/EC: Of the European Parliament and of the Council of 4 December 2000 on the incineration of waste.⁶
- AP 42 and Emission Factors: US Environmental Protection Agency.⁷

3. Quality assurance provisions

Documentation

Manufacturer must provide the buyer with manufacturing records and certifications related to the product and materials.

⁴ WHO. *Findings on an Assessment of Small-Scale Incinerators for Health-Care Waste*. Available at: http://www.who.int/water_sanitation_health/medicalwaste/en/smincinerators.pdf. Accessed December 2009.

⁵ US Environmental Protection Agency. Standards of Performance for New Stationary Sources and Emissions Guidelines for Existing Sources: Hospital/ Medical/Infectious Waste Incinerators; Final Rule. Oct 6, 2009. Available at: <http://www.epa.gov/ttn/atw/129/hmiwi/fr06oc09.pdf>.

⁶ *Directive 2000/76/EC: Of the European Parliament and of the Council of 4 December 2000 on the Incineration of Waste*. Available at: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0076:EN:HTML>.

⁷ Emissions Factors & AP 42. Available at: <http://www.epa.gov/ttn/chief/ap42/index.html>. Accessed January 2010.

Inspection by the purchaser

Inspection of the incinerator should be performed by a certified engineer upon installation. The certified engineer must have extensive experience with incineration technologies and must also be able to guide the process of construction.

4. Construction

In addition to the standard specifications for the performance of the incinerator, it is essential to have a clear specification of the construction timeline.

5. Training and maintenance

Tender documents must also list specific requirements for training of operators and maintenance of the equipment. The company that is awarded the contract should have the capacity to perform training and maintenance for a specific period of time after installation of the equipment.

Selecting equipment

When selecting a small-scale incinerator, the buyer will first need to determine whether they will purchase a locally manufactured or prefabricated incinerator. For locally built incinerators, all the raw materials are sourced and manufactured locally, transported to the site, and assembled there. For prefabricated or “imported kit” incinerators, parts are prefabricated, integrated with materials which may not be available locally (i.e., refractory bricks, refractory cement, and high-grade stainless steel), and imported from the manufacturer or a procurement agency, then assembled onsite. This decision should be made strategically by management and will have a substantial impact on capital costs, workload of the local implementing agency, and good operational performance.⁸

The choice between locally manufactured and prefabricated incinerators should be based on:

- Capacity and expertise of the company to provide quality control and procure materials required to build and operate the incinerator.
- Local availability of appropriate materials required to build the incinerator.
- Availability of local agencies with technical capacity to correctly and accurately construct the incinerator.
- The number of incinerators purchased and the ability of the manufacturer to meet supply needs.

Budgeting and planning for funding

Procurement or program personnel should research incinerator prices as a first step in order to develop a reasonable cost estimate. Initial price information can be obtained through websites and company representatives. It is also important to ask the company to provide a detailed description of what is included in the quote.

In addition to the price of the equipment, procurement personnel should estimate other associated up-front costs, such as shipping (if applicable), fees and commissions, technical consultancies, inspection and testing, out-of-pocket transaction expenses, import costs, and taxes. Operation costs will also need to be considered by program planners.

⁸ Managing health care waste disposal. Best practices in construction, use and maintenance of small-scale incinerators. October 2004. Available at: http://www.path.org/files/TS_waste_disposal_guide_part1.pdf. Accessed March 15, 2010.

Procurement

Planning for procurement

In addition to selecting the equipment type and model, it is essential to determine the procurement method for the purchase. The following are the most commonly used procurement methods.³

1. **Competitive bidding:** This is one of the most complex methods of procurement used and is the method of choice for most international lenders such as the World Bank. Competitive bidding would be ideal when several suppliers are available and reasonably large quantities are expected, as well as for systems that have adopted principles of good public-sector procurement. Tender documents provide product specifications and performance expectations in addition to rules and instructions about how to submit offers. Each offer is evaluated on its technical, commercial, contractual, and financial merit, and a winning bid is chosen in accordance with criteria described in the bidding documents. No negotiation is allowed except with regard to minor contractual points. Types of competitive bidding include:
 - *International competitive bidding (ICB).* This type of competitive bidding ensures that all suppliers available have an equal opportunity to participate in the tendering process. International competitive bidding is a complex process at the country level, but this process generally ensures the lowest price.⁹
 - *Local on national competitive bidding (LCB).* LCB is an efficient and economical way of procuring goods that are unlikely to attract foreign competition. Procedures are the same as ICB, but advertisement of the bid will only go to national press or local official publications.

When competitive bidding is not an option, other procurement methods can be chosen depending on the circumstances, expertise, and timeline of the program. Other procurement methods include:

- *Request for quotation (with or without negotiation).* Proposals are solicited from a limited number of manufacturers and suppliers. Offers are opened as they arrive, and price and content are considered on a case-by-case basis and may be negotiated. A contract is awarded based on the lowest price and what is considered to be the most advantageous offer.
- *Sole-source procurement (with or without negotiation).* Price and terms are negotiated with one chosen supplier without the benefits of competition.
- *Negotiated procurement.* The buyer approaches a small number of selected potential suppliers and bargains for price and conditions.
- *Shopping.* Selection is based on comparison of prices published or otherwise communicated by at least three suppliers. This is not appropriate for high-quantity or high-value contracts.

The procurement method is usually set by the entity that provides the funds to pay for the incinerators. The funder may be a government, a donor, a development bank, or an independent organization. Funders often specify the procurement method to be used depending on the financial threshold of the purchase. They may assign longer, more complex methods to higher-value purchases unless there are preventing circumstances such as a limited number of potential suppliers, which is currently the case for small-scale incinerators.

⁹ Procurement of vaccines for public sector programmes. A reference manual. Available at: http://whqlibdoc.who.int/hq/2003/WHO_V&B_03.16_PartI_eng.pdf.

Developing tender documents and inviting offers

Preparation of tender documents and inviting offers will depend upon the equipment option selected (e.g., purchase of a kit versus local installation), as well as the method of procurement that is chosen. **Note: Procurement decisions must be aligned with local procurement regulations and must comply with procurement requirements set by the funder.** The selected contractor must deliver according to the contracted specifications.

Procurement of prepackaged kits

Pre-packaged kits include all fabricated metal components and other materials (refractory bricks, cements, etc.) that are usually not available in country. However, the kit will not include everything that is required and some things will have to be procured locally. Buyers can purchase pre-packaged kits from suppliers and request quotes for construction, installation, and maintenance.

Procurement of locally produced components of a small-scale incinerator

In this case the buyer is required to solicit quotes for all materials required to build the incinerator, as well as quotes for construction, installation, and maintenance of the incinerator.

In general, the purchaser prepares a set of documents that include essential information and requirements that the manufacturer or designer of the incinerator must know in order to submit a response to the tender.

Table 3. Tender documentation required.

Procurement of prepackaged kits	Procurement of locally produced incinerators
Tender documents should include the following: <ul style="list-style-type: none"> ▪ Specifications of locally available materials not included in the kit. ▪ Construction, installation, and maintenance. ▪ Training of operators. <i>In this situation, the buyer purchases a prepackaged kit with specific features related to performance; therefore, there is no need to include performance specifications.</i>	Tender documents should include the following: <ul style="list-style-type: none"> ▪ Performance specifications. ▪ Specifications for all materials needed to build the incinerator. ▪ Construction, installation, and maintenance. ▪ Training of operators
In both cases, construction and installation will require guidance and direction from experienced engineering consultant services with track records of good installation of incinerators. Buyers need to plan for these services when budgeting for incinerators construction.	

See Annex 2 for examples of requests for quotes for small-scale incinerators.

Selecting suppliers

The evaluation of the supplier's documentation should be performed by a committee, which should include the following personnel:

- Technical experts in the field of incineration to help evaluate the documentation and certification submitted by the suppliers.
- Procurement person who is familiar with the process required to procure incinerators.
 - Program person who is familiar with field issues and the budget for the project.

Additionally, the evaluation committee should check to see that the suppliers have confirmed that they:

- Are capable of providing the quantities required within the desired timeframe.
- Have a proven record of manufacturing the product that conforms with the technical specifications described in the document.
- Accept the general and specific conditions of the contract.

Entering a contract

The signed contract between the purchaser and the supplier legally binds the commitment for the equipment specifications, delivery requirements, and performance obligations of both parties. It also provides legal recourse for the parties involved in case of lack of performance or disputes.

Besides the inclusion of the equipment specifications, schedule, and terms and conditions, the purchaser needs to consider the contract type and payment arrangement for the supplier. The most appropriate contract type for the purchase of incinerators is a firm fixed price contract. This means the equipment price is not subject to any adjustments and puts the cost risk and responsibility on the supplier.

There are several payment options that can be used for contract payment. In most procurement methods, the supplier is in a stronger position to dictate contract payment terms, but the purchaser is free to negotiate. Regardless of the payment option used, it is important for the purchaser to complete the payment arrangement responsibilities in a timely manner, as many international suppliers and international supply services will not accept the risk of beginning production or procurement of a large order until they have received either a letter of credit, a down payment, or cash in advance. Delays in processing payment arrangements are likely to cause a delay in shipping.

Finally, timely contract award is important because it avoids the possible expiration of a supplier's proposal pricing and helps ensure the equipment is available when needed.

Performance

Contract performance monitoring and maintenance

The key objectives of a contract performance monitoring system are to:

- Ensure that all technical specifications and contract requirements are met.
- Identify performance problems early on and correct them.
- Provide information on a supplier's performance when considering the supplier for future contracts.

Quality control of the following aspects is required to ensure successful installation and operation of the incinerator:⁸

- Planning and preparation: Validate decisions based on the form of procurement chosen (kit versus local procurement).
- Materials reception: Verify that the materials supplied comply with the technical and materials specifications.
- Evaluation of demonstration models by the agencies responding to the tender.
- Construction phase: Verify each step according to the timeline for construction.
- Operator and supervisor training and certification: Ensure training in best practices for all operators.
- Maintenance and service: Periodic supervisory visits to monitor post-installation maintenance and to ensure service support for a determined time period (recommended timeframe 10 years).

V. Installation

Installation of incinerators should include site preparation, equipment installation and commissioning, service and operating instructions provided by the manufacturer, assured manufacturer support, metal works (fuel tank, filter and supply lines, electrical power supply, etc.), and civil works (foundations, pits, water supply and run off for rinsing reusable recipients). Security and the safety of the installation need to be given great importance.

The following sections summarize civil engineering requirements applicable to permanent HCWM disposal sites.

Site selection

Certain measures need to be taken to protect the local communities from the possible hazards of medical waste. Incinerators should never be installed in areas where crops are grown; particles from the smoke emitted by the incinerators can settle on crops, making them highly toxic. If for whatever reason incinerators have been installed near cultivated land, the incinerator should be operated only when the wind is blowing away from the crops.

The selection of an appropriate location to install an incinerator is of paramount importance. Key factors to be taken into consideration are:

- The location should be at least 30 meters away from the closest occupied or inhabited building.
- The prevailing winds at the location should blow in a direction away from occupied buildings.
- There should be no regular public passage within immediate proximity of the incinerator.
- There should be no horticulture or leaf crops within 300 meters of the incinerator in the direction of the prevailing winds.
- The bottom of the ash pit should be above the maximum level of the water table.
- The location should be secure and free from risk of vandalism or theft.
- The location should permit construction of a facility to house the incinerator (unless designed for external use) and store the waste awaiting disposal. The site should also include an ash pit and placenta pit (as appropriate).

Incineration by itself is not a solution for medical waste disposal. A complete, self-contained waste management system needs to be put in place. This includes an incinerator; a secure waste storage facility; a fuel store; an area for glass and sharps deposit; a protected ash disposal pit; a lockable secure enclosure for the incinerator; a facility to store the tools, protective clothing, and operator records; and a washing area with waste water runoff.

Protective enclosure

Incinerators should be installed in a protective enclosure or suitably ventilated building to prevent access by unauthorized persons and to protect the incineration equipment. A protective enclosure or building should ensure that:

- The incinerator and other materials stored inside are protected from rain and UV radiation from direct sunlight.
- The incinerator is well ventilated and the stack emissions are clear of the building or enclosure so that the operator is not exposed to fumes when the incinerator is in use.
- The enclosure is robust and corrosion resistant, and its design-life is at least equivalent to the expected life of the incinerator.
- The enclosure or building can be securely locked against unauthorized entry.

- There is space within the enclosure to store the operator's protective clothing, tools, and equipment required to operate the system. There should also be sufficient space to conveniently store waste to be destroyed, as well as load and operate the incinerator.
- There is provision for an emergency exit should there be a fire or other emergency at the facility.
- There is storage space for solid fuels or a storage reservoir for fuel. This is best located within the incinerator enclosure to ensure adequate security.
- The enclosure has a provision for waste to be deposited without allowing the waste handle, to enter the enclosure or building.

Ash pit

All HCWM sites using incineration should be equipped with an ash pit that has sufficient capacity to store ash for a period of at least 5 years. Essential features of a pit are:

- The pit is positioned above any shallow aquifer.
- The pit is positioned to prevent risk of flooding.
- The pit is constructed of concrete, concrete blocks, or brick, with a water-resistant floor to ensure the pit will not collapse.
- The pit has provision to deposit ash or other authorized wastes (i.e., needle containers), without a risk to the waste handler.
- There is provisional access to the pit for purposes of leveling or removal of accumulated waste and subsequent transfer to a municipal landfill.
- The pit is protected from access by unauthorized persons.
- The pit is in the immediate proximity of the incinerator to ensure convenient transfer of ash.

Fuel storage

All incinerators require fuel either to preheat (in the case of auto-combustion incinerators) or to assist throughout the incineration process (in the case of fuel-assisted incinerators). Safe and secure storage of incinerator fuel is imperative. There should be adequate space to safely store dry solid fuel (wood, coconut husks, charcoal, etc.) sufficient for at least one week of operation of the incinerator at auto-combustion sites.

A storage reservoir, fuel filter, and shutoff tap or valve should be positioned within the enclosure or building to ensure the fuel supply is not exposed to excessive heat from the incinerator. It should be mounted at an appropriate level to ensure a gravity supply of fuel and deter access by unauthorized persons. Any storage reservoir should be large enough to store fuel for 3 times the period between normal waste deliveries.

Water supply

All HCWM disposal facilities should be equipped with a water supply (spigot) mounted above a concrete pad with either a gutter for runoff and percolation into the ground or connection to a drainage channel. All recipients (e.g., plastic containers, bins, etc.) should be thoroughly rinsed before being returned for reuse.

Glass disposal

Glass vials deposited in incinerators tend to clog grates and causes explosions when unopened. As a general rule, glass should not be incinerated. The increasing use of glass syringes for new prefilled vaccines represents a new challenge to waste disposal since these syringes are infectious and should not be incinerated with other waste.

A glass crusher with provision for crushed glass to be heated and sterilized will be essential at disposal facilities in the coming one to two years as new vaccines emerge packaged in glass. Provision of space within the enclosure or building for equipment to crush glass syringes and vials is important.

Placenta pit

If you are using a fuel-assisted incinerator at a facility where a maternity unit is located then, subject to local customs, a placenta pit should be built. Auto-combustion incinerators are not suited to destroying placenta. The pit should be located at some distance (20 meters or more) from the incinerator enclosure.

Equipment inspection

Each incinerator needs its own checklist. The manufacturer should help to put this checklist together, as they know best which parts might break and require replacement. The supervisor needs to inspect the system quarterly at a minimum. In order to determine the condition of the system, and predict possible problems or failures across the network. In this way, spare parts can be ordered in advance so they are available if and when the need arises.

Lessons learned: WDU Construction in Rwanda

Rwanda constructed 13 small-scale incinerators for HCW disposal in 2005. Design criteria for these incinerators included:

- A temperature gauge to help operators manage the performance of the incinerator to maximize combustion.
- Air-flow valve in the chimney to buffer the residence time of gas in the secondary chimney when different waste types were loaded.
- Addition of an underground ash pit with easy access to the ash chamber.
- A needle pit to safely contain needles removed with needle removers in clinical settings.
- A secure enclosure to control community access to equipment and to provide storage space for waste, tools, protective equipment, and record keeping.

A report was prepared by the PEPFAR-funded through CDC and USAID MMIS project in 2006 detailing lessons learned by partners during this project. (www.mmis.jsi.com). A 2008 assessment by the Rwanda Ministry of Health and PATH concluded that additional hands-on operator training was required; that personal protective equipment meeting performance specifications was not available in Rwanda; and that the weaknesses of construction materials, metalwork, and non-adherence to technical drawings could be overcome. The cost-effective method identified to tackle these issues was to import critical components including refractory bricks and precise metalwork in stainless steel. Recommended specifications for future construction of waste disposal units in Rwanda can be found in Annex 3. For more information, see: http://www.create.org.in/wdu_glance.htm.

VI. Training and Supervision

It is important that incinerator operators are considered as critical to safe health care waste disposal as the incinerator technology itself. A training program must be provided that develops a sense of pride in the role that incinerator operator plays in keeping health care workers and the community safe. Testing shows that the incinerator operator can impact the emissions generated by an incinerator by ensuring a primary chamber preheating temperature and controlling the rate of waste loaded.¹⁰

There must be a clear understanding of the guidelines for incinerator operation—as with all things, it is important that incinerator operators have an opportunity to practice the proper operation of the incinerator with an experienced trainer and that follow-up training is planned.

Trainers must understand and know how to teach the principles of incineration. Trainers must also be able to communicate complex tasks in simple terms and be able to train at the incinerator site, working with the participants in an interactive training environment.

Resources for training incinerator operators include's training resources (available at: http://www.path.org/projects/health_care_waste_resources.php#training) as well as WHO's Managing Health Care Waste Disposal: Operator's Manual (available at: http://www.path.org/files/TS_waste_disposal-operators.pdf).

MMIS/Kenya has also developed a guide for incinerator operators that will be available on PATH's HCWM resource page, as well as the MMIS Website (www.mmis.jsi.com).

¹⁰ Jangsawanga W, Fungtammasana B, Kerdsuwan S. Effects of operating parameters on the combustion of medical waste in a controlled air incinerator. *Energy Conversion and Management*. 2010;46(20):3137–3149.

VII. Operation and Safety Guidelines

Health worker safety

Health workers such as doctors and nurses, waste handlers, and incinerator operators are at risk of disease transmission from health care waste, and in particular from sharps infectious waste.

Personal protective equipment (PPE) must be selected to protect against risks specific to incinerator operators. The major risks to these staff are encountered either during direct contact with medical waste or when incinerator operators are exposed to heat or fumes emitted by incinerators while burning health care waste. Risks encountered during direct contact with medical waste include HIV and hepatitis B infection through needlestick injuries.

Wearing PPE reduces risk from sharps, germs, exposure to blood and other bodily fluids, splashes from chemicals, inhalation of exhaust, and sparks from the incinerator. A job aid was developed to remind incinerator operators what to wear in terms of PPE (see Annex 4).

PPE for incinerator operators includes:

- Helmet
- Safety goggles
- Respirator mask
- Heavy-duty, heat-resistant gloves
- Apron
- Clothes that cover the body
- Heavy-duty, heat-resistant boots

Image 1. An incinerator operator wearing PPE in Kenya.



Procuring PPE

It is important for programs to set aside budget to purchase equipment critical to ensuring health workers safety. Prices for PPE will vary depending on local availability and quantities procured. Product specifications for safety goggles; respirator masks; and heavy-duty, heat-resistant gloves are outlined in Annex 5. These specifications are intended to be a reference to help ensure quality equipment is purchased.

Proper operation

Proper operation of an incinerator ensures safe and optimal performance. When operated correctly there will be minimal emissions and waste will be treated more effectively. As previously noted, training is critical to proper operation.

The following are key steps that incinerator operators should follow. These steps were drawn from a job aid included as Annex 6.

1. Wear personal protective equipment—helmet, goggles, respirator, overcoat/overalls, heavy-duty gloves, apron, and boots.
2. Ensure fuel is available for operating the incinerator and that the waste to be incinerated is dry.
3. Record the number of safety boxes and bags to be burned.
4. Clean the incinerator.
 - Remove the ash and deposit it safely in the ash pit.
 - Place the grate/tray back in the incinerator.
5. Preheat the incinerator.
 - Place firewood or other material in the incinerator.
 - Light the wood or other material.
 - After 5 minutes of a steady burn, add more wood.
 - Continue this process every 5 minutes for 20 minutes total (4 cycles).

Notes on preheating the incinerator:

1. The loading door may be kept open for this operation. Add more wood or waste with a small quantity of diesel oil/kerosene (if available) until the flame is burning well. Add more dry waste and close the loading door. Light smoke should be observed coming out of the chimney top. Add more fuel at regular intervals until the flame can be seen burning fiercely through the primary air holes.
2. Before infectious waste is added, make sure that the chamber is at least 2/3 full of dry matter before adding waste and flames can be observed through the rear air hole in the secondary chamber. To hurry this process, more diesel/kerosene can be added in the liquid fuel version.

6. Load and burn the waste.
 - Load 1 safety box every 8–10 minutes.
 - Alternate loading bags of waste with loading safety boxes.
 - If the temperature drops, load combustable material such as paper.
 - If you see smoke the temperature is too low
 - If the temperature gets too high, add a bag of waste.
 - If you see fire in the chimney the temperature is too high.

Notes on burning waste:

1. Keeping the primary chamber as full as possible
2. Very wet loads should be separated with drier material, and in extreme cases supplemented by an extra increment of diesel/kerosene.
3. If the incinerator is being loaded with entirely plastic materials, such as syringes in sharps boxes, it is advisable to let one box burn almost completely before adding the next. The time can be gauged by noting when the smoke level decreases.
4. If the flame appears to be burning less fiercely, poke out any blockage in the transfer flue between the two chambers. This can be done using a length of steel pushed in through the air holes at the front.
5. When the loading door is opened, combustable gases may come into contact with air and burn suddenly and fiercely. This is harmless providing the operator is wearing a face mask/eye protection and is not peering directly into the chamber.
6. When the loading door is closed suddenly more burning gases may come through the air holes; thus the operator should load from the side.

7. Burn down the waste.

- Load the last safety box.
- Wait 10 minutes and add firewood to maintain the fire and ensure the waste is completely burned. This may take up to 30 minutes.
- When the waste is completely burned, allow the fire to die out.
- Do not leave the incinerator until the fire has burned down to embers.

VIII. Maintenance and Repair

Scheduled maintenance

All incineration equipment requires regular service and preventative maintenance. Unscheduled maintenance is also required in the event of failures. A service schedule should be established, and well-trained and qualified technicians should regularly visit incineration sites to inspect and service the equipment.

A budget to cover travel of service and maintenance personnel or contractors is essential. During site visits, task performed and consumables or spare parts used should be recorded. Consumables should also be stocked as part of a routine service program (fuel filters, burner nozzles, etc.). Fast-moving spare parts should also be stocked (temperature sensing probes, grates, etc.).

Operator logs

It is very important that operator logs are maintained and kept up to date. Information recorded in operator logs should include waste deposited and source, waste destroyed, fuel consumed, equipment defects, and service and maintenance history.

Annex 7 is an incinerator maintenance checklist for operators, which includes the following.

Daily Maintenance

- ✓ Check for evidence of cracks on the brickwork.
- ✓ Perform simple repairs but avoid makeshift solutions.
- ✓ Keep the area clean and disinfected.
- ✓ Carefully sweep the area around the incinerator.
- ✓ Clean tools and equipment.
- ✓ Store safety boxes and other health care waste in an orderly manner.
- ✓ Maintain fuel stock levels.

Weekly Maintenance

- ✓ Clean the chimney and remove the soot.
- ✓ Remove lumps of melted glass/plastics and clean grates.
- ✓ Properly reinstall the grates after cleaning.
- ✓ Maintain good housekeeping of the waste disposal site.
- ✓ Ensure the fencing is intact.
- ✓ Check the cement seal to brickwork.

Monthly Maintenance

- ✓ Ensure the fence of the site is intact.
- ✓ Check the vertical fixings of the chimney.
- ✓ Check the top sand seals.
- ✓ Check the external brickwork for evidence of thermal damage.
- ✓ Check the cement seal to brickwork.
- ✓ Check the ash door for corrosion.
- ✓ Check the ash door for damaged hinges.
- ✓ Check the ash door for latch blockage in the doorframe.
- ✓ Take an inventory of condition of tools and equipment.

Yearly Maintenance

- ✓ Inspect and replace metal parts, bricks and consumable parts.
- ✓ Inspect and replace stay wire/guy ropes.
- ✓ Overhaul the incinerator.
- ✓ Check the status of the ash pit.
- ✓ Perform annual audit.
- ✓ Ensure environmental audits and licenses are obtained.

IX. Available Technologies

A small-scale incinerator buyer's guide is included in this guidebook as Annex 1. The products included in this buyer's guide are those that are known as being commercially available. Developing-world use of these technologies varies, and independently published reports are limited. As the authors of this document, PATH is not endorsing any one product; manufacturers and models have been included for illustrative purposes only. When available, the following information is included about each technology.

- Manufacturer
- Model
- Fuel
- Lifespan
- Temperature range
- Capacity
- Estimated capital cost (US dollars)
- Installation requirements
- Contact
- References from the field

X. Additional Resources

PATH

http://www.path.org/projects/health_care_waste_resources.php#technical

PATH has gathered available resources on HCWM to provide easy access to the information. This web page is intended to serve as a resource for countries and programs working to improve HCWM. Included in these resources are some essential pieces of information for planning and decision-making.

Health Care Without Harm

www.noharm.org

Health Care Without Harm is an international coalition of 473 organizations in more than 50 countries working to transform the health care sector so it is no longer a source of harm to people and the environment.

Making Medical Injections Safer Project

<http://mmis.jsi.com>

The Making Medical Injections Safer (MMIS) project was a five-year initiative funded by the President's Emergency Plan for AIDS Relief (PEPFAR) through the United States Agency for International Development (USAID) and the Centers for Disease Control and Prevention (CDC). MMIS was implemented by John Snow Inc. in collaboration with PATH, Academy for Educational Development (AED), and the Manoff Group. The goal of the MMIS project was to establish an environment where patients, health care workers, and the community are better protected from the medical transmission of human immunodeficiency virus (HIV) and other bloodborne pathogens by project close (2009).

Safe Injection Global Network Alliance

http://www.who.int/injection_safety/sign/en/

The Safe Injection Global Network (SIGN) Alliance is coordinated through the World Health Organization (WHO). SIGN is a voluntary coalition of stakeholders aiming to achieve safe and appropriate use of injections throughout the world.

Technical Network for Strengthening Immunization Services

<http://www.technet21.org/index.htm>

Technical Network for Strengthening Immunization Services (TechNet21) is a professional network of experts in logistics who are involved in the management of immunization and other primary health care operations at the country and international levels. It serves as a forum where issues relevant to implementation of immunization services can be discussed, debated, and clarified. The forum is maintained by WHO.

WHO Health Care Waste Management Resource

http://healthcarewaste.org/en/115_overview.html

This website is managed by WHO. It is a resource for policy, planning, and management of health care waste and includes a number of databases that can be searched for technical reference material.

Annex 1: Small-Scale Incinerator Buyer's Guide

The products included in this Buyer's Guide are those that are currently known to PATH as being commercially available. Developing-world use of these technologies varies and independently published reports are limited. PATH is not endorsing any one product; these have been included for illustrative purposes.

De Montfort

Model: Mark 9
 Fuel: Not available
 Lifespan: 3-5 years
 Temperature range: 800°-1300°C
 Capacity: 50 kg/hr
 Estimated capital cost (USD): \$500-1,500
 Installation requirements: 5-6 days to build and install
 Contact: http://www.mw-incinerator.info/en/601_contact_us.html
 References from the field: http://www.path.org/files/TS_trt_alt_med_wst_disp.pdf



De Montfort

Model: Mark 8a
 Fuel: Not available
 Lifespan: 3-5 years
 Temperature range: Not available
 Capacity: 12 kg/hr
 Estimated capital cost (USD): \$250-1,000
 Installation requirements: 3-4 days to build and install
 Contact: http://www.mw-incinerator.info/en/601_contact_us.html
 References from the field: http://www.path.org/files/TS_trt_alt_med_wst_disp.pdf



De Montfort

Model: Mark 7
 Fuel: Not available
 Lifespan: 6-12 months
 Temperature range: Not available
 Capacity: 12 kg/hr
 Estimated capital cost (USD): \$250-1,000
 Installation requirements: 2 weeks to make components (to allow setting time); 4-5 hours to erect onsite
 Contact: http://www.mw-incinerator.info/en/601_contact_us.html
 References from the field: http://www.path.org/files/TS_trt_alt_med_wst_disp.pdf



Elastee Inc.

Model: Mediburn
Fuel: Diesel
Lifespan: 10 years
Temperature range: 1000°C+
Capacity: 18 kg/hr
Estimated capital cost (USD): \$20,000
Installation requirements: 110/120V if electrical or diesel;
level surface
Contact: 1309 W Marin
Carmi, IL 62821, USA
Ph: 1-618-382-2525
elastic@elastec.com

References from the field:
http://www.path.org/files/TS_trt_alt_med_wst_disp.pdf



Yayasan Dian Desa

Model: DD-Best
Fuel: Biomass
Lifespan: Not available
Temperature range: 800°-1300°C
Capacity: 35 kg/hr
Estimated capital cost (USD): \$3,333
Installation requirements: Not available
Contact: Jl. Kaliurang Gg Jurug Sari IV/19
PO BOX 19
YKBSYogyakarta 55281
Indonesia
diandes@ydd.org

References from the field:
http://technet21.org/fichiers_Word/IndonesiaMedWasteFinalReport.doc



Saubatech

Model: Macroburn 23B
Fuel: Biomass
Lifespan: 4 years
Temperature range: Not available
Capacity: Not available
Estimated capital cost (USD): \$5,585
Installation requirements: 12 days to install
Contact: PO Box 170
Northriding, Johannesburg
South Africa 6162
Ph: 27-11-794-8798
References from the field: Not available



<p><u>Saubatech</u></p> <p>Model: Macroburn 32B Fuel: Diesel Lifespan: 7 years Temperature range: Not available Capacity: Not available Estimated capital cost (USD): \$14,159 Installation requirements: 15 days to install Contact: PO Box 170 Northriding, Johannesburg South Africa 6162 Ph: 27-11-794-8798 References from the field: Not available</p>	<p>No photo available</p>
<p><u>The SA Incinerator Co.</u></p> <p>Model: LA 30 Fuel: Diesel Lifespan: 5 years Temperature range: Not available Capacity: 15 kg/hr Estimated capital cost (USD): \$4,400 Installation requirements: Not available Contact: PO Box 55128 Northlands, 2116 admin@saincinerator.com www.saincinerator.co.za Ph: 27-11-886-6638 References from the field: Not available</p>	
<p><u>CREATE</u></p> <p>Model: WDU Fuel: Biomass Lifespan: 5 years (component warranty) Temperature range: 600°-900°C Capacity: Not available Estimated capital cost (USD): \$5,000 Installation requirements: Not available Contact: G - A, Alsa Glenridge Ground Floor, 32, Langford Road Bangalore-560 025, India Ph: 91-0-98947-15168 http://www.create.org.in/wdu_charact.htm References from the field: Not available</p>	

Technology for Tomorrow Limited

Model: Mak IV
Fuel: Waste paper
Lifespan: Not available
Temperature range: 900°-1080°C
Capacity: 10 kg/hr
Estimated capital cost (USD): \$3,500 to \$7,200
Installation requirements: Not available
Contact: Dr. Moses Musaazi
Makerere University;
256-772-408 762
256-772-891 244
256-312-273 999
mkmusaazi@yahoo.com
nkmutaka@yahoo.co.uk
References from the field: Not available



Technology for Tomorrow Limited

Model: Mak V
Fuel: Waste paper
Lifespan: Not available
Temperature range: 850°-1050°C
Capacity: 42 kg/hr
Estimated capital cost (USD): \$17,800
Installation requirements: Not available
Contact: Dr. Moses Musaazi
Makerere University;
256-772-408 762
256-772-891 244
256-312-273 999
mkmusaazi@yahoo.com
nkmutaka@yahoo.co.uk
References from the field: Not available



Technologie Transfer Marburg e.V.

Model: UNIVERS
Fuel: Firewood or charcoal
Lifespan: Not available
Temperature range: 1000°C+
Capacity: 10-12 kg/hr
Estimated capital cost (USD): \$18,700
Installation requirements: Not available
Contact: Auf Der Kupferschmiede 1
D-35091 Cölbe, Germany
Ph: 49-0-6421-87373
Fax: 49-0-6421-87373-7
ttm@ttm-germany.de
http://www.refraserv.de/fotos/hwi/praese_ttm/data/menu.html
References from the field: Not available



Technologie Transfer Marburg e.V.

Model: HWI-5
Fuel: Diesel
Lifespan: Not available
Temperature range: 800°C+
Capacity: 15-20 kg/hr
Estimated capital cost (USD): \$26,700
Installation requirements: Not available
Contact: Auf Der Kupferschmiede 1
D-35091 Cölbe, Germany
Ph: 49-0-6421-87373
Fax: 49-0-6421-87373-7
ttm@ttm-germany.de
http://www.refraserv.de/fotos/hwi/praese_ttm/data/menu.html
References from the field:
<http://www.gtz.de/de/dokumente/f44-wasser04.pdf>



Annex 2: Examples of Tenders for Construction and Installation of Small-Scale Incinerators

Note: This example is a hypothetical tender. Organizations and countries may have templates and tendering guidelines or policies into which this information can be incorporated. This is not based on real circumstances. The organization's name (HCWM Inc.) is used as an example for training purposes only.

Case 1: Example of tender for construction and installation of small-scale incinerators when a prepackaged kit has been purchased

I. Summary of deadlines

Release of request for quotation	March 19, 2010
Confirmation of interest due	By March 26, 2010
Responses due	By April 2, 2010
Conclusion of process	By May 2, 2010

II. Project background and purpose of tender

HCWM Inc. is soliciting quotes from local entrepreneurs for the provision of materials and construction of a small-scale incinerator for a TB program in Tanzania.

III. Instructions for responding

A. Contacts

Procurement contact: *Include the name and email address of contact person.*

Technical/Program contact: *Include the name and email address of contact person.*

B. Confirmation of interest

Send a statement acknowledging receipt of this tender and your intent to respond or not respond no later than March 26, 2010. Send notice of your interest to the HCWM Inc. contacts listed above.

C. Final quotations due: April 2, 2010

Completed quotations should be submitted by email to the HCWM Inc. contacts listed above. The subject line of the email should read: Small-scale incinerators for TB program in Tanzania.

D. Conclusion of process

Applicants will be notified of HCWM Inc.'s decision by May 2, 2010. Final award is subject to the terms and conditions included in this request for quotation (RFQ), as well as successful final negotiations of all applicable terms and conditions affecting this work.

E. Submitting electronic responses

This is an electronic process. Quotations should be sent as attachments by e-mail to the HCWM Inc. contacts listed above. Respondents are encouraged to use MS Office (Word and Excel) or PDF for responses.

F. Language

Please note that English is the official language of this tender.

IV. Commodities description and specifications

Material	Quantity	General description
Steel column assembly	6	Steel column for the shed
Wall panel type A (Sht ½)	13 sets	Panel assembly for enclosure
Wall panel type B (Sht 2/2)	1 set	Panel assembly for enclosure
Door panels and details (2 sheets)	2 sets	Door assembly and hinge for enclosure
Fixture door panels and details	2 sets	Fixture door panels above the main door of enclosure
Horizontal connector, truss, and purlin (2 sheets)	1 set	Horizontal connector, truss, and purlin for enclosure
GI corrugated roof sheet	1 no.	GI corrugated sheets with apertures for chimney
Toolbox	1 set	Steel fabricated storage box for operator's tools
Chimney support cables	3 lengths of 6 m	4–6 mm diameter stranded corrosion resistant.
G I corrugated roof sheet	7 no.	Equal to or greater than 1.5 mm gauge, galvanized or equivalent (sheet = 2 m x 1 m)
6 mm J-bolt & nuts	50 sets	6 mm J-bolts and nuts for fixing the corrugated sheets with purlins
Polyvinyl chloride (PVC) pipe	1 no.	PVC medium gauge, 150 mm OD-1.5 meters long
Manholes	4 no.	Square manholes with cover (300 mm x 300 mm)
Hollow concrete blocks	705 no.	400 x 200 x 100 mm with crushing strength 50 kg/cm/sq
Portland cement	1.5 tons	Ordinary portland cement (O.P.C) 143 grade
Sand for concrete structure	3.5 m ³	Less than 4% silt or clay, less than 2% mica granular, size greater than 2 mm
Aggregate (gravel): RCC & PPC	2.08 m ³	5 parts less than 40 mm, 2 parts less than 12.5 mm, 1 part less than 3.35 mm

A. Product labeling

All products shall be clearly identified by labels. The label on the container shall show:

- The name of the product.
- A list with the quantity (weight, volume).
- The batch or final lot number assigned by the manufacturer.
- Recommended storage conditions or necessary handling precautions.
- The name and address of the manufacturer or the company and/or the person responsible for placing the product on the market.

B. Shipping labeling and packaging

Secondary packaging labeling

A label must be affixed either to the top and/or front surface of the secondary packaging. It should indicate the name of the commodity, the name of the manufacturer, quantity, and storage conditions.

Numbering of tertiary packaging

All boxes should be numbered consecutively. Shipping documents should be included in the box labeled number 1, and this box should be clearly labeled with the words “**Contains shipping documents.**”

The shipment must be packed in such a way that its contents withstand shipping conditions without breakage or damage. Outer shipping cartons must be sturdy enough for export.

C. Schedule for construction

Task	Time frame
Prepare (transportation of components and materials to site)	2 days
Build foundation, construct ash and needle pits (includes inspection and quality control)	21 days
Install incinerator (includes inspection and quality control)	10 days
Complete wall, roof, and enclosure structure (includes inspection and quality control)	12 days
Finish installation details (operator work zone, fence, door, storage facilities; includes inspection and quality control)	13 days
Total days	58 days

D. Training

Upon installation of the incinerator, the company chosen should also be able to provide the following:

- Introductory training for all new incinerator operators.
- Retraining of operators after approximately one year of operational experience.
- Follow-on training or retraining as considered necessary to ensure best practices for operation of the incinerator.

E. Maintenance

The company chosen should be able to provide to ensure the following:

- Maintenance (under a separate agreement) when necessary as considered by the purchaser. *Note: purchaser can create a separate agreement with a schedule for maintenance and supervisory visits.*
- Replacement parts.
- Unscheduled maintenance if unforeseen defects of the incinerator occur.

F. Manufacturer support

The manufacturer must provide the following:

- Warranties and guarantees for the expected life of the system.
- The terms and conditions for technical support.
- Training curriculum for installation, operation, and routine service.
- A proposal for maintenance and repair support for the life of the product (5 years if an auto-combustion type or 10 years if a fuel-assisted type).
- List of references.
- Service and operators manuals. Manuals must be provided in the local language and must be simple and explicit.

V. Qualifications and delivery schedule

Bidders must meet the minimum following qualifications, and quotations should include information substantiating the ability to meet these qualifications.

A. Overall qualifications

- Ideally, the product or manufacturer must be registered in Tanzania. Please state whether or not the product or manufacturer is registered in Tanzania. If not, please indicate whether this is possible or not prior to the first shipment being sent.
- Manufacturer must conform to the requirements for quality assurance of products.
- Please indicate whether or not the product being offered has any certificates from a national or international authority.
- Please list any of countries in which the product being offered currently has market clearance.

B. Experience and operations

Manufacturers should have experience in the design, construction and installation of incinerators. We encourage manufacturers to provide a list of current and past customers.

C. Product availability

Please provide the manufacturer lead-time from the receipt of a purchase order.

Delivery schedule and shipping information

- Products should be available at the construction site by June 30, 2010. *Note: the project preference is to receive the order earlier than June 30, 2010, if possible. Please list the latest date that the shipment can be available at the construction site.*
- The following documents must be provided to HCWM Inc. prior to shipment:
 - Proforma invoice
 - Packing slip

VI. Costs

Provide line item costs for the following:

1. Materials (each line item).
2. Any other related costs.
3. Freight from warehouse to construction site including insurance costs. Do not include customs clearance charges or customs taxes and duties.

Also note the payment terms and the validity of the offer being provided.

VII. Terms and conditions

Payment provisions:

1. Contract signature: 0% of total contract.
2. Inspection of pilot site and provisional acceptance of process: 15% of the total contract.
3. Final installation and inspection of proper operation: 60% of total contract.
4. Training of operators: 25% of total contract.

Case 2: Example of tender for construction and installation of locally produced small-scale incinerators

Note: This example is a hypothetical tender. Organizations and countries may have templates and tendering guidelines or policies into which this information can be incorporated. These are not based on real circumstances. The organization's name (HCWM Inc.) is used as an example for training purposes only.

I. Summary of deadlines

Release of request for quotation	March 19, 2010
Confirmation of interest due	By March 26, 2010
Responses due	By April 2, 2010
Conclusion of process	May 2, 2010

II. Project background and purpose of tender

HCWM Inc. is soliciting quotes from local entrepreneurs for the provision of materials and construction of a locally produced small-scale incinerator for a TB program in Tanzania.

III. Instructions for responding

A. Contacts

Procurement contact: *Include the name and email address of contact person.*

Technical/Program contact: *Include the name and email address of contact person.*

B. Confirmation of interest

Send a statement acknowledging receipt of this tender and your intent to respond or not respond no later than March 26, 2010. Please send the confirmation to the HCWM Inc. contacts listed above.

C. Final quotations due: April 2, 2010

Completed quotations should be submitted by email to the HCWM Inc. contacts listed above. The subject line of the email should read: Small-scale incinerators for TB program in Tanzania.

D. Conclusion of process

Applicants will be notified of HCWM Inc.'s decision by May 2, 2010. Final award is subject to the terms and conditions included in this request for quotation (RFQ), as well as successful final negotiations of all applicable terms and conditions affecting this work.

E. Submitting electronic responses

This is an electronic process. Quotations should be sent as attachments by e-mail to the HCWM Inc. contacts listed above. Respondents are encouraged to use MS Office (Word and Excel) or PDF for responses.

F. Language

Please note that English is the official language of this tender.

IV. Commodities description and specifications

A. Product description of final product

Architecture

- A minimum of two chambers: one to combust solids and one to combust gases.
- A temperature or visual indicator to advise on status of equipment.
- A durable refractory wall or liner capable of withstanding 100% plastic waste.
- A stack with a minimum height of 4 meters.
- A secure enclosure for the incinerator, an ash and needle pit, arrangement for destruction of vials and glass syringes, a washing facility for reusable recipients, and a secure storage facility for waste.

Performance

Any incinerator selected should:

- Operate in the range of 800°–1200°C when destroying medical waste.
- Emit visibly clear or near to clear emissions from the stack when destroying medical waste.
- Reduce weight of waste by 95% or more when destroyed.

Durability

Any selected incinerator should:

- Be capable of destroying medical waste where the plastic waste content is greater than 50% by weight of the total load.
- Be constructed of corrosion-resistant materials (stainless steel or cast iron).
- Be simple in design and operation, with minimal electronic components.

Rate of destruction of safety boxes

- Between 12 and 9 kg of safety boxes per hour.

B. Quantity: 1

C. Product life

Operate for at least 5 years if an auto-combustion type or 10 years if fuel-assisted when used under normal conditions.

D. Description of materials:

Material	Quantity	General description
Top frame primary chamber	1 set	Top frame on primary chamber and loading door hinge
Top loading door and hinge pin	1 set	-
Top frame secondary chamber	1 set	Top frame on secondary chamber
Front door frame	1 set	Frame of the ash door of incinerator
Front door	1 set	Front side ash door and hinge pin
Front bridge	1 set	-
Spigot	1 set	-
Grate	1	-

Material	Quantity	General description
Column for front side of primary chamber	1 set	-
Column for back side of primary chamber and in the secondary chamber	6 nos.	-
Tunnel	1 set	Tunnel joining primary and secondary chambers at the bottom
Fabrication drawing for general stack arrangement (2 sheets)	3 stack pipes; 1 set of comps	-
A self adjusting draft control and tee for chimney	1 set	Operating temperature: 0–800°C; 6" draft control; fine-threaded adjustment stud with balance weight on end; gives good regulation; draft regulated by turning adjustment screw; made of 28-gauge blued steel; adjustment range .01" to .12".
Stovepipe thermocouple and analogue dial indicator	1	Range 0–1200°C
Refractory brick	225 nos.	Dimensions: length (228–232 mm), width (114–116 mm), height (60–85 mm) Temperature range: up to 1200°C Composition: Al ₂ O ₃ (>40%), Fe ₂ O ₃ (<2%), SiO ₂ (<50%), CaO (<15%) Thermal conductivity: Low thermal conductivity, less than 0.5 W/mK Structural length: cols crushing strength not less than 40 MPa Porosity: 20–25%
Refractory cement or refractory mortar	30 kg or 110 kg	<u>Refractory cement</u> Composition: Al ₂ O ₃ (>40%), Fe ₂ O ₃ (<2%), SiO ₃ (<1%), CaO (>2% and <40%) Curing times: 24 hours before first firing Temperature range: ambient to 1200°C
High temperature paint	2 kg	Silver or black, polymer-based, usable up to 700°C
Rust-proof primer	2 kg	Weldable primer
Chimney pipe	1	Black stove pipe 24" straight joint, 6" black, 6" x 24", 24 gauge; entirely self-locking; no tools needed to close seams; put together by simply inserting tongue on one edge and pressing together until it snaps. Joint can be cut to any length without destroying the lock.
Steel column assembly	6	Steel column for the shed
Wall panel type A (sht ½)	13 sets	Panel assembly for enclosure
Wall panel type B (sht 2/2)	1 set	Panel assembly for enclosure
Door panels and details (2 sheets)	2 sets	Door assembly and hinge for enclosure
Fixture door panels and details	2 sets	Fixture door panels above the main door of enclosure
Horizontal connector, truss, and purlin (2 sheets)	1 set	Horizontal connector, truss, and purlin for enclosure
GI corrugated roof sheet	1 no.	GI corrugated sheets with apertures for chimney

Material	Quantity	General description
Toolbox	1 set	Steel fabricated storage box for operator's tools
Chimney support cables	3 lengths of 6 m	4–6 mm diameter stranded corrosion resistant
G I corrugated roof sheet	7 nos.	Equal to or greater than 1.5 mm gauge, galvanized or equivalent (sheet equal to 2 m x 1 m)
6 mm J-bolt and nuts	50 sets	6 mm J-bolt and nuts for fixing the corrugated sheets with purlins
PVC pipe	1 nos.	PVC medium gauge, 150 mm OD-1.5 meters long
Manholes	4 nos.	Square manholes with cover 300 mm x 300 mm
Hollow concrete blocks	705 nos.	400 x 200 x 100 mm crushing strength: 50 kg/cm/sq
Portland cement	1.5 tons.	Ordinary portland cement (O.P.C) 143 grade
Sand for concrete structure	3.5 m ³	Less than 4% silt or clay, less than 2% mica granular, size less than 2mm
Aggregate (gravel): RCC & PPC	2.08 m ³	5 parts less than 40 mm, 2 parts less than 12.5 mm, 1 part less than 3.35 mm

E. Product labeling

All products shall be clearly identified by labels. The label on the container shall show:

- The name of the product.
- A list with the quantity (weight, volume).
- The batch or final lot number assigned by the manufacturer.
- Recommended storage conditions or handling precautions that are necessary.
- The name and address of the manufacturer or the company and/or the person responsible for placing the product on the market.

F. Shipping labeling and packaging

Secondary packaging labeling

A label must be affixed either to the top and/or front surface of the secondary packaging. It should indicate the name of the commodity, the name of the manufacturer, quantity, and storage conditions.

Numbering of tertiary packaging

All boxes should be numbered consecutively. Shipping documents should be included in the box labeled number 1, and this box should be clearly labeled with the words “**Contains shipping documents.**”

The shipment must be packed in such a way that its contents withstand shipping conditions without breakage or damage. Outer shipping cartons must be sturdy enough for export.

G. Schedule for construction

Task	Time frame
Prepare (transportation of components and materials to site)	2 days
Build foundation, construct ash and needle pits (includes inspection and quality control)	21 days
Install incinerator (includes inspection and quality control)	10 days
Complete wall, roof, and enclosure structure (includes inspection and quality control)	12 days
Finish installation details (operator work zone, fence, door, storage facilities; includes inspection and quality control)	13 days
Total days	58 days

H. Training

Upon installation of the incinerator, the company chosen should also be able to provide the following:

- Introductory training for all new incinerator operators.
- Retraining of operators after approximately one year of operational experience.
- Follow-on training or retraining as considered necessary to ensure best practices for operation of the incinerator.

I. Maintenance

The company chosen should be able to provide the following:

- Maintenance (under a separate agreement) when necessary as considered by the purchaser. *Note: purchaser can create a separate agreement with a schedule for maintenance and supervisory visits.*
- Replacement parts.
- Unscheduled maintenance if unforeseen defects of the incinerator occur.

J. Manufacturer support

The manufacturer must provide the following:

- Warranties and guarantees for the expected life of the system.
- The terms and conditions for technical support.
- Training curriculum for installation, operation, and routine service.
- A proposal for maintenance and repair support for the life of the product (5 years if an auto-combustion type or 10 years if a fuel-assisted type).
- List of references.
- Service and operators manuals. Manuals must be provided in the local language and must be simple and explicit.

V. Qualifications and delivery schedule

Bidders must meet the minimum following qualifications, and quotations should include information substantiating the ability to meet these qualifications.

A. Overall qualifications

- Ideally, the product or manufacturer must be registered in Tanzania. State whether the product or manufacturer is registered in Tanzania. If not, indicate whether registration is possible prior to the first shipment being sent.
- Manufacturer must conform to the requirements for quality assurance of products.
- Indicate whether the product being offered has any certificates from a national or international authority.
- List any countries in which the product being offered currently has market clearance.

B. Experience and operations

Manufacturers should have experience in the design, construction and installation of incinerators. We encourage manufacturers to provide a list of current and past customers.

C. Product availability

Provide the manufacturer lead time from the receipt of a purchase order.

D. Delivery schedule and shipping information

- Products should be available at the construction site by June 30, 2010. *Note: the project preference is to receive the order earlier than June 30, 2010, if possible. List the latest date that the shipment can be available at the construction site.*
- The following documents must be provided to HCWM Inc. prior to shipment:
 - Proforma invoice
 - Packing slip

VI. Costs

Provide line item costs for the following:

1. Materials (each line item).
2. Any other related costs.
3. Freight from warehouse to construction site including insurance costs. Do not include customs clearance charges or customs taxes and duties.

Also note the payment terms and the validity of the offer being provided.

VII. Terms and conditions

Payment provisions:

1. Contract signature: 0% of total contract.
2. Inspection of pilot site and provisional acceptance of process: 15% of the total contract.
3. Final installation and inspection of proper operation: 60% of total contract.
4. Training of operators: 25% of total contract.

Annex 3: Specifications for Future WDU Constructions in Rwanda

Architecture

- Should have primary and secondary combustion chambers.
- Should be of auto-combustion type.
- Should not require auxiliary fuel during medical waste incineration except for warm-up and burn-down.
- Should not require electricity.
- Refractory IS-6 or higher brick with chemical composition minimum 30% Al₂O₃ and maximum 2.5%.
- Fe₂O₃, rated to 1300°C+, minimum CCC 200 kg/cm³, maximum AP 27%, service temperature PCE.
- 30+, load under temperature RUL 1300°C, and PLC +1%.
- Brick joining mortar should be a combination of high temperature refractory paper and refractory glue, both rated at over 1100°C.
- All incinerator components including stack should be SS409 or SS309 stainless steel.
- Both primary and secondary combustion chambers should have independent air intakes.
- Incinerator should be equipped with an analog battery-free temperature gauge rated up to 1300°C.
- Stack should be equipped with an automatic draft-control valve.
- Stack shall not be less than 4 meters high from ground level and 150 mm or more in diameter.
- Assembly should be possible on site with no power tools or electricity.

Capacity

- Incinerator should be able to tolerate 100% plastic or safety boxes.
- Destruction rate should be over 9 kg per hour for safety boxes or over 7 kg per hour for 50% safety boxes and 50% non-sharps hazardous waste (25% maximum moisture content).

Performance

- The incinerator must consistently be able to maintain secondary combustion temperatures of 800°C.
- The resulting ash residue must be less than 5% of the original waste by weight.
- Gas residence time must exceed 1 second.
- Emissions should conform to local environmental standards.
- When operated correctly, emissions should be clear and colorless.

Operator tools and safety equipment

- 2 pairs leather gloves covering wrists.
- 2 pairs shatter-proof eye wear.
- 2 sets half-face particulate mask with activated carbon cartridges.
- First aid kit.
- 1 set rake, shovel, dust pan, brush.

Warranty

- All stainless steel components should have a 5-year warranty.
- Spare parts.
- Two spare temperature gauges with probes.
- Two spare automatic flue-control flaps
- 4 sets activated carbon cartridges for half-face particulate masks

Annex 4: Personal Protective Equipment for Incinerator Operators

Protect yourself by wearing personal protective equipment (PPE) when handling waste and operating an incinerator.

Wearing PPE reduces risk from sharps, germs, exposure to blood and other bodily fluids, splashes from chemicals, inhalation of exhaust, and sparks from the incinerator.

- Helmet
- Safety goggles
- Respirator mask
- Heavy duty, heat-resistant gloves
- Apron
- Clothes that cover the body
- Heavy duty, heat-resistant boots



JULY 2008

Annex 5: Personal Protective Equipment Specifications for Incinerator Operators

PATH developed this resource to guide selection and purchasing decisions. These specifications are guidelines that can be adapted to local policies and product availability. For example, bin liners have a specified minimum acceptable thicknesses, rather than a specific thickness requirement.

Web links provide pictures and product information that demonstrate commercial equipment that meet these specifications. PATH is not endorsing any one product; these have been included for illustrative purposes. Although many of these are from the United States and of high price, they can serve as examples to show local dealers and manufacturers.

The following specifications were taken from a broader document that included specifications for PPE as well as segregation supplies. *Personal Protective Equipment and Segregation Supply Specifications: For Health Care Waste Management* can be found at http://www.path.org/files/TS_ppe_specs.pdf

Protective Gloves for Incinerator Operators

Managers may use these product specifications to select gloves suitable for incinerator operators to achieve hand protection against intermittent heat and infectious sharps present when handling biomedical waste during incineration.

Purpose:

To protect operators of small-scale, medical waste incinerators, gloves must protect against heat and be resist to punctures from contaminated sharps. Gloves must be designed to enable the incinerator operator to safely and effectively perform their duties, while being made of appropriate protective materials.

Basic Performance Specifications:

1. Resistant to puncture by used injection equipment.
2. Provide protection against contact, convective, or radiant heat.
3. Flame retardant.
4. Will not interfere with dexterity and tactile sensation required for work duties either by design or poor fit.
5. Durable, reusable design without compromised performance.
6. Available in sizes appropriate for all incinerator operators.

Materials:

For heat protection, gloves can be made of leather and/or insulated with aramid blends, Terrycord, or cotton blends. (www.gloveassociation.org) Newer, specialized knit materials such as KEVLAR® are available that offer heat protections and puncture resistance. A heavy neoprene design can provide needle resistance; however, this glove design will need a specialized liner to protect against radiant heat.

Design Specifications:

Glove Design	Hand-specific, designed for dexterity and comfort in addition to protection.		
Cuff Design	Safety cuff design that protects upper wrist but allows for quick glove removal in emergency situations.		
Thickness	Will be material dependant.		
Sizes	Small (7)	Medium (8)	Large (9)
Palm Width (mm)	90	102	120
Typical Length (mm)	Minimum 127 (5 inches)	Minimum 127 (5 inches)	Minimum 127 (5 inches)

Examples of Products:

<http://www.ansellpro.com/main/productSearch3.asp?pid=108>

<http://www.ansellpro.com/main/productSearch3.asp?pid=125>

http://www.perfectfitglove.com/products/product_detail.asp?id=47&catID=1&pseriesid=13

http://www.perfectfitglove.com/products/product_detail.asp?id=23&catID=1&pseriesid=6

<http://www.perfectfitglove.com/images/downloads/Perfect%20Fit%20Carbtex%20Brochure.pdf>

(see Heavyweight Terry Cloth with Leather Palm and Seamless Knit with Leather Palm options)

Relevant International Standards:

(a) *AS/NZS 2161: 1998 Occupational Protective Gloves (Excluding electrical and medical gloves)*

(b) *AS/NZS 2161.2: Occupational Protective Gloves – General requirements*

(c) *AS/NZS 2161.3-9: Occupational Protective Gloves – Selection for use against mechanical risks, thermal risks (fire and heat), cold, hand knives cuts and stabs, ionizing radiation and radioactive contamination*

Protective Eyewear for Incinerator Operators

Managers may use these product specifications to select protective eyewear for incinerator operators to achieve eye protection against uncontained infectious sharps and intermittent heat during handling and incineration of infectious health care waste.

Purpose:

Incinerator operators should be provided with protective eyewear to protect them from falling debris, potential bloodborne pathogens contained in medical waste, and heat.

Basic Performance Specifications:

1. Provide adequate protection against the particular hazards for which they are designed.
2. Reasonably comfortable when worn under the designated conditions.
3. Fit snugly and not unduly interfere with the movements of the wearer.
4. Durable.
5. Capable of being disinfected.
6. Able to be worn without disturbing the adjustment of any existing prescriptive eyewear.

Material: Polycarbonate.

Design Specifications:

Design	Glasses with side protection or goggle design.
Lens	Impact and heat resistant, molded, and 2.2 mm thick with anti-fog coating.
Heat Resistant	Self-extinguishing foam and heat-resistant materials.
Ventilation	At minimum, four indirect ventilation slots.
Fit	Wide contact between goggle and face.
Visibility	Unobstructed peripheral vision.
Strap	Adjustable support strap.

Examples of Products:

<http://www.professionalequipment.com/xq/ASP/ProductID.2732/id.8/subID.436/qx/default.htm>

<http://www.elvex.com/goggles.htm>

<http://www.hlbouton.com/hlblist.html>

Relevant International Standards:

(a) *CSA Standard CAN/CSA-Z94.3-92: Industrial Eye and Face Protectors*

(b) *ANSI Standard Z87.1-1989: Practice for Occupational and Educational Eye and Face Protection*

(c) *AS/NZS 1336: 1997 Recommended Practices for Occupational Eye Protection*

AS 1337-1992 Eye Protectors for Industrial Applications

Protective Respirators for Incinerator Operators

Managers should use these product specifications to select respiratory protection for incinerator operators for use during the incineration of medical waste.

Purpose:

To protect incinerator operators against particulates (dust, fiber, fumes, mist, soot, and smoke) generated during incineration. Paper or cloth surgical masks do not protect from hazards inherent in the incineration of infectious medical waste and should not be substituted for an air-purifying respirator (with cartridges).

Respiratory protection is only needed for personnel remaining in the immediate vicinity of the incinerator. Personnel should be properly fitted for an air-purifying respirator, and replacement cartridges must be made available approximately every six months depending on frequency of use.

A protective air-purifying respirator consists of two main parts—a face mask (half-mask) and two cartridges. The mask and cartridges are sold separately. The same brand of mask and cartridges should be purchased for compatibility.

Basic Performance Specifications for the Face Mask (Half-Mask):

1. Provides protection against dust, fiber, fumes, mist, soot, and smoke.
2. Is reasonably comfortable when worn under the designated conditions.
3. Fits snugly and does not unduly interfere with the movements of the wearer.
4. Mask material is capable of being disinfected regularly.
5. Strap is either elastic or adjustable.
6. Is made of silicone or thermal plastic polymer (TPE).
7. Is available in a minimum of three sizes: small, medium, and large. Size dimensions will vary by manufacturer and should be requested prior to ordering.

Basic Performance Specifications for the Cartridges:

1. Is able to achieve the National Institute for Occupational Safety and Health P100 or N100 rating, or equivalent European Committee for Standardization certification. P100 cartridges will protect against any particulates, including oil-based materials. N-series cartridges protect against solid and water-based particulates such as nuisance dust.
2. Contains a granular or porous material—such as carbon or coconut—which removes specific air particulates.
3. Is available in bayonet or push-in mounted cartridge or canister form; is able to remove 99.9% of dusts and non-oil-based mists.
4. Enables easy breathing during use.

Maintenance Guidance:

1. Ensure that the cartridges are replaceable and that adequate quantities of spare cartridges are purchased and provided to incinerator operators.
2. Replace filter cartridges approximately every six months (depending on frequency of use) or when breathing becomes difficult; this signifies that the cartridges are full and need to be replaced.
3. Train handlers on the cleaning and maintenance of protective respirators.
4. Each operator should have his or her own dust mask; if shared it should be cleaned and disinfected after each use.
5. Ensure the mask fits correctly and all parts are in good working order.
6. A mask must be inspected for damage before use and whenever it is cleaned. Defective respirators must be discarded or repaired by an appropriately trained person.
7. Incinerator operators must store their protective respirators in a place free from dust, sunlight, extreme temperatures, and moisture so that the face mask is not damaged.

Candidate Materials:

Silicone or thermal plastic polymer (TPE) mask with replaceable cartridges.

Design Specifications:

Design	P100 or N100 replaceable dual-cartridge, half-mask respirator.
Cartridge/Canister Filter	Bayonet or push-in mounted cartridge or canister form; able to remove 99.9% of dusts and non-oil-based mists.
Heat Resistant	Self-extinguishing, heat-resistant materials.
Ventilation	Adequate inhalation and exhalation valve to enable easy breathing.
Fit	Wide sealing flange for a secure seal with special nose bridge.
Visibility	Unobstructed peripheral vision.
Strap	Elastic straps for a good fit.

Examples of Products:

<http://www.anisafety.com/index.aspx?Command=GroupInfo&GroupID=10580>

http://www.moldex.com/pdfs/datasheets/8900_filter.pdf

<http://www.msaafrica.co.za/catalog/product502998.html>

<http://www.gemplers.com/half-mask-respirator>

<http://www.gemplers.com/product/124374/Premier-Half-mask-Respirator>

Example of Instructions for Use and Maintenance:

<http://www.moldex.com/pdfs/datasheets/8000seriesinstructionmanual.pdf>

Relevant International Standards:

- (a) *BS EN 143: 2000 Respiratory protective devices – Particle filters, requirements, testing and marking.*
- (b) *NIOSH-42 CFR Part 84: US Standards for Respiratory Protective Devices.*
- (c) *Law No. 57 of 1972: Japanese Standard for Dust Mask to Enforce the Industrial Safety and Health Law.*
<http://www.jniosh.go.jp/icpro/jicosh-old/english/law/DustMask/index.html>

Protective Footwear for Waste Handlers

Managers may use these product specifications to select protective footwear for waste handlers and incinerator operators to protect against uncontained infectious sharps and other hazards during handling and incineration of infectious health care waste.

Purpose: Waste handlers and incinerator operators should be provided with protective footwear to protect from falling debris, potential bloodborne pathogens contained in medical waste, and occupational heat exposure.

Basic Performance Specifications:

1. Made from cut-resistant materials.
2. Slip-resistant sole.
3. Puncture-resistant sole.
4. Protective against minimal impact.
5. Fit snugly and not unduly interfere with the movements of the wearer.
6. Durable.
7. Capable of being disinfected.
8. Available in sizes to fit all waste handlers (toes should be about 12.5 mm from the front).

Materials:

Uppers should be made from polyurethane. Soles may be made of polyurethane if a single mold design is used. A vulcanized nitrile rubber sole will also resist punctures and heat. For incinerator operators, boots should be made from heat-resistant materials when available

Design Specifications:

Toe Impact Protection	Toe impact energy up to 90 joules.
Sliding	Sole construction.
Sole Puncture Protection:	Minimum protection of 1200 Newtons.
Slip Resistant Sole	Deep tread with coefficient of friction >0.5.

Examples of Products:

- <http://www.idml.com/shop.asp?catid=38&ProdId=279>
- <http://shop.actecs.co.uk/ProductDetails.aspx?productID=709&CategoryId=457>
- <http://www.dickiesstore.co.uk/dickies-workwear/safety-boots-and-footwear/safety-wellington-boots/FW13105/0/>

Relevant International Standards:

- (a) *CSA Standard CAN/CSA-Z195-M92: Protective Footwear*
- (b) *ANSI Standard Z41-1991: American National Standard for Personal Protection, Protective Footwear*
- (c) *AS/NZS 2210.1: Occupational Protective Footwear, Guide to selection, care, and use*
- (d) *British Safety Institution Standard BS EN 345: 1993 Specification for Safety Footwear for Professional Use*
- (e) *British Safety Institution Standard BS EN 346: 1993: Specification for Protective Footwear for Professional Use*

Annex 6: Job Aid for Incinerator Operators

Incinerator Operator Guidelines

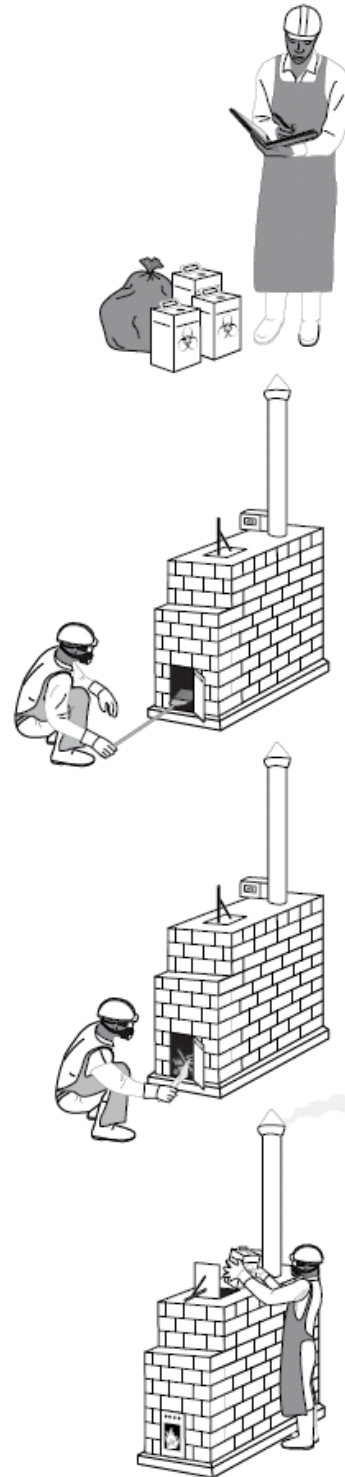


1. **Wear personal protective equipment—helmet, goggles, respirator, overcoat/overalls, heavy duty gloves, apron, and boots.**
2. **Ensure fuel is available for operating the incinerator and that the waste to be incinerated is dry.**
3. **Record the number of safety boxes and bags to be burned.**
4. **Clean the incinerator.**
 - Remove the ash and deposit it safely in the ash pit.
 - Place the grate/tray back in the incinerator.
5. **Preheat the incinerator.**
 - Place firewood or other material in the incinerator.
 - Light the wood or other material.
 - After 5 minutes of a steady burn, add more wood.
 - Continue this process every 5 minutes for 20 minutes total (4 cycles).
6. **Load and burn the waste.**
 - Load 1 safety box every 8–10 minutes.
 - Alternate loading bags of waste with loading safety boxes.
 - If the temperature drops, load combustible material such as paper.

⚠ If you see smoke the temperature is too low

 - If the temperature gets too high, add a bag of waste.

⚠ If you see fire in the chimney the temperature is too high
7. **Burn down the waste.**
 - Load the last safety box.
 - Wait 10 minutes and add firewood to maintain the fire and ensure the waste is completely burned. This may take up to 30 minutes.
 - When the waste is completely burned, allow the fire to die out.
 - Do not leave the incinerator until the fire has burned down to embers.



Annex 7: Maintenance Checklist for Incinerator Operators

Incinerator Maintenance Checklist



Daily Maintenance

- Check for evidence of cracks on the brickwork.
- Perform simple repairs but avoid makeshift solutions.
- Keep the area clean and disinfected.
- Carefully sweep the area around the incinerator.
- Clean tools and equipment.
- Store safety boxes and other health care waste in an orderly manner.
- Maintain fuel stock levels.

Weekly Maintenance

- Clean the chimney and remove the soot.
- Remove lumps of melted glass/plastics and clean grates.
- Properly reinstall the grates after cleaning.
- Maintain good housekeeping of the waste disposal site.
- Ensure the fencing is intact.
- Check the cement seal to brickwork.

Monthly Maintenance Checklist

- Ensure the fence of the site is intact.
- Check the vertical fixings of the chimney.
- Check the top sand seals.
- Check the external brickwork for evidence of thermal damage.
- Check the cement seal to brickwork.
- Check the ash door for corrosion.
- Check the ash door for damaged hinges.
- Check the ash door for latch blockage in the doorframe.
- Take an inventory of condition of tools and equipment.

Yearly Maintenance Checklist

- Inspect and replace metal parts, bricks and consumable parts.
- Inspect and replace stay wire/guy ropes.
- Overhaul the incinerator.
- Check the status of the ash pit.
- Perform annual audit.
- Ensure environmental audits and licenses are obtained.

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