Treatment Alternatives for Medical Waste Disposal

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Program for Appropriate Technology in Health (PATH)
1455 NW Leary Way
Seattle, WA 98107-5136 USA
Tel: 206.285.3500
Fax: 206.285.6619
www.path.org

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1. Overview

"Health care activities lead to the production of waste that may lead to adverse health effects. Most of this waste is not more dangerous than regular household waste. However, some types of health care waste represent a higher risk to health. These include infectious waste (15% to 25% of total health care waste), among which are sharps waste (1%), body part waste (1%), chemical or pharmaceutical waste (3%), and radioactive and cytotoxic waste or broken thermometers (less than 1%)."[1]

The purpose of this document is to inform the reader about different technology options for the treatment of infectious medical waste, particularly for developing countries. It describes incerneration, chemical treatment, autoclaving, microwaving, and shredding/compacting. Performance issues, environmental impact, and perspectives from several developing countries are described.

In seeking effective solutions for the disposal of medical wastes in developing-world health care settings, it is necessary to design and build a sustainable system for managing medical waste. All approaches to the management of medical waste must consider the environmental, financial, and technical feasibility of treatment and disposal technologies in the context of the following requirements:

1. Resolve the most critical factors first: Needlestick injuries and exposure to pathogens.
2. Identify affordable and cost-effective solutions in each specific health care situation.
3. Consider technical feasibility within the existing health and sanitation infrastructure.
4. Prioritize best environmental practices, considering local infrastructure.

2. Treatment Alternatives

Implementation of effective medical waste disposal is a progressive health management process. It is important to make initial approaches low cost, easy to implement, and focused on the critical problems. From this foundation, progressive improvements can over time bring procedures closer to those of the developed world.

When selecting an appropriate medical waste sterilization or disposal technology it is important to consider the following issues:

1. Types and quantities of medical waste produced.
2. Capital investment and operational costs associated with each technology.
3. Infrastructure requirements for installation and operation of each technology.
4. Medical waste volume and mass reduction issues that impact final disposal in landfill.
5. Occupational health and safety, including needlestick prevention.
6. Training and operation requirements.
7. Monitoring requirements for noncombustion technologies to ensure treatment efficacy.
8. Country-specific regulatory requirements.
9. Environmental (air, water, soil) impacts.
10. Locally available treatment and disposal technologies.
11. Community acceptability.

The following pages describe several treatment technologies, including their performance issues and environmental impact. Cost and manufaturer information are included in annexes A and B.

Thermal Destruction (Incineration)				
Description of Technology[2]	**Performance Issues**	**Environmental Impact**	**Costs (US$)**	**Where Used**
There is a range of thermal destruction technologies; however, in this document incineration is considered a technology that makes some attempt to control the combustion process, either through a two-chamber design or with air pollution control equipment. It is assumed that near-complete combustion is achieved through proper time, temperature, and turbulence. Incineration is the burning of waste at high temperatures. In high-temperature, modern incinerators, waste is fed into a primary chamber and exposed to lower temperatures (800-900 °C) under oxygen-starved conditions causing pyrolysis. The pyrolysis gases then pass into a second chamber where they burn at a higher temperature (+/- 1000°C) resulting in the formation of carbon dioxide and water. In small-scale, mid-temperature incinerators, waste is heated to approximately 800°C in the secondary chamber, with residence time of at least two seconds, to control dioxin and furan formation.	Operators must be well trained to minimize environmental impact and maximize performance parameters. Waste segregation systems must be strong in order to prevent any PVC-containing plastics and mercury compounds from being incinerated. Composition of waste will impact incinerator performance and must be monitored for proper performance. Volume of waste is significantly reduced. Complete combustion ensures disinfection of medical waste. Maintenance needs of small-scale incinerators include replacement of refractory bricks, regular ash removal to a designated ash pit, and regular supply of fuel (kerosene or husks) for preliminary ignition. Without pollution control equipment, it is practically impossible for incineration to meet the 30-minute legal limits set by European legislation. However, with proper segregation to minimize waste and remove mercury and lead containing materials, daily or weekly legal limits may be met. For large, modern incinerators, electricity or kerosene supply is required for operation. Level of in-country technical support required will vary by type of technology (small-scale to large, modern incinerators).	Emissions vary depending on waste type. Residual ash 3%–4% should be properly disposed of in a controlled or sanitary landfill to prevent soil and water contamination. Rigorously complying with segregation policies prior to incineration practically eliminates lead and mercury emissions. Particulate emissions, Arsenic, Cadmium, and Chromium emissions are significantly reduced.[3] Emissions to water only occurs when wet scrubbers are employed to remove particulates–only done in Western Europe. Emissions for DeMontfort-style incinerator are 13–20 ng TEQ/m3 Dioxin/Furan/PCBs. Dioxins and furans are formed in the presence of halogenated organic materials when secondary combustion temperature is below 800 °C and residence time is less than 2 seconds.	$2,000–$1,600,000	Small-scale incinerators are used throughout developing-country health care settings, including urban and rural areas. Large, commercial, high-temperature industrial incinerators are used in large hospitals in select settings, both in developed and developing countries.

Chemical Treatment				
Description of Technology[2]	**Performance Issues**	**Environmental Impact**	**Costs (US$)**	**Where Used**
Chemicals (ozone [gas], chlorine, formaldehyde, ethylene oxide [gas], propylene oxide [gas], periacetic acid) are introduced into a sterilization chamber. The effectiveness of each chemical agent depends on temperature and pH, and on the presence of compounds, which can interfere with disinfection. With proper exposure conditions, waste is sterilized. The process often includes shredding in order to reduce waste volume, increase complete exposure of waste to chemical disinfectant, and render waste unrecognizable before landfill.	Sterilization efficacy must be monitored; it will not be visibly apparent. Not all chemical agents are effective against all microorganisms. Bacterial spores and hydrophilic viruses are particularly resistant to many chemical agents, including alcohols and phenols. Aldehydes, such as formaldehyde and glutaraldehyde are effective, but their application is limited due to dangerous vapors. Halogens such as chlorine and iodine are widely used, particularly in public water supplies and sewage treatment. Chlorine will form dioxins if waste is subsequently incinerated at low temperatures. Shredding is required to maximize disinfection, increasing risk of infectious aerosol emissions (requires negative pressure or HEPA filters, which must be replaced regularly). Parameters that must be managed during chemical disinfection include chemical concentration, time of contact with waste, and waste particle size. Proper waste segregation is important. Mercury compounds, volatile organic compounds, and hazardous chemicals must be removed before chemical treatment. Not suitable for large pathological waste. Liquid effluent may or may not need to be treated before release into a sanitary sewer. Aerosol and particulate emissions must be controlled with air pollution devices. With shredding, volume is reduced by 60%–90%	Issue of toxic by-products. With some chemical systems there is potential soil contamination in landfills. No volume reduction and limited efficacy without shredding. Some landfills will not accept this type of treated waste. Sanitary water system must be able to handle chemical by-product in the effluent. Sewage treatment processes can be negatively impacted by residual chemical compounds.	Automated equipment: \$30,000–\$450,000	Used in US, Canada, and Israel. No known installation for medical waste treatment in developing-world clinic setting.

Steam-Based Treatment (Autoclaving)				
Description of Technology[2]	**Performance Issues**	**Environmental Impact**	**Costs (US$)**	**Where Used**
Steam under pressure is used to obtain a temperature of at least 121°C. The moist heat increases heat transfer and penetrates the waste load, assuming proper loading and the absence of closed containers. Shredding will increase the exposure of waste to steam as well as reduce waste volume.	Sterilization efficacy must be monitored; it will not be visibly apparent. Biological or chemical indictors can be used to verify disinfection efficacy. This will require basic bacterial culturing capacity. Local policies must be considered to determine whether municipal landfill disposal of autoclaved medical waste is an option. Shredding or compacting before adding to landfill is necessary to prevent reuse of nonautodisable technologies and to reduce waste volume. An external steam source or integrated steam generator is required. Installation requires connection to a sanitary sewer. Special plastic bags, resistant to high temperatures but penetrable to steam, must be available to line bins used for autoclaving. Air evacuation, either through gravity displacement or a vacuum, is required to ensure proper disinfection. A skilled operator is required for proper loading, safe operation, complete disinfection, and routine monitoring. Maintenance needs: monitor accuracy of thermocouples and pressure gauges, replace filters and gaskets, inspect regularly. Segregation system must remove mercury and other hazardous and volatile compounds. In-country technical support is mandatory. Residual waste is wet/heavy. Without proper ventilation can be an occupational hazard for staff and operators. Wet heat will disintegrate cardboard safety boxes. Body parts and other waste of significant mass cannot be disinfected by autoclave. Significant energy requirements.[4]	No volume reduction without shredding, with burden being transferred to landfill. Some emissions occur from degradation and leaching of waste residuals in landfills with potential for water and soil contamination. Water quality impacts from effluent. Odors are generated, and liquid and gaseous emission issues exist.	$36,000*–$889,000 *plus steam generator	Used primarily in developed-country settings. Increasingly used due to concerns about air quality impact from incineration. Large model program in South Africa, see http://www.nwmsi.co.za/hcw.html Some smaller standard autoclave models used for medical waste management in hospitals in Mexico, India, Puerto Rico, and Pakistan.[5] Advanced autoclaves used in US, Europe, Canada, Morocco, Egypt, and Argentina.

Microwave				
Description of Technology[2]	**Performance Issues**	**Environmental Impact**	**Costs (US$)**	**Where Used**
The microwave process uses radiant energy to heat moisture within the waste and/or heat water that is added to the waste. Microwaving units kill infectious agents through heat and pressure, not as a result of exposure to the microwaves. Shredding can be combined with microwaving to reduce volume. Waste is heated between 95°C–100°C and maintained for a regimented period of time.	Sterilization efficacy must be monitored; it will not be visibly apparent. Biological or chemical indictors must be used to verify disinfection efficacy. This will require basic bacterial culturing capacity. Typically requires three major types of equipment: material handling equipment, disinfection equipment, and environmental control equipment. Capacity ranges from a few kg per hour up to 400 kg per hour. Can operate in batch or semi-continuous mode. HEPA filter is needed to sanitize air extracted during process. A primary shredder will help expose waste to steam for disinfection. A secondary shredder may be added to help increase residual particles, which is important if sharps are included. Operator skills are required. Not all waste can be treated by microwave including some volatile chemicals and large-mass waste. Segregations system must be strengthened to remove all mercury- or lead-containing waste. Emergency technical support in-country is required.	No volume reduction without shredding, with burden being transferred to landfill. Some emissions occur from degradation and leaching of residuals in landfills. Potential soil contamination. Water quality impacts from effluent. Gaseous and liquid emissions must be managed to minimize environmental impact.	$600,000	Limited largely to the US.

Shredding (during/after treatment), Compacting, and Landfill				
Description of Technology[2]	**Performance Issues**	**Environmental Impact**	**Costs (US$)**	**Where Used**
Shredding	Mechanical nature of shredding can create maintenance problems, which can present occupational safety problems if shredder is used pre-sterilization or during an incomplete sterilization cycle. Plastic of syringes may melt with heat produced during extended operation, causing mechanical problems. In-country emergency technical support is required. Mixed composition of medical waste can be a technical problem for shredders. Shredding alone does not disinfect medical waste, so without integrated disinfection, waste remains infectious. Shredder blades will need periodic replacement. Shredder must be cleaned regularly, with monthly preventative maintenance. Electricity required for most commercial shredders. "Many people will be surprised to find out that shredding provides more opportunity for injury because all of the waste, including sharps, is not contained in bags. In addition, there are no visual indicators to verify the waste was in fact treated. People can shortcut the treatment process by simply shredding the raw medical waste and dispose of it without any treatment."[6]	Treated waste must still be disposed of in a sanitary landfill to prevent water and soil contamination. Methane is produced during degradation.	$15,000–$250,000	US, Europe, India.

Shredding (during/after treatment), Compacting, and Landfill (continued)				
Description of Technology[2]	**Performance Issues**	**Environmental Impact**	**Costs (US$)**	**Where Used**
Compacting	Some consider compaction inappropriate for sharps waste.[7] Many materials used in medical supplies are not easily compacted or will not remain in a compacted state. Compacting alone does not disinfect and waste will remain infectious.			
Landfill[8] There are three methods of land disposal–open dumping, controlled landfills, and sanitary landfills.	Open dumps are the most common method of land disposal in developing countries. This is the least costly disposal option financially, but is one with the most negative impacts on public and environmental health. Controlled landfills must consider basic hydro-geological conditions, have restricted access, control scavenging, manage waste discharge, use a soil cover regularly, control surface water and drainage, manage landfill gas, and keep basic records. Sanitary landfills will apply a bottom liner of low permeability, manage leachate and landfill gas, monitor ground water wells, use daily covers, and have a post-closure plan. Land must be available. Water table must be monitored to prevent contamination of ground water. Segregation to remove materials containing lead and mercury from inappropriate landfills and waste minimization is important.	Environmental impact of landfills should not be underestimated: “One half of available carbon is converted to methane during degradation. Methane is 25 times more destructive to the ozone layer than carbon dioxide.”[2]		Ubiquitous, although at various levels of sophistication.

3. Developing-Country Perspectives

National health care waste management (HCWM) plans must be submitted as part of the World Bank's Multi-Country Aids Project (MAP). In these management plans, country governments, primarily the ministries of health, assess their medical waste systems and propose action plans to reduce potential HIV transmission through contaminated waste. Specific comments from these reports describe the country-specific perspective on HCWM options:

Niger:[9]

1. Microwave, autoclave, chemical disinfection, and municipal landfill are not recommended.
2. Burial at health centers and open burning are in the process of being banned.
3. Incineration is recommended for local, regional, and national hospitals.

Cape Verde:[10]

1. Any implemented medical waste system must consider local context including the economic situation.
2. Microwave and autoclave technologies are considered prohibitively expensive.
3. With limited water resources in Cape Verde, this report cautions against controlled burial.
4. Small-scale incinerators are presented as an important option due to the affordable capital cost, feasibility of replacement, and low cost of operation.

Congo:[11]

1. Autoclaving and microwaving are not considered acceptable due to the cost.
2. The need to protect the environment is recognized as equally important to the need to protect health care workers and the community.
3. Chemical disinfection with chlorine is strongly recommended.
4. Burial is not recommended due to concerns about the water table.
5. Locally-made and modern incinerators are recommended at health centers and university/provincial hospitals, respectively.

Mauritania:[12]

1. Autoclave, microwave, and chemical disinfection are not recommended.
2. Modern incinerators are recommended in certain larger hospitals.
3. Small-scale incinerators are considered appropriate for health centers.
4. Burial is recommended for health posts in rural settings.

Malawi:[13]

1. Although incineration has its critics, it is difficult to choose another system for developing countries such as Malawi, given the economic and technical conditions.

The table on the following page summarizes the recommendations regarding different medical waste disposal systems in Niger, Cape Verde, Congo, Mauritania, and Malawi.

Summary of World Bank / MAP country report recommendations for medical waste disposal alternatives

System	Capital Costs	Operating Costs	Operator Skills	Available Spare Parts	Environmental Impact	Niger	Cape Verde	Congo	Mauritania	Malawi
Autoclave	Fairly High	Average	Very Qualified	No	Low	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Microwave	Very High	Average	Very Qualified	No	Low	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended
Modern Incinerator	Low	Average	Limited	Possible	Medium	Recommended at larger hospitals	Recommended	Recommended	Recommended at larger hospitals	Recommended at larger hospitals
Small-scale Incinerator	Low	Low	Limited	Yes	High	Recommended for district hospitals	Recommended	Recommended	Recommended at health centers	Recommended at health centers
Chemical Disinfection (chlorine)	Low	Low	Qualified	Yes	High	Not recommended	Not stated	Strongly Recommended	Not recommended	Not stated
Municipal Burial	Low	Low	Qualified	Yes	High	Not recommended	Recommends caution	Not recommended	Not stated	Not stated
Health Center Burial	Low	low	Limited	Yes	High	To be banned	Recommends caution	Not recommended	Recommended in rural settings	Not stated
Open Burning	Low	Low	Limited	Yes	High	To be banned	Not recommended	Not recommended	Not stated	Not stated

4. Environmental Impact of Disposal Technologies

A United States Environmental Protection Agency (US EPA) 1994 assessment identified medical waste incineration as the largest source of dioxin air pollution in the US. Stricter emission requirements for new and existing incinerators were introduced in the US in 1997. The European Union introduced even stricter emissions limits for medical waste incinerators in 2000. As a consequence of these environmental concerns and emissions standards, nonincineration technology options for medical waste management are increasing in the US and Europe. However, the financial and infrastructure resources needed to purchase, install, and operate these technologies are substantial.

The comparison of the environmental impacts from the different waste treatment technologies is complex. A feasibility study in South Africa of large, provincial health care waste management scenarios concluded that incineration, when not considering environmental emissions at the landfill, produced twice as much emission as nonburn treatment options. Of particular concern were the NO_x, HCL, SO_2, particulate matter, mercury, and dioxins produced by incineration. However, landfill area required for disposal of nonburn technologies was 30 times greater and caused the highest greenhouse gas emission. It was concluded that "it is not completely clear if non-burn or incineration is the environmentally best option, as the types of impacts and emissions caused are very different."[2]

In developing-world settings, emissions testing is not readily available and is expensive. Dust and heavy metals are analyzed together with particulate matter collected on a glass fiber filter and its content is determined gravimetrically. The cost is estimated at US$1,500. Determination of dioxins and furans is more difficult, and the analysis is available only in the US and Europe, so samples must be shipped for analysis. The potential toxicity of these samples requires international packing standards be followed. Proper measurement of dioxin/furan emissions from an incinerator in South Africa costs approximately US$9,500 and is expected to take two months. Measurement of gases such as HCl, SO_2, N_x, CO, NH_3 is estimated to cost US$800 per gas.[12]

5. Monitoring for Efficacy of Noncombustion Disposal Technologies

It is important to understand that noncombustion technologies require the development and application of monitoring standards to ensure that adequate levels of disinfection are achieved in order to safely manage medical waste.[13]

The US State and Territorial Association on Alternate Treatment Technologies (STAATT) set monitoring standards for noncombustion technologies on behalf of the US EPA. Level-III sterility is required for treatment of clinical waste, translating to a greater than 10^6 reduction in vegetative bacteria, fungi, lipophilic/hydrophilic viruses, parasites, and mycobacterium and an inactivation of bacteria spores greater than 10^4. These sterilization standards are monitored for all alternate disposal technologies with biological indicators on commissioning of installations and periodically during operation.

In South Africa, Gauteng Department of Agriculture, Conservation, Environment, and Land Affairs (GDACEL) requires that medical waste disposal plants using noncombustion technology demonstrate inactivation standards with biological indicators over a one-month period, during challenging loading scenarios, and once a month thereafter. Under GDACEL, if non-incinerator methods are introduced at an individual facility level, it is assumed that some level of monitoring procedure is followed to ensure that standards are met.

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Annex A. Estimated Costs Associated with Alternative Technologies

Technology	Machine	Capacity (kg/hr)	Capital Costs (US$)	Estimated Operating Costs (US$/kg) 2	Installation Requirements
Incinerator technologies (for comparison)					
Local Incinerator	DeMontfort	7 kg/hr	$2,500		▪ Fuel to commence burning ▪ Refractor bricks ▪ Local metal work capacity
Modern Incinerator (small)	MediBurn	20 kg/hr	$17,000 plus $475 freight		▪ 110/120 V if electrical or diesel ▪ Level surface
Modern Incinerator (medium)	Firestream Clinical				http://www.incinco.com/
Modern Incinerator (large)	Gencor	750 kg/hr	$1,600,000	$0.04/kg	
Alternative technologies					
Thermal non-steam	Demolizer System	3.7 kg/hr	$4,000		http://www.univec.com/demolizer.htm
Autoclave (small)	Mark Costello	50-200 kg/hr	$34,000–$38,000		▪ Steam: 60 psi regulated steam supply ▪ Electricity: 115 V 1-phase 5A ▪ Floor drain connected to sanitary sewer ▪ Vent and blowdown line ▪ Demineralized water ▪ Cement landing
Advanced Autoclave (shredding before disinfection)	Ecodas models T300, T1000, T2000	25-180 kg/hr	$145,000 and greater		▪ Max steam flow 170 kg/h ▪ Compressed air: 6 bars ▪ Electricity" 380 V / 3-Phase Surge Protection System 17 kW ▪ Consumption/Cycle: Steam Pressure–15 kg; electricity–3 kWh; water–100 L

Technology	Machine	Capacity (kg/hr)	Capital Costs (US$)	Estimated Operating Costs (US$/kg) 2	Installation Requirements
Advanced autoclave (shredding after disinfection)	130-2P and 230-2P, 230-3P, 240-3P (SaniPak)	50-700 kg/hr	$26,000–286,000 (not including shredder) (2001)		▪ A level concrete pad, with no more than 0.5 inch slope ▪ Electricity: Single phase Voltage: Actual Amperage Service Requirement 120VAC 16 amps 25 amps 240VAC 8 amps 15 amps ▪ Electricity: Three phase ▪ Voltage: Actual Amperage Service Requirement 208VAC 4.2 amps 10 amps 240VAC 3.6 amps 10 amps 480VAC 1.8 amps 5 amps ▪ Minimum steam pressure of 65 psi ▪ 1" insulated steam line ▪ A minimum of 97% to 100% saturated steam ▪ 1/2" water line at a minimum of 30-65 psi ▪ A drain should be installed near the connection point of the condensate tank, connected to a sanitary drain line
Advanced Autoclave (shredding during disinfection)	Nine models (Hydroclave)	25-910 kg/hr	$46,000–$375,000 (2001)	0.04-0.06[2]	

Technology	Machine	Capacity (kg/hr)	Capital Costs (US$)	Estimated Operating Costs (US$/kg) 2	Installation Requirements
Advanced Autoclave (shredding during disinfection)	MetaMizer Series I	30-50 kg/hr	$190,000 (2006)		▪ Electricity supply: 415 VAC three-phase supply. A 63 amp 4 core + earth supply is recommended ▪ Water Supply: Connection to mains via generic tap interface ▪ Air conditioning: Recommended for tropical environments ▪ Connection to sewer
Advanced Autoclave (shredding during disinfection)	Tempico Rotoclave® 1500 D1	Not on website (0.65 m^3)	600,000	0.02	http://www.univec.com/demolizer.htm
Microwave (shredding during disinfection)	HG-A 100, HG-A 250 (Sanitec)	250 - 450 kg/h	500,000–600,000 (US$ 2001)	0.03-0.05	▪ Only standard electrical and water hook-up.
Microwave (no shredding, steam generator is internal)	SINITON disinfector	35 kg/hour	450,000		▪ Electrical connection: 400 V, 50 Hz, 16 A (T) 3 P + N + PE (400V) 8.5 kW ▪ Water connection: 3/4" (cold water, < 20° C) ▪ Max. ambient temperature: 35° C
Chemical/Autoclave with shredding	STI Series 2000™	450 kg/hr	450,000	0.04	http://www.sti-wr2.com/

Annex B. Commercially Available Non-Incinerator Medical Waste Treatment Technologies

Type	Machine	Supplier	Country of Origin
Heat	Demolizer System (for sharps only)	Thermal Waste Technologies (aquired by Univec) http://www.univec.com/demolizer.htm	United States
Autoclave	Mark-Costello Co. Sterilizer	Mark-Costello http://www.mark-costello.com/medical_waste.shtml	United States
Autoclave	FB100	Fedegari http://www.fedegari.com/	Italy
Autoclave	T-Max sterilizer models	Tuttnauer http://www.tuttnauer.com/serve/templates/literature.asp	United States
Autoclave	130-2P and 230-2P, 230-3P, 240-3P	Sani-I-Pak http://www.sanipak.com/	United States
Autoclave plus shredder	MetaMizer Series I (includes shredder)	Medivac http://www.medivac.com.au/0019/index.html	Australia
Autoclave plus shredder	Tempico Rotoclave®	Tempico http://tempico.gostrategic.com/dynamic.php?pg=Applications/Medical	United States
Autoclave plus shredder	Multiple models	Hydroclave www.hydroclave.com	United States
Autoclave plus shredder	Ecodas models T300, T1000, T2000	Ecodos http://www.ecodas.com/en/index.php?menu=7&lang=en	France
Autoclave plus shredder	SSM technology	Red Bag Solutions http://www.redbag.com/	United States

Type	Machine	Supplier	Country of Origin
Pyrolysis-oxidation	Bio-Oxidizer system	Oxidation Technologies http://www.oxid-tech.com/bio_oxidizer/bio_oxidizer.html	United States (recently installed in Bermuda)
Microwave	Sanitec Microwave Disinfection Systems HG-A 100, HG-A 250	Sanitec http://www.sanitecind.com/	United States
Microwave	SINITON Disinfector	Sintion http://www.christof-group.at/www/en/cmb/produktbeschreibung.php?p_oid=PRODUKTE_16	Austria
Microwave	Medister 10 and Medister 140 and Needle Destroyer	Meteka http://www.meteka.com/	Germany
Chemical	STI Series 2000™ (NaOH with shedder)	Sterile Technology Industries (a WR2 company) http://www.sti-wr2.com/	United States
Chemical	SteriMed/SteriMed-Junior (with shredding)	MCM Environmental Technologies http://www.mcmetech.com/products.htm	United States
Shredders	Vecoplan/ReTech Medical Waste Grinder	Mark-Costello http://www.mark-costello.com/medical_waste7.shtml	United States
Shredders	BondTech Medical Waste Reduction System	BondTech http://www.bondtech.net	United States
Shredders	San-I-Pak Sharps Machine	San-I-Pak http://www.sanipak.com/products_sharps_specs.htm	United States
Compactor	General purpose compactor	Mark-Costello http://www.mark-costello.com/stationary_compactors.shtml	United States