Chapter 6

Low-Heat Thermal Technologies: Dry-Heat Systems

Just as circulating hot-air ovens have been used to sterilize glassware and other reusable instruments, the concept of dry-heat disinfection has been applied to treatment of medical waste. In **dry-heat processes**, heat is applied without adding steam or water. Instead, the waste is heated by conduction, natural or forced convection, and/or by thermal radiation. In force-convection heating, air heated by resistance heaters or natural gas, is circulated around the waste in the chamber. In some technologies, the hot walls of the chamber heat the waste through conduction and natural convection. Other technologies use radiant heating by means of infrared or quartz heaters. As a general rule, dry-heat processes use higher temperatures and longer exposure times than steam-based processes but the time-temperature requirements actually depend on the properties and size of the objects being treated.

The toroidal mixing bed dryer using high-velocity heated air (a technology designed for hospitals and offered by KC MediWaste) and the Demolizer (a small table-top device for hospital departments, clinics, medical offices, and other small volume generators) will be described in this chapter.

HIGH VELOCITY HEATED AIR

Overview of the Technology

The KC MediWaste System evolved out of efforts by Cox Sterile Products, Inc. to develop a rapid dry-heat sterilizer coupled with their adaptation of the Torbed technology by Torftech (UK), a dry-heat technology used in the processing of minerals, foods, and wastes. The first installation of the KC MediWaste technology is at the Mercy Health Center in Laredo, Texas.

The heart of the system is an air-tight stainless steel chamber into which shredded medical waste is introduced and exposed to high velocity heated air pumped into the bottom of the chamber through a ring of vanes or slots similar in design to turbine blades. The hot air is directed in a way that causes the waste particles to rotate turbulently around a vertical axis in a toroidal mixing action. Under these conditions, high rates of heat transfer take place. Within four to six minutes, dry unrecognizable waste is ejected. The waste can then be disposed of at a regular landfill.

How It Works

The operation of the KC MediWaste System is as follows:

- *Waste loading*: Red bags are loaded into carts that attach to a lifter-dumper which automatically opens an air-lock hopper door and empties the waste into the shredder hopper while maintaining a negative pressure to minimize aerosolization.
- *Internal shredding*: The waste is shredded to a relatively uniform size of about 19 mm (3/4 inch), passing through a changeable screen and collecting in a surge vessel.
- *Metering*: The amount of waste introduced into the chamber is controlled by a gate valve. It opens automatically when the chamber is empty, allowing a new batch to be processed. The chamber operates under a negative pressure.
- *Dry-heat treatment*: After the shredded waste is pulled into the chamber, it is exposed to high-velocity heated air (at about 171°C or 340°F). The temperature in the chamber drops initially but recovers in about four minutes.
- *Discharge*: At the end of a pre-set time, the dump door of the chamber is opened expelling the waste in a matter of seconds. The treated waste falls into a compactor dumpster under the chamber.
- *Compaction and disposal*: The dry, unrecognizable waste is compressed and put into sealed containers ready for disposal at a sanitary landfill.

Types of Waste Treated

The types of waste treated in the KC MediWaste System are somewhat similar to those treated in autoclaves or microwaves: cultures and stocks, sharps, materials contaminated with blood and body fluids, isolation and surgery wastes, laboratory wastes (excluding chemical waste), and soft wastes (gauze, bandages, drapes, gowns, bedding, etc.) from patient care. In addition, liquids such as blood and body fluids can also be treated in the unit. It is technically possible to treat human anatomical wastes but ethical, legal, cultural, and other considerations may preclude their treatment in this technology.

Volatile and semi-volatile organic compounds, chemotherapeutic wastes, mercury, other hazardous chemical wastes, and radiological wastes should *not* be treated in a dry heat system.

Emissions and Waste Residues

Exhaust gases from the air pulled from the shredder hopper are filtered through a high-efficiency particulate air (HEPA) filter and a carbon filter to remove aerosolized pathogens and odors prior to discharge. The hot air from the chamber is cooled in a venturi scrubber which also removes particulates. There are some odors in the vicinity of the unit.

The conditions in the chamber do not support combustion. Therefore, the air emissions are minimal as long as waste streams are properly segregated to prevent hazardous chemicals from being fed into the chamber. Since there are no combustion byproducts, the State of Texas has granted KC MediWaste exemptions from air quality permitting procedures. There is also no liquid effluent from the chamber.

The waste residue is dry and unrecognizable. With shredding and compaction, the waste volume is reduced by about 80% and has been accepted for disposal at a solid waste landfill. The mass of the dry treated waste is also reduced, depending on the amount of moisture it had contained.

Microbial Inactivation

Microbiological tests using *B. subtilis var. niger* strips (the variety traditionally used to test for dry-heat resistance) introduced into the chamber showed a 6 log10 kill in about three minutes.[1]

Advantages and Disadvantages of the Technology

Heated air technology has the following advantages:

- The basic design of the treatment chamber is simple (it has been described as a popcorn popper). The Torbed itself has been used for many years in other applications.
- If proper precautions are taken to exclude hazardous material, the emissions from the dry heat system are minimal.
- The technology can treat waste with varying moisture content, including blood and body fluids.
- There are no liquid effluents.
- The internal shredder and post-treatment compactor reduce waste volume by about 80 percent.
- The technology is automated and easy to use. It requires one operator.
- A combination of HEPA and carbon filters, and a venturi scrubber keep odors to a minimum.
- The treated waste is dry, unrecognizable, and compact.

The disadvantages include the following:

- If hazardous chemicals are in the waste, these toxic contaminants are released into the air or remain in the waste to contaminate the landfill.
- Some slight odors may be generated near the compactor.
- Any large, hard metal objects may interfere with the shredder.
- The KC MediWaste Processor is a relatively new technology.

Other Considerations

Below are some suggestions to consider when selecting this dry heat system:

- Again, make sure that an effective waste segregation plan is in place to keep hazardous materials from being treated in a dry-heat treatment system.
- The carts should be disinfected prior to reuse. A steam cleaning system is available.
- The Laredo, TX unit has a vertical configuration. Other designs are possible.
- Maintain records of biological indicator tests, treatment parameters, preventive maintenance activities, and periodic inspections.
- Provide worker training to include: a basic understanding of the dry-heat systems, standard operating procedures, occupational safety, record keeping, identifying waste that should not be treated in the unit, recognizing technical problems, periodic maintenance schedules, and contingency plans (e.g., what to do in case of a spill or power outage).

KC MediWaste[2]

Description

(See above)

Models-Capacities

Standard model capacity is 200 lb/hr; other sizes are available

Approximate Dimensions & Weight

18' x 10' x 23' H; weighs 14,500 lbs

Approximate Energy Consumption

About 63 kWh per hour

Typical Installation Requirements

Electrical – 480 V, 3-phase, 125 A; Compressed air – 100 scfm and 90 psig at peak; Water – 5 gpm at 60 psig; Drain – 1-1/2" line; Hydraulic unit

Features & Options

An air compressor, waste carts, weighing scale, and hydraulic unit for the compactor are optional.

Stage of Commercialization

Early stage of commercialization

Permitting Status

The technology is approved in Texas with approvals pending in Illinois and New York. Applications have been filed in other states.

Approximate Costs

Approximate capital cost is about $385,000

Vendor Information

KC MediWaste, 4219 University Boulevard, Dallas, TX 75205; Ph. 214-528-8900; Fax 214-528-0467

Note: Health Care Without Harm does **not** *endorse any specific technology or company. This technology is presented here as an example of a non-incineration treatment technology. Always check with the vendor for the latest and most accurate data and specifications.*

DRY HEATING

Overview of the Technology

The Demolizer (Thermal Waste Technologies, Inc., formerly DOCC) is a desktop system for treating small amounts of sharps and soft "red bag" wastes at or near the point of generation. It is used in clinics, physicians' offices, dental offices, veterinary clinics, and medical departments.

How It Works

The operation of a Demolizer unit is as follows:

- *Waste loading*: Waste is collected in one-gallon containers for sharps or soft waste. When filled up to a safety line, the containers are closed and transferred to the unit. The operator must push a door-release button to open and close the lid of the unit.
- *Start of documentation*: The operator places a print-out/verification label into a slot on the processing unit.
- *Dry heat processing*: The process begins when the cycle-start button is pressed. There is an 18-minute warm-up. The waste then undergoes a dry heat disinfection cycle at 350°F (177°C) for 90 minutes.
- *Cooling*: The unit allows the waste to cool down for about 52 minutes to below 95°F (35°C). At the end of the 2-1/2 hour treatment cycle, the unit sends an audible signal and display message.
- *Final documentation*: The operator removes the print-out label and fills in the date, start and stop times, and operator's initials. Half of the print-out label is placed in a log book, the other is placed in the processed container.
- *Removal and disposal*: The processed container is removed and disposed with regular garbage.

Types of Waste Treated

The types of waste treated in the Demolizer include sharps and soft wastes (gauze, bandages, gloves, etc.) from patient care. Small amounts of liquid waste such as dressings soaked with blood or body fluids may also be processed, but not liquids in bulk quantities.

Volatile and semi-volatile organic compounds, chemotherapeutic wastes, mercury, other hazardous chemical wastes, radiological wastes, and human or animal body parts should *not* be treated in the Demolizer system. The manufacturer also prohibits the treatment of cultures and stocks, isolation waste, and bulk liquids in the Demolizer.

Emissions and Waste Residues

The conditions in the Demolizer treatment chamber do not produce any combustion byproducts. Emissions from the chamber are passed through a dual filtration system comprised of an activated carbon filter and a high-efficiency particulate air (HEPA) filter to remove odors and bacteria. Exhaust from the Demolizer was tested by Valley Medical Laboratory (Springfield, MD) for microbial spores. Results using *B. stearothermophilus* showed no detectable releases of bio-aerosols from the Demolizer to the surroundings.[3]

The treated waste is dry. Although the waste retains much of its physical appearance, the waste is sealed and disposed in the processed container. The sharps waste generally melts down into a disk-shape solid plastic with metal portions embedded inside. A test[4] of treated medical waste by Leberco Testing (Roselle Park, NJ) for 8 heavy metals showed no metal concentrations above EPA limits. Six of the 8 metals including lead, mercury, arsenic, and cadmium were below detection limits. The other two (barium and chromium) were well below regulatory levels.

Microbial Inactivation

The vendor commissioned a series of tests in the early 1990s. Microbiological tests[5] were conducted to show an 8 $\log_{10}$ kill of *B. subtilis*. Tests[6] also showed no growth of *Staphylococcus aureus, Candida albians, Mycobacterium fortuitum, Mycobacterium bovis*, and *Giardia sp*. Additional tests[7], all showing no growth, were done by AMA Laboratories using *E. coli, Pseudomonas aeruginosa*, and *Staphylococcus aureus*. Another test[8] showed inactivation of duck hepatitis B virus by the Demolizer.

Advantages and Disadvantages of the Technology

The Demolizer technology has the following advantages:

- The small device—weighing about 35 pounds—is somewhat portable although designed for operation in one location. As a countertop unit, it is used at or near the point of generation and eliminates the need for on-site storage or transport of infectious waste.
- It is accepted or approved as an alternative technology in 45 States.
- If proper precautions are taken to exclude hazardous material, the emissions from the Demolizer are insignificant. There are no liquid effluents.
- The technology is automated, easy to use, and requires a minute or so of labor time per cycle to operate. It employs microprocessor controls that have fail-safe features.
- Odors are eliminated by a dual filtration system. The operation is virtually noiseless.
- The waste containers have a heat-sensitive color-changing strip to identify treated and untreated containers. They remain sealed when disposed in the trash. The device includes a print-out for labeling and documentation.
- The system has a low capital cost and requires no major installation except for a standard 110v grounded outlet.

The disadvantages include the following:

- If hazardous chemicals are in the waste, these toxic contaminants may concentrate in the filter, escape into the air, or remain in the solid waste to contaminate the landfill.
- Since the unit is designed for small-volume generators, it cannot handle the waste for all of a hospital or large health care facility.
- The facility must purchase a single-use collection container for processing in the Demolizer. This consumable item accounts for a significant portion of the operating cost.
- Even though sharps waste is reduced in volume by about 75 percent, the container in which the waste is disposed of does not change size and there is an insignificant loss of weight of the treated material.
- The use of a disposable waste can adds mass to the waste that goes to the landfill.

Other Considerations

Below are some suggestions to consider when selecting this dry heat treatment system:

- Again, make sure that an effective waste segregation plan is in place to keep hazardous materials from being treated in a dry heat treatment system.
- The Demolizer is intended for small-volume generators but it could also be used in hospitals as a supplemental technology in conjunction with a larger non-incineration technology.
- The unit is designed such that if the process is interrupted after the temperature reaches 120°F, the unit cannot be opened. Instead, the unit resets and begins the full 90-minute cycle.
- Maintain records of biological indicator tests, treatment parameters, preventive maintenance activities, and periodic inspections.
- Provide worker training to include: a basic understanding of dry heat systems, standard operating procedures, occupational safety, recordkeeping, identifying waste that should not be treated in the unit, recognizing technical problems, and contingency plans (e.g., what to do in case of a spill or power outage).

DEMOLIZER[9]

Description

The Demolizer is offered by Thermal Waste Technologies or TWT. (See also above description.)

Capacity

Demolizer *Model 47*: up to one gallon per cycle (about 2-1/2 hours)

Approximate Dimensions & Weight

19-1/4" D x 13" W x 12-1/4" H, weighs 35 pounds

Installation Requirement

Electrical – 115 V, 750 W, 60 Hz

Features & Options

Thermal Waste Technologies also offers waste cans, labels, log books, a magnet for removing the waste cans, wall-mount bracket, and sharps container funnel.

Stage of Commercialization
Fully commercialized

Permitting Status
Accepted or approved in 45 states with site-specific or pending approvals in other states

Approximate Costs
Approximate capital cost of about $4,000; sharps waste and soft waste cans are about $4.25 each

Vendor Information
Thermal Waste Technologies, Inc., 19 Stony Hill Road, Bethel, CT 06801; Ph. 888-336-6549 or 203-778-2210; Fax 203-778-3114

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NOTES

1. Data provided by KC Mediwaste.
2. Based on vendor brochures and technical data provided by KC MediWaste from 1997 to 2000, detailed written responses to technical questions, site evaluation of the technology installed at Mercy Health Center in Texas, and personal communications with Keith Cox.
3. "Bacterial Emission sample testing from the Demolizer System Medical Waste Treatment System," Valley Medical Laboratory, Springfield, MA, 1998.
4. "USEPA Regulatory Requirement Levels for Heavy Metal Concentration: Demolizer System Test Results," Leberco Testing, Inc., Roselle Park, NJ, August 2, 1993.
5. "Continuous Challenge/Validation Procedure for the Demolizer System" and test results, Leberco Testing, Inc., Roselle Park, NJ, December 9, 1994.
6. "Efficacy Testing of the Demolizer system medical waste treatment system," Leberco Testing, Inc., Roselle Park, NJ, November 10, 1992.
7. "Certificate of Analysis," AMA Laboratories, New City, NY, August 25, 1989.
8. "Efficacy of the Demolizer System on Hepadna Virus (Duck Hepatitis Virus), " tests conducted by Dr. Patricia Marion, Division of Infectious Diseases, Stanford University School of Medicine, November 9, 1992.
9. Based on brochures and technical data provided by DOCC, later TWT, from 1995 to November 1999, and personal communications with Jon Bricken.