

# Non-incineration Technologies: General Categories and Processes

Non-incineration treatment technologies can be classified in many ways—such as according to size, purchase price, types of waste handled, or market share. In this chapter, the technologies will be categorized based on the fundamental processes used to decontaminate waste. The four basic processes are:

1. Thermal processes
2. Chemical processes
3. Irradiative processes
4. Biological processes

The majority of non-incineration technologies employ the first two processes listed above. Presented below are each of these processes, as well as **mechanical processes** which supplement the four fundamental processes.

## THERMAL PROCESSES

Thermal processes are those that rely on heat (thermal energy) to destroy pathogens in the waste. This category is further subdivided into low-heat, medium-heat, and high-heat thermal processes. This further subclassification is necessary because physical and chemical mechanisms that take place in thermal processes change markedly at medium and high temperatures.

### Low-Heat Thermal Processes

Low-heat thermal processes are those that use thermal energy to decontaminate the waste at temperatures insufficient to cause chemical breakdown or to support combustion or pyrolysis. In general, low-heat thermal technologies operate between 200°F to about 350°F (93°C -177°C). The two basic categories of low-heat thermal processes are wet heat (steam) and dry heat (hot air) disinfection. Wet heat treatment involves the use of steam to disinfect waste and is commonly done in an autoclave (see Chapter 5). Microwave treatment is essentially a steam disinfection process since water is added to the waste and disinfection occurs through the action of moist heat and steam generated by microwave energy<sup>1</sup>. In dry heat processes, no water or steam is added. Instead, the waste is heated by conduction, natural or forced convection, and/or thermal radiation using infrared heaters.

### Medium-Heat Thermal Processes

Medium-heat thermal processes take place at temperatures between 350 to 700°F (177°C-370°C) and involve the chemical breakdown of organic material. These processes are the basis for relatively new technologies. They include reverse polymerization using high-intensity microwave energy and thermal depolymerization using heat and high pressure.

### High-Heat Thermal Processes

High-heat thermal processes generally operate at temperatures ranging from around 1,000°F to 15,000°F (540°C-8,300°C) or higher. Electrical resistance, induction, natural gas, and/or plasma energy provide the intense heat. High-heat processes involve chemical and physical changes to both organic and inorganic material resulting in total destruction of the waste. A significant change in the mass and volume of the waste also occurs. For example, low-heat thermal technologies that rely on shredders or grinders to reduce size decrease waste volume by about 60 to 70 percent, compared to 90 or 95 percent with high-heat thermal processes.

## CHEMICAL PROCESSES

Chemical processes employ disinfectants such as dissolved chlorine dioxide, bleach (sodium hypochlorite), peracetic acid, or dry inorganic chemicals. To enhance exposure of the waste to the chemical agent, chemical processes often involve shredding, grinding, or mixing. In liquid systems, the waste may go through a dewatering section to remove and recycle the disinfectant. Besides chemical disinfectants, there are also encapsulating compounds that can solidify sharps, blood, or other body fluids within a solid matrix prior to disposal. One developing technology uses ozone to treat medical waste, and others utilize catalytic oxidation. A novel system uses alkali to hydrolyze tissues in heated stainless steel tanks.

## IRRADIATIVE PROCESSES

Irradiation-based technologies involve electron beams, Cobalt-60, or UV irradiation. These technologies re-

quire shielding to prevent occupational exposures. Electron beam irradiation uses a shower of high-energy electrons to destroy microorganisms in the waste by causing chemical dissociation and rupture of cell walls. The pathogen-destruction efficacy depends on the dose absorbed by the mass of waste, which, in turn, is related to waste density and electron energy. Germicidal ultraviolet radiation (UV-C) has been used as a supplement to other treatment technologies. Irradiation does not alter the waste physically and would require a grinder or shredder to render the waste unrecognizable.

## BIOLOGICAL PROCESSES

Biological processes employ enzymes to destroy organic matter. Only a few non-incineration technologies have been based on biological processes.

## MECHANICAL PROCESSES

Mechanical processes—such as shredding, grinding, hammermill processing, mixing, agitation, liquid-solid separation, conveying (using augers<sup>2</sup>, rams, or conveyor belts), and compaction – supplement other treatment processes. Mechanical destruction can render the waste unrecognizable and is used to destroy needles and syringes so as to minimize injuries or to render them unusable. In the case of thermal- or chemical-based processes, mechanical devices such as shredders and mixers can also improve the rate of heat transfer or expose more surfaces to chemical disinfectants. Mechanical processes can add significantly to the level of maintenance required.

A mechanical process is supplementary and cannot be considered a treatment process *per se*. **Unless shredders, hammermills, and other mechanical destruction processes are an integral part of a closed treatment system, they should not be used before the waste is decontaminated.** Otherwise, workers would be exposed to pathogens released to the environment by mechanical destruction. If mechanical processes are part of a system, the technology should be designed in such a way that the air in and from the mechanical process is disinfected before being released to the surroundings. It is especially important for air to be drawn into the mechanical process (away from the inlet) when waste is being fed. This is often done using a draft fan which maintains a negative pressure in the mechanical processing chamber; air taken from the mechanical process passes through the disinfection chamber or through a high efficiency particulate air (HEPA) filter before being released to the environment. Shredders, grinders, and hammermills are commonly used

size-reduction equipment. Other terms, such as granulators, particlizers, and cutters, are also used. In general, size reduction is accomplished by shearing the material between two surfaces (as in shredders) or by impact against a solid surface (as in hammermills). A screen is usually added to control the size of particles that exit the device. Sometimes, a ram is used to push the waste through the shredder or grinder.

**Shredders** are designed with hardened steel cutting knives, hooks, disks, or blades mounted on rotating shafts. These knives cut against stationary knives on the casing (single-shaft shredders) or against other knives mounted on one or more counter-rotating shafts (multiple-shaft shredders). Because waste material can get lodged between the blades, many shredders used for medical waste are equipped with reverse action, e.g., when an overload occurs, the normal rotating motion is stopped and a reverse rotating motion is used to clear the obstruction. This action may be repeated several times automatically. If the blockage is still not removed, the shredder shuts off and the operator is sent an audio-visual or electronic alert. Removing the blockage then requires manual operation. Shredders generally operate at low speed and high rotation force.

**Grinders** refer to size-reduction equipment using a series of rollers that operate at high speed. Terms like crusher and pulverizer are also used. When the rollers are equipped with teeth or knives, they operate much like multiple-shaft shredders, which is why the terms shredder and grinder are sometimes used interchangeably. A **hammermill** has a rotating shaft with swinging T-shaped steel hammers or beaters mounted on it. As the hammermill rotates at high speed, waste is crushed by the hammers against a plate. Hammermills tend to be noisier and use more energy.

All these devices are maintenance-intensive. Hammers need periodic resurfacing, dull cutting knives need sharpening, and worn or broken shredder blades need to be replaced. Some shredders and grinders have a breakaway pin to protect the shaft during those rare but inevitable times when a prosthetic steel joint ends up in the shredder. When that happens, it is safer and easier to replace the breakaway pin than to replace the entire shaft. However, hard metal objects would likely cause shredder blades to break or chip especially if the device has automatic reverse action. Mechanical devices should have an alternative way of disinfecting the waste in the event that the equipment needs to be opened for repair; otherwise service personnel could be exposed to pathogens. In addition to metal parts that can dull or chip shredder blades, soft waste such as cloth, gauze, or moist paper can also cause problems by wrapping around shredder blades and shafts.

Some hot (molten or softened) plastics can flow around shredder parts and harden upon cooling. Some equipment can handle these problems better than others. When considering a technology that has a grinder or shredder, facilities should evaluate the size-reduction equipment based on real-world experiences of other facilities dealing specifically with medical waste. They should also inquire about: safety; overload protection; how the equipment handles temporary obstructions; alternative disinfection procedures during repairs; average life span of blades, cutting knives, hammers, and other items that wear out; cost of sharpening and of their replacement; and preventive maintenance procedures, among others. The amount of wear depends on the types of waste treated. For example, treating sharps may result in more frequent replacement than treating soft wastes. Access to repair and maintenance records of facilities that have installed the specific device could be valuable in evaluating the reliability of different size-reduction equipment.

### Unrecognizability

Mechanical destruction processes render the waste unrecognizable. Some states require that treated medical waste must be rendered unrecognizable before landfilling. Other states only specify that body parts be unrecogniz-

able. Many states require that sharps be broken (or ground up), made unusable, and/or packaged in puncture-resistant containers. Facilities should check with their state agencies to determine if any of these requirements applies to them.

Even in states where there is no “unrecognizability” requirement, facilities need to check with local municipal landfill operators. In places where treated medical waste can remain recognizable, landfill operators may refuse to accept the waste. Some groups have argued for “unrecognizability” for aesthetic reasons, as an added indication that the waste has been treated, or because rendering the waste unrecognizable usually entails a reduction in waste volume—an obvious benefit in areas where landfill capacities are dwindling.

## NON-INCINERATION TECHNOLOGIES BY CATEGORIES

Table 4-1 lists some non-incineration technologies according to category. These technologies range from small units for use at or near the point of generation to high-capacity systems for large medical centers or regional facilities.

**TABLE 4-1. NON-INCINERATION TREATMENT TECHNOLOGIES FOR MEDICAL WASTE**

NON-INCINERATION TECHNOLOGIES	TECHNOLOGY VENDORS
LOW-HEAT THERMAL PROCESSES	
Autoclave or Retort	Bondtech (Somerset, KY)
Autoclave or Retort	Environmental Techtonics Corp. (Southampton, PA)
Autoclave or Retort	Mark-Costello (Carson, CA)
Autoclave or Retort	Sierra Industries (Santa Ana, CA)
Autoclave or Retort	SteriTech (Bloomington, IN)
Autoclave or Retort	Tuttnauer (Ronkonkoma, NY)
Vacuum-Steam-Compaction	San-I-Pak (Tracy, CA)
Steam-Mixing-Fragmenting/Drying/ Shredding	Tempico (Madisonville, LA)
Shredding/Steam-Mixing/Drying, Chemical	Sterile Technologies Inc. (West Chester, PA)
Shredding-Steam-Mixing/Drying	Antaeus Group (Hunt Valley, MD)
Shredding-Steam-Mixing/Drying	Ecolotec (Union Grove, AL)
Steam-Mixing-Fragmenting/Drying	Hydroclave Systems Corp. (Kingston, Ontario, Can.)
Pre-Shredding/Steam-Mixing	Aegis Bio-Systems (Edmond, OK)
Shredding/Steam-Mixing-Compaction	LogMed (Erdwisch ZerkleinerungsSysteme GmbH)
Microwave Treatment	Sanitec (West Caldwell, NJ)
Microwave Treatment	Sintion/CMB (Austria)
Electro-Thermal Deactivation	Stericycle (Lake Forest, IL)
Dry Heat Treatment	KC MediWaste (Dallas, TX)
Dry Heat Treatment	Demolizer

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**TABLE 4-1. NON-INCINERATION TREATMENT TECHNOLOGIES FOR MEDICAL WASTE  
(CONTINUED)**

NON-INCINERATION TECHNOLOGIES	TECHNOLOGY VENDORS
<b>MEDIUM-HEAT THERMAL PROCESSES</b>	
Reverse Polymerization	Environmental Waste International (Ajax, Ontario)
Thermal Depolymerization	Changing World Technologies (West Hempstead, NY)
<b>HIGH-HEAT THERMAL PROCESSES</b>	
Pyrolysis-Oxidation	Oxidation Technologies (Annapolis, MD)
Plasma Pyrolysis	DayStar/Prometron (Tokyo, Japan)
Plasma Pyrolysis	Electro-Pyrolysis, Inc. (Wayne, PA)
Plasma Pyrolysis	HI Disposal Systems (Indianapolis, IN)
Plasma Pyrolysis	Integrated Environmental Systems (Richland, WA)
Plasma Pyrolysis	MSE Technology Applications (Butte, MT)
Plasma Pyrolysis	Plasma Pyrolysis Systems (Stuyvesant Falls, NY)
Plasma Pyrolysis	Startech Environmental Corp. (Wilton, CT)
Plasma Pyrolysis	Unitel Technologies (Mt. Prospect, IL)
Plasma Pyrolysis	Vance IDS/Bio Arc (Largo, FL)
Plasma Pyrolysis	Vanguard Research Inc. (Lorton, VA)
Induction-Based Pyrolysis	Vanish Technologies/LFR (Raritan, NJ)
Laser-Based Pyrolysis	Anara Group (Las Vegas, NV)
Superheated Steam Reforming	Duratek (Columbia, MD)
Advanced Thermal Oxidation	NCE Corporation (Carrollton, TX)
<b>CHEMICAL PROCESSES</b>	
Sodium Hypochlorite-Hammermill	Circle Medical Products (Indianapolis, IN)
Sodium Hypochlorite-Shredding (mobile)	MedWaste Technologies Corp. (Houston, TX)
Chlorine Dioxide-Shredding/Grinding	Encore/Medical Compliance (El Paso, TX)
Ozonation	Lynntech (College Station, TX)
Electrocatalytic Wet Oxidation	MeDETOX/Delphi Research (Albuquerque, NM)
"Stericid"-Shredding-Mixing	MCM Environmental Technologies (Gilboa, Israel)
Dry Inorganic Chemical-Shredding	Positive Impact Waste Solutions (Pearland, TX)
Dry Inorganic Chemical-Shredding	Premier Medical Technology (Houston, TX)
Peracetic Acid-Grinding	Ecocycle 10/STERIS Corp. (Mentor, OH)
Alkaline Hydrolysis	WR <sup>2</sup> (Indianapolis, IN)
<b>IRRADIATION PROCESSES</b>	
Electron Beam	BioSterile Technology (Fort Wayne, IN)
Electron Beam-Shredding	U. Miami E-Beam (Coral Gables, FL)
<b>BIOLOGICAL PROCESSES</b>	
Enzyme-Based Treatment/Extrusion	Bio Conversion Technologies, Inc. (Norcross, GA)

N/a = not available

**NOTE:** The above technologies are described in subsequent chapters. Health Care Without Harm does not endorse any technology, company, or brand name. These technologies are listed here as examples of alternatives to traditional incineration. HCWH does not claim that this is a comprehensive listing.

## Non-Incineration Technologies for Off-Site Treatment

Most of the technologies presented in this report can be installed on-site at a hospital or medical center. Many technology vendors offer multiple models with different capacities to meet the needs of small to large health care facilities. The following vendors manufacture units with high throughput rates suitable for off-site regional treatment centers:

- ▶ Bondtech
- ▶ Environmental Techtonics Corporation
- ▶ Mark-Costello
- ▶ Sierra Industries
- ▶ Tuttnauer
- ▶ San-I-Pak
- ▶ Tempico
- ▶ Sterile Technologies Inc.
- ▶ Hydroclave Systems Corp.
- ▶ Aegis Bio-Systems
- ▶ Sanitec
- ▶ Bio-Oxidation/Oxidation Technologies
- ▶ Electro-Pyrolysis, Inc.
- ▶ Integrated Environmental Systems
- ▶ Startech Environmental Corporation
- ▶ Anara Group
- ▶ Circle Medical Products
- ▶ Positive Impact Waste Solutions
- ▶ Premier Medical Technology
- ▶ Bio Conversion Technologies, Inc.

The following technologies are primarily for off-site regional treatment facilities:

- ▶ Environmental Techtonics Corporation
- ▶ Aegis Bio-Systems
- ▶ Stericycle
- ▶ HI Disposal Systems
- ▶ Anara Group
- ▶ Encore/Medical Compliance
- ▶ Matrix
- ▶ Bio Conversion Technologies, Inc.

## SOURCES OF INFORMATION

The alternative treatment technology industry is relatively new, compared to the incineration industry. As with any new dynamic market, technologies come and go. Many new technologies that existed only a year or two ago are no longer in business. Furthermore, technology designs have evolved rapidly in response to changing needs and requirements. For this reason, **it is important to contact technology vendors to get the latest and most accurate data and specifications on non-incineration technologies.**

The technology descriptions that follow are based on vendor information (such as vendor websites, brochures, and personal communications), non-proprietary technical data provided by vendors or manufacturers, evaluations by non-profit institutions and private consultants (such as the author), research by academic institutions, government studies, and other sources. An effort was made to corroborate or verify the accuracy of vendor information where possible. Claims by vendors that were deemed misleading or dubious were left out of the descriptions. The information presented is intended to provide an overview and general understanding of non-incineration technologies. Health care facilities, however, should conduct their own technical and economic evaluations of the technologies before deciding on any particular option.

## NOTES

1. Various studies show that the lethal effect of microwaves on microbial organisms is primarily due to moist heat; without water or steam, microwave energy alone results in no significant cell inactivation. See, for example, G.R. Vela and J.F. Wu. *Applied and Environmental Microbiology*, 37(3), 552, 1979.
2. An auger is essentially a large screw that rotates inside a cylinder, thereby moving the waste forward.

